Title

Changing Environments, Social Adaptations, Divergent Trajectories: The Application of Socio-Natural Systems Thinking and Geospatial Modeling to the Late Bronze/Iron Age Transition in West-Central Syria, ca. 1350-750 BCE

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By
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Abstract

Changing Environments, Social Adaptations, Divergent Trajectories: The Application of Socio-Natural Systems Thinking and Geospatial Modeling to the Late Bronze/Iron Age Transition in West-Central Syria, ca. 1350-750 BCE

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The transition for the Late Bronze to the Iron Age in the Eastern Mediterranean is still only incompletely understood, with explanations ranging from social disintegration to environmental degradation. Especially the idea of societal collapse has had a strong influence on this discourse and continues to be frequently invoked as an explanatory model, despite recent advances in the historical and archaeological understanding of this transitional period. Mediated by Classical Greek and biblical tradition, this ongoing appeal of collapse theory can be attributed to the (overt or subliminal) persistence of 18th-20th century CE intellectual paradigms, which are often enmeshed with ill-defined concepts of race, ethnicity, or social evolution. In the context of the Late Bronze/Iron Age Levant, traditional applications of collapse theory reveal more about Western scholarly self-perceptions, than they contribute to an understanding of this critical period.

This dissertation argues that Socio-Natural Systems (SNS) thinking, borrowed from ecology, offers a theoretical and methodological framework with which the Late Bronze/Iron Age transition can be analyzed and understood in more detail. Rather than relying on incompletely understood and ultimately restrictive classificatory labels, SNS thinking promotes the analysis of processes of change across multiple scales, both temporal and geographic. SNS analysis acknowledges the interrelatedness of social processes and environmental conditions, and provides a structure through which the interactions between societies and their respective environments can be studied.

The principles of SNS analysis are applied to a study region in Western Syria and Northern Lebanon, termed West-Central Syria, in a preliminary analysis of socio-natural interactions in the late 2nd and early 1st millennia BCE. Geospatial analysis is used not only to investigate and quantify relationships between social and environmental processes, but also to overcome significant gaps in current data availability. GIS modeling is used to retrodict climatic conditions in the late 2nd and early 1st millennia BCE, but also to develop a predictive model of agricultural suitability, enabling the analysis of the effects of climatic change on the environment and ancient agricultural economies. Combining the results of these models with geostatistical analysis, palaeoenvironmental data, and the historical and archaeological record, this dissertation argues that processes of change and transformation in Late Bronze/Iron Age West-Central Syria were geographically and chronologically specific, and conditioned on a highly complex interplay of both social and environmental factors.

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All lapses and mistakes remain the author‘s sole responsibility.

CHAPTER 1
INTRODUCTION

> “Given the extent of change observed in the Iron Age, considerable debate has been conducted over the nature of the transition between the Late Bronze and Iron Ages in Syria and elsewhere. Were there abrupt transformations and significant influence from external invaders like the Sea Peoples, or was the transition more of a gradual and endogenous process?” (Akkermans and Schwartz 2003, 361)

1.1 INTRODUCTION

Even today, over a decade after Akkermans and Schwartz took stock of the archaeological data from Syria, the processes by which the Late Bronze culture was transformed into that of the Iron Age remain somewhat of a mystery.

Traditionally, the most prominent explanatory model to describe this transitional period has been the idea of collapse. The very concept itself has a long and complex intellectual history in Western thought, harking back to social ideals of 18th and 19th century CE Enlightenment thinking (Tainter 1988). Due to this convoluted history, and a plethora of social, cultural, geographical, and chronological contexts it has been applied to, the very concept of collapse can refer to a wide range of phenomena, making it almost impossible to develop an all-encompassing, agreed-on definition of the term.

The Late Bronze/Iron Age transition in the Levant constitutes a particularly prominent case to which collapse thinking has commonly been applied. As Riehl *et al.* (2014) have recently remarked, applications of collapse theory to the end of the Late Bronze Age in the Eastern Mediterranean have oscillated between two primary extremes: cultural determinism on the one hand, and environmental determinism on the other. Proponents of cultural change have concentrated on evidence for migration and foreign invasion, socio-political and socio-economic decline, political and ideological disenfranchisement, technological change, and the role of imperial power structures in holding together the social fabric. Ecological explanations, on the other hand, have drawn on textual sources suggesting agricultural and economic hardships, as well asan ever-increasing corpus of palaeoclimatic and palaeoenvironmental proxy data, and have proposed a direct link between late 2nd millennium BCE climate change and the decline of Bronze Age culture.

In the context of Late Bronze/Iron Age Syria, such interpretations of societal collapse are plagued by two main issues. First, it needs to be recognized that collapse thinking, at least in this particular context, is still influenced by the intellectual baggage of several centuries of Western historical thinking. Biblical traditions, which shaped the cultural, religious, racial, or ethnic perceptions of early Near Eastern archaeologists, exerted a strong influence on how the archaeological and textual remains of the Late Bronze and Iron Ages were interpreted and, to some degree, continue to do so. Similarly, conceptions of the uniqueness and evolutionary singularity of Western culture, fueled by a Philhellenic intellectual climate, provided the template through which social transformations and developments were seen, interpreted, and valuated. Second, new archaeological discoveries of the past few decades have provided significant evidence for material, ideological, or political continuities between the two periods. Despite these advances in archaeological knowledge, however, interpretations and explanations of this period have not always kept pace with these new developments and discoveries. Quite on the contrary, discussions frequently exhibit a strong tendency towards conservativism, often reverting back to old explanations and paradigms in constructing a historical narrative.

As a result of these inadequacies, which are specific to the context of the Late Bronze and Iron Age Levant, explanations centered on the idea of collapse have not yet succeeded in satisfactorily explaining the processes that led to the development of a new social, political, and economic structure at the beginning of the Iron Age. On the one hand, a reliance on the concept of collapse fails to significantly enhance a deeper understanding of this period. On the other, close analysis of the scientific discourse suggests that the very concept of collapse is often only applied as a general label, steeped in tradition, but largely devoid of specific meaning. Often, collapse only serves as a shorthand to describe the general phenomenon of social change.

To circumvent these issues inherent in the collapse discourse, this thesis proposes to abandon the language of collapse altogether when talking about the Late Bronze/Iron Age transition in Syria and the Levant. Instead, it is argued that scholarly attention should focus on an investigation and detailed description of transformative processes in order to explain how various factors and developments, be they social or ecological in nature, contributed to the end of the Bronze Age sociopolitical structure. Socio-Natural Systems (SNS) thinking is proposed as an alternative framework with which the analysis of social change can be conceptualized, structured, and conducted. Rather than relying on broad, and potentially empty, labels, the approach outlined and presented in this thesis pays close attention to the relationships between various components of the social sphere, as well as the natural environment. Socio-Natural Systems thinking constitutes an approach with which the interactions between humans and their respective environment can be analyzed. This is necessitated by the mounting evidence for climatic change that has recently become available and this perspective draws upon the realization that social interactions are invariably tied to the environment in which they take place.

This, however, is not an argument in favor of environmental determinism. Quite the contrary, in fsct. Following recent discussions in ecology and ecological archaeology, this thesis proposes to investigate the relationship between humans and their environments in detail in order to make an argument in favor, or against, the role of climatic and environmental change in social transformation.

Building on these recent theoretical developments, and drawing on a large corpus of available materials, consisting of archaeological, palaeoenvironmental, archaeobotanical, geographical, climatic, and historical data, this thesis presents a study of socio-environmental relationships during the transition from the Bronze to the Iron Age in West-Central Syria, ca. 1350-750 BCE. Due to the character of the available data, however, this thesis does not purport to conclusively solve the issue of the Late Bronze/Iron Age transition, nor does it pretend to present the only viable approach to studying socio-natural interactions. Instead, this thesis constitutes the first application of a dedicated Socio-Natural Systems perspective on the Late Bronze and Iron Age record of West-Central Syria.

1.2 Geographical and Chronological Boundaries

To apply the principles of Socio-Natural Systems research, and to test their applicability to the issue of societal transformation, this study will focus on a sub-region of Western Syria (**Fig. 1.1**).[1] This study area, designated here as West-Central Syria, extends for approximately 170 km in an east-west and 234 km in a north-south direction, covering an area of almost 36,000 km^2 in Syria and northern Lebanon. It incorporates portions of the modern Syrian governorates of Aleppo, Idlib, Latakia, Hama, Tartous, Homs, and Damascus Countryside (*Rif Dimashq*), as well as large areas of the Lebanese Beqaa Valley, Mt. Lebanon, and Northern Lebanon governorates.

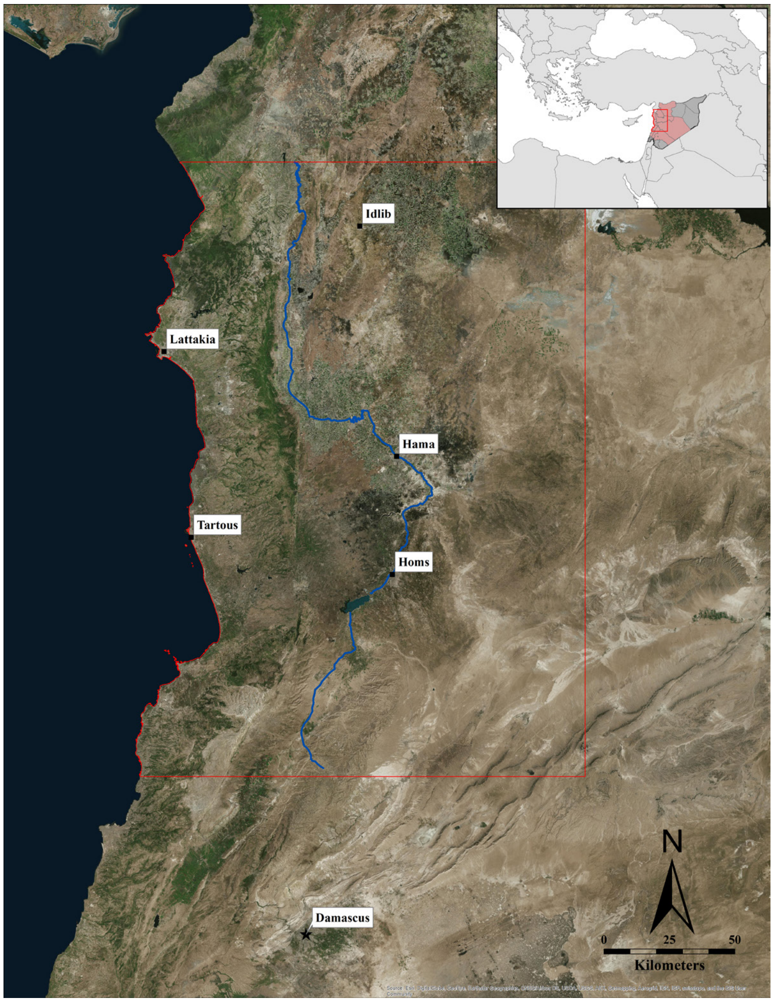

Fig. 1.1: The location and extent of the study area ('West-Central Syria').

This region is characterized by considerable topographic and environmental variability, comprising the rain-laden coastal plains of the Syrian and Lebanese littoral; the hill slopes and mountain peaks of the Syrian Coastal Mountain Range and the Lebanon mountains; the fertile Orontes River Valley and other valleys, like the Ghab depression as well as the Rouj Basin; and the arid upland plateau bordering the Syrian Desert (al-Maqdissi 2013). The coastal strip consists of three large plains, the Northern Coastal Plain, the Jableh Plain, and the Akkar Plain, and receives high quantities of rainfall, around 750-1,000 mm per year. The geomorphology of the coastal area consists mostly of limestone outcrops, covered by quaternary sedimentary topsoils of black or red color. Numerous small perennial and seasonal streams

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[1] The definition of Syria is, in itself, a complicated issue, as aptly summarized by Bunnens (2000). The term has a complex history, ultimately being of Greek origin and related to Assyria, of which it constitutes a diminutive. As the two terms were originally used interchangeably, their exact geographical, political, cultural, or even ethnic connotations remain elusive. As a further result of this association with Assyria, ancient Syria has in the past often been regarded not as a study object in its own right, but rather as the periphery of Mesopotamia. In modern scholarship, the term Syria is primarily understood as a geographical designation, in large parts coterminous with the borders of the modern Syrian Arab Republic, although some definitions include surrounding regions such as southern Turkey, northern Lebanon, or northern Jordan. Some scholars, however, such as Klengel (1992), have enmeshed this purely geographic designation with culture-historical concepts, interpreting ancient Syria as a cultural, geographic, and historical unit, defined by unique political, cultural, and social developments. In this study, the term Syria is used with its geographical meaning, that is, denoting the territory of the modern nation-state, with Western Syria referring to the area to the west of the Euphrates river. Conversely, the term West-Central Syria, the particular study area used here, denotes a specific region that encompasses parts of both Syria and Lebanon, as described below.

transect the plains in an east-west direction, due to the steady rise of the topography from the coast towards the coastal mountains (Riis *et al.* 2004, 23). Together with the favorable climate, these characteristics make the coastal plains one of the most fertile areas of the entire region (**Fig. 1.2**). In the vicinity of Tell Tweini in the Jableh Plain, recent geo-archaeological investigations (Baeteman 2010) have provided evidence for the existence of marshy wetland conditions until the late 2nd millennium BCE and have also called hypotheses of ancient sea incursions in this region into question (*contra*, al-Maqdissi *et al.* 2007).

Fig. 1.2: Landscape of the Coastal Plain and Mediterranean Coast at Ras Shamra/Ugarit (courtesy Sarah Lange).

The coastal areas are separated from inland regions by the limestone karsts of the Syrian Coastal Mountain Range (*Jebel al-Nusayriyah*) and the Mount Lebanon (*Jebel Lubnan*), which rise up to 1,575 m and 3,088 m, respectively (see, Brew *et al.* 2001). Two main thoroughfares, the valley of the *Nahr al-Kebir Shemali* river in the north and the Homs Gap towards the south, afford a direct link with inland areas. Further inland, precipitation levels decline steeply. The fertile Orontes river basin today receives on average around 644 mm of rain per year, although precipitation can range between 300-800 mm along its course. Yet, the river is primarily fed by groundwater, which is responsible for around 90% of its total stream flow and depends largely on snow cover in the Lebanon and Anti-Lebanon mountain ranges. Despite numerous anthropogenic alterations to its course, the river today still retains some natural characteristics, for example a high winter discharge at Jisr es-Shughur on the Syrian-Turkish border. In addition to the Orontes river, the region is marked by numerous smaller perennial and seasonal streams (UN-ESCWA and BGR 2013).

In its lower course, the Orontes traverses a low basin, the Ghab depression, a Pliocene/Holocene pull-apart structure of about 60 km length, which is part of the Dead Sea Transform fault system (Brew *et al.* 2001). In the past, this valley was prone to flooding from the Orontes river and heavy winter rains, resulting in a seasonal marshland that extended over almost the entire length of the valley and relegated much of local occupation to the surrounding mountain flanks (Casana 2004; Dion 2006; Dornemann 2003a; Fitchett and Deford 1973; Le Strange 1890; Weulersse 1940; Wieser 2012). These Ghab Valley marshes were recorded by Greek and Muslim authors, such as Strabo (65 BCE-23 CE), Ibn Butlan (1001-1038 CE), and Abu al-Fida (1273-1331 CE), but also appear in 20th century CE scholarly accounts (e.g., Weulersse 1940) and on military maps (e.g., Great Britain 1924; Heer 1942). In the course of agricultural projects of the 1950s and 1960s, these swamps were drained and transformed into fertile agricultural land.

The regions to the east of the coastal mountains are defined by the basalt and marl landscapes of the Orontes river valley (Philip 2007; Philip and Bradbury 2010; Philip *et al.* 2011) and the limestone outcrops of the upland plateaus, both of which receive considerably less rainfall than the coastal regions (**Fig. 1.3**). The numerous small tributary streams of the Middle Orontes Valley are characterized as so-called 'underfitted streams,' being much smaller in size than they used to during wetter periods in the past (Cremaschi 2007; Cremaschi *et al.* 2008; Cremaschi *et al.* 2002; Cremaschi *et al.* 2003).

Fig. 1.3: Landscape of the Middle Orontes Valley at (a) Hama and (b) Sheizar (courtesy of Sarah Lange).

The climatic regime of the region is of typical Mediterranean character, defined by hot and dry summers and warm and wet winters, although marked variability exists between and within individual seasons (Allen 2001, 4). The variegated topography and relief of the area have a significant effect on local climates, resulting in considerable climatic variation, for example in precipitation levels, over relatively short distances (Allen 2001, 4, 33). Typical Mediterranean-type vegetation characterizes the region, including olive (*Olea europaea*), holm oak (*Quercus ilex*), fig (*Ficus carica*), Aleppo pine (*Pinus halapensis*), mastic trees (*Pistacia lentiscus*), terebinth (*Pistacia palaestina*), and various aromatic plants. Evergreen oak forests and coniferous forests, including the famous Lebanese cedar (*Cedrus libani*), exist in the high elevations of the coastal mountains, whereas in the far east of the study area steppe vegetation gives way to the arid conditions of the

Syrian Desert (Allen 2001). Consequently, the study area comprises a variety of topographical and environmental zones, including the fertile coastal plains and river valleys suitable for intensive agriculture, high mountain ranges, upland plateaus, and even the desert fringe.

This study area has been chosen for several reasons. First, the area's environmental diversity aids in the analysis of socio-natural interactions. Different types of terrain, climate, and other environmental variables are expected to have significant effects on human-environmental interactions and will therefore affect modeling results. Being able to investigate these different variables within one single area creates the possibility to directly study the effects of these variables and better assess their significance in social and environmental change. Several drought episodes recoded in Syria over the past century (e.g., Gleick 2014; Kelley *et al.* 2015) make it seem likely that indicators for climatic and environmental shifts are present within the study area and will be available for analysis on a regional scale.

Second, although this area has received considerable archaeological attention in the past, being amongst the earliest regions investigated by Near Eastern archaeologists, an analysis inspired by SNS thinking has so far not been applied to West-Central Syria, especially with regard to the Late Bronze and Iron Ages. Although a variety of studies in the Northern Levant and Western Syria espouse SNS principles and methodologies, these studies tend to focus on earlier archaeological periods, with little to no attention being paid to the Late Bronze/Iron Age transition in this region.[2] The fairly high quality of the archaeological record, as well as a high degree of survey coverage in this region make West-Central Syria a prime area to investigate socio-environmental relationships, and explore the connections between archaeological and environmental datasets.

Third, the study area as defined here largely overlaps with the boundaries of the Iron Age kingdom of Hamath, or Hamath and Lu'ash. This political entity is known from a variety of textual sources, for example the Assyrian inscriptions of Tukulti-Ninurta II (890-884 BCE), Ashurnasirpal II (883-859 BCE), Shalmaneser III (858-834 BCE), or Tiglath-Pileser III (744-727 BCE), or indigenous sources, like the Zakkur Inscription from Tell Afis (Lipiński 2000, 251-254). According to these sources, the territory under Hamath's control extended from the Orontes Valley to the Mediterranean coast and from the Lower Orontes river to the northern parts of the Beqaa Valley in Lebanon, at least during parts of the 8th century BCE (Lipiński 2000).[3] Through a careful analysis of the textual record, and the historical topography contained within them, Lipiński (2000) was also able to suggest the identification of several toponyms with known archaeological sites, including $^{\text{URU}}$*Gu-ub-la* (Jableh), $^{\text{URU}}$*Si-a(n)-nu* (Tell Siano), $^{\text{URU}}$*Us-nu-u/ú* (Tell Daruk), $^{\text{URU}}$*Ṣi-mir-ra* (Tell Kazel), $^{\text{URU}}$*Áš-ta(m)-ma-ku* (Tell Mastuma [?]), and potentially also $^{\text{URU}}$*Nu-qu-di-na* (Tell el-Kerkh), mentioned in Assyrian campaign reports. Together with Tell Afis (Hazrek), Tell Qarqur (Qarqar), Hama, Tell Mishrifeh (Qatna), and Tell Nebi Mend (Qadesh), for which their ancient toponyms are generally well known and agreed on, this creates the unique situation that the archaeological record,

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[2] The recent inception of the CRANE (Computational Research of the Ancient Near East) project has only slightly rectified this situation. While data collection and analysis at a large scale, including archaeological, historical, and environmental data, is one explicit goal of the project (Harrison 2016), almost all contributions that have so far been published concentrate on earlier archaeological periods, especially the Early Bronze Age, and different historical phenomena, such as the development of urban culture. Therefore, it is hoped that this thesis can contribute significantly to not just a general understanding of the Late Bronze-Iron Age transition in West-Central Syria, but also provide some additional perspectives to collective efforts of analysis, such as the CRANE project.

[3] The exact boundaries of the kingdom of Hamath, however, are difficult to grasp from the texts alone, especially since the boundaries shifted over time, according to political and social developments (Lipiński 2000, 282). Not only were the borders of the kingdom of Hamath and other Syrian principalities subject to dispute through armed conflict with outside powers, but also due to internal politics (Sader 2014). As a result, the political boundaries of this ancient kingdom can only be approximated from the available sources and should not necessarily be regarded as fixed in neither time nor space.

historical data, and geospatial models can be analyzed in conjunction. Since the precise political and social functions for some of these settlements are not yet entirely understood, the possibility of combining these different types of evidence offers a new perspective with which their status within the larger settlement system can be investigated and interpreted. Especially Geographic Information Systems (GIS), with the capability of detecting and analyzing patterns within the spatial configuration of the settlement system and its relation to important environmental variables, are expected to contribute to these efforts to better understand the significance of archaeological sites.

An extended period, between ca. 1350 and 750 BCE, has been chosen for analysis, thus straddling the Late Bronze/Iron Age transition, but also including a significant portion of the later Iron Age. The use of such an extended time frame not only facilitates an analysis of climatic change over time, but also makes it possible to conceptualize and analyze socio-economic or political structural adaptations within a long-term perspective. Such a broad chronological perspective is also necessitated by data limitations and especially influenced by the coverage of the available palaeoenvironmental and archaeological data (see Chapter 4). From a historical point of view, this time frame includes the final centuries of the Late Bronze Age and the demise of its political system, the re-structuring of the social, economic, and political landscape during the Early Iron Age, as well as the period of final prosperity of the Syrian Iron Age kingdoms before being conquered and annexed by the Neo-Assyrian Empire. Thus, it becomes possible to study the internal processes that led to the formation of the Iron Age kingdoms, particularly the kingdom of Hamath, during the earlier stages of the period, largely unimpeded by Neo-Assyrian influence, whose military and administrative involvement entailed dramatic changes to the social, demographic, economic, and political structure of West-Central Syria.

1.3 A Brief Historical and Archaeological Overview

The time frame chosen for this project straddles two distinct historical and archaeological periods, the Late Bronze Age (ca. 1500-1200 BCE) and the Iron Age (ca. 1200-330 BCE). Both periods are particularly well attested in the textual record of the Ancient Near East, either through the diplomatic correspondences of the Late Bronze Age or the Neo-Assyrian royal inscriptions of the later Iron Age. Although considerable portions of both periods technically lie outside of the immediate purview of this dissertation, it is necessary to develop a general historical framework to situate the study in its wider context. In the following sections, some of the most important historical events and processes will be sketched and discussed in relation to the social and political history of the Levant and the Ancient Near East.

In addition, major developments in the archaeological record of the Late Bronze and Iron Ages will be at least briefly outlined, in order to present an overview of the main chronological markers, including ceramics and other aspects of material culture. Attention to chronological issues is necessitated by the chronological focus of this dissertation which, after all, seeks to elucidate long- and short-term social developments within the Late Bronze and Iron Ages. Archaeological chronology, thus, constitutes an important influence on the data used in the analysis of socio-natural interactions and transformations throughout these periods. Although (archaeological) chronological schemes for both the Late Bronze and Iron Ages are still subject to debate, especially the excavations at Tell Afis (Cecchini and Mazzoni 1998; Mazzoni 1998), and even more recently Tell Tweini (Bretschneider *et al.* 2014; Vansteenhuyse 2010), by virtue of their careful excavation techniques and dedicated interest in the Late Bronze/Iron Age transitional period, have contributed significantly to the chronology of 2nd and 1st millennia BCE Syria. Although similarly careful excavations have been carried out at several West-Central Syria sites in the past decades (e.g., Tell Mishrifeh, Tell Qarqur, Tell Nebi Mend, Tell Kazel), well-stratified deposits dating to this transitional period have only been recorded at very few sites.

While the historical and archaeological outline will focus primarily on documents and contexts from West-Central Syria itself, the discussion will also draw on materials from outside the immediate confines of the study area. Especially for the discussion of archaeological materials from the Iron Age, frequent reference to Mazzoni's (Mazzoni 1997, 2000b, 2000c) work, which constitutes the most comprehensive and most widely accepted chronological scheme,[4] will be made. Additional important contributions to this subject have been made by Lehmann (2007, 2013), especially with regard to the Aegeanizing ceramics of the Early Iron Age.

1.3.1 The Late Bronze Age

1.3.1.1 The Historical Evidence

The second half of the 2nd millennium BCE, the Late Bronze Age, is best known for the development of a system of international politics and the occurrence of the first Ancient Near Eastern territorial empires. Hence, this period is commonly referred to in the literature as an era of 'Empires and Internationalism' (Akkermans and Schwartz 2003), 'The Club of Great Powers' (Van de Mieroop 2007), 'The Great Powers' (Kuhrt 1995) or the 'Herrschaft expansiver Territorialstaaten' (Klengel 1989). During this period, the Levant, which consisted of a patchwork of small kingdoms and city-states centered around a capital city, became fully integrated into an international system revolving around the interactions of a handful of major political actors: the Egyptian New Kingdom under the 18th-20th Dynasties; Kassite Babylonia in Southern Mesopotamia; and the Mitanni Kingdom in Upper Mesopotamia (**Fig. 1.4**). After the military defeat of Mitanni, two new political contenders, the Hittite Empire in Anatolia and the Middle Assyrian Empire in Northern Mesopotamia, assumed its position, changing the geostrategic constellation of the region (Van de Mieroop 2007). Relations between the royal courts and the stability of the political structure were sustained by a diplomatic system in which luxury items, rare materials, and even people were exchanged between rulers and courts (Kuhrt 1995; Liverani 2014; Van de Mieroop 2007). A significant corpus of diplomatic letters and messages was discovered at the short-lived Egyptian capital of Akhetaten, modern el-Amarna, from which another epithet, the 'Amarna Age' is derived, although similar archives were found at other settlements as well.

Sandwiched between these great powers were numerous smaller states and kingdoms, whose Small Kings (*ŝarru ṣiḫru*) usually owed allegiance to one of the Great Kings (*ŝarru rabū*), with political hierarchies deeply entrenched in court protocol and the language of diplomacy (Liverani 2014, 280-281). In West-Central Syria, the most important of these small states were Ugarit, centered around the city of Ugarit on the Syrian coast; Nuhashshi, located in the Jazr Plateau to the north-

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[4] Mazzoni's chronological scheme divides the Iron Age into three major sub-periods, the Iron Age I, Iron Age II, and Iron Age III. Both the Iron Age I and II are further subdivided into the Iron Age IA-C and Iron Age IIA-B, respectively (see, Mazzoni 2000c, 56, tab. 1). The same general scheme is followed by Cooper and Fortin (Cooper and Fortin 2004, 27) who, however, propose an additional Iron Age IIC/III sub-phase between the Iron Age II and III (cf., Besana *et al.* 2008, 142). Lehmann (2013), however, has proposed a slightly different scheme. While he maintains Mazzoni's general Iron Age IA-C and Iron Age IIA-B subdivision, he has argued for slightly different date ranges of these sub-phases. Both Mazzoni and Lehmann have linked the end of the Iron Age II to the destruction of Hama by Sargon II (ca. 720 BCE) (e.g., Lehmann 1998, 13), which, however, has been criticized recently by Whincop (2009).

Fig. 1.4: Map of the political landscape of the Ancient Near East in the 13th century BCE (Wittke et al. 2010, 15).

east of the Orontes River; Qadesh/Kinza, with its capital at modern Tell Nebi Mend; and Amurru along the Mediterranean coast in the Akkar Plain. Further to the north lay the kingdoms of Mukish (Alalakh), Halab (Aleppo), and Ashtata (Emar). At the beginning of the Late Bronze Age, these kingdoms were vassals of the Great King of Mitanni, but were brought under Hittite influence in the aftermath of the military campaigns of Suppiluliuma I (1344-1322 BCE), who wrested the area from Mitannian control in the mid-14th century BCE, when the Hittite Empire reached the zenith of its political and military power (Bryce 2009; Liverani 2014; Van de Mieroop 2007).

The treaties concluded between the Great Kings and their vassals are quite informative on the political realities of the day. An excerpt from a treaty between the Hittite Great King Suppiluliuma I and Aziru of Amurru (CTH 49; Laroche 1971), preserved in both Hittite and Akkadian versions, can be taken as exemplary of these documents, which generally followed a similar outline. The second paragraph of the treaty reads:

> "Previously […] the King of Egypt, the King of the land of Hurri, the king of the land [of Ashtata (?)], the king of the land of Nuhashshi, the king of the land of Niya, the king of the land [of Kinza(?), the land of Mukish], the king of the land of Aleppo, and the king of the land of Carchemish – all of these kings – suddenly became hostile [to My Majesty]. But Aziru, king of the land [of Amurru], came up from the gate of Egyptian territory and became a vassal [of] My Majesty, [King] of Hatti. And I, My Majesty, Great King, [accordingly rejoiced] very much. Did not I, My Majesty, Great King, accordingly rejoice very much? As I to Aziru […]. Because Aziru [knelt down] at the feet [of My Majesty, and] came from the gate of Egyptian territory, and knelt [down at the feet of My Majesty], I, My Majesty, Great King, [took up] Aziru and ranked him (as king) among his brothers." (Beckman 1999, 33)

The treaty not only gives an indication of the geographical position of the kingdom of Amurru, but also describes the geopolitical situation at the time, referring to the conflict between the Egyptian and Hittite Empires, as well as Suppiluliuma's recent conquest of the area, which compelled Aziru to seek an alliance with the Hittite king. Similar treaties were also concluded with other rulers, such as king Tette of Nuhashshi (CTH 53), or Tuppi-Teshup of Amurru (CTH 62). Interestingly, each of these treaties lists the surrounding petty kingdoms as potential enemies, resulting in a complex network of mutual dependencies and non-aggression contracts, highlighting how wary the major powers were of their local subordinates. But treaties were also concluded between individual small kingdoms, as exemplified by a treaty between Ugarit and Amurru found at Ugarit (RS 19.68) and a treaty between Tunip and Mukish from Alalakh (AIT 2), which are concerned with border disputes and the return of fugitives, respectively (Janowski and Wilhelm 2005).

Especially the latter aspect, the return of fugitives to their respective sovereign, features prominently in the correspondence of the Late Bronze Age. Liverani (2014) has attributed this to the socio-political situation during the period. The development of a dedicated military elite, the charioteers, which owed their service to the palace, left both the military elites and the royal court in a position to acquire considerable wealth and the debt obligations of the general populace (Liverani 2014, 276). Diminishing agricultural yields resulted in the abandonment of formerly cultivated areas, a contraction of settlement into more fertile regions, a reduction in population size and the decline of urban centers, and the development of an economy primarily based on trade and the production of luxury items, leading to the progressive impoverishment and disenfranchisement of the common people (Liverani 2014, 278, 325-329).

From Liverani's perspective, the structure of the Late Bronze Age political system, with its social and economic implications, precipitated its own demise, especially when an already precarious economic situation was exacerbated by environmental degradation and crop failure. Letters found at Ugarit draw a bleak picture of the economic situation at the end of the 2nd millennium BCE. In an Akkadian letter (RS 20.212) written by a Hittite prince to the king of Ugarit, the sender writes:

> "[Folgendermaßen…]; [zu…], dem König des Landes Ugarit sprich: Für Meine Sonne steht alles zum besten. Der König hat dich von der Dienstverpflichtung als Vasall befreit. (Doch) als der König dir die gesiegelten Tafeln (darüber) gab, (sprach) er da nicht in Hinsicht auf diese (Angelegenheit) folgendermaßen? 'Was ich ihm schreiben werde, wird er anhören und dann tun.' Und warum tust du jetzt nicht, was er dir schreibt? Tue stets alles, wie es der König, dein Herr ver[langt hat]; er hat [dich] (von der Dienstpflicht) befreit, und du, du tue, was der König, de[in] Herr dir schreibt! Jetzt haben die Einwohner der Stadt Ura von Meiner Sonne Verpflegung gefordert. Die Sonne hat ihnen 2000 (...-Maß) Getreide aus dem Land Mukiš angewiesen. Und du, gib ihnen ein großes Schiff und Seeleute, damit sie das Getreide in ihr Land bringen. Sie werden (es) in ein oder zwei Fuhren transportieren, und du darfst ihnen das Schiff nicht verweigern. In dieser Angelegenheit hat die Sonne Ali-ziti, den Eunuchen des Königs, und Kunni zu ihnen gesandt. Es ist eine lebenswichtige Angelegenheit! Rüste sie sofort mit [...] aus! Veranlasse den Transport und übergib (das Getreide) ihren Ältesten. Entweder aus [diesem] Land oder aus einem anderen Land soll man sie verpflegen (und) am Leben erhal[ten]! Gib! Es geht um Leben oder Tod!" (Janowski and Wilhelm 2006, 260-261)

In another letter (RS 18.038), written in Ugaritic, the Hittite king reprimanded the king of Ugarit for not sending food supplies, although he seemed aware of the fact that Ugarit itself suffered from food shortages (Janowski and Wilhelm 2006, 268). Although the king of Alashiya, on Cyprus, offered the provision of food shipments to the king of Ugarit (RS 18.147; Janowski and Wilhelm 2006, 268-269), this does not appear to have significantly altered the degree to which the Levantine coast and adjacent areas were experiencing a breakdown of agricultural production.

The vivid, and oftentimes dire, images portrayed by these letters have helped shape scholarly perceptions of this period, including its economic and political fortunes, as well as its ultimate disintegration, or collapse. While instances of people feeling their king's territories have been taken as indicators of political unrest, reports of crop failure and famine have been understood as evidence of wide-spread ecological misfortune. Textual sources of the Late Bronze Age seemingly support both social and environmental explanations of change at the end of the 2nd millennium BCE, potentially indicating an interplay of internal social and external environmental/climatic factors.

1.3.1.2 The Archaeological Evidence

In contrast to the wealth of textual data from the Levant and the Near East in general, West-Central Syria is characterized by a dearth of excavated sites with secure Late Bronze Age contexts. With the notable exception of Tell Mishrifeh and Tell Afis, secure archaeological contexts from Late Bronze Age inland Syria are still limited in number (e.g., Akkermans and Schwartz 2003; Döpper 2014; Mazzoni 2002).[5] To make things worse, a lack of abrupt stratigraphic, architectural, and ceramic

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[5] In part, this can be attributed to archaeological practice. At Hama, horizontal exposure of Late Bronze Age levels has been quite

breaks between the Middle and the Late Bronze Ages oftentimes complicates a clear distinction between these two periods (Akkermans and Schwartz 2003, 331). To some degree, however, this situation reflects the historical reality of the period, with declining economic conditions leading to a material impoverishment and the decline of urban settlement in the area (Mazzoni 2002, 130).

Despite these insecurities, scholars generally subdivide the period into three successive stages, the Late Bronze Age I, IIA, and IIB, with sometimes additional subdivisions being made between the Late Bronze Age IA and IB (Akkermans and Schwartz 2003; Döpper 2014; Mazzoni 2002). Problems in adequately differentiating between these sub-periods, however, are particularly apparent in the common wares, with shallow bowls, small jars, and jugs/juglets enjoying a high popularity throughout the entire period (Akkermans and Schwartz 2003, 331).

Therefore, one must turn to the imported ceramics, especially Cypriot and Aegean wares, to realize a more detailed archaeological subdivision. Cypriot Base Ring I and II wares, which are chronologically concurrent, appear already in the Middle Bronze Age and continue into the Late Bronze Age. They are often associated with White Slip ware, which shows a more nuanced chronological development, White Slip I usually being confined to the Late Bronze Age I, whereas White Slip II is typical of the Late Bronze Age II, especially the Late Bronze Age IIB, around the 13th century BCE. Although more frequently attested in the Southern Levant and on the Syrian coast, some examples of White Slip ware have also been found in the Middle Orontes Valley (Akkermans and Schwartz 2003; Döpper 2014). Other Cypriot ceramic wares include Monochrome ware, popular in both the Late Bronze Age I and II, and White Shaved ware, which occurs primarily in the latter part of the period. Palestinian Bichrome ware, on the other hand, occurs primarily in Late Bronze Age I contexts, where it is often found in association with White Slip I and Base Ring I wares. Red Lustrous Wheelmade ware, potentially a coastal Syrian tradition, occurs only at the beginning and the very end of the Late Bronze Age, with a noticeable hiatus in between (Döpper 2014).

Cypriot imports, starting already in the Middle Bronze Age, are thus present throughout the entire Late Bronze Age, with some wares more popular than others at certain times. Mycenaean imports, on the other hand, occur only later in the period, with Mycenaean LH IIIA and IIIB wares being equated with the Syrian Late Bronze Age IIA and IIB, respectively (Akkermans and Schwartz 2003; Döpper 2014). Over the course of the Late Bronze Age, proportions of Aegean imports increase relative to those from Cyprus, which start to decline in numbers towards the end of the period.

High quantities of Cypriot and Aegean imports have been identified at numerous coastal sites, such as Tell Sukas (Lund 1986; Riis 1970, 1996), Tell Tweini (al-Maqdissi *et al.* 2008; Bretschneider and van Lerberghe 2008a), Ras ibn Hani (Bounni *et al.* 1998; Bounni *et al.* 1976, 1978), and Ras al-Bassit (Courbin 1986). Similar influences have been noted at inland sites, for example at Tell Afis, where Cypriot and Aegean, but also Anatolian ceramics have been recovered (Mazzoni 2002; Venturi 2011). This evidence suggests the continued existence of maritime trade links with other regions of the Eastern Mediterranean, with Aegean influences gradually becoming more important in the final decades of the Late Bronze Age (Akkermans and Schwartz 2003).

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limited and the lack of stratigraphic detail has repeatedly been criticized (cf., Dornemann 1997; Thuesen 1988; Whincop 2009). Other sites, such as Tell Rifa'at to the north of the study area, have only yielded limited Late Bronze Age exposures, or, as is the case with Tell Mardikh and Tell Nebi Mend, have so far only been published in preliminary fashion.

Oftentimes, the occurrence of these imported wares, and particularly their concentration at coastal sites, has led scholars to hypothesize a connection between ceramic traditions and ancient population movements, in this case in the form of raids and invasions by foreign peoples, especially the Sea Peoples.

1.3.2 The Iron Age I (Early Iron Age)

1.3.2.1 The Historical Evidence

Towards the second half of the 12th century BCE, textual sources become scarce, making it difficult to provide a secure historical outline of this important transitional phase. Besides socio-political disintegration and economic stress, it has often been assumed that the so-called Sea Peoples, migrating people of likely Aegean origin and featured prominently Egyptian sources, constituted a major impetus leading to the demise of the Bronze Age system, although their role has been progressively downplayed in modern research (Bryce 2009, xlvii).

As far as we can tell at the moment, the political structure of Syria (but also its settlement system and material culture) underwent some more-or-less pronounced changes. In part, the new political system of the Iron Age was built on Bronze Age models (Bryce 2009; Liverani 2014; Van de Mieroop 2007). This is most clearly attested at Carchemish on the Euphrates, where the royal seal of Kuzi-Teshup, discovered at nearby Lidar Höyük (Sürenhagen 1986), attests to the continuity of the Hittite royal dynasty in this area (Hawkins 1995, 2002).

Recently discovered textual evidence suggests that the 11th and 10th centuries BCE saw the development of another new kingdom in the Amuq Valley, the former territory of Mukish (**Fig. 1.5**). The territory of this kingdom of Palistin/Walistin[6] appears to have extended beyond the confines of the Amuq Valley proper, stretching as far as Aleppo and possibly even Carchemish in the north-east, as well as to the vicinity of Hama in the south (Bryce 2012, 129), attested by several Luwian inscriptions commissioned by its most important (only?) ruler, king Taita. These inscriptions include the Meharde and Sheizar stelae found close to Hama, an inscription from Tell Ta'yinat, Tayinat 1, as well as two inscriptions from the Aleppo temple, Aleppo 6 and 7 (Hawkins 2000, 2011). Apart from these inscriptions, strikingly little is known of this potentially important political entity and it has so far not been possible to adequately relate the historical record to the archaeological remains found at Tell Ta'yinat, the site of the likely capital city of the kingdom (see also, Harrison 2013).[7] In fact, even the information contained within these inscriptions does not provide enough reference points for a full historical outline.[8]

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[6] See Hawkins (2011), who proposes a re-reading of the hieroglyphic name of the kingdom from formerly PaDAsatini to Palistin/Walistin. This reinterpretation is based on the re-evaluation of the readings of the signs  (L.172, ta_5) and  (L.104, sà), proposed by Rieken (2010) and Rieken and Yakubovic (2010).

[7] In fact, both the geographical and chronological dimensions of this kingdom remain elusive. Whereas both Bryce (2012) and Hawkins (2009, 2011) prefer an 11th century BCE date, other authors have suggested a much later date, such as Sass (2010) advocating a late 10th century BCE dating, while Mazzoni (2009) prefers a 9th century BCE date. Furthermore, after re-investigating the Meharde, Sheizar, and Aleppo 6 and 7 inscriptions, Hawkins (2011) has raised the possibility that both Aleppo inscriptions are significantly older in date that the other two, based on paleographic evidence. This would mean that the two groups of inscriptions might belong to two different kings of the same name, with significant ramifications for the chronological and geographical development of this enigmatic political entity.

[8] Both Tayinat 1 and Aleppo 7 are too fragmentarily preserved to warrant coherent translations (Hawkins 2000, 2011). Aleppo 6 records the dedication of the temple of the storm god of Aleppo by king Taitas, whereas Meharde and Sheizar contain a dedicatory inscription and a funerary inscription, respectively (Hawkins 2000).

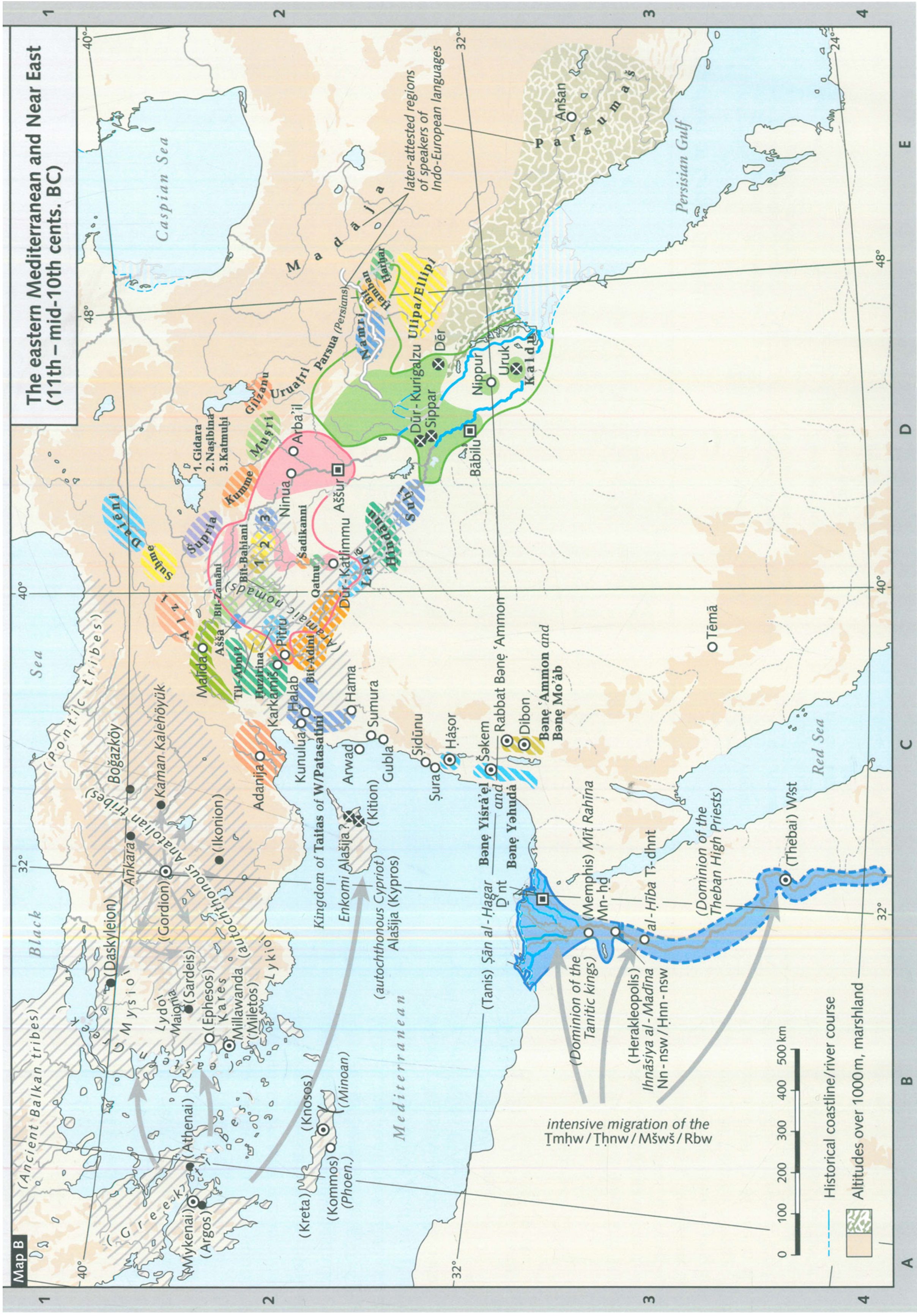

Fig. 1.5: Map of the political landscape of the Ancient Near East in the 11th and 10th centuries BCE (Wittke et al. 2010, 33).

Apart from these rather scanty sources on the kingdom of Palistin, very little is known about the general political history of Syria during this period. This lack of information is striking not only because the 12th and 11th centuries BCE are considered the formative period of the Iron Age kingdoms (Bryce 2012, 200-201; cf., Van de Mieroop 2007), but also because this period coincides with the expeditions of Tiglath-Pileser I (1114-1076 BCE). This king's reign marks an important caesura in Assyrian history. Not only is he the first Assyrian king to reach the Mediterranean coast, but his inscriptions are also the first ones considered truly annalistic in style, emulated and further developed by his successors (Grayson 1991, 6). In the royal annals, military events are narrated in chronological order, with accounts of different years clearly divided, although no dating or numbering scheme is employed (Grayson 1991, 7). In his most famous inscription, A.0.87.1 (Grayson 1991), he narrates his campaign to the west, where he gathered tribute in the form of large numbers of livestock, horses, mules, donkeys, and cattle,[9] as well as his conflicts with the so-called *aḫlamû*-Aramaeans:

> „With the support of the god Aššur, my lord, I took my chariots and warriors (and) set off for the desert. I marched against the *aḫlamû*-Aramaeans, enemies of the god Aššur, my lord. I plundered from the edge of the land Suḫu to the city Carchemish of the land Ḫatti in a single day. I massacred them (and) carried back their booty, possessions, and goods without number. The rest of their troops, who fled from the weapons of the god Aššur, my lord, crossed the Euphrates. I crossed the Euphrates after them on rafts (made of inflated) goatskins. I conquered six of their cities at the foot of Mount Bešri, burnt, razed, (and) destroyed (them, and) brought their booty, possessions, and goods to my city Aššur." (Grayson 1991, 23)

Additional themes of the inscription include the erection of fortifications, the expansion of agriculture in the Assyrian heartland, as well as prayers for abundant rain (Grayson 1991, 26, 29). Military expeditions to the west, which he calls "the land Amurru," as well as confrontations with Aramaean groups are also recorded in other inscriptions, for example A.0.87.3 and A.0.87.4

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[9] Lines iv43-v21: "At that time, with the exalted might of the god Aššur, my lord, with the firm approval (through divination) of the god Šamaš, the warrior, with the support of the great gods with which I have ruled properly in the four quarters and have no rival in battle not equal in conflict, at the command of the god Aššur, (my) lord, I marched to the lands of Nairi whose distant kings, on the shore of the Upper Sea in the west, had not known submission. I pushed through rugged paths and perilous passes, the interior of which no king had previously known, blocked trails (and) unopened remote regions. Mounts Elama, Amadānu, Elḫiš, Šerabeli, Tarḫuna, Terkaḫuli, Kiṣra, Tarḫanabe, Elula, Ḫaštarae, Šaḫišara, Ubera, Miliadruni, Šulianzi, Nubanāše, and Šēše, 16 mighty mountains – (I rode) my chariot over smooth terrain and I hacked out the rough terrain with copper picks. I cut down *urumu*-trees which grow in the mountains, (thereby) constructed good bridges for the passage of my chariots and army, (and) crossed the Euphrates. The king of the land Tummu, the king of the land Tunubu, the king of the land Tualu, the king of the land Dardaru, the king of the land Uzula, the king of the land Unzamunu, the king of the land Andiabu, the king of the land Piladarnu, the king of the land Adurginu, the king of the land Kulibarzinu, the king of the land Šinibirnu, the king of the land Ḫimua, the king of the land Paiteru, the king of the land Uiram, the king of the land Šururia, the king of the land Abaenu, the king of the land Adaenu, the king of the land Kirinu, the king of the land Alabaia, the king of the land Ugina, the king of the land Nazabia, the king of the land Abarsinu, the king of the land Daiēnu, altogether 23 kings of the lands Nairi combined their chariotry and army in their lands (and) advanced to wage war, strife, and combat. With the onslaught of my fierce weapons I approached them (and) destroyed their extensive army like a storm of the god Adad. I laid out like grain heaps the corpses of their warriors in the open country, the plains of the mountains, and the environs of their cities. I seized in battle 120 of their chariots with equipment (and) 60 kings of the lands Nairi, including those who had come to their aid, I chased at Arrowpoint as far as the Upper Sea. I conquered their great towns (and) brought out their booty, possessions, (and) property. I burnt, razed, (and) destroyed their cities (and) turned them into ruin hills. I brought back extensive herds of horses, mules, (and) donkeys – the livestock of their pastures – without number. I captured all of the kings of the lands of Nairi alive. I had mercy on those kings and spared their lives. I released them from their bounds and fetters in the presence of the god Šamaš, my lord, and made them swear by my great gods an oath of eternal vassaldom. I took their natural, royal, sons as hostages. I imposed upon them a tribute of 1,200 horses (and) 2,000 cattle. I allowed them to return to their lands." (Grayson 1991, 20-22).

(Grayson 1991). Similar themes also appear in the inscriptions of his immediate successor, Ashur-bel-kala (1073-1056 BCE), who again relates conflicts with Aramaean groups and expeditions to the Mediterranean Sea and the land of Amurru on his famous Broken Obelisk (A.0.89.7; Grayson 1991). Despite the detail contained within these narratives, these campaign reports are conspicuously silent about the political situation in West-Central Syria during that time, and no apparent reference to any known historical kingdom is made, possibly indicating a general lack of political integration.

1.3.2.2 The Archaeological Evidence

In archaeological terms, the beginning of the Iron Age I is marked by destruction horizons at many sites, both on the coast (Ras Shamra, Ras al-Bassit, Ras ibn Hani, Tell Tweini, Tell Kazel) and in the hinterland (Tell Afis). Most of these settlements are immediately reoccupied, although these new settlements are generally smaller in size and less densely settled than before (du Piêd 2006-2007; Mazzoni 2000a, 2000c). The appearance of large quantities of locally-produced Aegean-style Late Helladic (LH) IIIC:1b ceramics immediately after these destructions has been noted as one of the hallmarks of the Early Iron Age (Lehmann 2007, 521), dating the transition to the very late 13th and early 12th centuries BCE. An additional marker of this transitional period is the so-called Handmade Burnished Ware, a type of cooking pot which has been found primarily at Ras al-Bassit and Ras ibn Hani, but also at Ras Shamra and Tell Sukas, Tell Daruk, and Beirut further south (du Piêd 2006-2007; Lehmann 2007).[10]

Following the initial episode of re-occupation in the 12th century BCE, West-Central Syria experienced a period of gradual re-urbanization throughout the Iron Age I. This process is particularly well attested at Tell Afis, where flimsy Iron Age IA remains are replaced in the Iron Age IB by a new residential quarter, with houses built with well-dressed stone foundations and brick walls, and open spaces with silos and waste pits. This residential quarter was in turn replaced by a new urban layout with courtyard houses and a rectilinear street plan, attesting to an increasingly dense urban agglomeration during the Iron Age IB. Marking the Iron Age IB-C transition, destruction layers have been recognized at Tell Afis, Hama, and Tell Kazel (Mazzoni 2000b, 2000c), whereas other sites, such as Tell Sukas or Tell Tweini, experienced an uninterrupted development.

In summary, the Iron Age I in West-Central Syria is marked by a number of trends in ceramics and other aspects of material culture. The most distinct trait of this Early Iron Age period is the presence of LH-style ceramics, appearing in Syria in the Iron Age IA-B (Lehmann 2007, 2013). Yet, imported Aegean ceramics are by no means an entirely new phenomenon in the Levant, as LH IIIA and IIIB ceramics were already imported from the Aegean in the 14th and 13th centuries BCE. These were later replaced by derivative styles, probably produced in the Eastern Mediterranean and Cyprus, often referred to as White-Painted Wheelmade III, which were found in the terminal Late Bronze Age levels of Ras Shamra and dated to the late 13th/early 12th centuries BCE (Lehmann 2007, 2013).[11] These White-Painted Wheelmade III wares, more commonly referred to as

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[10] Lehmann (2007, 509) has raised the possibility that cooking pots of the Handmade Burnished Ware tradition were in fact more widely distributed than currently recognized, but might have been overlooked in many of the earlier excavations.

[11] The term White-Painted Wheelmade III was introduced by Kling (1991) as a simplified designation for all matt-painted, wheel-made pottery of Mycenaean appearance, but produced outside of the Aegean. This category, thus, includes several individual groups and styles, such as Levanto-Helladic ware, Decorated Late Cypriote IIIC, Rude Style/Pastoral Style, Late Helladic IIIB Late/Simple Style, Late Helladic IIIB:2, Late Helladic IIIC (including Mycenaean IIIC:1 and IIIC:1b), or Sub-Mycenaean (cf., Lehmann 2007, 2013).

This discussion offers only a fairly abridged overview over the development and chronological significance of Aegeanizing ceramics in Syria and the Levant in general. For more detail, see the discussions in Killebrew (1998) and Lehmann (2007, 2013).

LH IIIC:1b in the Levant, are characteristic of the Iron Age IA in Syria and forms consist primarily of tablewares, like bowls and kraters. The closest parallels for this style come from Cyprus, but chemical analyses have confirmed a local, Levantine origin. The Iron Age IB, on the other hand, is characterized by the appearance of Wavy-Line/Granary Style and Proto-White Painted wares. Of the latter, only relatively few examples have been found in the Northern Levant, especially at Ras ibn Hani, Tell Afis, and at several sites in the ‘Amuq Valley in southern Turkey (Lehmann 2007, 2013).[12]

The appearance of these decorated vessels stands in contrast to the situation encountered in the terminal phases of the Late Bronze Age, especially in inland West-Central Syria, where local painted wares are negligible in quantity (Venturi 2013). During the Iron Age IA, Aegeanizing LH IIIC ceramics occur only in fairly limited numbers, with the largest quantities coming from coastal sites, whereas in the Iron Age IB, LH IIIC ceramics reach a much wider distribution, but also appear in larger overall quantities (Lehmann 2007, 2013).[13] During the Iron Age IC, painted wares decline noticeably in quantity, whereas local ceramics are characterized by a tendency towards mass production and standardization in common, storage, and cooking wares (Mazzoni 2000b, 124).

Otherwise, the Early Iron Age is marked by a progressive architectural development, from the impoverished and ephemeral occupation levels of the Iron Age IA, to the increasingly urbanized residential districts of the Iron Age IB and IC. This apparent prosperity, especially during the 10th century BCE, is also observable in the resurgence of monumental architecture and sculptural decoration, particularly at Carchemish. Evidence for architectural stone sculpture in Early Iron Age West-Central Syria might be identified at Hama, where Mazzoni (2000b, 2009) has proposed to date some of the Building I gateway lions to the 10th century BCE, or even earlier. This rise in political and economic integration, however, also entailed a rising degree of political and military competition, which is not only attested in the royal inscriptions, but also potentially evinced in the destruction levels already mentioned above (Mazzoni 2000b, 2000c).

The unique combination of few textual sources, clearly identifiable destruction horizons at coastal sites, and the more widespread occurrence of Aegean-style ceramics has often been viewed as evidence for Late Bronze Age societal collapse in the Eastern Mediterranean. In contrast to the textual sources of the Late Bronze Age, which would suggest a combination of internal social and external environmental factors, the evidence of the Early Iron Age has often been adduced by proponents of an ethno-centric interpretation of social transformation.

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[12] This discussion offers only a fairly abridged overview over the development and chronological significance of Aegeanizing ceramics in Syria and the Levant in general. For more detail, see the discussions in Killebrew (1998) and Lehmann (2007, 2013).

[13] As Lehmann (2007, 2013) has discussed, the appearance of LH IIIC and related wares in the Iron Age Northern Levant has often been interpreted as evidence for the migration of foreign peoples into the region, particularly the so-called Sea Peoples. However, there are also several scholars, including Lehmann himself, who are skeptical of this interpretation, and who prefer to interpret the appearance of these ceramic styles as evidence for the continuation of trade relationships between Cyprus and the Levant.

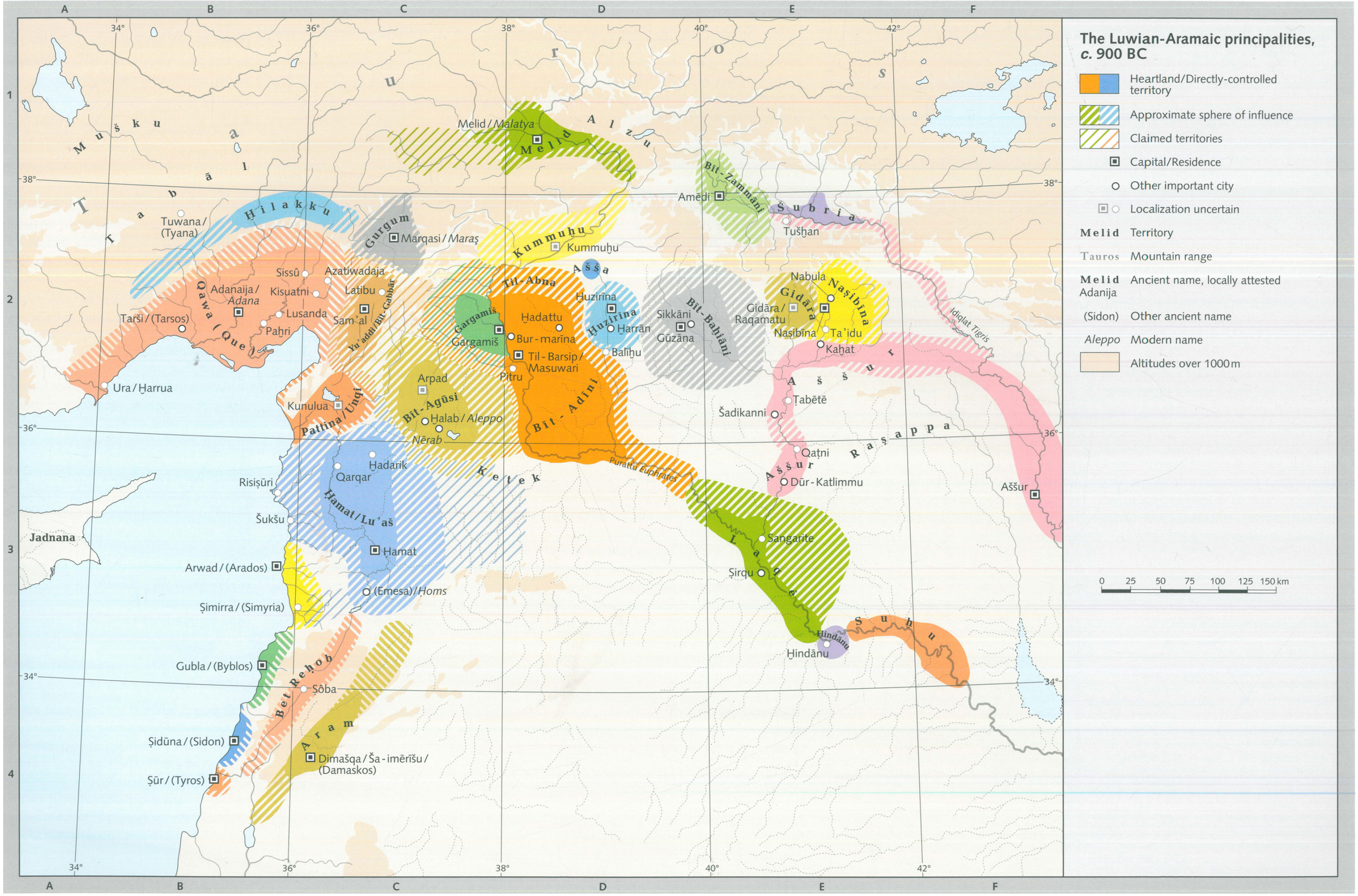

Fig. 1.6: Map of the political landscape of the Ancient Near East, ca. 900 BCE (Wittke et al. 2010, 43) [© MIrko Novák].

1.3.3 The Iron Age II

1.3.3.1 The Historical Evidence

After the reign of Tiglath-Pileser I, the situation in Assyria must have deteriorated dramatically, which is suggested by a later chronicle fragment (VAT 10453+10465) which recounts an extremely dire economic situation, as well as potentially the pillaging of Assyria by Aramaean groups (Grayson 1975, 189).

The period following the reign of Tiglath-Pileser I, approximately from the mid-11th century to the early 9th century BCE, must have witnessed the development of most of the Iron Age kingdoms of Western Syria (Bryce 2012, 201). For, when the annalistic campaign reports fully resumed under Ashurnasirpal II, a completely different political situation presented itself (**Fig. 1.6**). In his longest, and most famous inscription from the Ninurta temple at Nimrud (A.0.101.1; Grayson 1991), Ashurnasirpal recounts his forays into Western Syria in the course of his 9th campaign, which probably took place sometime between 875-867 BCE (Liverani 1992, 73). He provides extensive and detailed lists of the booty and tribute which he received during the campaign, primarily valuable metals, luxury furniture, jewelry, and livestock. The kingdoms encountered on this expedition include Bit-Adini[14] and Carchemish[15] in the north-east, as well as Patina[16] in the west. From there, Ashurnasirpal moved south along the Orontes river, established an Assyrian presence at the city of Aribua, and raided the region Luhutu, before finally moving on to the land of Amurru (Grayson 1991, 218). His son and successor, Shalmaneser III also campaigned extensively in West-Central Syria, and his inscriptions make ample reference to conflicts with kingdoms such as Carchemish, Sam'al, Patina, Amurru, Bit-Agusi, and Hamath (Grayson 1996), in the context of which also belongs the famous battle(s) at Qarqar, which Shalmaneser fought against a local coalition in 853 BCE, and again in 849, 848, and 845 BCE (Cooper and Fortin 2004; Yamada 2000). Again, these campaign reports contain detailed lists of the booty and tribute acquired by the Assyrian king, including precious metals, luxury items, agricultural products, and livestock.

In many ways, the lands and kingdoms mentioned in these Iron Age inscriptions differ from those known from the Late Bronze Age letters and treaties. In both periods, the "land of Amurru" designates an area between the Orontes river and the Mediterranean coast, especially the Akkar Plain

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[14] Lines iii60-62: "Moving on from the land Azallu I approached Bīt-Adini. I received tribute from Aḫunu, a man of Bīt-Adini, silver, gold, tin, bronze, bronze casseroles, ivory dishes, ivory couches, ivory chests, ivory thrones decorated with silver (and) gold, gold bracelets, gold rings with trimming, gold necklaces, a gold dagger, oxen, sheep, (and) wine." (Grayson 1991, 216-217).

[15] Lines 64b-68: "Moving on from the land Bīt-Adini I crossed the Euphrates, which was in flood, in rafts (made of inflated) goatskins (and) approached the land Carchemish. I received tribute from Sangara, king of the land Ḫatti, 20 talents of silver, a gold ring, a gold bracelet, gold daggers, 100 talents of bronze, 250 talents of iron, bronze (tubs), bronze pails, bronze bath-tubs, a bronze oven, many ornaments from his palace the weight of which could not be determined, beds of boxwood, thrones of boxwood, dishes of boxwood decorated with ivory, 200 adolescent girls, linen garments with multi-coloured trim, purple wool, red-purple wool, *gišnugallu*-alabaster, elephants' tusks, a chariot of polished (gold), a gold couch with trimming – (objects) befitting his royalty." (Grayson 1991, 217).

[16] Lines iii71-77a: "Moving on from the land Carchemish I took the way between the Mounts Munzigānu (and) Ḫamurga. Leaving Mount Aḫānu on my left I approached the city Ḫazazu which (was ruled by) Lubarna, the Patinu. I received golf (and) linen garments. Passing on I crossed the river Aprê, pitched camp (and) spent the night. Moving on from the River Aprê I approached the city Kunulua, the royal city of Lubarna, the Patinu. He took fright in the face of my raging weapons (and) fierce battle and submitted to me to save his life. I received as his tribute 20 talents of silver, one talent of gold, 100 talents of tin, 100 talents of iron, 1,000 oxen, 10,000 sheep, 1,000 linen garments with multi-coloured trim, decorated couches of boxwood with trimming, beds of boxwood, decorated beds with trimming, many dishes of ivory (and) boxwood, many ornaments from his palace the weight of which could not be determined, 10 female singers, his brother's daughter with her rich dowry, a large female monkey, and) ducks. As for him, I showed him mercy. I took with me the chariots, cavalry, (and) infantry of the Patina (and also) took hostages from him." (Grayson 1991, 217-218).

(Liverani 1992, 78), although at least in the inscriptions of Tiglath-Pileser I it might also include some regions further inland (Bryce 2009, 41-42). Both Ashurnasirpal II and Shalmaneser III refer several times to the kingdom of Patina, which has developed in the ‘Amuq Plain in the territory of Late Bronze Age Alalakh (Bryce 2009, 534-536).

The most important of these kingdoms, at least for present purposes, was that of Hamath. Textual references to this kingdom appear as early as the reign of Tukulti-Ninurta II, but are especially common under Shalmaneser III and Tiglath-Pileser III, although some references to Hamath can also be found in Hebrew sources (Bryce 2009, 2012; Hawkins 2000). In addition to these outsider’s accounts, references to the kingdom of Hamath also occur in a few local inscriptions, for example the Aramaeans inscription of the Zakkur Stele (KAI 202; Donner and Röllig 1962). Its main political center, or at least one of them, was located at the city of Hama, which appears to have been relatively insignificant during the preceding Late Bronze Age (Hawkins 2000, 399). At the time of Ashurnasirpal II’s campaign in West-Central Syria, Hamath was the main political power controlling the central Orontes Valley. Later, its influence also extended to the Syrian coast, as suggested by the list of “19 districts” that were separated from the territory of Hamath by Tiglath-Pileser III in 738 BCE after an unsuccessful revolt (Bryce 2009; Hawkins 2000; Weippert 1982).

Somewhat less clear, however, is the relationship between Hamath and the land of Luhutu. It first appears in the inscriptions of Ashurnasirpal II and Shalmaneser III, written as $^{\text{KUR}}$*Lu-ḫu-ti/te* in Akkadian. In Aramaic inscriptions, for example the Zakkur Stele, it appears as Lu’ash (written *l‘š*). Scholarly consensus equates Luhutu with Nuhashshi during the Late Bronze Age and locates it to the north-east of the Orontes river, with its capital city at Hatarikka, or Hazrek, modern Tell Afis (Bryce 2009; Hawkins 1987-1990; Liverani 1992). At some point, this region was incorporated into the kingdom of Hamath as its northernmost territory, either in the mid-9th century BCE (Hawkins 2000, 399), or around 800 BCE at the latest (Bryce 2012, 133).

Most of the historical information on this period stems from Assyrian campaign reports. As discussed above, the inscriptions of king Taitas of Palistin/Walistin possibly constitute the earliest textual sources from this region in the Iron Age. Comparable monuments and inscriptions only started to appear at other important settlements, such as Carchemish and Zincirli, in the late 11th and 10th centuries BCE, whereas the earliest inscriptional evidence from Hama dates to the 9th century BCE (Bryce 2012; cf., Gilibert 2011). The inscriptions of king Urhilina (ca. 853-845 BCE) deal with issues such as the dedication of a temple (Hama 4), and the building of the royal city (Rastan, Qal’at al-Mudiq, Hines), as do the inscriptions of his son, Uratamis (around 830 BCE), whose inscriptions celebrate the construction of a fortified city (Hama 1-3, Hama 6, Hama 7) (Hawkins 2000). This preoccupation with building projects and military accomplishments is observable in most of the existing Luwian inscriptions from the general region, but is also part of the Aramaic corpus, for example the inscription of the Zakkur Stele from Tell Afis (Gibson 1975).

For the most part, then, the existing textual sources from West-Central Syria, and Western Syria more generally, provide evidence for a prosperous period of political and economic growth, in which settlements were frequently founded (either re-foundations or entirely new foundations), and citadels fortified and equipped with monumental public structures and their associated sculptural programs (Gilibert 2011; Mazzoni 1994, 1995, 1997).[17]

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[17] It is interesting to note that other social and economic aspects are often missing from these inscriptions. This is especially apparent with regard to the issue of environmental degradation, which is presumed to have played a significant role in the end of the Late Bronze Age system, as well as the development of a new settlement structure in the Iron Age (see above, Liverani 2014). The only reference to the agricultural system at Hama could be seen in HAMA 8, which refers to a granary built by the king (Hawkins 2000). Comparable references to the construction of granaries, and their provisioning, are included in the inscriptions

Assyrian influence and involvement in West-Central Syria was fairly limited until the late 9th century BCE. Although the Assyrian kings acquired significant quantities of resources, finished goods, and livestock during their campaigns in the west (Van de Mieroop 2007), these early expeditions only had a limited effect on the development of the region. In a seminal paper, Liverani (1988) termed the Assyrian Empire a "network empire," characterized by a discontiguous and fragmented territory, and an ambiguous relationship between the areas under direct control and those more remote from the center. This interpretation is further supported by his more recent studies (Liverani 2004, 2011), where he identifies an important difference between the reigns of Ashurnasirpal II and Shalmaneser III. Whereas the former concentrated on the recapture of formerly lost territories, the latter's campaigns were more commonly directed at areas not previously under Assyrian control. Shalmaneser III is also credited with transforming the irregular payments received during military campaigns into regular tribute obligations imposed on defeated states, an aspect that has also been stressed by other scholars (e.g., Bär 1996; Klengel 1997; Tadmor 1975). It is only with Shalmaneser III that an Assyrian presence in West-Central Syria became more permanently established. Still, it is only with later Assyrian kings, most notably Tiglath-Pileser III and Sargon II (721-705 BCE) that West-Central Syria becomes directly incorporated into the Assyrian administrative and provincial system.

1.3.3.2 The Archaeological Evidence

Whereas fixing a date to the Late Bronze Age to Iron Age I transition is aided by the appearance of decorated Aegeanizing ceramics, the transition from the Iron Age I to Iron Age II is less clear, due to a lack in reliable archaeological markers (Mazzoni 2000b, 2000c). On the one hand, this can be attributed to a significant degree of continuity between the two phases, as well as to a concentration of the archaeological evidence in the later parts of Iron Age II (Mazzoni 2000b, 125). On the other hand, the introduction of the so-called Red-Slipped Burnished Ware (RSBW), one of the most important diagnostic markers of the Iron Age II, does not appear simultaneously at all sites, nor does it spread evenly across the region (Mazzoni 2000b, 125; 2000c, 42). At Ras al-Bassit, the appearance of Red-Slipped Burnished Ware is dated to the 9th century BCE (based on the co-occurrence of imported Greek pottery). At Tell Kazel and Tell Qarqur, its introduction is dated already before the 9th century BCE, whereas at Tell 'Arqa, RSBW ceramics are dated to the 8th and 7th centuries BCE (Mazzoni 2000b, 125-126).

At inland sites, such as Tell Afis, the ceramic assemblage of the Iron Age II continues the trends already started in the preceding period. Painted wares continue to decrease in quantity, whereas common wares, RSBW, and Cypriot imports increase steadily (Mazzoni 2000b, 2000c). A similar continuity in ceramic traditions is observable at other Syrian sites, such as Tell Qarqur and 'Ain Dara (Mazzoni 2000b, 127). In addition, there is considerable evidence for architectural continuity at several sites. At Hama, the transition between Levels F1 and E2 is gradual, with earlier architecture being incorporated into later buildings, whereas Tell Kazel and Tell Afis show a similar degree of continuity without apparent destruction horizons present in the stratigraphy (Mazzoni 2000b,

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KARATEPE 1, KARKAMIS A30h, and TELL AHMAR 5 (Hawkins 2000). Of the Aramaic inscriptions, the PANAMUWA I (KAI 214) and PANAMUWA II (KAI 215) inscriptions from Zincirli boast of the increase of agricultural cultivation and the restoration of economic prosperity, respectively. It is only in the MESHA Inscription (KAI 181) from central Jordan that an explicit reference to the building of a reservoir and a cistern, that is, to hydraulic construction, is made (Donner and Röllig 1962; Gibson 1971). The omission of such themes is perhaps not surprising, considering that these inscriptions, and the sculptures with which they were associated, served a particular function, closely tied to the legitimization of the ruler through the celebration of dynastic lineage, ritualistic performance, or military prowess (see, Gilibert 2011). While civic and military construction played an important role in these accounts, building programs were usually confined to palatial and cultic structures.

127). During the Iron Age IIB, Red-Slipped wares are much more widely distributed throughout Syria and close affinities between coastal and inland ceramic repertoires develop (Mazzoni 2000c, 54).

In general, the Iron Age II is characterized by a significant degree of continuity, both in ceramic and architectural traditions. Many archaeological sites exhibit a dense succession of occupation layers with frequent destructions and re-buildings, while the ceramic corpus attests to only rather small and subtle changes over time (Mazzoni 2000b, 2000c). Other developments of this period include a progressive specialization of the minor arts, with highly specialized luxury goods appearing in this period, especially in metalwork and ivory carving (Mazzoni 2000c).

These characteristics make it rather difficult to assign precise dates to the Iron Age II, at least from an archaeological standpoint. The high degree of continuity both between the Iron Age I and the Iron Age II, as well as within the Iron Age II itself, does not provide evidence for significant breaks in the material culture. Thus, textual and art-historical evidence play a significant role in the phasing scheme of the Iron Age II proposed by Mazzoni. While she considers the 9th century BCE as a reasonable starting date of the period, mainly on the basis of the occurrence of RSBW ceramics (Mazzoni 2000c, 41), she uses textual evidence, primarily the campaign reports of Sargon II, to fix the end of the period at the end of the 8th century BCE, around 720 BCE (Mazzoni 2000b, 130).

1.4 Thesis Structure

In Chapter 2, previous explanations of social collapse will be presented and discussed. But rather than providing a full literature review of the concept and its long and convoluted intellectual history, the discussion will focus on three aspects that have shaped the discourse on Syria and the Levant in particular: social evolution, race and ethnicity, and environmental determinism. Through a close reading of the sources and the language used in the discourse, it will be suggested that the concept of collapse is suffering from unresolved intellectual issues that seriously call its applicability into question, especially with regard to the Late Bronze and Iron Age in West-Central Syria.

Building on recent development in ecology and ecological archaeology, Chapter 3 will present a new approach to social change inspired by Socio-Natural Systems thinking. A concise literature review will present the most important aspects and features of this kind of thinking and discuss how these perspectives can be applied to the archaeological record. Therefore, Chapter 3 is not solely theoretical in character, but also aims at bridging the divide between theory and method, proposing specific questions and approaches that can be used to investigate the relationships between human communities and their environments. As it will be argued, GIS modeling and statistical analyses constitute useful tools with which these analyses can be conducted.

Chapter 4 will be largely methodological in character. In this chapter, the available evidence and data will be presented, discussed, and assessed. Although large quantities of both climatic and geographical data are theoretically available for analysis, not all of these data can be usefully applied to a study in West-Central Syria in the Late Bronze and Iron Ages. In fact, since this region and time period has not featured prominently in previous analyses of socio-environmental interactions, significant gaps exist in the data that need to be accounted for and dealt with. In the case of palaeoclimatic data, which is only scantily available in Syria itself, climatological modeling is used in order to bridge these gaps in data availability.

Chapter 5 will present a GIS-based and statistical analysis of climatic/environmental change between ca. 1350 and 750 BCE, and its effects on the settlement system and economic structure of the region. Following the theoretical principles outlined in Chapter 3, and based on the archaeological, climatic, and geographical data presented in Chapter 4, this section present the results of environmental analysis. The first part of this chapter revolves around the results of climatic modeling and the development of a predictive model of wheat crop suitability, through which the effects of climatic change on agricultural production and the socio-economic system can be investigated. The modeling results will be analyzed at various scales, ranging from the regional to the local, to highlight a number of chronological and spatial trends within the data, but which would otherwise be obscured by concentrating on only one particular scale of analysis. In a second part, this chapter will present the analysis of trends within the settlement data. Using geo-spatial statistics and other statistical tools, this section will explore how settlement systems in West-Central Syria changed over time and how these changes might have been related to (or not related to) a variety of environmental factors, including climate and topography.

Chapter 6 will then present an integrated discussion of all the available data, bringing the archaeological, historical, climatic, environmental, and topographic evidence together in a discussion of social and environmental change in West-Central Syria between 1350 and 750 BCE.

1.5 A Preliminary Study of Environmental Change and Social Adaptation

This dissertation proposes to abandon the rather rigid notion of collapse when studying the Late Bronze/Iron Age transition in West-Central Syria (or the Levant in general), which, after all, implies some sort of drastic transformation. As will be discussed in Chapter 2, notions of collapse are to this day plagued with unresolved issues and should therefore be replaced with a different concept. Socio-Natural Systems thinking, it is argued here, offers a viable theoretical and methodological alternative with which social, political, economic, and natural transformations can be investigated and understood within a framework of mutual dependencies. As a corollary of this focus on connections and influences, SNS perspectives circumvent some of the most critical issues of traditional interpretations, that is, the need to identify one single specific cause that led to the demise of a social, cultural, or political entity and the establishment of a new one. Rather than explaining specific patterns in the archaeological record as the direct results of racial, ethnic, or cultural differences between certain population groups, Socio-Natural Systems studies perceive the archaeological record as the result of a multitude of social, economic, political and cultural processes developed in relation to broader environmental processes, including (but not limited to) climatic change and environmental deterioration.

1.5.1 Research Objectives and Research Questions

Beginning with a critique of the concept of collapse in Late Bronze and Iron Age Levantine research, this dissertation develops a theoretical (and methodological) framework that can be utilized to investigate the various complex and interrelated linkages that exist between society and its surroundings and conceptualizes social change as an adaptive behavior in the light of climatic variability, but also in relation to other processes potentially unrelated to environmental variables.

In this regard, the first aim of this dissertation it to provide a detailed and thorough criticism of specific aspects of collapse theory and develop a ‘new’ theoretical perspective that can serve as a substitute.

From a methodological perspective, this project develops a GIS-based approach with which socio-environmental relationships can be studied and analyzed. Such an approach is necessary not just to fill some more-or-less pronounced gaps in the data currently available, especially from an environmental point of view, but also because an analysis of socio-environmental interactions requires that mutual relationships and influences are made explicit and quantifiable (see, Contreras 2016). GIS-based analysis, among other things, enables the statistical analysis of interactions between different spatial variables and therefore lends itself particularly well to SNS-inspired research.

It has long been suspected, and repeatedly argued, that climatic deterioration at the end of the Late Bronze Age played a significant role in the demise of the Bronze Age socio-political system (e.g., deMenocal 2001; Kirleis and Herles 2007). Recent palaeoenvironmental research appears to support this interpretation, indicating the onset of more arid conditions towards the end of the 2nd millennium BCE. However, it has never been questioned whether these climatic changes were in fact significant enough in scale to have a negative effect on the agricultural potential of West-Central Syria, resulting in the decline of agricultural fortunes and economic hardships. Such a link between climatic change, environmental deterioration, and economic stress has often been *assumed*, without any efforts to actually *prove* it. Therefore, this dissertation not only seeks to model diachronically and geographically specific patterns of climatic change, but also seeks to analyze the effect these changes had on the economic system and, by extension, society as a whole.

1.5.2 Results

Several conclusions can be drawn from this study. First, GIS analysis can provide a valuable tool when seeking to operationalize SNS principles for archaeological research. Besides statistical analysis, GIS provides a way through which climatic and environmental variables can be extrapolated from specific, dispersed locations and modeled on a regional scale and across time. Not only does this allow for a diachronic and geographically specific analyses of environmental processes, but also makes it possible to relate the environmental record to the available archaeological data. In this regard, GIS modeling constitutes a tool through which gaps in the data can be dealt with. As will be shown below, in the case of West-Central Syria these data gaps relate especially to the palaeoenvironmental proxy record and sometimes the results of GIS modeling constitute the only way through which environmental changes in the Late Bronze and Iron Ages can be analyzed at all.

Second, it will be shown that climatic changes throughout these periods were far from uniform, both from a geographical and a chronological standpoint and that careful, small-scale analysis is necessary when talking about the effects of climate change. Furthermore, it will be shown that there exists a difference between climate change on the one hand and the effects thereof on the other. Only because there is evidence towards the progressive aridification of an environment, it cannot automatically be assumed that these changes were significant enough to have an adverse effect on people’s lives or their subsistence base. In other words, climatic change should not be simply equated with social change. Instead, careful analysis is necessary in order to differentiate between the two.

Third, combining the data from the environmental modeling and analysis with the available archaeological and historical evidence, it will be shown that not all processes of social transformation in Late Bronze and Iron Age West-Central Syria can be attributed to climatic or environmental fluctuations. In fact, there exists several instances where climatic changes appear not to have significantly influenced the environment, whereas at other times, environmental changes appear to have been important enough to result in a number of socio-economic adaptations. As a result, then, it will be argued that West-Central Syria in the late 2nd and early 1st millennium BCE constitutes a complicated patchwork of climatic shifts, environmental changes, and social transformations that are related to each other in geographically specific contexts. Thus, the transformations observable in this region between the Late Bronze and the Iron Ages cannot be ascribed to either environmental or social causes alone, but should rather be seen as a complex interplay of a variety of variables within geographically and chronologically specific contexts.

CHAPTER 2

TALES OF COLLAPSE: COLLAPSE THEORY AND SOCIAL GTRANSFORMATION IN THE LEVANT

> “There has been inordinate fascination with societal collapse […]. The concept has intuitive appeal but ambiguous meaning, and has been applied to states, nations, or complex societies, in the sense that such entities rise and flourish, but eventually disintegrate and fail.” (Butzer 2012, 3632)

2.1 INTRODUCTION

In just a few words, this opening passage to Butzer’s recent paper *Collapse, Environment, and Society* highlights some of the most prominent themes within the anthropological and archaeological literature on social collapse. At the same time, it brings to the fore one of the most vexing and unresolved issues related to the study of this particular concept: terminological ambiguity. Its meaning can range from small-scale systemic adaptation to changing conditions, to a wholesale demise and breakdown of cultural entities. But even the very entities that are said to collapse can take vastly different forms, as they can be states, nations, or even entire civilizations, or as Yoffee (1988b) puts it, “great traditions.” When contemporary perspectives of political science are considered, an additional, and decidedly modern, layer of complexity is introduced by drawing a further distinction between the state and civil society.[18] In this regard, the very term can refer to a wide variety of phenomena across different scales, from the global to the local, encompassing entire socio-political entities, or merely some of their constituent parts. Consequently, there exist almost as many understandings of what the term collapse actually refers to as there are books and articles published dealing with the subject. These ambiguities notwithstanding, the entire concept has proven to be extremely persistent, even in the light of growing intellectual opposition and criticism.[19]

In the Eastern Mediterranean, the transition from the Late Bronze Age to the Iron Age, generally dated to the early 12th century BCE, has often been cited as one prominent instance of societal collapse. To a significant degree, this viewpoint has been based on textual sources from Egypt, the Levant, and Anatolia, which cast a rather bleak picture of the 12th century BCE as a period of widespread unrest and conflict, but has also been influenced by the archaeological record, which

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[18] The term ‘civil society’ refers to a variety of social, economic, or political groupings that, while potentially under its control, are distinct from ‘the state’ as a separate social entity (Zartman 1995). Civil society enjoys a complicated and uneasy relationship with the state, as it designates the sphere where the legitimacy of the state is generated, negotiated, and potentially even challenged. Society generates the institutions that make up the state and when society is no longer able to create and maintain these institutions, societal collapse ensues (Zartman 1995, 6). Of course, it is not suggested here that this modern conception can be applied to the archaeological record, or that it has any bearing on the study of social collapse in the Ancient Near East. However, as a brief example, it serves to elucidate the immense complexity inherent in the study of collapse as a social and historical phenomenon.

[19] In reviewing the archaeological literature on collapse, it becomes clear that the discipline appears to be moving towards a primarily socio-political interpretation of collapse. The main impetus for this process has been Tainter’s work, particularly his 1988 book *The Collapse of Complex Societies*. His approach has been taken up by a range of other scholars, among them Butzer (1997, 2012), Butzer and Endfield (2012), Chew (2007), Schwartz (2006), and Weiss and Bradley (2001). In all these instances, collapse is understood as the reduction of some form of social complexity, entailing a broad range of social, political, economic, or even ecological factors.

provides evidence for the violent destruction of many Late Bronze Age sites, particularly on the Syrian coast. Over the past century, many different causes for the breakdown of the Bronze Age socio-political and socio-economic system have been proposed, including: the invasion of foreign peoples, primarily the Sea Peoples; the overexploitation of the poor by the elites, resulting in political disenfranchisement and civil strife; climatic and environmental changes, entailing crop failures and famine; or the overexploitation of the environment and ecological mismanagement.

Rather than comprehensively reviewing the entire corpus of literature on social collapse in archaeology, this chapter will focus on only three specific aspects that had the most noticeable effects on the scholarly discourse on the Late Bronze and Early Iron Ages in the Levant. Due to the nature of the discussions reviewed, and because of the considerable influence Classical Greece has had on Western self-perceptions in the past, frequent reference to related discussions in Greek archaeology will have to be made, but perspectives from other archaeological regions will also be introduced into the discussion where necessary.

The first of these aspects can be described as 'social-evolutionist,' drawing primarily on the paradigms of traditional evolutionary perspectives. An evolutionary view of history first emerged in the Enlightenment period, pronouncing social and intellectual progress as one of the grand themes of human history (Trigger 1989). In this regard, it is surprising to see that evolutionist sentiments continue to exert a considerable degree of influence on modern archaeological thought, even though they have long been considered superseded by the development of culture historical and neo-evolutionary perspectives developed during the 20th century CE. Social-evolutionary arguments on the Late Bronze/Iron Age transition in the Eastern Mediterranean tend to focus on the delineation of qualitative differences between the two periods, based on perceived discrepancies in the quality of material remains, but also in overall forms of socio-political and economic organization. As will be shown below (**§2.2**), social-evolutionist perspectives are generally not the product of a dedicated world-view or research design, but primarily manifest themselves in the terminology used to discriminate between archaeological periods and their salient material and cultural characteristics.

The second aspect concerns the role played by foreign peoples and the degree of influence exerted by newly developed ethnic and social groups or identities on the social fabric of ancient communities. These arguments are intrinsically tied to 20th-century CE culture-historical thought and its conception of culture (*Kultur* or *Kultur-Gruppe* in early German academia) and ethnicity. Although the overt racist connotations of this particular approach to human history have long been realized and denounced (Trigger 1989), it might be suggested that some of its central concepts have never been officially renounced in Near Eastern archaeology. This becomes especially apparent when considering the basis on which distinctions between purported ethno-linguistic groups (like Aramaeans or Hittites) are drawn in the archaeological and textual record. Of course, this is not to say that modern research on the archaeology and history of these groups is inherently racist, or even slightly so, but it is important to note that the basic distinctions between certain cultural and ethnic groups are ultimately based on an intellectual heritage long considered obsolete and unsustainable (**§2.3**).

Finally, there is a prominent strand of archaeological thought that has advocated an ecological interpretation of the Bronze Age collapse, arguing for climatic and environmental changes as the ultimate cause of social transformation. Such environmental perspectives have been part of archaeology almost since its inception, rising to prominence in the ecological determinism of later 20th-century CE neo-evolutionary thought (Contreras 2016; Trigger 1989). Although still to some degree grounded in 19th-century CE Malthusian theories of population ecology, recent research has largely eschewed earlier deterministic connotations and devoted much attention to the development of a complex understanding of the interactions between human societies and their natural environments, the so-called Socio-Natural Systems perspective (**§2.4**).

In reviewing these themes, the present study does not purport to be able to solve any of these issues by providing a new definition of social collapse, nor does it intend to provide a comprehensive overview over the extremely vast field of collapse studies, both within archaeology and without.[20] This thesis also does not pretend to establish the only viable causal chain that conclusively explains the character and scale of the social, political, and economic collapse that might have characterized the transition from the 2nd to the 1st millennium BCE in the Levant. Such an endeavor would not only be futile in the light of the massive corpus of literature that has accumulated on this subject, but it would also require to gloss over significant intellectual and theoretical concerns that are unique to Near Eastern archaeology in general, and the Levant in particular.

Instead, a completely different argument is made here: Collapse as a theoretical concept does not significantly advance or support the analysis and understanding of processes of social transformation in the Levant. Given the vast range of different interpretations and meanings that the term covers, both in colloquial parlance and academic discourse, the concept itself has indeed lost most of its explanatory value. As Butzer and Endfield argue,

> "*Societal collapse represents transformations at a large social or spatial scale, with long-term impact on combinations of interdependent variables*: (i) environmental change and resilience; (ii) demography or settlement; (iii) socio-economic patterns; (iv) political or social structures; and (v) ideology or cultural memory." (Butzer and Endfield 2012, 3628; italics in original)

Viewed from this perspective, collapse becomes a catchphrase encompassing virtually every single aspect of social life, from the material remains of economic activity, to the intangibles of social interaction and communication. In a certain way, collapse thus simply becomes a metaphor for transformation or change. This is also apparent in the definition recently given by Schwartz:

> "If collapse entails, at least in part, the disintegration of states, urban systems, or ideologies, then regeneration should consist of the reconstruction of the same kinds of institutions and phenomena. It is important to emphasize that by regeneration we mean the reappearance of societal complexity (states, cities, etc.) after periods of decentralization, not the reappearance of *specific* complex societies." (Schwartz 2006, 7; italics in original)

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[20] Many excellent comprehensive and detailed treatises have been written on the history of the archaeological and anthropological preoccupation with collapse as a social and historical phenomenon. Tainter's (1988) *The Collapse of Complex Societies* is probably one of the most detailed and most authoritative accounts of its intellectual history within the discipline. His recent publications (Tainter 2006, 2008) provide important new insights, especially in light of the ecological perspectives that have become increasingly popular lately. In addition, a number of edited volumes provide both general discussions as well as detailed case studies, including Yoffe and Cowgill's (1988) *The Collapse of Ancient States and Civilizations*, Schwartz and Nichols' (2006) *After Collapse*, as well as McAnany and Yoffee's (2010a) *Questioning Collapse*. Besides presenting a range of interpretations and perspectives on societal collapse, these volumes also roughly sketch the intellectual development that has characterized collapse studies over the past approximately 20 years. Finally, some very interesting critical perspectives have been offered by Karl Butzer and colleagues, especially Butzer (2012) and Butzer and Endfield (2012).

From this perspective, social complexity, or rather the lack thereof, becomes the hallmark of social collapse. Yet, it remains obscure and rather ambiguous what precisely is meant by the term ‘social complexity.’ Judging from the above quote, it appears that social complexity is associated with some level of political, economic, or spatial organization of society, but it remains unclear what specific aspects can be used to identify complexity, nor is it spelled out how complexity can be measured or identified in the archaeological record. If a loss of social complexity is understood as the rearrangement of society into less densely urbanized settlements or less hierarchically organized political units, for example, it might be asked if collapse, then, does not simply become a shorthand for change, where one form of organization (social, economic, political, etc.) is replaced by a different one.

2.2 Collapse as an Evolutionary Watershed

From the vantage point of an evolutionary model of human history, the idea of collapse of ancient societies and states has enormous appeal, as each break in the archaeological and historical continuum entails the potential for the subsequent advancement of humanity as a whole. And although evolutionist perspectives largely fell out of favor sometime in the 1980s (Schwartz 2006, 3) their legacy still appears alive and well in contemporary research, evinced by the survival of concepts developed centuries or decades ago.

2.2.1 Enlightenment Thinking and Social Evolutionism

The 18th century CE clearly marks a major milestone in academia’s ‘inordinate fascination’ with the decline and demise of past societies. During that time, first inquiries into this phenomenon were sparked by the travels of a few individuals and the fantastical descriptions of ancient ruins they produced, especially with regard to the Middle East (Liverani 2009). Out of this fascination arose Gibbon’s (1777-1788) famous *The History of the Decline and Fall of the Roman Empire*, a monumental treatise on Roman history and widely regarded as the earliest attempt to study collapse as a historical phenomenon. In essence, Gibbon argues for the victory of the despotic *imperium* over the free and virtuous *republic* (Pocock 1977, 291-293). Rome’s eventual destruction is brought about by the decay of its moral, social, and political institutions, and the rise of religious superstition, that is Christianity, at the expense of the philosophical skepticism of the Greeks and the early Roman republic (Butzer 2012; Pocock 1977; White 2014).

Its focus on the moral aspects of Roman decline squarely situates Gibbon’s study within Enlightenment thinking (Knellwolf 2004; Pocock 1977; Trigger 1989). Drawing considerable inspiration from the newly developed natural sciences, particularly Newtonian mechanics, and their claim of establishing the general principles and laws of the physical world, Enlightenment thinkers dreamt of determining similar rules for social behavior as well (Henry 2004). As optimism about technological progress and the capabilities of the nascent sciences grew, the idea that human history trended towards general progress became the new intellectual paradigm (Trigger 1989). But as colonial expansion brought Europeans into contact with seemingly less sophisticated societies, the presumed uniform character of human nature suddenly seemed less certain, spurring interest in the underlying principles of social cohesion (Butzer 1997; Knellwolf 2004). In the process, technologically less advanced societies came to be seen as living examples of primordial social and economic conditions (Trigger 1989).

In the context of the nascent social sciences, particularly the historical sciences, Gibbon's *History* occupies an important position. Together with his contemporaries Voltaire and Hume, Gibbon initiated the shift away from a narrative focusing on individual historical figures and specific forms of government towards a discussion of the larger social and political structures in which they were embedded (Wright 2004).[21] Through this comparative approach, Gibbon and his contemporaries came to think of the Roman Republic as a "[...] paradise lost, a golden age of good government, wise rule, harmony, and peace, when all was right with the world." (Tainter 1988, 39).

But although the *History* marks the beginning of scientific inquiry into the phenomenon of social collapse, it was certainly not the first attempt. A preoccupation with the destruction of human societies can be identified in a variety of sources dating back to the Hebrew Bible (Tainter 1988, 52) and Greco-Roman thought (Trigger 1989, 60), but is also evident in the writings of well-known ancient, medieval, and early modern thinkers, such as St. Augustine, Petrarch, Ibn Khaldun, Machiavelli, Montesquieu, Volney, or Herder (Brunk 2002; Tainter 1988). Similar to Gibbon, for many of these writers, the demise of historic societies was the result of mysterious and largely unknowable factors, such as moral decay or a decline in military prowess, attesting to the strong moralistic conceptions prevalent at the time (Brunk 2002; Tainter 1988).[22]

2.2.2 The Study of Civilizations

Gibbon and his contemporaries of the 18th and 19th centuries CE were firm proponents of a social-evolutionary view of history, in which human history at large was seen as continuously and inevitably progressing towards higher levels of technology, social organization, politics, morality, or religion, punctuated by episodes of collapse which enabled the development into new directions (cf., Trigger 1989). But even later 20th century CE audiences were beguiled by the idea of collapse as the driving force behind social evolution. On the end of the 3rd millennium BCE in the Near East, Childe wrote:

> "Soon after 2300 B.C. the imposing state organizations […] and the economic system they dominated disintegrated. In Egypt, Mesopotamia, and India, eras of prosperity that have left a vivid impression in the archaeological record were succeeded by Dark Ages from which few buildings and inscriptions survive. In India civilization itself seems to have been extinguished. In Egypt and Mesopotamia it soon re-emerges, and re-emerges liberated from some of the shackles of ancestral barbarism and deepened so as to benefit more fully new classes in society. In the interval in the newly urbanized areas like Assyria the germs of civilization have had time to develop on original lines." (Childe 1942, 159)

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[21] Voltaire's *The Age of Louis XVI* (1751), unlike his earlier works, marks the first historical narrative to consider aspects of culture, society, and politics across a large chronological span, whereas Hume's *The History of England* (1754-1762) constitutes the first attempt to trace the origin of a distinct national identity, in this case the British, backwards in time. On the other hand, the final books of Gibbon's *History* contrast the decline of the Roman Empire with the concomitant rise of a new European civilization (see, Wright 2004, 211-213).

[22] Apart from setting the precedent for the study of collapse as a historical phenomenon, these early writers also introduced some of the analytical terminology that came to characterize the academic discourse later on. As noted by Liverani (2009, 16-17), the application of formerly mathematical language, such as the term 'revolution,' until then restricted to astronomy, was first introduced by Gibbon and his contemporary Volney (1792). Yet, the use of biological terminology, including concepts like 'rise' and 'birth' in describing the developmental stages of human societies can be traced back in European thought all the way from the Renaissance through the Middle Ages to Classical Antiquity, again illustrating the immense pedigree of the scholarly vocabulary familiar to the modern reader.

According to Childe, the barbarism of less developed people ushers in the demise of imperial economic control and the annihilation of centers of political power. Civilization is subsequently rebuilt and the upper echelons of the social hierarchy, merchants, soldiers, administrative specialists, priests, and artisans, enjoy the benefits of heightened prosperity and independence from palatial control. Economically, this new-found independence provides a stimulus for the circulation and importation of goods, while industrial production expands significantly. This further leads to the emancipation from despotism and the establishment of codified law. Whereas, according to Childe, the Dark Age at the end of the 3rd millennium BCE resulted in the initial establishment of civilization across the Near East, the Dark Age at the end of the 2nd millennium BCE propelled it to new evolutionary heights, including the spread of new writing forms (the alphabet) and the development of new forms of government and political discourse (democracy, republic). Finally, the authority of divinely sanctioned kingship, characteristic of the Bronze Age, was replaced by new, moralizing religions (Judaism) and the foundations of modern scientific rationale (Childe 1942).

The main thrust of Childe's argument is clear: Near Eastern civilization, first developed at the beginning of the Bronze Age, was established as the barbarism, anarchy, and chaos of the preceding periods were overcome. Out of the Bronze Age crisis rose an invigorated civilization, replete with the trappings of modern Western society, including monotheistic religion and scientific inquiry. Similar themes were also pondered by American scholars. Shifting their attention from politics towards issues of culture and civilization, scholars like Spengler (1962), Toynbee (1962), Kroeber (1944, 1957), Coulborn (1954, 1966), and Gray (1958) irrevocably enmeshed the study of culture with that of civilization. As the hallmarks of civilization, the decline and disappearance of certain cultural forms, like art, architecture, literature, music, or philosophy, came to signify civilizational demise writ large (Tainter 1988, 40).

Within collapse studies, the idea of civilizations as meaningful categories of social complexity still continues to hold some currency. Yoffee (1988a, 1988b) draws a distinction between the collapse of a state and an entire civilization, the latter of which constitutes an extremely rare phenomenon in human history (see also, Cowgill 1988). Similarly, Tainter defines collapse as a situation in which "[...] *a rapid, significant loss of an established level of sociopolitical complexity*" occurs (Tainter 1988, 4; italics in original). Described in this way, a clear separation between social and civilizational collapse is drawn, civilization being the "[...] cultural system of a complex society" (Tainter 1988, 41), which can encompass several individual societies or political entities, and only ceases to exist as social complexity is wiped out entirely. Still, it remains unclear how complexity is defined and how it can be identified in the data.

2.2.3 'Civilization' vs. 'civilization'

The concept of civilization, while generally highly important in collapse studies, has featured particularly prominently in the archaeology of the Near East and the Eastern Mediterranean, particularly Greek archaeology.

Here, the double-edged character of Dark Ages, on the one hand signaling a severe socio-cultural crisis, on the other providing fertile grounds for the rejuvenation and invigoration of ancient civilization, is easily perceptible. For example, for Starr, "Greek civilization could never have arisen if that disruption [at the end of the Bronze Age] had not occurred and had not shaken the old conventions" (Starr 1961, 74.) Much like Childe and others, Starr equates civilization with developments in the cultural, political, and intellectual sphere, encompassing epic poetry, art, architecture, democracy, able statesmen, and the invention of philosophical ethics (Starr 1961: 77, 322-325), sentiments also expressed by other authors, such as Chew (2007) or Sourvinou-Inwood (1993).

While Starr cites both the tangible and intangible elements of civilization, Carpenter (1966) focuses primarily on material aspects, particularly material wealth and epigraphic finds. According to him, climatic changes at the end of the Bronze Age ushered in a "[…] Mycenaean cultural decline equivalent to the virtual annihilation of all higher civilization" (Carpenter 1966, 35-36), similar to earlier episodes of decline which entailed the disappearance of artistic skill, decreasing levels of craftsmanship, and impoverished means of subsistence.[23]

For Classical Greek civilization to develop, a dramatic break between the Bronze and the Iron Age was necessary, which was characterized by considerable impoverishment and decline in all social and cultural spheres. At least for Starr, this break was brought about by the arrival of Indo-European newcomers, the Dorians,[24] which put an end to an already ailing civilizational superstructure and introduced an innovative spirit not observable in the local population,[25] whose political, social, and economic simplicity is mirrored in rudimentary forms of pottery decoration during the Dark Ages (Chew 2007, 95-96; Starr 1961, 105). This aspect of cultural and material impoverishment also constitutes a major focus of Desborough's analysis:

> "From the point of view of material culture, the Greek Dark Ages have little to offer or excite. There are indeed achievements, considerable in relation to the times themselves, but not to be compared with those of the Mycenaeans before or of the Archaic and Classical Greeks later. The main interest lies elsewhere. The Dark Ages, by their nature, exercise a fascination and present a challenge. What really was happening?" (Desborough 1972, 12)

Clearly, the cultural achievements of the period do not warrant scholarly attention by themselves, for they are of inferior quality when compared to those of other periods. Still, even the artistic achievements of the Bronze Age paled in comparison to those of the Classical period:

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[23] These ideas about diminishing levels of material wealth and artistic skill, it might be argued, are strongly influenced by Greek tradition itself. As Snodgrass (1971, 2-3) has pointed out, the perception that wealth and skill of Greek society steadily decreased over time is already present in Homer's *Iliad*. Hesiod, on the other hand, introduced the concept of associating different ages with certain metals - gold, silver, bronze, and, after an intervening 'heroic age,' iron. However, in this conception, the different ages are not so much associated with degrees of skill or wealth, but rather with moral integrity (Snodgrass 1971, 4). Interestingly, these concepts of cultural decline over time are inverted in Thucydides' writings. His historical narrative is one of steady, albeit slow, progress, which implies a certain degree of continuity between the Bronze and the Iron Age (Snodgrass 1971, 7-9).

[24] The Dorians themselves are, in fact, a product of ancient Greek historiography adopted by later authors. One of the earliest, yet obscure, reference to Dorian groups is contained in Book XIX of Homer's *Odyssey* (Homer 1992), where they are reported to inhabit the island of Crete. Later references are found, for example, in Book I of Herodotus' *Histories* (Herodotus 2008), where the Dorians are being identified on the basis of a diffuse set of ethnic and linguistic connotations.

[25] As noted by Sourvinou-Inwood (1993), the identification of these innovations, however, often rests on rather questionable evidence. For example, the characteristics of Dark Age religion are actually not identified in the archaeological record. Instead, observations on the better-known religious sanctuaries of the Classical period are simply extrapolated back in time, to fit into the concept of the Dark Age as the period in which Classical Greek culture developed (Sourvinou-Inwood 1993: 1-2). Upon more careful examination of the historical and archaeological record, however, she argues for a continuous development from the Bronze to the Iron Age, without any dramatic innovations during the intervening period (Sourvinou-Inwood 1993, 11).

> "Such artistry and craft [of the Mycenaean period] were not to be seen again in Greece for at least four hundred years. But it was a perfection of technique rather than of the spirit, and the reason for this is that it seems to have been encouraged for only one purpose, the magnificence of the ruling class." (Desborough 1972, 16)

Although Mycenaean artists and craftsmen attained the highest levels of skill and technology, their products severely lacked an intellectual appeal which, according to Desborough, could only be achieved through emancipation from royal patronage. True artistry, in other words, was linked to intellectual and political freedoms which, it might be assumed, only the democratic experiment of the Greek polis could provide. Much like Starr or Carpenter, Desborough interpreted the Dark Ages as a period of decline in the level of artistic skill and technological know-how, but which also contained elements of stability and rejuvenation, providing the foundations for the revival of Greek civilization centuries later (Desborough 1972, 352).

This perception of the Bronze and Iron Ages constituting two distinctly different stages of civilizational development is by no means limited to Greece alone. Near Eastern historians and archaeologists have identified breaks and transitions within the record in equally strong terms (Hallo 1992). Until the very late 20th century CE, the end of the Bronze Age in the Eastern Mediterranean was commonly associated not only with the end of palatial culture and administration, but also with artistic production (Muhly 1992). Bronze and Iron Ages were commonly conceptualized as two strikingly different periods, with one period being qualitatively superior to the other:

> "[...] there was an essential qualitative difference between the culture of the Late Bronze Age period, which is manifested so well at Ugarit, and that of the Iron Age. Ideas which were received were transmitted further, even into the Hellenistic period, but the emphasis was placed differently. The introduction of new deities and the modification of the spheres of action of already existent numina cannot simply be explained as the effects of evolution through time, but rather are based on changes in the ethnic sphere resulting from political events." (Röllig 1983, 90)

In essence, the Iron Age, although continuing the transmission of certain Bronze Age ideas, is a period of innovation. In this particular case, the innovative character of the period is located primarily in the religious sphere, through the introduction of new deities and religious concepts. It is noteworthy, however, that in this context innovation is not seen as an indigenous, local development, but rather as conditioned by the arrival of new ethnic elements.[26]

But technological innovations have also been discussed without recourse to foreign people invading the region. Liverani (1987), for example, argued for technological innovations in seafaring, water management, and metallurgy, but also economic innovations like private enterprise, increased commercial exchange, and a profit-oriented entrepreneurial spirit, as the hallmarks of Iron Age society. Similarly, in comparing the economic and political structures of Bronze and Iron Age states and kingdoms of the Levant, Hallo (1992) argued for a qualitative difference between

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[26] Similar arguments, attributing innovations in technology and in socio-political organization to outside sources, have been made by Alt (1944) and Raban and Stieglitz (1991), referring to new naval and military technologies. These arguments, however, are strongly influenced by culture historical perceptions of culture and ethnicity, as well as their role in social change, and therefore a more detailed discussion will be postponed until later.

the two periods. For him, the Bronze Age was characterized by individual city-states based on an essentially agrarian economy, whereas the Iron Age saw the advent of large, territorial empires, driven by military conquest and an exploitative tribute economy.[27]

In fact, this focus on socio-political and economic aspects has characterized much research on the Late Bronze/Iron Age transition since the 1980s. Several scholars have followed Liverani's lead, identifying the demise of the palatial economy, the emergence of the nation state or 'ethnicizing state', the expansion of private commerce, and the development of new water-management technologies as the hallmarks of the Iron Age (e.g., Joffe 2002; Mazzoni 1994, 1995; McClellan 1992; Sader 1992).

The degree to which interpretations of the transition from the Late Bronze to the Iron Age in the Levant have become enmeshed with conceptions of socio-political, economic, and technological decline, but also with migratory movements, has been summarized by Harrison as follows:

> "It has become axiomatic that the collapse of the Egyptian and Hittite empires at the end of the thirteenth century B.C.E., and with them the collapse of the widely integrated economic and political networks that characterized the terminal phase of Bronze Age civilization in the Eastern Mediterranean, ushered in a prolonged 'Dark Age' in the region. Coinciding with reports of widespread famine and political conflict, largely precipitated (according to the conventional view) by the migratory incursions of the 'Sea Peoples' - often portrayed as the 'Vikings' of the ancient world - these events brought to an end the centralized state bureaucracies that had long held sway in the region, ending the rich literary traditions (and archives) they had created. The ensuing Dark Age, correspondingly, devolved into an era of political fragmentation and turbulence marked by chronic ethnic strife, yet out of which eventually emerged the small territorial 'nation-states' of biblical fame in the early centuries of the first millennium B.C.E."[28] (Harrison 2009a, 171)

The conflicts, economic misfortunes, population movements, and the ensuing chaos and decentralization of the Dark Age are conceptualized as the direct antithesis of the Bronze Age, characterized by economic prosperity, demographic stability, and the literary achievements of a highly-developed society. Although the succeeding Iron Age is regarded as a period of significant socio-political innovation, and the establishment of large empires and nation states, it is nonetheless often regarded as inferior.

Often, this distinction is not made readily apparent and is primarily observable in the language employed in the discourse: In the above quote, as in many similar descriptions, the term civilization is reserved for the Bronze Age, whereas the following periods are only described through their respective trademark characteristics. No mention of 'Iron Age civilization,' let alone 'Dark Age civilization,' is made. A qualitative difference between the periods is established through the very language used in the description. This phenomenon is actually fairly common in archaeological

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[27] Yet, in his attempt to define the peculiar character of the Bronze Age, Hallo (1992) also mentions aspects of writing and literature, monumental architecture, craft specialization, and the institution of kingship, some of which were transmitted into the Iron Age, or even further expanded in scope and importance. Therefore, it might be questioned whether these elements serve to differentiate Bronze and Iron Ages on a qualitative level, as done by Hallo. In this case, the only truly differentiating aspects between the two periods remains the transformation of small Bronze city-states into large Iron Age territorial empires, effectively making the distinction one of socio-political organization and scale.

[28] This is only one example of how the conventional view of the Bronze to Iron Age transition has been characterized in recent scholarship. Other examples could be cited as well. See, for example, Venturi (2011, 2013).

and historical discussions in the Ancient Near East. For Liverani (1987), Near Eastern civilization collapsed at the end of the Bronze Age, but the same language is not used to describe the succeeding periods. A similar use of the term is observable in the works of Caubet (1992),[29] Hallo (1992), or James *et al.* (1991) who likewise use the term solely to describe the Bronze Age, whereas Weiss describes the period between 1200-825 BCE as a time when civilization "[...] regressed almost everywhere throughout the eastern Mediterranean and Near East from Late Bronze Age levels" (Weiss 1982, 182)

At the same time, it can be observed that language is often used in order to create a rather bleak image of the transitional period between the Late Bronze and Iron Age. Suggestive, and sometimes quite harsh, language is often employed to clearly mark the difference between the two periods, or to establish the transitional period as rather desolate and grim, using terms and phrases such as 'crisis,' 'demise,' 'disruption,' 'swept away,' 'vanished,' 'void,' or 'widespread destruction' (e.g., Caubet 1992; Dornemann 2003b; Joffe 2002; Müller-Karpe 1976; Raban and Stieglitz 1991; Weiss 1982).[30]

The same kind of language also characterizes the discourse on Greek history and archaeology, as already argued by Snodgrass (1989) over two decades ago. According to him, Mycenaean Greece is often perceived as a period of particular splendor and wealth, associated with the heroic tales of Greek legend, whereas Classical Greece enjoys a privileged position as the precursor to modern Western civilization. The intervening period, the Early Iron Age in archaeological terms, is variously referred to as 'post-Mycenaean,' 'proto-historic,' 'pre-Classical,' the 'Dark Ages,' or even the 'Greek Middle Ages.' This terminology helps to underscore the inferiority of this period and particular the last one likens Greek history to that of later Europe, which experienced a cultural Renaissance after the purported crisis of the Middle Ages (Snodgrass 1989, 23).

Although one would be seriously mistaken to characterize all Greek archaeology and history in this way, similar sentiments have by no means been disowned by modern academia. The recent archaeological and historical synthesis *The Greeks: History, Culture, and Society* (Morris and Powell 2006) shows how deeply entrenched views like these still are. The authors' focus on Classical Greece is not only betrayed by the book's basic outline, lumping everything from 10,000 to 700 BCE into one category ('The Greeks Before History'), but also by the authors' conceptual differentiation between pre- and post-collapse society (Morris and Powell 2006, 4). Consequently, the Classical period is elevated to a unique position within history, marking the beginning of democracy, an egalitarian spirit, a philosophical mindset, the invention of drama and theater, and the development of new forms of representational art. What is more, in referring to the works of Herodotus and Thucydides, this period is also identified as the inception of historiography, natural and political sciences, anthropology, and mathematics. Conversely, the end of the Bronze Age, when Minoan and Mycenaean civilizations ceased to exist, is portrayed as a period of conflict, violence, demographic changes and the decline of political control (Morris and Powell 2006, 69-73).[31]

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[29] In fact, Caubet uses the term 'civilization' in two different combinations, that is, "Ugaritic civilization" (1992, 123) and "urban civilization" (Caubet 1992, 128). However, both usages relate exclusively to the 2nd millennium BCE, highlighting the conceptual differences between Bronze and Iron Ages.

[30] The same kind of language is employed by more sweeping, synthetic studies of worldwide collapse, such as Chew (2007) and Diamond (2005). In the first case, the author relies on the familiar language of 'destruction,' 'demise,' 'desolation,' 'decline,' disruption,' devastation,' or 'lack of vitality,' which is found throughout the book. In the latter case, highly normative language, such as 'bold,' courageous,' or 'anticipatory' is used to establish a qualitative difference between various social responses to ecological degradation, serving as a putative explanation for societal or civilizational collapse (see, Tainter 2008, 352).

[31] Similar ideas of collapse and civilizational decline are perceptible in other recent studies on Aegean archaeology (Dickinson 2006) and Classical Greek history (Rhodes 2006). Yet, due to their generally much more careful and balanced tone, these two studies also illustrate the intellectual and interpretive changes that have taken place over the past couple of decades.

This interpretation is not a far cry from the image developed by Starr several decades ago. On the contrary, several similarities are blatantly clear: The Bronze Age is a period of prosperity, marked by all the trappings of a flourishing civilization, including written sources, cultural practices, and technological achievements. The Dark Age, in contrast, is defined by a decrease in these spheres, also mirrored in a recent study by Bintliff, who associates it with the "extinction of literacy" and "many other striking signs of 'de-skilling'," including the disappearance of monumental architecture, decreased circulation of metal products, the absence of humanoid representational art, and large-scale changes in settlement patterns and socio-economic interaction (Bintliff 2004, 312). Following these dramatic developments, living standards and technological capabilities improved again during the Iron Age, ushering in new social, economic, technological, and intellectual accomplishments (cf., Morris and Powell 2006, 77-81; Starr 1961, 61).

Again, such concepts about civilizational collapse are by no means limited to Greek archaeology, nor are they solely a feature of the academic discourse of past decades. In his recent book *1177 B.C.: The Year Civilization Collapsed*, Cline (2014), relies heavily on this kind of terminology, although the discussion is otherwise marked by a careful and nuanced analysis and synthesis of recent archaeological findings. Right from the beginning, the qualitative differences between the Bronze and Iron Ages is made clear in his description of the late 2nd millennium BCE as a time period

> "[…] when the Bronze Age Mediterranean civilizations collapsed one after the other, changing forever the course and the future of the Western world. It was a pivotal moment in history - a turning point for the ancient world." (Cline 2014, xv)

The magnitude of the Bronze Age collapse, as well as its supposedly colossal impact not just on Mediterranean history but world history at large, is echoed in very striking terms only a few pages later:

> "Although I am primarily interested in examining the possible causes of the collapse of Bronze Age civilizations in this area, I also raise the question of what it was that the world lost at this pivotal moment, when the empires and kingdoms of the second millennium BC came crashing down, and the extent to which civilization in this part of the world was set back, in some places for centuries, and altered irrevocably. The magnitude of the catastrophe was enormous; it was a loss such as the world would not see again until the Roman Empire collapsed more than fifteen hundred years later." (Cline 2014, xviii)

From Cline's perspective, the Late Bronze Age occupies a privileged position in world history, one that "[...] has rightfully been hailed as one of the golden ages in the history of the world, and as a period during which an early global economy successfully flourished." (Bloedow 1995, 176). For centuries to come, humankind would not recover from the shock that constituted the demise of the Bronze Age system, and the civilizations that defined it. Through language, in this instance extremely evocative and vivid language, a qualitative difference between the Bronze Age, as a period of considerable social and economic achievements, and the Iron Age, a period lacking in civilizational accomplishments, is established.[32]

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[32] In this regard, it is also interesting to consider Cline's use of the term 'civilization' throughout the book. As seen in the above

For many authors, the issue is not the collapse of a civilization (lower case), which is replaced by another, but rather the collapse of Civilization (upper case) in the sense of a general category of human history at large. This is not only true for Classical Greece, but also the Near East, where the Late Bronze Age is often portrayed as a temporary high point of social evolution, unmatched by the developments of later centuries.

2.2.4 The Problem of Archaeological Data

Yet, this should not be taken to mean that Cline's argument relies exclusively on such normative language and broad, sweeting descriptions. As already briefly mentioned above, he does make extensive use of recent archaeological, paleoenvironmental, and historical data, tying them into a nuanced and detailed discussion. However, this clearly highlights the uneasy relationship that exists between the archaeological data and such general statements, not just in his work, but in the academic discourse in general.

Already more than 20 years ago, McClellan (1992) and Muhly (1992) called for closer attention to the actual archaeological record, as well as its regional variability. Following his call, scholars have studied a variety of archaeological materials and contexts in more detail, including: the stratigraphic record; local and regional developments in material culture, primarily ceramics, household equipment, figurines, seals and sealings, and other small-scale items; large-scale artistic production and crafts; settlement patterns and trade networks; epigraphic and textual evidence; and agricultural systems (Caubet 1992; Charaf 2007-2008; du Piêd 2006-2007, 2011; Fortin and Cooper 2013; Harrison 2007, 2009a, 2010, 2013; Kealhofer *et al.* 2009; Klengel 2000; Mazzoni 2000a; Morandi Bonacossi 2013; Pruss 2002; Rahmstorf 2005, 2011; Routledge and McGeough 2009; Sader 1992; Vansteenhuyse 2010; Venturi 2008, 2010, 2011, 2013; Weiss 2012; Wilkinson 1997).

In general, these studies have confirmed Muhly's (1992, 15) claim of strong continuities between the Late Bronze and the Early Iron Age. Many regions of the Eastern Mediterranean, particularly those in inland Syria, yield considerable evidence for the continuation of Bronze Age traditions, recognizable in pottery traditions, artistic forms, and political organization (Harrison 2009a; Venturi 2010, 2013). Consequently, it has been argued that this transitional period can only be regarded as a Dark Age when relying exclusively on the epigraphic evidence (Klengel 2000, 21), which indeed experiences a considerable decrease in quantities. Notwithstanding some dissenting views,[33]

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quote, he speaks of Bronze Age civilizations in the plural, although he also refers to Bronze Age civilization in the singular at various places throughout the book. However, there is only one instance in which the term is associated with the Iron Age. Thus, the application of the term appears somewhat inconsistent and not clearly defined. However, it is clear that it is primarily used in connection with the Bronze Age, again reinforcing the qualitative difference between that period and those that follow (or came before).

[33] For example, Strobel (2011) prefers to interpret the developments at the end of the Late Bronze Age as merely the gradual transition from the palace centered political and economic system of the Bronze Age to one defined by small political entities and new commercial networks, rather than the complete breakdown or cessation of Bronze Age traditions and civilization as a whole. Similarly, Harrison (2009a) prefers to see the collapse of the Bronze Age system primarily as a political phenomenon, relating to the dissolution of the large hegemonic empires, such as the Hittite or Egyptian Empire. On the other hand, Hawkins (2002, 143) maintains that: "The view that the Bronze Age ended in widespread political collapse across the Mediterranean still seems the most reasonable interpretation of the evidence, as does also the belief that this was followed by a more or less prolonged Dark Age lacking the written historical records of the preceding period." Although he focuses primarily on the political sphere, he maintains the label 'Dark Age' due to an apparent "[...] dearth of epigraphic and archaeological evidence for the period c. 1200-900 BC [...]" (Hawkins 2002, 143). Similarly, Dornemann regards the cultural horizons of the Bronze and Iron Ages as distinctly different, although he also acknowledges the impossibility to assess the degree of continuity or disruption of state structures and everyday practices between the two periods (Dornemann 2003b, 199-201). These are, of course, only a few select examples of the different sides and positions within the discourse at the moment. As Charaf (2007-2008) has pointed out, the question of whether scholars prefer to identify either continuity or disruption between the Bronze and the Iron Ages ultimately depends on the materials focused on. While certain ceramics are understood to suggest strong continuity, shifts in

it appears that there exists a consensus in the field, according to which the Early Iron Age in the Levant should not be interpreted as the total demise of Bronze Age social, economic, and political traditons, which is to some degree implied in the term ‘collapse,’ but should rather be interpreted as a period chacterized by a compelx web of continuities, changes, and transformations on different, region-specific scales and trajectories (cf., du Piêd 2011).

2.2.5 The Legacy of Socio-Evolutionary Thinking

As has become clear, socio-evolutionary perspectives and interpretations still continue to influence and affect the discourse on the Early Iron Age in the Levant and the Eastern Mediterranean. These perspectives were initially developed over two centuries ago and are firmly grounded in Enlightenment thinking, espousing the view that human society gravitates towards continuous development and social, political, or economic progress (Trigger 1989). To achieve this, it is usually necessary to establish the qualitative difference between the two periods, portraying one as inferior to the other. Interestingly, the exact periods which are interpreted as ‘more advanced’ differ from region to region, as do the precise characteristics which are used to make this distinction.

In Greece, this distinction is clearly an intellectual one. The Classical period is seen as the epitome of civilization, a period where most categories of modern Western thought were first established, including philosophy and scientific thought. Material aspects also play a role. Minoan and Mycenaean cultures, by virtue of their technological and socio-political sophistication, also qualify as examples of civilizational achievements, whereas the intervening periods are represented as the antithesis to this. Greek history is characterized by two civilizational high points, with the Classical period taking clear precedent. Again, Starr’s descriptions are particularly evocative:

> “Fifty years ago scholars were so dazzled by the beauty and freshness of Minoan civilization, [...], that they tended to describe the palace of Cnossus [sic] as the culmination of Aegean prehistory. Even now, as one wanders down the corridors of Cnossus, Phaestus, and other Cretan palaces which lead to lovely staircases and the living quarters of their erstwhile lords, one must muse on the gay, polished life passed by the kings and ladies of Crete while Greece was still in barbarism.” (Starr 1961, 36)

> “The century of most evident change covered the decades 750-650. In this era potter, smith, and poet developed amazingly their skill and clarity. The media of architecture and large-scale sculpture, new to Greek civilization proper, made their appearance. No longer must we be content to handle a Geometric vase and to sense instinctively in it the qualities of logic and symmetry which mark Hellenic civilization; for by the end of the age of revolution many of the basic values of this outlook had attained clear expression in physical and intellectual form. Taken in sum, the achievements of the epoch represent an enlarged dimension for Greek civilization and, by extension, for Western culture.” (Starr 1961, 221)

In the Near East, this situation is somewhat different. Here, the Bronze Age is clearly perceived as the civilizational high point, whose unraveling not only spelled disaster for the region, but was also of such magnitude that it took several centuries to re-establish a similar degree of civilizational

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imports and the introduction of new pottery types is often interpreted as clear evidence for considerable change (Charaf 2007-2008, 89).

development. Iron Age contributions to human civilization are generally limited to two specific aspects: intellectual-philosophical, with the development of monotheistic religion; and political, through the emergence of the first territorial empires and the nation state.[34]

Problems with these social-evolutionist perspectives are not only confined to the theoretical realm, but also pertain to the uneasy relationship these interpretations enjoy with the archaeological data. On the one hand, it can be observed that an increased attention to the archaeological record has had the effect of successively downplaying the quantitative differences between Bronze and Iron Ages, at least in Levantine archaeology. Apparently, a qualitative differentiation did not stand the test of detailed archaeological scrutiny, which is particularly evident in the ceramics data, but also in other aspects of material culture.[35] Yet, despite these critiques, the idea that the end of the Bronze Age constitutes a classic case of societal or even civilizational collapse is constantly perpetuated, even today. Unsupported by the actual archaeological data, this distinction is primarily the result of the language used to structure the discourse. Even in instances where a detailed archaeological analysis is part of the discussion, general overviews rely primarily on the familiar terminology of collapse and break-down. Not only does this introduce a significant divide between various scales of analysis, but it also makes it difficult to fully appreciate and understand the degree to which these transitional periods are characterized by change and continuity in material culture and other aspects.[36]

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[34] In this context, it is interesting to note that New World archaeology, particularly Maya archaeology, does not seem to rely to a similar degree on value-laden language to characterize the differences between two periods, or to describe such transformative processes. In the publications surveyed here, only Peterson and Haugh (2005) rely on strong and evocative language like ‘abandon,’ ‘ruin,’ ‘demise,’ etc. with some regularity. It might therefore be argued that a normative approach to civilization and collapse is largely a phenomenon in Old World archaeology, at least in contemporary research. Perhaps this is due to the significant position both Greece and the Near East occupy in Western conceptions of the history of Western Civilization.

[35] Over the past few decades, a massive amount of scholarship has accumulated, providing an extensive corpus of archaeological, artistic, and epigraphic data supporting the idea that the material culture of the Bronze and Iron Ages, but also its socio-political and ideological underpinnings, share a number of important similarities and that Iron Age material culture, to some degree, develops organically out of its Bronze Age precursors. The discovery of the royal seal of Kuzi-Teshup at Lidar Höyük (Sürenhagen 1986) has created a direct chronological link between otherwise historically attested figures linked to the Hittite kingdom (Hawkins 1995). Explorations, or re-investigations of archaeological sites like ‘Ain Dara, Aleppo, Tell Afis, Tell Ta’yinat, or Tell Nebi Mend (e.g., Abou-Assaf 1990; Bourke 2012; Cecchini and Mazzoni 1998; Gonella *et al.* 2005; Harrison 2001a, 2001b, 2007, 2009a, 2009b, 2010, 2013; Kohlmeyer 2000, 2008, 2009, 2011, 2012; Matthiae 1979a; Venturi 2007) have provided enormous amounts of new evidence, but have also managed to refine and rethink local and regional chronologies. Finally, more detailed investigations of monumental architecture and sculpture have pointed out the various iconographic and stylistic connections that link Bronze Age sculpture to those of the Iron Age (e.g., Gilibert 2011; Özyar 1991, 1998).

[36] These tensions are not unique to Near Eastern archaeology. To some degree, the same tension between a detailed archaeological record on the one hand and the rather vivid use of language on the other hand can also be observed in Greece. Bintliff, for example writes: “In the late thirteenth and early twelfth centuries B.C. the Bronze Age palace civilization of Aegean Greece went down in flames” (Bintliff 2004, 312), a rather strong image, whereas he attempts to show how a biased archaeological record has been used by scholars to create the idea of massive depopulation and widespread catastrophe. While the use of terminology such as “civilization” in the context of Greek history has already been commented on, there is another element that warrants closer attention: In their discussion, Morris and Powell (2006) draw several parallels between Greek civilization and modern Western civilization, comparing Classical Greece to Western Enlightenment (Morris and Powell 2006, 6) and likening the development of the Greek polis to issues of equality and justice in modern society (Morris and Powell 2006, 3). In addition, and quite strikingly, by stating that “Greek language is better than Semitic language” (Morris and Powell 2006, 88), these authors openly employ a language that is strongly and openly value-laden.

2.3 Race and Ethnicity as Drivers of Change

The second major concept that has exerted considerable influence on the idea of the Bronze Age collapse in the Levant concerns the role played by cultural, ethnic, or even racial groups, both foreign and indigenous. In the Southern Levant, these groups consist primarily of the Israelites and Philistines, known from the biblical sources. In the Northern Levant, relying on an extensive corpus of Assyrian, Luwian, and Aramaean inscriptions, scholarship has focused on two groups in particular: Aramaeans and Hittites (or, Neo-Hittites).

Despite repeated attempts to define the traits and historic origins of these groups, their particular characteristics can hardly be considered well established. In particular, the complex relationships between culture, ethnicity, and potentially even race have not been conclusively established, and are often hardly even fully articulated. As Harrison writes:

> "Textual sources for the early centuries of the first millennium B.C. depict the political landscape of northwest Syria as dynamic and in transition, with the Aramaeans emerging as the dominant cultural presence in the region by the end of the ninth century. Despite their rise to prominence, however, very little is actually known about the origins of the Aramaeans, and surprisingly few attempts have been made to delineate what defines them as a distinctive cultural group." (Harrison 2001a, 135)

While it is well established in the literature that a group called the Aramaeans at some point came to exert considerable political and cultural influence in the Northern Levant, the processes that led to their establishment are badly understood. Even more problematic, their cultural characteristics that differentiate themselves from other groups are not clear, at least when considering more than just linguistic evidence. In fact, in reading Harrison's statement, it seems that designations, such as Aramaean or Hittite, are made in spite of, or precisely because of, an almost complete lack of evidence that would support such a differentiation.

2.3.1 Invented Identities and the Discovery of Iron Age Syria

An understanding of the cultural, political, ethnic, or linguistic categories, along with their intellectual histories and problems for archaeological research, however, will contribute greatly to an investigation of the way in which the influences of distinct population groups on the Late Bronze/Iron Age transition have been conceptualized.

Indeed, the putative qualitative differences that are said to have existed between the two periods are often attributed to large-scale population movements and the linguistic, racial, ethnic, or cultural identity of these peoples. Identification of these groups and identities is to some degree based on Bronze Age texts from the Near East, which place an inordinate emphasis on the ethnic identity of competing population groups (Yoffee 1988a, 63). In itself, the theory that foreign invasions caused the demise of ancient states, the so-called 'Invasion Hypothesis,' is only a sub-theme of a wider field of historical explanations unified by a common set of underlying assumptions:

> "It [the Invasion Hypothesis] is, in fact, only one aspect of a general theory of historical explanation which assumes, *a priori*, that important and seemingly abrupt cultural change must be evidence of the arrival of new peoples. Thus the ethnic history of a

> given region may be viewed in much the same way as one views the cross-section of a stratified mound: as a series of disconnected 'layers,' each with its own peculiar characteristics." (Adams 1968, 194)

On account of the sometimes unclear and unstated relationships between different population groups, Adams has also dubbed this set of theories the "theory of successive populations" and traced its origins all the way to Classical antiquity (Adams 1968, 194). While it also held a certain appeal to Enlightenment audiences, as shown by Gibbon's argument of a morally weakened Roman Empire succumbing to invading barbarian tribes, it is particularly deeply rooted in the culture-historical thinking of the early and mid 20th centuries CE (Trigger 1989).

The idea of distinct racial, ethnic, and linguistic groups has been prominent in Near Eastern archaeology from its very inception in the 19th century CE. In fact, it has significantly influenced and affected the very discovery of Near Eastern history, particularly in the Levant, and is therefore closely intertwined not just with the study of the Early Iron Age, but also with the development of Near Eastern archaeology as an academic discipline.

In 1812, the same year that Grotefend deciphered the first cuneiform signs, the Swiss traveler Burckhardt (1784-1817) recorded a number of decorated basalt blocks with traces of hieroglyphic inscriptions at Hama (Sayce 1888, 78), although scholarly attention was only fully aroused several decades later (Burton and Drake 1872; Clermont-Ganneau 1873; Heath 1873; Wright 1873). Full publication of the 'Hamathite Stones,' as they were commonly referred to, thus postdate the earliest excavations at the Assyrian capitals of Nimrud and Khorsabad in the 1840s, as well as the 1856 decipherment of the Akkadian language, but predate the discovery and translation of the Gilgamesh Epic in 1875 (Renger 1979). They stand at the very beginning of Near Eastern archaeology and philology.

However, the language of the hieroglyphic inscriptions of these stones was still completely unknown at the time and these early reports contained a good deal of speculation, with some quickly postulating a non-Semitic origin of the script (Burton and Drake 1872; Wright 1886). Following these proposals, Sayce (1877, 27) associated the Hama stones with what he called the "Hittite race," which, at the time, was only known from biblical narratives and some Assyrian inscriptions. Consequently, he preferred the term Hittite, rather than Hamathite (Sayce 1881, 248), and grouped them together with similar inscriptions found at Aleppo and Ivriz.[37]

The interpretation of the Hama inscriptions as Hittite was based on the identification of the mound of Jerablus with the ancient city of Carchemish, proposed by Smith in 1876 (Sayce 1881, 248), from which several monuments bearing relief images and hieroglyphic inscriptions were recovered. As Carchemish was identified as a Hittite city in both biblical and Assyrian accounts, scholars did not hesitate to link the recovered monuments to the Hittite Empire known from the texts (e.g., Wright 1886). By way of comparison, the same identification was proposed for the Hama stones and their inscriptions (Sayce 1881; Wright 1886). Around the same time, similar monuments were being discovered at Anatolian sites like Boğazköy and Alaça Höyük, but also at the important North Syrian site of Zincirli (von Luschan 1893).

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[37] Sayce neither specifies the date of discovery of the Aleppo inscriptions, nor does he provide a detailed description. As for the Ivriz rock monument, he attributes the discovery to Davis' publication in the *Transactions of the Society of Biblical Archaeology* (1876), which explicitly links it to the Hama inscriptions. However, the confirmed reports concerning this relief compiled by Hawkins (2000) date back to at least the early 18th century CE. The earliest known sketch of the Ivriz rock monument can be found in Ritter (1858), and dates back to a visit by Fisher in 1838. See Hawkins (2000, 516-517) for an outline of the history of discovery and a list of available publications.

Working within previously uncharted historical and archaeological territory, and with inscriptions in a hitherto unattested language, scholars were forced to rely extensively on outside sources in order to make sense of their new discoveries. Egyptian and Assyrian sources provided more-or-less direct references to the Hittite state as a major contender for political power and were eagerly embraced by scholars (Messerschmidt 1903; Puchstein 1890; Sayce 1888).[38] Based on these documents, scholars labeled the area incorporating parts of Anatolia and Northern Syria as Hittite.

At the same time, the peculiar character of these newly discovered artworks was hotly debated. Initial ideas about potential Greek influences on Hittite art (Puchstein 1890; Sayce 1881) were soon abandoned in favor of distinctly Near Eastern influences. For example, Sayce (1888) grouped all sculptural remains from Anatolia and Northern Syria into one general Hittite category, although he was criticized by Puchstein (1890) who rejected both his Hittite identification, as well as his 2nd millennium BCE dating, instead proposing a differentiation between genuinely Hittite monuments and those that evinced considerable Assyrian influence. As he saw Assyrian-influenced monuments as more refined in style, he argued that they should represent a later phase of artistic development belonging to the 1st millennium BCE (Puchstein 1890, 7-9). His interpretation is not just strikingly different from Sayce's in chronological terms, but also led him to dissociate the North Syrian monuments from the Hittite Empire proper, instead attributing them to the arrival of a different group of people of unknown linguistic and national affiliation.

Inevitably, this enmeshed the discussions about Hittite art and language in debates concerning the racial and national character of the people they represented. As soon as the Indo-European character of the Hittite language was established (e.g., Hrozný 1920, 26), its dissimilarity to the surrounding languages became apparent and was quickly perceived as the primary evidence for differences between population groups.[39] The idiosyncratic character of Hittite art was perceived as further corroborating this position, and differences in style were interpreted as faithful representations of real biological differences, demonstrating the national or racial character of the Anatolian people:

> "[The] Hittites were a people with yellow skins and 'Mongoloid' features, whose receding foreheads, oblique eyes, and protruding upper jaws are represented as faithfully on their own monuments as they are on those of Egypt, so that we cannot accuse the Egyptian artists of caricaturing their enemies. If the Egyptians have made the Hittites ugly, it was because they were so in reality. The Amorites, on the contrary, were a tall and handsome people. They are depicted with white skins, blue eyes, and reddish hair, all the characteristics, in fact, of the white race." (Sayce 1888, 16-17)

The normative racial bias is clearly perceptible. Hittites are ugly and inferior, whereas Amorites are noble, handsome, and, most importantly, had white skin. Although each race was perceived as

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[38] The biblical accounts, however, were regarded with more suspicion and ambiguity. Whereas Sayce (1888, 12) took this newly emerging evidence as confirmation of the historical value of the Old Testament narratives, Messerschmidt (1903, 3) regarded them as chronologically and geographically too far removed.

[39] For example, Burton and Drake (1872) proposed to link the script of the Hama Stones to Georgian and other languages of the then-acknowledged 'Cuacaso-Tibetan' family. On the other hand, Sayce (1881) proposed to group the inscriptions with the 'Alarodian' language family, whose linguistic status today is far from clear. While several scholars, referred to simply as "several eminent linguists" by Wright (1886, 83) without further detail, apparently preferred to identify the inscription of the Hama Stones as Semitic, Wright was among the first to clearly argue in favor of a non-Semitic identification of the language. Today, the language of the script, called Luwian, is grouped among the Anatolian languages, to which also Hittite belongs, which are considered an isolated group within the Indo-European language family (Yakubovich 2010).

having its own homeland, Northern Syria and the Levant in general came to be regarded as a region where they mixed and mingled, and in the case of the Hittites, lived "[...] in a state of constant hostility to their Semitic neighbours" (Sayce 1881, 252).

Around the same time, following the excavations at Zincirli (Andrae 1943; von Luschan 1893, 1898, 1902; von Luschan and Jacoby 1911) and Tell Halaf (von Oppenheim and Hrouda 1962; von Oppenheim and Moortgat 1955; von Oppenheim and Naumann 1950; von Oppenheim and Schmidt 1943) and the discovery of the Zakkur Stele in 1907, the first studies on Aramaean history appeared (Kraeling 1918; Šanda 1902; Schiffer 1911; Streck 1906). When these studies were published, discussions surrounding the origins of Semitic peoples and their role in Mesopotamia and the Levant were already several decades old (Streck 1906, 185), but had only yielded insufficient results and had let to the development of several competing hypothesis, the most prominent one again being the Invasion Hypothesis:

> "Die Theorie, daß Arabien als die Völkerkammer der Semiten anzuerkennen sei, hat, wenn sie auch nicht ohne weiteres zum Dogma erhoben werden darf, in der Tat viel für sich. Die Arabische Halbinsel hat sicher nicht blos einmal - im Zeichen des Islam -, sondern zu wiederholten Malen beträchtliche Völkerschwärme über die angrenzenden Kulturländer ausgeschüttet. Die spätere geographische Verteilung der Semiten würde sich bei der Annahme Arabiens als Herd ihrer Ausstrahlung wohl am ungezwungensten erklären. Bei dieser Auffassung des Sachverhalts müßte sich dann die aramäische Invasion in Mesopotamien und Babylonien als ein Glied einer ganzen Kette von Völkerbewegungen darstellen [...]." (Streck 1906, 186)

To compensate for the striking lack of evidence to support this theory of Aramaean migration, its adherents had to rely on certain assumptions which are readily apparent in Streck's summary. First, extrapolating from the Islamic expansion of the 7th century CE, a series of similar large-scale migrations was hypothesized for prehistoric periods as well, and the presumed Aramaean migration was perceived as only one instance of a succession of similar events (cf., Šanda 1902, 3). Second, the notion of conflicts between population groups of different social-evolutionary stages of development was introduced, even if only in a rather subliminal way. The cultured and civilized regions, *Kulturländer*, of Mesopotamia and the Levant were implicitly contrasted with the uncivilized nature of the foreign invaders. In some instances, this dichotomy between civilized sedentary societies and presumably uncivilized migratory Semitic groups also entailed the idea of racial struggles:

> "Jene gewaltige Völkerbewegung, durch welche die ältesten Semiten aus ihrer ursprünglichen Heimat Arabien nach Norden getrieben wurden, um den siegreichen Kampf mit einer *heterogenen hochentwickelten Rasse*, den Sumerern aufzunehmen, liegt vorläufig im Dunkel einer für uns unerreichbaren Vorzeit. [...] Der nächste *sprachlich und national* von den 'babylonischen' und 'kanaanäischen' Semiten scharf unterschiedene Völkerstrom, der sich tausend Jahre später von Süden her in das Kulturland zu ergießen begann, waren die Aramäer. " (Šanda 1902, 3; italics added)

Although not all authors were as explicit in the racial terminology they used, the question of the national character of Semitic and Aramaean peoples was posed repeatedly, observable in the proliferation of concepts like *Volksgruppe, Völkerfamilie, Völkerschwärme* or their English equivalents, like *nation*.

Obviously, these interpretations hinge on the way in which a *nation*, *race*, or *ethnic group* is defined and conceptualized and are therefore highly dependent on the intellectual climate of the time. Historical research of the late 19th and early 20th centuries CE was dominated by the culture-historical paradigm, which not only focused on the study of human intellectual life and its development, but also attempted to link human intellectual developments to the history of one particular group or nation (Schaumkell 1901, 3). The concept of nation has a long history in western thought and can be traced back to the Greek text of the Septuagint. Here, the term *nation* (*έθνος*) is used in reference to non-Israelite, or 'gentile' people that are clearly differentiated from the tribes of the Israelites. In later English usage, *ethnic* came to be used primarily in relation to non-Christian or non-Jewish peoples, assuming a general meaning of heathen or pagan (Dictionary 1996, 2; Kidd 2006). Hence, in this early form of use, the term primarily carried religious connotations, drawing a clear distinction between members of the Judeo-Christian tradition on the one hand, and everybody else on the other. Eventually, a shift occurred away from the idea of religious otherness towards concepts of racial, national, or cultural dissimilarity and in 19th century CE intellectual discourse, racial identity became a central concept not only in biology and anthropology, but also in historical research, where it was seen as a more fact-based explanation of historical processes than such abstract concepts like states or empires (Kidd 2006, 121).

Differentiation into distinct groups also formed an important aspect of Enlightenment and Romanticist thought, particularly evident in the historical writings of the German philosopher Johann Gottfried Herder (1744-1803), especially his *Ideen zur Philosophie der Geschichte der Menschheit*, written between 1784 and 1791. Rather than defining difference as the result of racial or civilizational superiority, Herder maintained that each group represented an individual expression of the shared human capacity for cultivation, or *Bildung* (Wimmer 2009, 246). Differences between populations were located within their psychological traits, which he traced back to differences in physiology and adaptation to environmental conditions, which for him defined the *racial* character of peoples (Wells 1959, 52). Differences in character result in distinct forms of identity, in which each group is defined by its own specific culture and language, which in turn define a group's unique worldview (Wimmer 2009, 246). Ethnic differences are not so much seen as a product of social interactions, but rather as the natural, self-evident categories of human difference (Wimmer 2009, 245), which Herder perceived as characterized by repeated migrations and movements (Wells 1959, 75). On the other hand, nation (*Volk*) is used to describe a clearly defined group of people, bound together by a 'national spirit' observable in its literary accomplishments (Schaumkell 1901, 60, 67). Herderian philosophy, thus, combines a number of aspects that came to define later perceptions of *race* and *ethnicity*, as well as their relationship to each other. Of particular importance are the explicit linkages between individual groups, their physiological traits and intellectual capacities, and their unique expressions of language and culture, which are perceived as observable in the physical world. Such perspectives, however, have been criticized as tainted by implicit ideas of whoite racial superiority (Kidd 2006, 80).[40]

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[40] A different approach, however, was taken in the nascent social sciences. Anthropologists of the 19th century CE used the concept of *ethnicity* to differentiate between the various groups and peoples they encountered in their studies across the world (Dictionary 1996, 3). In this sense, the concept is imbued with a general meaning of difference and other-ness, irrespective of religious or racial attributes, serving the ethnographical goal or describing and classifying human populations. In his monumental *Wirtschaft und Gesellschaft*, Max Weber (1996) provides a different perspective. As he points out, "[...] race creates a

These ideas were adapted in archaeological research, where a connection was drawn between actual physical finds and ethnographic culture (Trigger 1989). Particularly the work of Gustaf Kossinna (1911) stands out as important. By correlating the distribution of distinct material assemblages (culture-areas, or *Kulturengruppen*) to historically known peoples, cultures became a reflection of ethnicity and cultural continuity, and continuity in the archaeological record was equatred with ethnic continuity (Hauser 2005; Jones 1997; Lucy 2005; Trigger 1989). Within this framework, archaeological distribution maps are used to define the settlement areas of ancient populations in an attempt to identify their original homeland, particularly that of the Indo-Germanic (or, Indo-European) peoples (Hauser 2005, 533-534). As advanced cultures were seen as expressions of biological superiority, not social development, the concepts of culture and ethnicity were enmeshed with ideas about race (Trigger 1989, 166). This also meant that cultures could not develop, as posited by social-evolutionary perspectives, but had to be spread through migration. As the mixing of cultures was seen as a hindrance to creative development, racist overtones also permeated the discourse, despite some later efforts to disavow these connotations (Jones 1997; Trigger 1980, 1989).[41]

At the same time, general attitudes towards the study of ancient history underwent significant transformations. Philhellenism, especially rampant in 18th and 19th century CE Germany, was challenged by the relatively young Oriental Studies (*Orientalistik*), which was until the late 19th century CE largely confined to the study of biblical languages and theological debate (Hauser 2004; Marchand 1996).[42] Against this background, it is not surprising that several scholars of Assyriology and Semitic philology had close connections with the study of the Old Testament and its languages. To a certain degree, scholars of the Hebrew Bible paved the way for the rise of fields like Assyriology and Near Eastern archaeology, which in turn effected a change in research interests. In an intellectual climate where the traditional sanctity and status of the Old Testament was challenged, the study of contemporaneous peoples and cultures assumed a prominent position

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'group' only when it is subjectively perceived as a common trait: this happens only when a neighborhood or the mere proximity of racially different persons is the basis of joint (mostly political) action, or conversely, when some common experiences of members of the same race are linked to some antagonism against members of an *obviously* different group." (Weber 1996, 52; italics in original). While physiological, biological, or social differences may objectively exist, they only become important through human interaction. Racial and ethnic difference, which appear to be used interchangeably by Weber, assume a social dimension through the individual perception of social actors, and can be based on a variety of cultural traits, including physiology and customs, but also shared memories (Weber 1996, 56). Social customs, a major element of ethnic differentiation from this perspective, are influenced by religion, economy, and politics, but also language, which is also stressed by modern linguistic scholarship (e.g., Fishman 1989). For Weber, *ethnic* groups possess the qualities of imagined communities based on shared perceptions and memories. What matters is not so much the factuality of difference, but rather its recognitions and appropriation for political action.

[41] Naturally, perceptions and interpretations of concepts like race and ethnicity have changed dramatically over time, with modern discourse being much more nuanced and complex than what was common throughout much of the 19th and 20th centuries CE. Even today, both race and ethnicity continue to be highly contentious concepts and are discussed controversially in the literature. Due to the immense breadth and complexity of this topic, the present discussion cannot, and does not, pretend to constitute a comprehensive overview over the complex intellectual history of these two concepts. Instead, the reader is directed to the large corpus of literature written on this subject. For a detailed discussion of racial concepts in Western thought, see Kidd (2006). For discussion about ethnicity, from various perspectives, see Barth (1969, 1994), Fishman, (1989, 2010), Fought (2006), Makihara (2010), Verdery (1994), Vermeulen and Covers (1994), and Wimmer (2009). For specifically archaeological perspectives on the issue of ethnicity, and its analysis, see Díaz-Andreu and Lucy (2005), Haarmann (2014), Jones (1997), Knapp (2014), Lucy (2005), McInerney (2014), as well as Bahrani (2006), Bryce (2014), Kamp and Yoffee (1980), and Killebrew (2014) for ancient Near Eastern perspectives. Suffice it to say, race, much like ethnicity, is today perceived not simply as biological reality, but as a complex issue of identity, partially enmeshed with concepts of ethnicity and dependent on interpretation and self-identification (see, Kidd 2006).

[42] The first professorship in Semitic philology in Germany was established in 1872 at the newly founded *Kaiser-Wilhelms-Universität* in Strasbourg (today University of Strasbourg), inaugurated that same year (Hanisch 2003: 5). Shortly thereafter, in 1875, Eberhard Schrader, who is generally credited with establishing the field of Assyriology in Germany, was appointed as professor for Assyriology at the *Friedrich-Wilhelms-Universität* (now Humboldt Universität) in Berlin (Renger 1979, 153).

and became a way to contextualize, or vindicate, the biblical narratives (Marchand 1996).[43] Due to these intimate links to biblical scholarship, linguistic and racial concepts of population groups, derived from scripture, were absorbed by the fledgling disciplines of Near Eastern archaeology and Assyriology, and influenced how Near Eastern populations, particularly Semitic groups like the Aramaeans, were studied.[44] The Old Testament narratives provided a historical, religious, and ethnic background against which the archaeological evidence could be compared (Kraeling 1918; Schiffer 1911), whereas Egyptian, Hittite, and Assyrian texts were used to further define the geographical boundaries of both Semitic and non-Semitic peoples.

The scholarly interest in Hittite history was initiated by the discovery of inscribed orthostat blocks and rock reliefs in Anatolia and Northern Syria, and thus from the beginning closely linked to the study of archaeological and art-historical evidence. Discoveries, such as the ones from Hama, Ivriz, Aleppo, Carchemish, Zincirli, or Maraş,[45] were readily incorporated into the discussion and served as the basis for the first attempts of art-historical treatments of Hittite sculpture. Despite an initial dominance of outside textual sources, those interested in Hittite history attempted to include multiple lines of evidence into their arguments. On the other hand, research on the Aramaeans took a very different route. The dominating influence of the biblical texts was only rivaled in importance by the Assyrian inscriptions, a situation that was not even significantly altered by the discovery of the first local Aramaic inscriptions, like the Zakkur Stele or the Zincirli monuments. This new evidence was only hesitantly incorporated into the discourse, which for a considerable time remained dependent on biblical exegesis.

The peculiar character of Hittite sculpture - both the Luwian hieroglyphic script and the style of the reliefs - clearly differentiated the Hama Stones and similar monuments from the surrounding traditions of Assyria and Egypt. It was thus an easy step to associate these monuments with a discrete group of people, defined through putative racial, linguistic, and cultural differences. Often, scholars tended to interpret linguistic and artistic differences in a negative way, instinctively separating Hittite art from that of the purportedly true high cultures of the Ancient Nar East, Assyria and Egypt. As a result, discussions on Hittite racial, or ethnic, identity included an inherently negative perception of racial difference.

To some degree, this stands in contrast to those conceptions that structured the discourse on the Aramaeans. Although Semitic peoples were perceived of as underdeveloped in comparison to other population groups (e.g., Šanda 1902), there was no attempt to substantiate this idea with any type of evidence, as was done in the case of the Hittites. According to the principles of culture-historical thinking, differences in the archaeological and historical record were not interpreted as the results of social, political, or economic processes, but rather as direct evidence for the intrusion

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[43] Quickly, Berlin, due to the rapid expansion of the *Friedrich-Wilhelms-Universität*, developed into an intellectual center for the study of the Ancient Near East (cf., Gunter and Hauser 2005; vom Bruch 2005). Many important German academics in the field held positions or received their doctorates there (Hanisch 2003; Hauser 2005; Renger 1979). In addition, a number of academic societies, associations, museums, and newspapers were founded there, generating public interest (Renger 1979), which was also accelerated by the short-lived *Babel-Bibel Streit*, in which Friedrich Delitzsch criticized attempts to use new archaeological and textual data to historicize the biblical narratives (Hauser 2001; Lehmann 1999).

[44] Although European scholars constitute the focus of this discussion, a similar argument can be made for American scholarship of the time. American scholars, oftentimes educated at European, primarily German universities, or European expatriates working and living in the US, had similarly strong commitment to their Judaeo-Christian traditions, which provided a lens through which ancient history and foreign cultures were perceived and appropriated for Western scholarship (see, Kuklick 1996).

[45] A first stele was recorded by Puchstein in 1882 and published in 1890. Similar monuments and fragments were recorded by various scholars at several instances in the late 19th and early 20th centuries CE. See Hawkins (2000, 252-281) for a detailed discussion and list of publications.

of foreign groups into the region. The idea of linking archaeological and textual remains with certain ethnic, racial, or national groups lies at the heart of the Invasion Hypothesis, which posits a violent clash between discrete and mutually exclusive population groups over land and resources.

Even later discussions were not entirely dissociated from the intellectual history of concepts like culture or ethnicity. On the one hand, Herzfeld (1928, 1930), for example, drew a clear distinction between culture on one side, and ethnic, linguistic, or political aspects on the other. On the other hand, at times his writings evince strong similarities with those of his predecessors:

> "Betrachten wir aber die Rolle, die die semitischen Völker sonst auf dem Gebiete der bildenden Kunst gespielt haben, so wird man an dem angeborenen Mangel der Semiten an Begabung für darstellende Kunst nicht zweifeln können: In Assyrien erscheint die bildende Kunst erst im Augenblick, wo sich das rassenmäßig erschöpfte semitische Element durch Verpflanzung ganzer fremdrassiger Stämme nach Assyrien ergänzt. Die Aramäer und die Juden haben niemals irgendwelche bildende Kunst von Bedeutung hervorgebracht." (Herzfeld 1928, 37)

Semites, particularly Aramaeans and, in his words, the Jews, never managed to create any meaningful works of art on their own. Only the replacement, or augmentation, of one inferior racial element with that of another, more vigorous one, does a meaningful artistic tradition emerge in their settlement region. His perception of cultural and artistic change is steeped in racial terminology. Yet, his exact definition of culture, and its relationships to other categories like race or ethnicity, remains unclear, and several ambiguities exist in the way these concepts were applied in his writings, particularly with the regard to Hittite culture (*Hethitischer Kulturkreis*), which he used without reference to distinct geographic, ethnic, linguistic, or religious entities, or in connection to the Bronze Age Hittite Empire (Hauser 2005, 545).

Despite later attempts to define Iron Age monumental sculpture in geographical (Moortgat 1934), stylistic (Akurgal 1949), or geographic-and-chronological terms (Orthmann 1971), the role of Aramaean artistic production, and its identification in the archaeological record, remains ill-defined and highly controversial. This is not only observable in some mid-20th century studies (e.g., Albright 1975; Dupont-Sommer 1949; Malamat 1973), but has also influenced more recent discussions. For example, in her influential study on the Aramaean states of the Iron Age, Sader (1987, 1) defines her selection criteria as follows:

> "Le choix de ces États appelle quelque justification car il a été établi sur la base d'un ensemble de critères. Nous avons en effet choisi de traiter:
>
> 1. les États sur lesquels ont régné des dynastes portant des noms araméens,
> 2. les États qui ne nous sont pas seulement connus par les textes mais aussi par l'archéologie,
> 3. les États sur lesquels nous avons des informations assez substantielles qui peuvent fournir une donnée de base pour une étude historique,
> 4. enfin des États qui ont vécu assez longtemps pour accéder au rang de vrais royaumes et qui ont joué un rôle déterminant dans la politique syrienne de l'époque"

Still, some issues continue to plague this kind of approach. Archaeological data were not used to facilitate the identification of particular states as Aramaean, despite her explicit goal of using archaeological data in the analysis. Instead, the selection has already taken place beforehand and the available archaeological evidence is used to narrow the research focus, not to critically evaluate it. In this regard, textual materials still take clear precedent over the material record in defining Aramaean identity *a priori*. As archaeological data is mainly used in a summary of excavation results and architectural descriptions, the particular Aramaean character of the material record remains unclear. In fact, sculptures are repeatedly identified as Neo-Hittite or Assyrian, following Orthmann (1971), and in concluding the study, the impossibility of defining the Aramaean character of material culture against that of other groups is openly admitted (Sader 1987, 281).

Recognizing the difficulty inherent in these attempts to point to specific cultural, ethnic, or racial characteristics in the artistic and archaeological record, today's scholarship seeks to bridge the divide previous scholarship has created between Hittites and Aramaeans, investigating the two as aspects of a single phenomenon of Iron Age North Syria (e.g., Bonatz 2000; Gilibert 2011; Mazzoni 1997, 2011; Pucci 2006, 2008). In some instances, the term Late Hittite, with its implicit links to the Bronze Age Hittite Empire has been exchanged with Syro-Hittite, or even Syro-Anatolian, whose geographical and political connotations refer to the most prevalent aspects of Iron Age Northern Levantine culture (e.g., Bonatz 2000; Bryce 2012; Bunnens 2013; Novák 2005; Osborne 2011). And in instances where ethnic concepts are still used (e.g., Harrison 2001a; Novák 2002, 2005), attempts are made to ground these designations in the social scientific literature on issues of group formation and identity creation.

2.3.2 Ethnicity, Migration, and Collapse: An Uneasy Relationship

As this discussion has shown, a clear understanding and definition of concepts of culture, ethnicity, race, or nation is essential when trying to understand the relationship between certain population groups. But it is also important to keep these concepts and their complicated histories in mind when attempting to understand how ideas of Bronze and Iron Age Northern Syria were formed and developed, and how the transition between the two periods has been understood and conceptualized.

Indeed, issues of racial, ethnic, linguistic, or even national affiliation have had a profound impact on Mediterranean archaeology in general, and Near Eastern archaeology in particular. The appearance of new groups, such as the Sea Peoples, Phoenicians, Aramaeans, or Israelites in the Levant, or the Dorians in Greece has often been taken as the critical stimulus for cultural developments in new directions. The positions of Desborough (1972), Carpenter (1966), Starr (1961), and Raban and Stieglitz (1991), who attribute technological innovation and social stimulus to invading peoples, have already been discussed above. In Egypt, scholars have often attributed a similar role to the Hyksos, whose large-scale movements and military conquest have until recently been associated with a presumed Hurrian expertise in horse breeding (Oren 1997, xxii).

In many instances, and particularly during the 19th century CE, distinct cultural, ethnic, or racial groups became the main focus of attention as the perpetrators of collapse and as a convenient way to study breaks in the historical and archaeological record (Liverani 2009). The discovery of ancient Assyria and Babylonia further spurred these discussions and their respective collapse was seen as evidence for the chaotic nature of Near Eastern history, as opposed to the presumed regularity of Western European society (Butzer 2012, 3632). But similar issues continued to fascinate 20th century CE audiences, as the moral implications of human agency in state collapse regained in importance after the catastrophic military conflicts of that period (Butzer 1997; Tainter 1988, 2008).

Often, race played an important role in these discussions, particularly with respect to the presumed course of Indo-European migration. Particularly in Anatolia and Greece, the idea of Indo-European migration has been hotly debated. In the 19th and 20th centuries CE, Indo-European movement into the Mediterranean region was intimately linked with innovations in horse-breeding and the invention of the horse-drawn chariot, innovations commensurate with these peoples' presumed origin in the steppe environments of south-central Asia or north-eastern Europe (Drews 1988). As their place of origin was located outside of the region, the Hittites, whose language was recognized as belonging to the Indo-European family, were interpreted as foreign invaders. At the same time, the arrival of the Greeks, bearers of another Indo-European language, was associated with the same population movement. Within the racial discourse of the time this was extremely important, as Indo-Europeans were thought to have invented the idea of private property, as well as being equipped with special intellectual capacities and religious restraint (Drews 1988, 6). Thus, the development of Greek civilization was attributed to foreign migrations, in the same way as the introduction of military technologies and the development of centralized government was linked to the rise of the Hittite Empire. Their shared Indo-European ancestry provided an easy explanation for their arrival, as well as their historical significance. Not surprisingly, though, both the Indo-European invasions of Greece and Anatolia appear to have primarily existed in scholarly imagination, largely unsupported by archaeological evidence and dependent on *a priori* assumptions about race and migration (Drews 1988, 53).

Often, conceptions of race and ethnicity, particularly prevalent during the late 19th and early 20th centuries CE, have functioned independently of the actual historical and archaeological record. But in many instances, pre-conceived notions of race, ethnicity, and culture have also been brought to bear on the evidence. Attempts to link certain material remains to specific cultural, political, geographical, linguistic, or even ethnic traditions have been a staple of Near Eastern archaeology more or less since its beginnings. These attempts have always been influenced by the prevailing conceptions of culture, and its relationship to both the material and historical record. In the case of the Aramaeans it is particularly striking that an identification in the material record is made primarily through the absence of evidence, that is, an absence of clear cultural or ethnic markers in the archaeological record of both the Late Bronze and Iron Ages. Usually, a clearly defined concept of "[...] culturally ascribed identity groups which are based on the expression of real or assumed shared culture or common descent" (Jones 1997, 84), as common in modern anthropological and archaeological thought (e.g., Barth 1969; Jones 1997; Lucy 2005) is missing, except for a few notable exceptions (e.g., Buccelati 2013; Harrison 2001a).

Finally, it is worth reiterating that issues of race and ethnicity have also often served as a justification for studying such newly discovered groups as the Hittites or the Aramaeans. In the early days of Near Eastern archaeology, while Mesopotamia, Egypt, Israel, and especially Greece had already taken their place as great traditions or civilizations and sometimes even as the ancestors of Western culture, the same was not true for the two groups discussed at length in this section. On the contrary, Northern Syria, by virtue of its geographical location, was seen as a melting pot whose main purpose was to help understand its neighboring civilizations (Wright 1886, 125). In this respect, Hittite art was at first studied primarily as additional evidence for the development of Greek sculpture, but also for the study of the Old Testament (e.g., Puchstein 1890; Sayce 1888). Presumed Hittite monuments, such as the Hamathite Stones, promised additional information on these traditions and were welcomed as such, especially since they also promised a way to historicize the biblical narratives. Especially the Aramaeans were initially primarily relegated to this role (ef., Kraeling 1918). In some instances, similar sentiments persist even until today, for example in Lipiński's recent and influential study on Aramaean history:

> "We see the Aramaeans as a nation that represents one of our cultural ancestors, as one of the point of departure for us in the West. We think it is necessary to consider how the impulses of the western civilization originated in the Middle East, although the currently accessible sources are noted for their paucity, partiality, and obscurity." (Lipiński 2000, 12-13)

Admittedly, this statement cannot, and should not, be taken as representation of the entire discourse, but it is important to note that arguments like this still appear in the literature from time to time. In part, their perseverance can be attributed to the unbroken preeminence of textual sources over archaeological data. Among these textual sources, outsider's perspectives, like the Assyrian royal inscriptions or the Old Testament, take precedent, whereas local sources are relegated to the role of supporting evidence. To some degree, this can be attributed to the focus and breadth of the Assyrian and biblical texts, which satisfy a scholarly (and public?) demand for broad historical overviews over an entire period and region, whereas most Luwian and Aramaean inscriptions concentrate on local affairs and do not contribute significantly to a wide-ranging historical narrative.[46]

2.4 Ecological Degradation and Environmental Determinism

Within the foregoing discussion, the issue of societal collapse has been dealt with primarily as a social phenomenon, related to concepts of social and civilizational progress and evolution, or human migration and group identity. Yet, there also exists a vast field of approaches emphasizing the role of environmental factors, especially the effects of climatic variability and environmental degradation and the availability of natural resources, on social stability (Middleton 2012, 2016; Tainter 2008; White 2014).

Probably the earliest application of such an ecological perspective in archaeology was John Myres' (1911) *The Dawn of History*, although at that time the discussion was couched in racial language, as droughts were interpreted as the causes for migrations of Indo-Europeans and Semites and their conquest of foreign lands (Trigger 1989, 168). A similar argument was made by Huntington (1917), who related the decline of the Roman Empire to processes of land degradation, a decrease in agricultural production, and barbarian invasions driven by climatic change.[47] Developed within an intellectual framework of environmental determinism, these studies identified climatic and en-

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[46] According to Hawkins (2000, 13), a total of around 95 major and at least more than 50 minor Luwian inscriptions have been discovered over the last century. To these can now be added at least three additional major inscriptions (Dinçol *et al.* 2012; Dinçol *et al.* 2015), an inscribed stele fragment in the Kahramanmaraş Museum (Marchetti and Peker 2015), and a number of recently discovered inscriptions from Carchemish (Marchetti 2015; Peker 2016). In addition, Gibson (1975) lists some 19 relevant major and minor Aramaean inscriptions, to which can be added at least three additional more recent discoveries (Abou-Assaf *et al.* 1982; Biran and Naveh 1993, 1995; Pardee 2009).

[47] His work was based on his earlier study on the relationship between climate and civilization (Huntington 1915), in which he attempts to establish a link between aspects of climate, rainfall, temperature, humidity, etc., and the character and vigor of various civilizations around the world. Much like the work of Myres, his discussion is steeped in racial language, used to justify distinction between different races and their social, political, and economic fortunes. Nonetheless, this deterministic approach to the relationship of human societies to their natural environment became highly influential during the first half of the 20th century CE (Issar and Zohar 2007).

vironmental factors as the prime causes for societal change (Wilkinson and Hritz 2013, 9). Similar perspectives, positing direct links between climatic and environmental change and societal transformation, were developed throughout the 20th century CE in a variety of contexts, ranging from Mesoamerica to the Mediterranean and the Near East (e.g., Adams 1981; Carpenter 1966; Cooke 1931; Jacobsen 1982; Jacobsen and Adams 1958; Lamb 1982; Sanders 1962, 1963).[48]

The discourse on social collapse from an environmental perspective has been aptly summarized and reviewed in Middleton's (2012) substantial discussion of environmental explanations for societal transformation. In reviewing the literature, he has observed a certain tendency of contemporary archaeologists to revert to certain deterministic views of change in human societies with regard to climatic change and environmental degradation. At the same time, however, he has recognized a recent development in anthropological and archaeological thought, which focuses on issues of adaptability and resilience and which has recently gained in importance within the field (McAnany and Yoffee 2010a; Santley 2000; Scarborough 2007, 2009).

The following discussion will focus on two particular forms of environmental collapse, part of the triad of causal explanations of environmental collapse established by Middleton (2012): Malthusian overshoot and climate change. While the latter has become particularly important in the archaeology of Late Bronze and Iron Age Northern Syria in recent years, theories of overshoot and collapse have been applied to a wide range of case studies from the Eastern Mediterranean and beyond. In addition, the two theories might very well be linked, as climatic change might push a formerly stable society beyond the threshold of sustainability.

2.4.1 Malthus Resurrected: Overshoot and Collapse

In recent years, Malthusian (or sometimes called neo-Malthusian) explanations of environmental collapse have captivated the imagination of both academic and public audiences (Tainter 2008), but also resulted in much controversy. Two authors are particularly indicative of this trend.

In his widely known popular study *Collapse: How Societies Choose to Fail or Succeed*, Diamond (2005) compares a diverse range of actual and presumed cases of social collapse, including such geographically and chronologically disparate cases like historic Easter Island (*Rapa Nui*), Pitcairn and Henderson islands in the Pacific; the Maya of Central America; and the Vikings of Europe and Greenland. To these he adds numerous modern instances, such as contemporary Rwanda, resulting in a study of immense geographic and chronological breadth. From these case studies, Diamond deduces a number of generalizations about societal collapse, like the problematic relationship between environmental constraints and population size, which in turn leads to increased social conflict and heightened resource depletion due to conspicuous consumption and other social processes (Diamond 2005, 177). The depletion of natural resources – deforestation, species loss, and agricultural degradation – is a major theme in this type of narrative which, in effect, argues that societies destroyed their own subsistence base. Overexploitation of natural resources sounded the death knell of ancient societies, whose economic practices had become unsustainable.

A similar ecological perspective was advocated by Chew (2001) in *World Ecological Degradation: Accumulation, Urbanization, and Deforestation, 2000 B.C.-A.D. 2000*. Already the title suggests that deforestation is considered the main issue, and the study sample is equally broad and all-

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[48] Starting in the 1940s, such nature-centered perspectives, which blamed natural causes for environmental deterioration were challenged by opposing views, which identified humans as the sole perpetrators of environmental degradation and change (Issar 1990, 5-6). More recently, more nuanced approaches to human-environmental interactions have been proposed, as will be explored in this section and especially in the following chapter.

encompassing as Diamond's. Chew's main premise is that human-environment relationships tend to be exploitative in nature, leading to environmental stress in the guise of species loss, pollution, siltation, and natural disasters, resulting in health hazards, population loss, and ultimately the collapse of entire civilizations (Chew 2001, 1). Significantly, for Chew, such an extreme case of environmental crisis occurs if the pace of socio-cultural transformations of the environment outstrips the rate at which the ecosystem can compensate for these changes and recover from the stresses imposed on it (Chew 2001, 3). From this ecological perspective, Dark Ages are interpreted as positive events, where social demise and fragmentation considerably slow down the anthropogenic transformation of the environment, enabling ecological regeneration (Chew 2001, 10; cf., White 2014, 3).

This model of over-exploitation and environmental collapse was later expanded to include a chronological element, as he argued for the cyclical recurrence of phases of ecological degradation and subsequent recovery (Chew 2007, 3). In this 'ecological world system history perspective,' as he calls it (Chew 2007, xvi), Dark Ages become

> "[…] important moments in world history for they provide opportunities for the ecological balance to be restored, political and economic opportunities for some peripheral groups to advance up the zonal power matrix, and for reconfiguration of the hierarchical division of political economic power of the world system at specific conjunctures of world history." (Chew 2007, 14)

Ecological collapse not only entails the demise of the social group responsible for its exploitation and degradation, but it can also become a mechanism through which marginalized groups can transform the social hierarchy and attain power themselves. Ecological collapse, then, is not just a socio-environmental phenomenon, but also a means to achieve social justice. Ecological collapse becomes an important aspect of human history writ large and, it might be argued, also has some moral component to it.

Notwithstanding the public appeal of studies like these, much criticism has been leveled against the conclusions drawn by Diamond and Chew. Particularly problematic is the two authors' use of archaeological data. This has already been noted by Tainter, who, in the case of Diamond's examples of Pitcairn/Henderson and Norse Greenland, has argued that the available data shows no transition from a complex to a less complex society, but rather the wholesale abandonment of the regions, either through death or emigration (Tainter 2006: 69). Strictly speaking, none of these cases should classify as a collapse as defined by most authors, including Diamond himself, who defines collapse as a "[...] drastic decrease in human population size and/or political/economic/social complexity, over a considerable area, for an extended time" (Diamond 2005: 3). This conceptual fuzziness becomes even more apparent through his inclusion of Rwanda within his study group, effectively equating genocide with social collapse (Tainter 2006, 69).

In Chew's case, the situation is slightly different. As Tainter has put it somewhat polemically:

> "Chew provides no data, merely sweeping assertions, on the extent of deforestation or erosion in northern Mesopotamia, the Indus River watershed, Minoan Crete, and Mycenaean Greece." (Tainter 2006, 68)

This observation, although generally correct, warrants some further clarification. In his earlier study, Chew (2001) indeed relies primarily on very general statements, which are usually not supplemented with relevant archaeological data that would support his conclusions. In the cases where data is explicitly discussed, these are often taken from older publications. In the context of the Ancient Near East, this becomes especially problematic when population statistics are based on outdated, or methodological questionable, studies from the early days of Near Eastern archaeology.[49] While his later study is much more detailed in its use of archaeological data, a similar issue persists. On the one hand, he associates the end of the Bronze Age in the Eastern Mediterranean with widespread destructions of urban centers (Chew 2007, 79), an interpretation that has successfully been called into question based on archaeological data. In the specific case of the Iron Age Levant, he postulates an "[…] insular society with few foreign contacts and lower standard of living" (Chew 2007, 100), a claim few archaeologists nowadays would subscribe to, especially given the regionally vastly different trajectories of decline and resurgence in outside contacts and trade relations across the Levant as a whole (e.g., Routledge and McGeough 2009). On the other hand, his identification of 700 BCE as the time when a restoration of the social structure of the Eastern Mediterranean can be identified (Chew 2007, 111) appears rather arbitrary, considering the regionally very diverse evidence for continuity and discontinuity in the archaeological and historical record.

The studies by Diamond and Chew provide only two examples out of the many focusing on aspects of ecological potential and population dynamics and similar explanations have been offered in Mesoamerica, North America, and the Mediterranean region (e.g., Binford *et al.* 1997; Bloedow 1995; Haug *et al.* 2003; Hodell *et al.* 1995; Kohler 1992; Kohler and Varien 2012; Lucero 2002; McNeil *et al.* 2010; Mills 2002, 2004; Ogelsby *et al.* 2010; Peterson and Haugh 2005; Pringle 2009; Runnels 1995, 2000; Wells *et al.* 1993; Wills 2009).

In the context of the Ancient Near East, a well-known adaptation of such a perspective is the work by Adams (1988), Jacobsen (1982), and Jacobsen and Adams (1958), who have argued that salinity constituted a major issue for the cultivation of the Mesopotamian river valleys and that progressive soil salinization, exacerbated by intensive agriculture and artificial irrigation, caused the decline of soil fertility and caused the decline of Mesopotamian agriculture (cf., Middleton 2012; Powell 1985). Another example is the work by Weiss *et al.* (Weiss 2000, 2012, 2016; Weiss and Bradley 2001; Weiss and Courty 1993; Weiss *et al.* 1993), who have argued in the context of the late 3rd millennium BCE decline of the Akkadian Empire that an imperial system of over-intensified agricultural production became unstable under increasingly arid conditions. Although the argument made by Weiss *et al.* is more complex than presented here, also involving a discussion of social and economic adaptation, their argument still relies heavily on the idea of collapse as well as overexploitation of the environment by an imperial administration.

These concepts, focusing on the effects of mounting population pressures on the sustainability of an area, are generally summarized under the term overshoot, implying that the demands of a growing human population at some point exceed the ecological capacity of the environment, resulting in the break-down of the entire socio-natural system. To a significant degree, the intellectual history of these approaches can be traced back into the 18th century CE, specifically to the writings of Thomas Malthus (Ellenblum 2012; Middleton 2012; Tainter 2006).

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[49] In this context, it should also be noted that fluctuations in calculated population densities cannot simply be equated with population loss, as done by Chew. Wilkinson (Wilkinson 1997, 92), for example, has argued that changes in population sizes and densities might also indicate factors such as differences in fertility and death rates, or population movements.

In 1798 the English economist Malthus published his *Essay on the Principle of Population*. Malthus' theory, which argued that overpopulation was the primary threat to English society, was based on two basic propositions: First, animals and plants have a theoretical capacity for infinite growth. Second, the theoretical capacity is in reality severely curtailed by available resources, such as nourishment and space (Malthus 1809, 3). From these very basic assumptions, Malthus deduced a general law of population development:

> "It may safely be pronounced, therefore; that population when unchecked goes on doubling itself every twenty-five years, or increases in a geometrical ration. The rate according to which the productions of the earth may be supposed to increase, it will not be so easy to determine. Of this, however, we may be perfectly certain, that the ratio of their increase must be totally of a different nature from the ratio of the increase of population. A thousand millions are just as easily doubled every twenty-five years by the power of population as a thousand. But the food to support the increase from the greater number will by no means be obtained with the same facility. Man is necessarily confined to room. When acre has been added to acre, till all the fertile land is occupied, the yearly increase of food must depend upon the melioration of the land already in possession. This is a stream, which, from the nature of all soils, instead of increasing, must be gradually diminishing. But population, could it be supplied with food, would go on with unexhausted vigor; and the increase of one period would furnish the power of a greater increase the next, and this, without limit." (Malthus 1809, 8)

In other words, while both population and subsistence resources are both capable of significant growth, there exists a subtle, yet important, distinction between the two: Whereas the former increases according to a geometrical, that is exponential, progression, the latter's increase is only linear in nature (Hofmann 2013, 399). Not surprisingly, then, after only a few growth cycles population will by far outstrip the available resources, which grow only at a much smaller rate, making the entire socio-ecological system unstable (Malthus 1809, 12-13). Ultimately, this uneven relation between population and resources will lead to a severe imbalance between the resources necessary to sustain a population and those actually available, which, in addition, also tend to further decrease over time as a result of over-exploitation.

However, as Malthus also noted, this situation only prevails in instances where population growth is left unchecked. According to him, these population checks, which prevent or at least delay the collapse of the entire system, consist of various factors influencing the conditions and length of human and animal life, and their abilities for reproduction. These can be either social, or 'preventive,' which are peculiar to humans and enacted in anticipation of shortages in subsistence goods, or natural, or 'positive,' which actively limit the rate of population increase (c.f., Hofmann 2013, 405-406; Malthus 1809, 15). To curb unfettered population increase, and to avert the impending collapse of the socio-economic system, Malthus proposed a number of social measures, which today would be subsumed under the heading of social engineering (Hofmann 2013). Through these means, the reproductive capacity of the lower classes could be controlled and harnessed, for the long-term benefit of society and in order to forestall economic catastrophe. Only the poor had to be pushed against, or even beyond, the limits of subsistence, which would otherwise have to be done to society as a whole (Hofmann 2013, 422).

Numerous objections have been raised concerning Malthus' population theory. Of his early critics, both De Quincey (1890) and Hazlitt (1932 [1817]) already took issue with his basic premise of two differential growth progressions for human populations and their resource base, calling them either "false and groundless" or "entirely fallacious - a pure fiction" (see, Hofmann 2013, 399-400). Other commentators, though, such as Cannan (1894, 1914) and Mill (1848), saw Malthus' mathematical two-ratio construct either as not essential to his argument, or superseded by other already implicitly stated concepts, like the 'law of diminishing returns' (Hofmann 2013: 400). Furthermore, it has been noted that at the time when Malthus wrote his *Essay*, neither economic literature nor modern statistics had yet been established. Notwithstanding these limitations, a central problem in Malthus' writings persists. According to him, (human) populations are hypothetically subject to unrestricted increase, whereas the growth of subsistence means follows different mathematical laws (Hofmann 2013, 404). As a result, economic and social collapse becomes more of a certainty than a distant possibility.

Despite these criticisms, Malthus' *Essay* has had a significant impact on the social sciences, ushering in the development of a distinct approach to social collapse, referred to as overshoot theories (cf., Ellenblum 2012, 12; Tainter 2006, 60). Such monocausal models of collapse like that of Malthus, simply plotting the chronological development of two variables against each other, have successively been replaced in archaeology by more complex, multi-causal models, as observable in the study of the Maya collapse of the 1st millennium CE where more nuanced, but still Malthusian, arguments concerning the interplay between population dynamics and natural resources have been put forward (e.g., Abrams and Rue 1988; Meggers 1954).

Such Malthusian explanations of overshoot and collapse are difficult to grasp in the context of the Late Bronze and Iron Age Levant. This situation can, at least in part, be attributed to the lack of research into economic and agricultural aspects of Late Bronze and Iron Age societies, at least as far as non-textual sources are concerned. Nonetheless, the idea that an overexploitation of natural resources and the agricultural capacity of the landscape contributed to the demise of the Bronze Age socio-political system appear from time to time in the literature, for example in Liverani's (1987) analysis of the Bronze Age collapse, or Sommer's (2016) recent study on the economic background of the kingdom of Ugarit at the time of its destruction in the early 12th century BCE (see also, Akkermans and Schwartz 2003, 359).

A consistent and unifying aspect of many Malthusian and neo-Malthusian theories is their clear educational agenda (Ellenblum 2012, 15). For Malthus, the most severe crisis Britain faced at the time was that of overpopulation and resource shortage. His *Essay* offers not only an analysis and explanation of the problem, but also makes a number of specific policy suggestions through which the impending catastrophe could be avoided. While archaeologists and historians today generally avoid making propositions of this kind, the educational underpinnings of the Malthusian school are still visible in some contributions. Burroughs (2005), Chew (2007), and Fagan (2004) all use the final chapters of their books to hypothesize and speculate about the future of modern society in relation to environmental and climatic factors.

2.4.2 Climate Change as Explanation

Although Neo-Malthusian theories focus primarily on the issue of increasing population and its deleterious effects on the surrounding environment and agricultural production, they can in some way be related to theories of climate change, as in many cases, climatic variability can cause an economic system to cross its critical threshold of sustainability. For the most part, however, climate change explanations have focused primarily on episodes of marked climatic variability, in order to establish a causal relationship between environmental processes and human responses to such outside stresses. In the Near East, such theories have been advanced by numerous scholars, including Neev and Emery (1967), Klengel (1974), Weiss (1982), Issar and Tsoar (1989), Neumann and Parpola (1987), Issar *et al.* (1992), Heltzer (1988), Weiss *et al.* (1993), Cullen *et al.* (2000), deMenocal (2001), Weiss and Bradley (2001), Burroughs (2005), and Langgut *et al.* (2014), to name only a few.

In most cases, these arguments are made with the support of recently published palaeoenvironmental proxy data, including: pollen, sediment, or ice cores; cave speleothems; land snails; archaeological sediment layers; and archaeobotanical samples.[50] Particularly the 4.2 kya event (also sometimes called the 4.2 kya aridification event), a well-defined episode of climatic deterioration at the end of the 3rd millennium BCE, has been used to argue for a series of events of social disintegration across the Eastern Mediterranean, ranging from Greece to India (Staubwasser *et al.* 2003; Staubwasser and Weiss 2006). In particular, it has been associated with the demise of the Akkadian Empire around that time, which collapsed under the environmental pressure exerted by shifting precipitation patterns (Bar-Matthews *et al.* 1999; deMenocal 2001; Weiss *et al.* 1993). In other instances, for example at Tell Leilan in Upper Mesopotamia, both archaeological and palaeoenvironmental data have been used to argue in favor of social collapse as a direct result of climatic change (Cullen *et al.* 2000).

Climate change theories of social change and collapse have often been criticized as overly deterministic. On the one hand, scientific study of the palaeoenvironmental and archaeobotanical record has revealed that past climates were dynamic and often unstable, with significant variability existing between local, regional, and global climate patterns. On the other hand, many environmental explanations of environmental collapse suffer from issues regarding the evaluation of the evidence and the establishment of clear causal relationships (Middleton 2012, 268-270), which is oftentimes achieved by correlating different diagrams and the variability they exhibit.

Interestingly though, climate change theories are often linked to theories about migration and population movement. Oftentimes, these links are only made implicitly, but in many cases they are stated openly, sometimes even implying a direct cause-and-effect relationships between climate change and migration:

> “It is the author’s opinion that this movement of nations [widespread migration of population] began already during the cold period of the Late Bronze and Early Iron Age, which pushed towards the south the people of the northern plains of Central Asia causing a ‘domino effect’ which reached the countries of the Eastern Mediterranean two centuries later. Another possibility is that here two factors combined: namely, that the socio-economic tumult was triggered by Hellenic tribes, which started their move south-westward, due to the cold spell of the Late Bronze, beginning of the Iron Age. Then as they started to penetrate into the Levant, this region started to go through an economic crisis, due to the warming of the climate. This may explain the destruction of the great Mycenaean culture in the Aegean Sea, where there is no evidence of newcomers and violence but there are signs of abandonment and migration.” (Issar 1998, 122)

Clearly, the movement of people into different areas is considered an important aspect of societal collapse in the Eastern Mediterranean at the end of the Late Bronze Age. However, rather than

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[50] For a more detailed discussion of these data and the discussions surrounding them, see below (**§4.3**).

commenting on the potential ethnic or racial qualities of these groups, he only passingly refers to a vague concept of nation without further clarification, and the effects of population movements are couched within a discussion of both ecological overshoot and climatic change.

Similar direct connections between climate change, environmental degradation, and the collapse of the Late Bronze Age socio-political and economic system have been made by Kaniewski *et al.* (2010; 2011). Combining textual, archaeological, and palaeoenvironmental evidence, the authors argue for a series of drought-induced migrations along the Levantine coast, which they associate with the textually known Sea Peoples. Similarly, Kirleis and Herles (2007) suggest a direct connection between climatic change and the formation of a distinct population group, the Aramaeans, towards the end of the 2nd millennium BCE. Drawing on both textual sources and palaeoclimatic evidence, pollen diagrams from across the Near East, the authors argue that increased aridity between the 12th and 9th centuries BCE led to population shifts and migrations in the fringes of the Syrian steppe, bringing these population elements into conflict with the Assyrian state. In both instances, a direct connection is made between palaeoclimatic evidence, which does provide evidence for episodes of climatic and environmental change, and the formation and migration of distinct population groups. The palaeoenvironmental evidence used in these arguments, however, is highly localized, as in the case of Kaniewski *et al.* (2010), or even ambiguous, as conceded by Kirleis and Herles (2007). Furthermore, both arguments do not account for the controversial discussions surrounding both population groups, Sea Peoples and Aramaeans, and the material remains used to identify them in the archaeological record.

2.4.3 Resilience Theory as a Way Out?

While ecological explanations of societal collapse have gained considerably in importance, particularly due to a number of more popular studies (e.g., Diamond 2005; Flannery 2005; Kolbert 2006; Linden 2006), they have also drawn substantial criticism. Dissatisfaction with both (neo-) Malthusian and environmentally deterministic explanations of climate-induced collapse has risen over the past several years.

Indicative of this trend is a recent edited volume, *Questioning Collapse: Human Resilience, Ecological Vulnerability, and the Aftermath of Empire* (McAnany and Yoffee 2010a). Diamond's (2005) popular study is particularly credited as the book's *raison d'être* (McAnany and Yoffee 2010c, 2), sparking a heated debate (Diamond 2010; McAnany and Yoffee 2010b). As one contributor (McNeill 2010) notes, a major problem in Diamond's analysis is the rather arbitrary and haphazard use of temporal scales, ranging from a few decades to several centuries, which predefine his judgement of failure or success of any given society. By simply extending or decreasing these temporal scales, McNeil argues, most of Diamond's conclusions can be called into question.[51]

Following the arguments of Eisenstadt (1988) and Tainter (2006), who maintain that a collapse in Diamond's sense does not exist in the historical or contemporary world, the authors in this volume instead advocate to focus on aspects of human resilience instead, which they perceive as the norm in human history (McAnany and Yoffee 2010c, 10-11). In this context, resilience is defined as the

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[51] Additional nuanced, and at times more benevolent, criticisms and evaluations have been offered in deMenocal *et al.* (2001). In this response to Diamond's *Collapse*, several authors criticize both his units of analysis, containing many islands and other isolated geographic groups, and his rather undifferentiated and flawed concepts of culture and society. Balée (2006) has similarly criticized Diamond for his inclusion of many insular case studies, but has focused on the fact that insular ecosystems differ fundamentally from continental ones, being more prone to species extinction due to different biological selection strategies. Despite these critiques, some authors do indeed concur with Diamond's use of the archaeological data, particularly in the Pacific, and credit him for his attempt to synthesize and discuss evidence across academic disciplines.

capacity of a system to absorb outside stress and adapt to changing conditions, without fully foregoing its basic and characteristic functions (McAnany and Yoffee 2010c; Walker and Salt 2006), although it remains somewhat unclear how these characteristics are defined, let alone identified. Thus, the central element of resilience theory is the notion of change and the idea that humans are part of complex, interdependent social-ecological systems. These systems are characterized by specific thresholds which, once transcended, are reconfigured to adapt to changed conditions and a new state of stability and equilibrium within the system is assumed (Costanza *et al.* 2007a; Costanza *et al.* 2007c; Walker and Salt 2006).

These characteristics have made resilience theory an important new approach to the study of adaptive processes in human-nature relationships (**§3.2.2**). In this regard, resilience thinking has become an important approach in thinking about contemporary climatic and environmental challenges in light of the growing demands of modern society and economy (Walker and Salt 2006). Resilience theory has been used as an important new counter perspective to traditional explanations of social change and collapse in archaeology and anthropology (Costanza *et al.* 2007a). A large number of studies has been published emphasizing the importance of gradual change and human adaptation, instead of relying on traditional concepts of collapse and decline (Costanza *et al.* 2007a, 2007b; Costanza *et al.* 2007c; Kealhofer *et al.* 2009; McAnany and Yoffee 2010a; Scarborough 2007, 2009; Schwartz and Nichols 2006). Within this perspective, the complex nature of change has been especially highlighted, according to which change is neither gradual nor sudden, but rather episodic, and occurs across various temporal and spatial scales (Redman 2005).

However, some issues remain. As Middleton has noted, the discourse on resilience is still somewhat confusing, especially with regard to the collapse of a system. In some cases, adaptive processes do not succeed in the development of a new, stable system, leading to eventual collapse, while at other times, social and ecological adaptations can result in the successful mitigation of stresses. Collapse appears as some kind of sub-type of resilience and adaptation and the result of unsuccessful, or maladaptive, processes (Middleton 2012). It thus seems that the very notion of collapse has not been eschewed or superseded by a resilience perspective. In many cases, scholars still make explicit reference to interpretations of collapse, which is not surprising given that resilience perspectives have been adopted in archaeological research primarily as a counter-narrative to earlier collapse theories.

2.5 Conclusion

This chapter's discussion has shown that the idea of collapse is complicated, convoluted, and flawed. First, the terminology of collapse is highly complex and confusion about concepts and definitions is widespread. Although this chapter has not focused much on this point, the literature on this particular issue is vast and does not yield specific 'results,' and it has become clear that various definitions and applications compete with each other. Collapse can be framed as a social, economic, political, civilizational, or ecological issue, among others, significantly influencing the ways data are interpreted and conclusions are reached.

Second, the very concept itself is rife with the intellectual baggage of centuries of Western thought, especially with regard to the Eastern Medietrranean and the Ancient Near East. From a social evolutionary perspective, the idea of collapse is often invoked in strong and evocative language to establish a qualitative difference between one period and another. Particularly Classical Greece has been fashioned as the basis of Western culture (or civilization) in this way. In doing so, the idea of the Bronze Age collapse in ancient Greece appears to be invoked primarily to placate a particularly Western need for the superiority of Western culture within an evolutionary scheme of history. But the same kind of thinking has also been applied to the Near East, where the concept of collapse is invoked to fashion the Bronze Age as a golden age in history, contrasted by the rather meager conditions of the Iron Age.

In many instances, these notions are also enmeshed with issues of race and ethnicity. At the outset of Near Eastern archaeology in the late 19th and early 20th centuries CE, the discourse was characterized by ideas of racial superiority of certain population groups over others. These were employed to explain processes of human migration, but also to explain the presumed differences between different artistic traditions. One the one hand, racial concepts were used to explain the presumed superiority of Indo-Germanic people and trace it through history. In other instances, racial, ethnic, or national concepts were used to appropriate certain population groups for a narrative about the development of Western Judeo-Christian tradition. However, these discussions usually (although not always) lack clear definitions of racial, ethnic, or national identity. Moreover, the material and non-material correlates of these identities are generally not made clear, the only exception being linguistic affiliation. This is especially relevant in the discussions surrounding both the Aramaean and Neo-Hittite (or Luwian) states of the Iron Age Northern Levant. The multi-ethnic character of these states has been noted by several scholars, as has the difficulty in drawing a clear distinction between the two groups in the material record (e.g., Bryce 2012; Sader 2014). Should this not call the entire distinction and grouping of these states into question, or make it obsolete altogether?

Finally, ecological explanations, which have become widely popular in recent decades, also have their problems. Often, theories of ecological collapse build on a tradition of Malthusian overshoot, simply evaluating population dynamics against the capacity of the natural environment. Approaches like these have received much criticism, especially since this dependence on simple, uniform variables obscures the multitude of ways in which societies can respond to environmental stress, but also how social processes shape and form the natural environment (Middleton 2012, 266). Other explanations of environmental collapse rely on an overly deterministic thinking, in which climatic change and environmental degradation are often perceived of as the sole factor influencing social change. And even though resilience thinking has been proposed as a new approach to think about the complex relationships between humans and their environment, ideas of social collapse are not entirely eschewed and the relationships between the two concepts are not always as clear as one would wish.

In conclusion, it appears that the notion of collapse, at least in the Eastern Mediterranean and the Near East often appears as a modern scholarly construct, a convenient narrative with which preconceived notions can be imposed on the archaeological and historical record, sometimes with the aim of justifying notions of Western superiority, sometimes simply to bring structure to a highly complex and vast set of evidence and data.

Therefore, rather than proposing a new approach to the study of collapse, a futile effort given the already vast amounts of published research, it is argued here that a study of the Late Bronze/Iron Age transition in the Levant, particularly West-Central Syria, is best conducted without recourse to the very idea of collapse. Instead of adding yet another definition of collapse, it is argued that the concept itself should be put aside and retired altogether. Today's discourse already places a significant emphasis on issue of change and the relationship between humans and the environment, particularly due to the vast amounts of palaeoenvironmental data produced recently. Resilience perspectives, which already try to tackle some of these issues, certainly constitute a significant step in the right direction. However, it will be necessary to further develop these ideas and integrate them into a theoretical perspective that forgoes any association with collapse theories, which are highly problematic and potentially detrimental to a detailed understanding of the processes and developments that define late 2nd and early 1st millennia BCE in West-Central Syria and the Northern Levant.

CHAPTER 3

CHANGE AND ADAPTATION: A SOCIO-NATURAL SYSTEMS FRAMEWORK

> "In studying sociopolitical devolution, understanding connections may be more productive than trying to establish causes." (Butzer 1997, 280)

3.1 INTRODUCTION

Many of the theoretical approaches discussed in the previous chapter are intimately linked to attempts to establish the sole (or primary) cause of social demise, variously identifying migrating people, destructive economic practices, or other factors as effectuating social demise. Several years ago, Butzer criticized this urge to establish the causes of collapse, questioning the value of such enterprises. This exclusive focus on cause-and-effect relationships not only runs the risk of being overly deterministic, laying the blame at one particular aspect to the exclusion of others, but the use of broad and generalizing labels also obscures the myriad of small-scale changes and transformations that take place during such transformative periods in human history. Recognizing the importance of such changes, however, is particularly important considering that in modern discourse the very term collapse has become a kind of shorthand metaphor for change and adaptation, meriting further explanation and calling its own effectiveness as a catchphrase into question.

Yet, despite the validity of Butzer's criticism, there remains a subliminal tension between an overzealous identification of cause-and-effect relationships on the one hand, and dreary descriptions without any explanatory value on the other. Clearly, the goal must be to strike a balance between the two, providing a detailed description of the processes of change, without squeezing the data into preconceived categories, while at the same time providing a way in which the effects of such changes and transformations can be gauged and interpreted. The goal, thus, must be to develop a research program that focuses on the identification of connections and interrelations, but that also enables a detailed analysis of these processes and their mutual relationships.

Therefore, this chapter will outline a different approach which facilitates the detailed analysis of processes of change and transformation, inspired by Socio-Natural Systems (SNS) thinking. Perspectives like these, which were originally developed in ecology, have become highly popular in recent decades, including archaeology, where they have been adopted as a way to circumvent the environmental determinism of cultural ecology (Contreras 2016; Trigger 1989). Such a perspective, considering both social and natural aspects of social, cultural, and economic change, is particularly important with respect to the Late Bronze/Iron Age transition in the Levant, given the considerable evidence for climatic change and environmental degradation provided by palaeoclimatic, palaeoenvironmental, and archaeobotanical studies.

The framework proposed here will build on existing theoretical concepts and therefore not provide a radically new theoretical perspective. As will be discussed below, Socio-Natural Systems thinking is already widespread in archaeological research, including the Near East and the Levant, but has so far not been applied to Late Bronze and Iron Age contexts in West-Central Syria. Therefore, the innovative qualities of this thesis lie not so much in the development of a novel theoretical perspective, but rather the application of an already popular concept to a new study area and time period. In addition, this thesis will develop a methodological approach, or rather a set of methodologies, facilitating the qualitative and quantitative analysis of the complex relationships between human society and its environment. The methods proposed here will rely primarily on Geographic Information Systems (GIS) and its capabilities of geo-statistical analysis and spatial modeling, but also rely on other, non-spatial types of data, including the archaeological and textual record. However, due to the immense complexity of human-environmental relationships, the approach proposed here should be understood only as a preliminary application of these principles, requiring future development and elaboration in future studies.

3.2 Developing a Socio-Natural Systems Framework

3.2.1 The Basics of Socio-Natural Systems Thinking

Studying the relationship between humans and their environments has a long history in scientific thinking. Interest in the mutual dependencies between nature and society can be traced back to the ideas of Greek and Roman philosophers, who contemplated the ways humans transformed their environment (Kirch 2005), and the 16th century CE author Georgius Agricola, who discussed detrimental environmental effects on human health (Scholz 2011, 4). With the beginning of the Industrial Revolution in the late 18th century CE, economists like Malthus studied the effects of environmental constraints on humanity, while geographers and anthropologists developed an interest in studying different cultures and land use practices, whereas early ecologists and conservationists became concerned with anthropogenic landscape change (cf., Chapin *et al.* 2009; Scholz 2011). The integration of ecological thinking with archaeology, called environmental archaeology, was pioneered by Butzer in his study *Environment and Archaeology* (Butzer 1971) early on and further advanced in his *Archaeology as Human Ecology* (Butzer 1982), laying the foundations for modern archaeological interests in environmental research (Kirch 2005). Other scholars chimed in and in the mid-late 20th century CE, a debate on the effects of climatic change on human society had developed with some scholars arguing that climatic conditions varied throughout the Holocene (e.g., Butzer 1958; Lamb 1977), whereas others, such as Raikes (1967), maintained that climate had essentially remained stable since the start of the Holocene (Wilkinson and Hritz 2013, 11).

While the effects of climate change on human activity have remained a highly contested field of research (Widell *et al.* 2013a, 11), these debates have contributed to the development of the modern concept of Socio-Natural Systems.[52] The central tenet of this approach is the rejection of the traditional dichotomy between society and nature as two distinct spheres. Instead, SNS argues that human societies and their actions constitute an integral aspect of nature itself (Adger 2006, 268), or that social and environmental aspects constitute two complementary and coupled elements of a single system (Scholz 2011, 31). These systems are conceptualized as comprised of several interrelated social and ecological subsystems, bound together by mutual interactions and feedback loops that influence both spheres alike (Allen *et al.* 2014; Fischer *et al.* 2015; Folke 2006; Gallopín 1991, 2006; Gunderson and Holling 2002; Holling and Gunderson 2002; Holling *et al.* 2002a; Holling *et*

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[52] Also sometimes called Socio-Ecological Systems (Gallopín *et al.* 1989), Social-Ecological Systems (Berkes and Folke 2001), or Coupled Human-Environment Systems (Turner *et al.* 2003). See, Janssen and Ostrom (2006) and Young *et al.* (2006)

al. 2002b; Liu *et al.* 2007a; Liu *et al.* 2007b; Ostrom 2009). These subsystems consist of physical components, for example landscape features, resources, or living creatures, and the products of social and economic activities, like processed goods or the built environment (Chapin *et al.* 2009).

In this regard, SNS perspectives are closely related to the field of historical ecology, which understands landscape change as the outcome of interrelated social and natural phenomena, advocating an integrated analysis of these relationships and their development through time (Balée 2006; Kirch 2005), and what has been termed 'full ecology' by Scholz (2011, 12), which considers humans as the main driver of the dynamics within a system of human-environment interactions. These notions have developed over the past couple of decades and, as van der Leeuw (2001) has discussed, have shifted considerably during that time period. The first major shift of perception occurred in the 1980s, when the environmentally deterministic view of cultural ecology, where cultural change was forced by a non-transformable environment, gave way to a concept of humans actively shaping (and destroying) nature through invasive social and economic practices. Since the 1990s, however, a new perspective has taken hold, emphasizing the reciprocal nature of human-nature interactions, interpreting environmental crisis neither as culturally nor environmentally determined, but rather as the outcome of an imbalance within the socio-natural system (cf., Balée 2006). Today, Socio-Natural Systems are perceived as neither deterministic nor predictable (Folke 2006) and scholars instead stress the importance of non-linear interactions between individual elements of the system (Allen *et al.* 2014; Balée 2006; Costanza *et al.* 1993; Gunderson and Holling 2002; van der Leeuw 2009), an aspect also emphasized in other approaches to systems thinking (e.g., Brunk 2002).

3.2.2 Key Concepts: Resilience, Vulnerability, and Adaptation

Three concepts are particularly important for Socio-Natural Systems thinking: resilience, vulnerability, and adaptation.

Resilience was first introduced into ecological research by Holling (1973) through his seminal work on ecological systems (**§2.4.3**). He adopted the concept from physics and engineering (Folke 2006; Folke *et al.* 2010; van de Noort 2011; van der Leeuw 2001), where resilience refers to a mechanism by which a system can regain its stability and return to a state of equilibrium in the wake of external disturbances (Gunderson 2000). In ecology, however, resilience is understood in a slightly different way. In the context of socio-natural systems, the resilience perspective emphasizes the effects that multiple discontinuous and non-linear events can have on the stability and integrity of a particular system (Holling *et al.* 2002a). Resilience is understood as the system's capacity to absorb external stress and cope with changes, while retaining its fundamental characteristics and structures (Adger 2006; Berger *et al.* 2007; Chapin *et al.* 2009; Folke 2006; Folke *et al.* 2010; Glaser *et al.* 2008; Gunderson 2000; Gunderson and Holling 2002; Liu *et al.* 2007a; Walker *et al.* 2004). Put differently, resilience refers to the amount of change required to fundamentally alter a system, to change its basic functions and attributes, and transform it into an entirely new system (Anderies *et al.* 2004). After the transformation, the new system again assumes a state of local equilibrium and again achieves stability within its current environment. Therefore, the concept of socio-natural equilibrium is quite different from other perceptions of resilience, such as Rappaport's (1967) idea of cultures as equilibrium-based systems, since the possible existence of multiple, local equilibria is explicitly acknowledged (Folke 2006, 255; Holling and Gunderson 2002; Holling *et al.* 2002a; Holling *et al.* 2002b).

Vulnerability, on the other hand, refers to the degree to which a given system is unable to cope with the impacts of disturbances and change (Adger 2000; Glaser *et al.* 2008; Janssen and Ostrom 2006; Liu *et al.* 2007a). Even though there generally exist certain ways and mechanisms within a system to mitigate against the inimical effects of change, for example by reducing exposure to harmful influences (Chapin *et al.* 2009, 22), at some point the system is not able to retain its stability.

Finally, adaptation is used to describe the process of structural change within a system in direct response to external stresses, with the goal of adjusting to changing external circumstances and to better cope with the results of these changes (Smit and Wandel 2006; Young *et al.* 2006). As such, adaptation refers to a system's capacity to adjust and alter its structural and functional characteristics (Folke *et al.* 2010; Glaser *et al.* 2008) and is therefore often invoked in studying human responses to climate change (Janssen and Ostrom 2006). As Smit and Wandel (2006, 282) put it: "Adaptation in the context of human dimensions of global change usually refers to a process, action or outcome in a system [...] in order for the system to better cope with, manage or adjust to some changing condition, stress, hazard, risk or opportunity." And in the specific context of climate change, adaptation refers to a range of behaviors in direct relation to both actual and perceived climatic and environmental changes, and their perceived impacts on the social system. This adds the dimension of human perception, as adaptive practices do not necessarily have to relate to real processes and developments. As human impacts on their environments require constant adjustments in the relationships between social and environmental sub-systems, adaptation is a constant element of human-environmental relationships (Scholz 2011).

All three concepts can only be understood as intimately linked processes and aspects of a Socio-Natural System (Vogel 2006, 235-236). Especially vulnerability and adaptation, however, are specific to any given system, given their intricate relationship. Different types of stresses and perturbations have different effects on various aspects of socio-natural interaction, which might be quite vulnerable to certain strains, but perfectly able to cope with others through adaptive reconfiguration (Gallopín 2006).

Based on these key concepts, SNS perspectives study the various dynamics that link the social and environmental spheres in a complex system. As such, they are particularly widespread in studies of global change (Smit and Wandel 2006), with a major focus on the linkages between climate change, environmental degradation, and human response, which are acknowledged as interrelated and predicated on each other (Fischer *et al.* 2015; Janssen and Ostrom 2006). Having eschewed the traditional boundaries between social and environmental spheres as clearly differentiated and unrelated entities, SNS approaches have moved towards a more holistic understanding of the multiple connections and influences that characterize the relationships between the two spheres and the complexity inherent in these relationships (Glaser *et al.* 2008; Machlis *et al.* 1997; Young *et al.* 2006).

3.2.3 The Centrality of Change

Socio-Natural Systems place considerable emphasis on the notion of change. In fact, social change constitutes an integral aspect of SNS thinking, particularly with regard to social resilience, as constant adjustments are necessary to stabilize the socio-natural system, or to adjust it to altering conditions. The very concept of resilience, which lies at the heart of Socio-Natural Systems, is closely tied to the idea of change, which is understood as a system's capacity to cope with outside influences, that is, change.

In the SNS perspective, human-nature interactions are in constant flux, given the intimate ties and mutual influences between a vast array of social and environmental factors that affect and shape the entire system. Social practices are constantly affecting and shaping the natural environment which, in turn, affects people's behavior and interactions with their surroundings. Change, therefore, is conceptualized as a complex phenomenon in itself, occurring on various chronological and spatial scales, ranging from the slow and gradual to the fast and episodic, and from the local to the global (Holling and Gunderson 2002; Holling *et al.* 2002a). Change defines the emergent properties of a Socio-Natural System, resulting in a complex interplay of action and reaction, and a process of constant adjustment of social and economic practices to changing conditions.

These changes do not threaten the integrity of the system, as long as certain threshold levels are not transgressed. Allen *et al.* (2014) define thresholds as the boundaries between interaction spheres and scales within a system which, when crossed, require the adoption of a new functional structure. Adaptive social processes have the potential to mitigate against these changes, rendering the system resilient within the threshold boundaries (Folke *et al.* 2010). Only when these perturbations exceed the system's capability of adjustment and adaptation does it become vulnerable, resulting in systemic transformation. This also means that not all forms of change are uniformly and equally severe in their effects on the SNS, as some changes might be more easily compensated for through adaptive strategies than others. In this perspective, change is a regular feature of society and its relationships with the environment. As these relationships are predicated on the effects of constant shifts in the environment and related social practices, adaptation becomes an integral aspect of human-nature relationships in order for the system to retain its overall structure (Machlis *et al.* 1997).

Thus, change is not perceived of as some kind of cataclysmic event resulting in the wholesale demise of socio-political or socio-economic structure and complexity. It is much more mundane in nature, being a basic characteristic of the day-to-day interactions of humans with their environments and leading to a constant need to re-adjust these relationships. This approach to change strongly sets SNS perspectives apart from other theories of social change, especially those that perceive of change as sporadic and drastic. Even in those instances where perturbations are severe enough to alter the basic functional attributes of the system does it not automatically entail the wholesale demise of all the system's components, as some might be abandoned, while others are reconfigured to meet new demands and respond to altered necessities.

3.2.4 Shifting Scales, Flexible Hierarchies

It has been argued by many authors that a full understanding of Socio-Natural Systems requires an appreciation of the multi-scalar character of the elements and processes that make up the system as a whole (Chapin *et al.* 2009; Costanza 1991; Costanza *et al.* 1993; Fischer *et al.* 2015; Folke *et al.* 2010; Gallopín 1991; Holling and Gunderson 2002; Levin *et al.* 2012; Liu *et al.* 2007a; Liu *et al.* 2007b; Machlis *et al.* 1997; Redman *et al.* 2004; Smit and Wandel 2006; van der Leeuw 1994, 2001; van der Leeuw and Redman 2002; Vogel 2006). As mentioned before, a Socio-Natural System consists of a diverse range of sub-systems. In the natural realm, these include a range of global, regional, and local phenomena, for example climates, geology, topography, weather, and vegetation. In the social sphere, they can also range across multiple scales, from large-scale institutions down to localized decision making on the level of communities, households, or even individuals. Each sub-system is defined by a unique set of spatial and temporal parameters which govern the stresses and influences that act upon the sub-system and the range of possible equilibria and coping mechanisms the system might employ to deal with these stresses (Holling and Gunderson 2002; Westley *et al.* 2002).

Often, these sub-systems are hierarchically nested within each other, with large-scale phenomena having an effect on local circumstances, and vice versa, dubbed a 'Panarchy' by some scholars (Allen *et al.* 2014; Holling and Gunderson 2002; Holling *et al.* 2002b). Although higher-level phenomena may assert considerable influence on processes at lower levels within the hierarchy of sub-systems, they do not control them in their entirety. Instead, the linkages between higher and lower levels are bidirectional, with global processes exerting their influence mainly through input-output exchange mechanisms ('top down'), whereas local processes influence global phenomena through aggregation ('bottom up'), with the specific nature and extent of these linkages differing across various locations (Allen *et al.* 2014; Gallopín 1991; Liu *et al.* 2007b).

However, the interactions between global and local systems do not only differ on a spatial scale, but are also characterized by considerable temporal variability. It has been noted that especially global processes, such as climate change, operate on broad and slow time scales, whereas many local social and ecological processes occur with much higher frequency and over shorter periods of time (Gallopín 1991; Holling and Gunderson 2002; Westley *et al.* 2002). This also means that the effects of various social and natural processes, or of the interactions between them, become apparent over varying time scales (Liu *et al.* 2007b). For example, climatic change may occur over long periods of time, with the effects only becoming apparent long after the process has initially started. And while human responses to these changes, such as altered forms and patterns of resource exploitation, might be implemented relatively quickly, their effects on the pace and extent of climatic change might only be noticeable in the long run. Consequently, social adaptation to changing environmental conditions is never a straight-forward, linear process, but rather intermittent and incremental (Smit and Wandel 2006; van der Leeuw 2001), always conditioned on various feedback relationships and the differential spatial and temporal timescales that characterize individual social and natural processes.

Hence, SNS analysis needs to take into account a variety of scale-related issues. Although social-environmental interactions permeate all possible scales of analysis, from the local to the global, these relationships might not be equally well identifiable at all levels. As Fischer and colleagues (Fischer *et al.* 2015, 147) note, socio-natural interactions might appear idiosyncratic at small scales, but abstract and unspecific at large ones. In addition, interactions and mutual influences might materialize at different time scales, with considerable lags between cause and effect (Fisher *et al.* 2009b, 3). Taking into account these issues and providing an analysis at various geographical and chronological scales constitutes one of the major challenges for SNS analyses today (cf., van der Leeuw and Redman 2002).

3.2.5 A Framework, Not a Paradigm

Socio-Natural Systems thinking raises a number of important issues: First, SNS perspectives vehemently deny an artificial differentiation into separate social and natural spheres when investigating the relationships between societies and their environments, and instead advocate an approach that includes both aspects within a holistic analysis of systemic interactions and mutual influences (Janssen and Ostrom 2006). Humans are not just an integral aspect of the ecosystem (Redman *et al.* 2004, 161), but both social and environmental processes can effectuate change in the entire system, or some of its sub-systems (van de Noort 2011, 1043). Second, Socio-Natural Systems are made up of a multitude of connections and the relationships between lower-level sub-systems and processes of social adaptation cannot be investigated as detached from other aspects, such as resilience or vulnerability (Young *et al.* 2006, 305). Third, SNS perspectives have abandoned a static view of human-nature relationships, instead favoring explanations that account for continuous change, systemic instability as an adaptive strategy, and fluctuating relationships between the various action spheres (Fisher *et al.* 2009b, 8). Finally, SNS thinking stresses the importance of scale and hierarchy in examining socio-natural processes, acknowledging the differential spatial and temporal nature of many processes and aspects that constitute the system and affect its structure and performance (Fisher *et al.* 2009b, 8).

These issues are commonly acknowledged and debated in ecological research, but have also found their way into archaeology. SNS perspectives have been applied to Central and South American contexts, for example in Lombardo *et al.*'s (2011) GIS-analysis of pre-Columbian earthworks in Bolivia, or Turner and Sabloff's (2012) study of pollen data to explain the end of the Classic Maya period. In Eurasia, Barton and colleagues (Barton *et al.* 2011b) have combined the study of lithic assemblages with agent-based modeling to investigate the interactions between different human populations, whereas Berger *et al.* (2007) have traced the development of the settlement system of the Rhône Valley in France over two millennia in relation to the geological and topographical characteristics of the region. In the Southern Levant, scholars have combined palynological, archaeobotanical, and archaeological data in order to study the economic and social impacts of plant domestication and cultivation for Neolithic and Bronze Age communities (Fall *et al.* 2004), or developed computer models to simulate and analyze landscape dynamics in various archaeological periods (Barton *et al.* 2010b; Hill 2000, 2004, 2006).

In the Levant and Mesopotamia, recent SNS-inspired research has focused on the relationships between settlements and their environment, land use practices, issues of site formation and site taphonomy, and the application of computer modeling to analyze landscape dynamics (Bradbury 2009; Casana 2003, 2007, 2008, 2013; Lawrence *et al.* 2016; Philip 2007, 2016; Philip *et al.* 2003; Philip *et al.* 2005; Philip and Bradbury 2010; Philip *et al.* 2011; Philip and Newson 2014; Ur and Wilkinson 2008; Wilkinson 1989, 2003, 2005; Wilkinson *et al.* 2010; Wilkinson *et al.* 2013), although only a handful of analyses have made explicit use of complex modeling approaches (e.g., Arıkan 2014, 2015; Arıkan *et al.* 2016; Welton and Christiansen 2016).

Interestingly, though, no explicit reference to SNS theory is made by Near Eastern archaeologists, although most of these studies follow the SNS principle of conceptualizing and studying social and natural processes as interrelated and interdependent phenomena and often rely on SNS concepts, such as adaptation or resilience. Already a few select examples suffice to illustrate how the different research questions, theoretical underpinnings, and methodological approaches of contemporary Near Eastern archaeology fit within the general framework of Socio-Natural Systems analysis.

Casana's (2008) study on soil erosion, land use, and climatic change provides a good example of how the relationships between environmental processes and anthropogenic influences can be analyzed in an integrated research effort. Incorporating geomorphological analyses and archaeological survey for the *Jebel al-Aqra* region at the Turkish-Syrian border (on the northern fringes of West-Central Syria), Casana investigates the contribution of natural and anthropogenic factors to Mediterranean landscape degradation, a debate that has been raging since the early 20th century CE (e.g, Huntington 1911; Reifenberg 1936; Vita-Finzi 1969; Wilkinson 1999; cf., Wilkinson and Hritz 2013). Through a combination of (modern) environmental, palaeoclimatic, and geomorphological data with a textual and archaeological analysis of the development of settlement patterns, Casana argues that soil erosion within the *Jebel al-Aqra* occurred at relatively low, stable rates during several centuries of Bronze and Iron Age low-intensity agricultural cultivation, but was dramatically increased following the Roman-era expansion of intensive agricultural practices into the upland regions of the mountain range. On the one hand, Casana is able to make a compelling argument linking land use practices (agricultural intensification) and environmental change (soil erosion). On the other hand, he has to concede difficulties in conclusively proving the linkages between environmental degradation, climatic change, and social practices (Casana 2008, 438), which might be attributed to his having to rely on a heterogeneous dataset and simple temporal correlations between social and natural processes.

In another study, Arıkan (2016) has employed predictive GIS modeling to simulate and analyze the long-term impacts of agro-pastoral land use strategies on the natural environment of Early Bronze Age Southeastern Turkey. These impacts are studied through a combination of climatic and agent-based modeling and conducted for several site types at various scales. These results indicate that different forms of social organization, represented by differences in site size, impact their environments in different ways and at different scales. Although such an analysis is dependent on a number of assumptions, such as the correlation of site size with social complexity and organization, Arıkan's study nonetheless illustrates the potential of using modeling approaches to investigate complex and non-linear socio-natural interactions across temporal scales. Similar complex modeling approaches have been used in Northern Mesopotamia to study processes of social, economic, and political formation in relation to agricultural practices (e.g., Altaweel 2008a; Wilkinson *et al.* 2007).

In many ways, these archaeological studies have echoed several of the arguments already made by ecologists. On the one hand, they have highlighted the intricate relationships between humans and their environments, exposing the long history of anthropogenic environmental degradation, even before the onset of the Industrial Revolution (Hill 2006, 3). On the other hand, they have stressed the importance of considering both small and large temporal and geographic scales in studying socio-natural processes. Short-term actions by ancient people may have had unforeseen long-term consequences for the ecological system, highlighting the complex linkages between various phenomena at different scales (e.g., Arıkan *et al.* 2016; Contreras 2016; Hill 2006; Hill *et al.* 2009).

The diversity evident in these studies highlights one of the major characteristics, and challenges of contemporary Socio-Natural Systems approaches: theoretical and methodological plurality and indeterminacy. Scholars have repeatedly highlighted the lack of a unified body of theories, concepts, and methodologies adhered to by all scholars of Socio-Natural Systems (Adger 2003; Anderies *et al.* 2004; Fischer *et al.* 2015; Fisher *et al.* 2009a) and many different concepts and approaches compete with each other. For example, in his discussion and outline of what he calls a Human-Environment System (HES) framework, Scholz (2011) has identified a total of sixteen different schemes for studying the relationships between human societies and their environments (cf., Fischer *et al.* 2015).[53] Additionally, problems have been identified in properly linking the different scales of analysis (micro vs. macro, local vs. global) and in accounting for the reflexive nature of humans in their relationship with their surroundings (Janssen 1998, 2006).

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[53] According to Scholz (2011), these sixteen approaches can be roughly grouped into four different categories. The first category includes only his HES framework, which is grounded in a combination of environmental decisions research, systems theory, and epistemology. The second category of 'natural science accentuated' approaches entails frameworks such as resilience approaches, vulnerability analysis, earth system analysis, landscape change science, and political ecology. These frameworks share a common natural-scientific agenda, originating in the academic fields of ecology, geography, and climatology. The third category consists of primarily social-scientific approaches, which have their origins in psychology, economics, political science, sociology, or human ecology. The final group of 'action-oriented' frameworks consists of a broad range of approaches,

Undoubtedly, these issues stem from the immense range of research interests covered by SNS perspectives, which aim at investigating human-environment interactions and relationships in all their complexity and variability. To achieve this, both theoretical and methodological approaches to these issues have to be sufficiently broad and flexible, in order to enable and facilitate the analysis of such differential and highly diverse phenomena and processes. Hence, it has been repeatedly argued that Socio-Natural Systems perspectives should be understood as general frameworks, rather than theories and paradigms in the Kuhnian sense (e.g., Anderies *et al.* 2004; Chapin *et al.* 2009; Scholz 2011), a claim also made by Balée (Balée 2006, 76) in the context of historical ecology.[54] For example, Scholz (2011, 408) argues that his HES framework, or any SNS framework for that matter, does not constitute a scientific theory, as it does not provide a clearly defined set of definitions, principles, and theorems. Instead, he perceives of SNS frameworks as heuristic tools that can be used to structure the inquiry into human-environmental interactions and help to conceptualize the complexity inherent in these relationships. Similarly, Chapin *et al.* (2009, 6-8) suggest that in order to understand the relationships between social and ecological processes, a broad, interdisciplinary framework is required, which combines a systemic perspective with a broad range of interdisciplinary approaches and concepts taken from both the social and natural sciences.

According to this perspective, a framework is established to identify a broad set of variables and linkages that are considered critical for investigation and some general theories about the effects of these variables and changes within them are established. In practice, however, multiple approaches, techniques, and models are used to study these variables, leaving sufficient room for individual research interests and allowing for theoretical and methodological innovation and context-specific analyses (cf., Balée 2006, 76; Folke 2006, 260). Such a viewpoint has lately gained in popularity within the sustainability science community, allowing for the simultaneous existence of multiple conceptual and methodological approaches, enabling a broad range of studies with different perspectives and research interests (Fischer *et al.* 2015, 146).

3.3 Operationalizing a Socio-Natural Systems Framework

It remains to be answered how the concepts and propositions outlined above can be operationalized in an archaeological study and used to investigate processes of socio-economic and socio-political change, especially in conjunction to climatic and environmental shifts. Therefore, the following section will discuss how a Socio-Natural Systems perspective can be applied to an archaeological context. As Barton *et al.* (2011a) have pointed out, it will be necessary to make explicit the methodological approaches used to analyze the complex, multiscalar, and multidirectional interactions between societies and their environments.

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ranging from medical system theory to the social and natural sciences.

[54] According to the influential philosopher of science, Thomas Kuhn, a scientific paradigm constitutes a set of shared rules and standards that provide the basis for academic research and guides scientific practice. In his early works, Kuhn (1962) proposed that paradigmatic change in science occurs in revolutionary cycles in which an old paradigm is replaced by a new one, the two becoming incommensurable in the process. In his later writings, he adopted a slightly different position of *local incommensurability*, which acknowledges continuities between successive paradigms, and refers primarily to semantic differences (Hoyningen-Huene 1990; Sankey 1993). Although Socio-Natural Systems perspectives have exacted a considerable change in the vocabulary and structure of the discourse on cultural and social change, they nonetheless do not necessarily seek to completely replace older approaches; instead, they seek to shift the focus of research and integrate a variety of different approaches, methodologies, and viewpoints on a complex phenomenon. In addition, SNS perspectives do not provide the researcher with a well-defined and limited set of either theories or methodologies. On the contrary, one of the hallmarks of SNS thinking is a deliberate theoretical, conceptual, and methodological flexibility.

3.3.1 How to Study Socio-Natural Systems

Studying human-environmental relationships within a Socio-Natural Systems framework is largely a study of change and the relationship between different components of a large, interrelated system. On the one hand, this requires an understanding of the scales, mechanisms, and patterns of change (see, Gallopín 1991), but also an understanding of how societies perceived of these changes and the ways through which they attempted to mitigate against these changes and adapt (see, Kirch 2005). There are several ways in which social and environmental change can be conceptualized and studied within a SNS approach.

Social Change: The structure of the social system, its patterns, and institutions have been recognized as an important proxy indicator with which the relationships between human-environment interactions can be studied and analyzed (Adger 2000, 354). The social structure, observed in patterns of settlement, transportation, and communication is highly dependent on the environment and how communities engage with it. Studying the movement of populations, both on a regional and sub-regional scale, can be important indicators of changing relationships between humans and their environments. As Folke *et al.* (2010) argue, transformational change often involves significant shifts within the configuration of the social network, including patterns of interaction and overall organization. However, within a SNS perspective, population movements are not necessarily perceived as negative or evidence for severe perturbations within the system. From a resilience perspective, demographic changes like population aggregation or dispersal can be part of land use strategies and adaptive strategies designed to cope with changing environmental conditions (cf., Adger 2000; Hill 2004, 2006). Therefore, it is necessary to pay close attention to the nature and scale of such shifts in population mechanisms (Berger *et al.* 2007).

Economic Change: Economic structure is an aspect closely related to demographic and settlement structures. Especially agricultural practices, like crop cultivation, horticulture, and animal husbandry, are closely related to the settlement structure, which determines the scale and pattern of agricultural activities. Archaeology, particularly archaeobotany and zooarchaeology, can contribute significantly to an analysis of changes within the agricultural system. Faunal remains provide evidence for the appearance, use, and disappearance of certain types of animal livestock, whereas plant remains furnish evidence for crop husbandry regimes, preferential use of certain plant taxa, and landscape changes, such as deforestation and aridification (Kirch 2005; Redman *et al.* 2004).

Technological Change: Smith and Stirling (2010) argue that technologies play an important role in social resilience. Technologies not only enable the communication of individuals through different channels, but also have an effect on how communities interact with their environments. This is especially significant in relation to economic practices. Agricultural technologies determine the degree to which human shape and degrade their environment, but can also function as an adaptive tool from a resilience point of view, as they have the potential to mitigate deteriorating conditions. The development of new water collection and storage technologies, for example, would be such an adaptive strategy in light of diminishing rainfall or groundwater levels. Technologies, thus, are both determined by social practices, while at the same time having the potential to influence the ways in which human-environment relationships are structured (cf., Berger *et al.* 2007; Smith and Stirling 2010).

Environmental Change: Climatic change has been the primary research focus of most palaeoenvironmental studies conducted so far and constitutes one of the main aspects of the SNS framework. Through its reciprocal relationship with human communities, the environment is assumed to have a major effect on the social system, both enabling and limiting certain social practices and forms of interaction. According to Berger *et al.* (2007) attempting to understand the structure of Socio-Natural Systems, an understanding of both landscape and climate dynamics is essential. Climatic, geological, and hydrological data provides the primary evidence to study these dynamics, but proxy indicators such as changes in land use practices or resource exploitation can also play an important role (cf., Contreras 2016; Redman *et al.* 2004).

3.3.2 GIS, Model Building, and the Analysis of Socio-Natural Systems

Due to the complexity of Socio-Natural Systems, a major challenge in studying the relationships between social and environmental aspects consists of integrating different kinds of data and establishing meaningful connections between them.

As Contreras (2016) has remarked, this aspect has unfortunately been neglected in many previous SNS studies, especially in those that deal with the role of climatic change in social transformation and societal collapse. In many cases, arguments of climate-induced social change have been based on coarse synchronicities between human activities and environmental processes. These correlations, however, merely raise the possibility that the two processes are indeed linked, but they do not provide actual evidence of these linkages, nor do they explicate how these links and mechanisms function. According to this perspective, the establishment of correlations should therefore be regarded more as a starting point for further analysis, rather than its result. Once putative correlations between different processes have been established, it needs to be asked how these correlations can be further analyzed and cause-effect relationships established (Contreras 2016, 9-10).

A variety of tools and approaches have been proposed to achieve this. For example, Liu *et al.* (2007b, 645) suggest that integrating mathematical and statistical models with computer simulations, Geographical Information Systems (GIS), and remote sensing data provides a useful approach to analyze the structures and mechanisms that characterize socio-environmental dynamics. A similar argument is made by Redman *et al.* (2004), who similarly advocate the use of remotely sensed data and GIS. Particularly GIS recommends itself to Socio-Natural Systems research due to several distinct features and characteristics:

GIS is able to integrate large quantities and different types of data. As GIS belong to the family of so-called Database Managed Systems (DBMS), they can be used to both store and retrieve records (Conolly and Lake 2008, 51) and it is possible to enter both spatial and attribute data. Moreover, by linking the two types of data, spatial and attribute, it is possible to generate a relational database in which certain attribute values can be linked to specific geographical locales. This not only enables the mapping of certain types of data, but also makes it possible to analyze their distribution in space. GIS support different data formats, such as point, vector, or grid/raster data, but also different types of data, such as qualitative and quantitative observations. Notwithstanding some potential issues raised by integrating archaeological point data with the large-scale, and often continuous, phenomena important in ecology (Barton *et al.* 2010b, 365), the use of GIS makes it possible to investigate data on vastly different phenomena within one single analytical framework.

Different types of data are also characterized by differences in scale, resolution, and coverage. Whereas raster data is used to model continuous phenomena at large geographical scales, point data are geographically much more precise, but also spatially confined in their extent. Already the data types used for analysis can have an effect on the scale of the analysis. In addition, by querying the data, it is possible to analyze the entire data set, or only certain sub-sets of the sample, easily changing the scale and focus of the analysis. By subdividing the entire data set into various subsamples and subgroups, it is possible to shift between large and small scales within the analysis.

One of the most important features of Geographic Information Systems is their capacity for statistical analysis. Beyond merely storing and mapping data, GIS typically include a wide range of powerful and rigorous statistical tools, which enable the exploration and analysis of the data from different perspectives and with different research objectives. Unlike traditional statistics, spatial statistics explicitly consider the spatial dimensions of the data being analyzed, making it possible to identify and scrutinize geographical patterns and processes. Of particular importance for the study of Socio-Natural Systems is the capability of these statistical tests to establish and evaluate the relationships between different variables (Conolly and Lake 2008, 45). As discussed above, this is of particular importance when attempting to develop an argument on the causal relationships between various processes (cf., Contreras 2016). In this regard, GIS can be used to investigate the relationships between social phenomena, for example settlement or artifact distributions, in relation to environmental variables, such as topographic features (Bevan and Conolly 2006; Conolly and Lake 2008).

Finally, Geographic Information Systems can be used to create spatial models. Models are abstract, sometimes idealized, representations of real-world phenomena offering the possibility of integrating theory, data, and explanation into a single analysis (Barton 2013; Costanza *et al.* 1993; Lock 2003; Matejicek 2010). Models can be used to simulate the geographic distribution of specific phenomena and illustrate the underlying processes (Conolly and Lake 2008, 45). In the context of archaeological socio-natural studies, models can be used to investigate the relationships between social and environmental variables, compare the outcomes to the actual archaeological record, and study the consequences of alternate scenarios over large time periods in a controlled laboratory-like environment (Arıkan *et al.* 2016; Barton *et al.* 2010b; Conolly and Lake 2008; Matejicek 2010; Verhagen 2007).

Predictive models have become particularly important for studying the dynamics between social and environmental variables. In the US, they have been employed in cultural resource management programs since the 1970s, often in order to augment data acquisition efforts by establishing potential site locations in previously un-surveyed regions (Verhagen 2007). In research-driven archaeological studies, predictive models have been used to analyze and quantify the relationships between settlement location and their physical environments, in an effort to better understand human-environmental dynamics and their effects on ancient settlement systems (Bevan and Conolly 2006; Verhagen 2007).[55]

Being firmly grounded in mathematical and statistics procedures (Lock 2003, 148), one of the most critical aspects of predictive models, but also one of their main advantages, is that the variables and values used as input data are made explicit. On the one hand, this makes both analytical and interpretive processes highly transparent, as the differential effects of changing variables can be directly observed. On the other hand, this reliance on statistics has spawned some criticism, of both predictive models and GIS applications in general. As Verhagen (2007) points out, predictive models are often based on incomplete data sets, while at the same time relying on a number of potentially flawed theories and assumptions about human behavior, leading to the charge of determinism (Barton *et al.* 2010b; Lock 2003). At the same time, some of the statistical tools included in

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[55] For a more detailed discussion on the history and uses of predictive modeling in archaeological research and cultural resource management, the reader is referred to Verhagen (2007), especially his first chapter.

GIS may create the idea that certain patterns and processes apparent in the data are only dependent on only one particular variable, potentially obscuring more complex interactions between different variables (cf., Bevan and Conolly 2006).

Notwithstanding these criticisms, the capabilities of GIS for statistical analysis and modeling constitute an important contribution to the investigation of human-environmental interactions within a Socio-Natural Systems framework. On the one hand, geo-statistical tools provide a much-needed methodology to investigating connections and correlations between different variables and processes in a statistically robust, and quantifiable, way (Contreras 2016; Ostrom 2009). On the other hand, predictive models, especially deductive (theory-driven) models provide a way to analyze some of the underlying assumptions of human-environmental interactions and the explanatory models commonly employed (see, Barton *et al.* 2011a).

3.3.3 The Contribution of Site-Catchment Analysis

Investigation of the modeling results on a regional scale allows for the identification of broad, large-scale patterns of climatic and environmental change. Yet, in order to fully make the connection between natural and social processes, it is necessary to apply the principles of SNS thinking to smaller, local contexts. The connections between settlements and their natural setting are of crucial importance in this regard, as the "[...] linked settlement-territorial system continues to provide a crucial context for understanding human social development [...]" (Wilkinson 2005, 124). By adopting the principles and approaches of site-catchment analysis, these connections can be established.

Site-catchment analysis (SCA) describes a range of approaches and analytical methods focusing on the relationship of three main variables: 1) natural resources, their availability, and distribution; 2) geographic features, including physiography and topography; and 3) settlement system, particularly their spatial patterning (Hunt 1992; Roper 1979), effectively resulting in an analysis of social and natural variables within reach of a specific site (Vita-Finzi and Higgs 1970). As such, site-catchment analyses do not constitute an exercise in environmental determinism, where natural factors such as resources unilaterally determine site locations, but rather constitute a way in which human behavioral and organizational patterns can be investigated in relation to the natural environment (Steward 1938; cf., Williams 2004, 21).

Ultimately, SCA approaches originate in the writings of the German agricultural economist and economic geographer von Thünen (1826), although modern applications owe most of their inspiration to Chisholm's (1962) seminal work in geography. In the 1960s and 1970s, site-catchment analysis was introduced into archaeology (Higgs *et al.* 1967; Vita-Finzi and Higgs 1970), where it became a common tool for processual archaeologists (Wilkinson 2005, 124). One of the primary applications of SCA was the study of anthropogenic effects on the landscape (Hunt 1992, 283), but today the scope has been enlarged to include a multitude of natural and social processes in which archaeological sites are imbedded (Williams 2004).[56] Combining approaches and principles borrowed from geography, cultural ecology, and central place theory, site-catchment analyses

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[56] In this regard, site-catchment analyses are closely related to archaeological predictive models. Early interest in settlement pattern analysis (e.g., Willey 1953, 1956), established the connection between natural environment and social behavior in archaeological thought. Through site-catchment analysis, propagated by Chisholm (1962) and others (e.g., Vita-Finzi and Higgs 1970), predictive modeling, as an approach to investigate the spatial underpinnings of human social behavior, became established in archaeological research (see, Verhagen 2007).

have become an important tool to evaluate the environmental and ecological factors that have influenced past human behavior, observable primarily in settlement patterns and their relation to topographical and environmental features (Williams 2004).

Applications of site-catchment analysis are based on the underlying principle that human activities are limited to a certain range around inhabited places, beyond which the benefits of exploiting a resource are counterbalanced by time, energy, and resource expenditures necessary for its acquisition (Chisholm 1962; Hill 2006; Hunt 1992; Roper 1979; Surface-Evans 2012; Vita-Finzi and Higgs 1970). Commonly, site-catchment analyses focus on ancient subsistence economies, based on the argument that "[...] site positioning reflects basic needs that vary according to cultural adjustment; and that sites are located near the major source of food" (Dawson and Sullivan 1973, 2). Often, ethnographic or ethno-historical analogy plays an important role in site-catchment studies, as it is often assumed that similar landscape features lead to comparable subsistence strategies and land use practices (Widell *et al.* 2013a, 56).

Despite these shared underlying assumptions, the ways in which site-catchment analyses have been applied and operationalized differ widely between individual studies and there is no generally accepted and undisputed approach to implementing site-catchment analysis into archaeological research. One of the most common approaches to performing site-catchment analysis has been summarized as:

> "[...] delimiting an arbitrary territory or set of territories surrounding a site and then assessing the resource potential within that area. There are several ways this analysis may be accomplished. Most studies have used either circular territories of fixed radii or time contours." (Tiffany and Abbott 1982, 314)

Following the first methodology, Hastorf (1980) has used a regular 4 km distance to delineate the area of most prehistoric subsistence practices, with the exception of gathering and big game hunting activities, for which a 10 km radius is used. Similarly, Williams (2004) employs a circular 1 km radius around prehistoric sites in the southern United States to evaluate the distribution of various environmental variables and their relationships to archaeological sites, whereas Herhahn and Hill (1998) used 5 km as the maximum distance between settlements and their agricultural plots in the Rio Grande Valley of the Southwestern United States. Comparable applications of straight-line measurements on a Cartesian plane have also been used by Hally (1999) and Higgs *et al.* (1967) (cf., Hunt 1992, 285).

The second approach was pioneered by Vita-Finzi and Higgs (1970) through their work in the Southern Levant. According to their research, a walking radius of two hours constitutes a reasonable approximation of movement patterns of hunter-gatherer communities, whereas agricultural societies are much more restricted in their movement, due to their dependence on access to agricultural plots. This estimate is based on analogies with contemporary hunter-gatherer societies, for example the work by Lee and DeVore (1968) (cf., Williams 2004). Similarly, Lönnqvist *et al.*(2009) have based their estimates of walking distances for pastoralist communities in ancient Syria on analogies with modern African transhumant societies.

Such time-based approaches have become quite common in archaeology. Not only do they constitute a reasonable approximation of otherwise subjective perceptions of distance and travel paths (Livingwood 2012, 177), but they also do not rely on the assumption that all locations in an area are equally accessible or even desirable for resource exploitation (Surface-Evans 2012, 128) and are adaptable to context-specific environments (Rissetto 2012, 12). As such, time-dependent calculations of site-territories constitute a more accurate representation of the ways humans interact with their environments than simple Cartesian measurements can provide.

These advantages notwithstanding, time-based site-catchment analyses are not without their opponents. For example, some scholars prefer to use caloric expenditures or other metabolic processes as the defining variables for human movement (cf., Hill 2000, 2004, 2006; Livingwood 2012; Rademaker *et al.* 2012). Yet, such complex algorithms are often rather difficult to implement, given that many of the required input variables (such as metabolic rate, caloric input, etc.) are potentially unknown (Kantner 2012, 228).[57]

In the Near East, a group of researchers around Tony Wilkinson has taken a different route to investigate site-catchment territories. Working primarily in Upper Mesopotamia, they have developed the concept of site-sustaining areas, first used by Oates (1968), Adams (1981), Wattenmaker (1990), and Stein (1994) to investigate how communities exploited their surrounding territories, with a particular emphasis on agricultural production (Ur and Wilkinson 2008; Widell *et al.* 2013a; Wilkinson 2005; Wilkinson *et al.* 2005). Site-sustaining areas are defined through a combination of archaeological, textual, ethnographic, and spatial data, using site size as a proxy for population size, which is then converted into an estimation of cultivated land required by this community (e.g., Widell *et al.* 2013a; Wilkinson 1994, 2005; Wilkinson *et al.* 2005).[58]

Such an analysis is greatly aided by the historical and archaeological record of Upper and Lower Mesopotamia. Unlike other regions, such as West-Central Syria, 3rd millennium BCE Mesopotamia furnishes a wealth of textual evidence on agricultural organization, facilitating a detailed analysis of agricultural practices during that particular period (Widell *et al.* 2013b). In addition, extensive survey work in Upper Mesopotamia has revealed the existence of extended sherd scatters around archaeological sites, while aerial imagery provides evidence for ancient travel paths, so-called Hollow Ways. Whereas sherd scatters are being recognized as the residue of intensive cultivation practices, in the form of field manuring (Wilkinson 1982, 1989, 1994), Hollow Ways have been interpreted as the remains of ancient road systems by which farmers accessed their fields and which can thus be used to delineate the boundary of agricultural cultivation (Ur and Wilkinson 2008; Widell *et al.* 2013a; Wilkinson 1993, 2005; Wilkinson *et al.* 2010). Whereas sherd scatters tend to be particularly dense within ca. 05-1 km around settlements, gradually becoming less intense at ca. 3-4 km distance, Hollow Ways usually range in length between 1-6 km. Together, this indicated that in Early Bronze Age Upper Mesopotamia, site-catchment territories reached a maximum radius of about 4-6 km around settlements, similar to the 3-4 km maximum range proposed by Chisholm (1962) and the 5 km economic threshold suggested by Vita-Finzi and Higgs (1970) (Widell *et al.* 2013a; Wilkinson 1994). At the same time, these findings also suggest

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[57] Both time- and energy-dependent approaches to site-catchment analyses are closely linked to contemporary approaches to Least-Cost Path modeling. Modern GIS applications have made it relatively easy to incorporate either time or energy as significant variables into path modeling procedures (e.g., Barry 2014; de Gruchy 2015; Fábrega Álvarez and Paercero Oubiña 2007; Herzog 2013a, 2013b, 2014, 2016; Howey 2007; White and Barber 2012; Whitley and Burns 2008). They often make assumptions about human preferences for certain paths, which are typically based on time or energy constraints, but can also take other factors, such as social variables, into account. Least-cost path calculations lend themselves particularly well for site-catchment analysis as a relatively time effective way to delineate site-catchment territories based on a limited set of parameters and assumptions, such as time or energy expenditure (Herzog 2014). In her recent study, de Gruchy (2015) has combined information from path modeling with data gathered from archaeological survey and preserved Hollow Ways. As will be discussed later (Chapter 5), this study utilizes a least-cost approach to site-catchment modeling as well.

[58] Similar approaches have recently been applied to archaeological context in Central Jordan (e.g., Arıkan 2012). However, in this particular instance, the model is not based on Ancient Near Eastern textual data, but uses ethnographic analogy to establish suitable values for population density, crop yields, etc.

that larger sites tend to be surrounded by larger catchment territories than smaller ones, without a single one-size-fits-all metric applying to all sites alike, another point already made by Chisholm (cf., Chisholm 1962; Wilkinson 1994).

Comparable Hollow Way features have recently been mapped in Northern Syria and other regions in the Near East by Casana (2013). Both at Early Bronze Age Ebla, as well at Iron Age Tell Rifa'at, a similar relationship between archaeological site and route features can be observed, with the Hollow Ways radiating out for about 2-3 km, before gradually fading out, thus indicating the likely boundary of the agricultural zone. In the Ghab Valley, however, preserved Hollow Way features are much different in character, being shorter and connecting individual sites of the Roman period, suggesting different formation processes and associated land use practices. Yet, due to a lack of adequate textual sources on agricultural practices, and since surveys in West-Central Syria have not taken off-site sherd scatters into account, considerably less information is available for reconstructing ancient site-catchment territories in an equally data-driven way. Therefore, taken the above discussion into account, it can be proposed that distances of about 3-5 km constitute a reasonable approximation of ancient site-catchment territories in Late Bronze and Iron Age West-Central Syria as well.

In summary, SCA constitutes an approach through which the principles of SNS analysis can be applied to local contexts and with explicit links between environmental, social, and economic variables. Again, the application of SCA is greatly aided by the use of Geographic Information Systems, which provide a fairly easy and accessible tool to delimit catchment territories, which can then be subjected to further analysis.

3.3.4 Spatial Statistics and Statistical Analysis

Settlement pattern analysis is often employed in archaeology as a way to "[...] build up from the static spatial distribution of material culture and anthropogenic modifications visible in the contemporary landscape to an understanding of the dynamic cultural and environmental processes of human settlement systems" (Bevan and Conolly 2006, 218). In other words, analyzing archaeological site data for spatial patterns can be a way to study interactions between human societies and their environments, manifested in the distribution of sites across the landscape and in their relation to particular environmental features, and to investigate changes within these patterns. Although this is still often conducted intuitively, spatial statistics tools, such as the ones offered by GIS, constitute a more rigorous, quantitative approach to analyzing these patterns, which also makes it possible to compare and contrast differences and similarities between settlement systems and identify those processes that might have played a role in the establishment of these systems (Bevan *et al.* 2013).

One of the most useful tools to analyze the spatial distribution of archaeological sites is Multi-Distance Spatial Cluster Analysis, also known as Ripley's K (Ripley 1976, 1977, 1981). Ripley's K can be used to analyze whether a point feature exhibits evidence for statistically significant clustering or dispersal over a range of distances, that is, whether point features exhibit trends towards aggregation or segregation in space (Bevan and Conolly 2006, 221). For every feature, in this particular case the point locations of archaeological sites, the Ripley's K function calculates the average number of neighboring features at a given distance according to the formula

$$L(d)=\sqrt{\frac{A\sum_{i=1}^{n}\sum_{j=1,j\neq 1}^{n}k_{i,j}}{\pi n(n-1)}}$$

where d is the distance, n the number of features, A the total area of the features, and k a predefined weight parameter. This calculated, or observed, spatial distribution ('Observed K') is evaluated against the null-hypothesis of Complete Spatial Randomness, that is, against the assumption that the features are distributed in space according to a random, or stochastic process ('Expected K') (Bevan *et al.* 2013). Thus, when the observed number of neighboring features is found to be higher than what would be expected from a random distribution (Observed K > Expected K), the distribution of features is interpreted as spatially clustered. Conversely, when less features than expected are found within a particular feature's neighborhood (Observed K < Expected K), then the distribution is said to be dispersed.[59]

Still, several authors have cautioned that apparently random distributions of archaeological sites might be dependent on hidden social and environmental factors (cf., Bevan and Conolly 2006; Daniel 2001; Maschner and Stein 1995; Woodman 2000), necessitating the use of additional analytical tools (cf., Bevan and Conolly 2006; Bevan *et al.* 2013). One of these tools is the chi-squared test (x^2-test), which can be used to investigate dependencies between different variables. In this particular case, the x^2-test can be used to determine whether there exist statistically significant relationships between the location of archaeological sites and surrounding environmental features (Conolly and Lake 2008; Verhagen 2007). The x^2-test is defined as

$$\chi^2=\sum\frac{(O_{r,c}-E_{r,c})^2}{E_{r,c}}$$

where $O_{r,c}$ is the observed frequency of variable A at level r and of variable B at level c, whereas $E_{r,c}$ is the expected frequency of the two variables at levels r and c, respectively. The results of the x^2-test are evaluated against the null hypothesis which posits that variables A and B are independent of each other. The null-hypothesis is rejected if the result of the test (the p-value) falls below a certain significance level, whereas a p-value higher than the significance levels means that the null-hypothesis will be accepted. In this particular case, a significance level of 0.01 has been used, meaning that the null-hypothesis will only be rejected when a statistical relationship can be established with a confidence of 99 % or higher. Yet, as has been argued by Verhagen (2007, 47), the x^2-test is only an initial step in investigating the relationships between site locations and environmental parameters, since the test itself only establishes the existence of a relationship, but does not provide any information on the significance of this relationship, or the specific variable's influence on site location.

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[59] Detailed discussions of the statistics behind the Ripley's K function, and its adaptation in ArcGIS, are given in Bailey (1995), Boots and Getis (1988), Getis (1984), and Mitchell (2005).

3.4 CONCLUSION

Socio-Natural Systems thinking offfers a flexibe concept with which social processes and the (environmental) contexts in which they take place can be conceptualized and studied. The lack of a unified body of theory, or an agreed-on methodology, does present a possible source of criticism, but this flexibility also constitutes one of its biggest strengths, as it allows for the simultaneous existence of different, complementary, and non-exclusive research programs. The possibility of combining a variety of context-specific theoretical perspectives and methodological approaches makes SNS research a flexible tool in studying the complex, variable, and non-linear relationships between human society and its surroundings.

These merits of SNS-inspired research have been akcnowledged by many scholars and SNS thinking has already found its place in archaeological research. This applies to the Ancient Near East and the Levant as well, although in some cases the principles of SNS research are only implicitly stated and usually not openly discussed.

In the context of this thesis, the Socio-Natural Systems framework is applied with the specific goal of investigating the chronological and spatial characteristics of climatic change during the late 2nd and early 1st millennia BCE, but also to study the effects of these changes on both the environment and socio-political and socio-economic structures. Geostatistical and statistical tools offer a way of quantifying the relationships betwen social and natural variables, enabling further analysis and discussion.

Having outlined the basic principles of SNS analysis, the following chapters will present a succession of individual steps through which these concepts can be operationalized and applied to a specific archaeological case study, beginning with data collection and assessment, and moving through various stages and scales of analysis and interpretation.

CHAPTER 4

THE BUILDING BLOCKS OF SOCIO-NATURAL SYSTEMS ANALYSIS: DATA COLLECTION AND ASSESSMENT

4.1 INTRODUCTION

In order to implement the theoretical approach outlined in the previous chapter, and to enable the analysis of human-environmental interactions on a regional level, it is necessary to gather and synthesize the required spatial and archaeological data. Archaeological data is widely available, thanks to decades of archaeological surveys and excavations in the region. Yet, other important data, including topography and climatic factors, are not as readily available and have thus not been applied consistently in the debates. But it is not only important to acquire and integrate these different types of data. The ability to conduct quantitative and statistical analysis is an integral element of qualifying and quantifying changes in the relationships between human society and its environment. Only by showing that certain patterns, like settlement distribution, land-use suitability, or social integration, changed significantly over time, and that these changes were indeed related, will it be possible to argue that climatic and environmental change had a profound impact on peoples' lives and led to a reconfiguration of social structures.

Geographical Information Systems not only offer the possibility of integrating data of different types and scales (e.g., global satellite data, regional environmental records, and site-specific archaeological evidence), but also offer a tool with which systematic statistical analyses of these datasets can be conducted. While the visualization capabilities of GIS software make it possible to highlight and discuss patterns and observations in the data and present them on a regional scale, its analytical capabilities, particularly its spatial statistics capabilities, make GIS a powerful tool with which the data can be queried and analyzed.

The required materials include environmental data, such as topography, soil types, or hydrogeology, climatological simulations, and archaeological evidence from excavations and surveys. However, these data are quite different in nature, extent, and quality, and until now in many instances have not yet been properly reviewed and analyzed for their utility. For example, there exist at least four types of topographical models, in the form of Digital Elevation Models (DEMs), which could be used. However, each of the datasets is characterized by slight differences in resolution, accuracy, or production methods, resulting in quite significant differences. Likewise, climate data can be gathered either from a variety of environmental proxy studies or through the application of modern climatological computer simulations. These models and simulations do not only vary in the output they generate, but also suffer from limitations in scale, resolution, and data distribution. Climate simulations often tend to operate on global or continental scales, whereas proxy studies often have to rely on a disparate and widely dispersed dataset, adversely affecting their comparability and compatibility.

This chapter will review the available data in detail and discuss their utility for a Socio-Natural Systems analysis. Although the discussion will also provide some general background and information on the data, its main focus will be their applicability to the specific context at hand, that is, West-Central Syria in the Late Bronze and Iron Ages. This chapter will not only present the data, but also provide an assessment and evaluation of their accuracy, as well as their usefulness for the analysis proposed in this thesis.

Data evaluation will rely on a variety of methodological, or theoretical approaches. For spatial data, such as topographic, or some climatic data, this will be conducted with the help of widely accepted statistical methods. For other types of data, such as palaeoclimatic and palaeoenvironmental data, evaluation will be based on a thorough literature review or a qualitative assessment. Similarly, archaeological data will be evaluated through a discussion of archaeological practice, primarily excavation and survey methodologies, and research aims, that have been used in generating the archaeological record.

This evaluation of the available evidence is a necessary preliminary step to identify those data sources most appropriate for an analysis of Late Bronze and Iron Age West-Central Syria. The actual application of the Socio-Natural Systems perspective is therefore postponed to the following chapters.

The data presented here consist of a variety of types and formats. For the most part, these data were freely available from a variety of sources, published either online or in print, as indicated below. In some instances, data that were not readily available, such as materials from unpublished surveys or the exact coordinates of surveyed sites, were solicited from colleagues where necessary.

To integrate the data into the GIS, it was decided to use the UTM coordinate system. Using the UTM system makes it possible to utilize the full range of spatial and statistical analyses offered in GIS, which is not possible using other, non-projected, coordinate systems, where site locations are expressed in degrees of latitude and longitude. Since the study area of this project straddles two distinct UTM zones, 36N and 37N, with the dividing line roughly running through the coastal mountain range, it was decided to only use Zone 36N. Hence, the locations of archaeological sites were recorded in UTM 36N or re-projected to this system where necessary. Other data, such as topographic and geological maps were geo-referenced in their native projection and then re-projected to UTM 36N.

Before engaging in the actual analysis of socio-natural interactions in West-Central Syria, the following discussion will present the available data and their principal characteristics. Through systematic sampling of the data, their respective strengths, but also their limitations and weaknesses, will be evaluated. This comparative study, which will utilize statistical and spatial analysis, will make it possible to argue for the inclusion (or exclusion) of certain datasets in the modeling process. The raw data used in these analyses can be found in the data tables included in the appendices, as indicated in the text.

4.2 Archaeological Data

Archaeological data provide the primary basis for investigating the social aspects of socio-environmental interactions in ancient West-Central Syria. Past scholarly attention to this region has resulted in a large and diverse corpus of materials available for analysis. Broadly speaking, these can be divided into three different categories, according to their scale.

From a regional perspective, survey work, particularly in the late 20th and early 21st centuries CE, provides a way to assess the settlement system at a regional and sub-regional scale. As archaeological excavations have concentrated on a select number of (mostly) large sites in the area, data from excavations are rather localized in scale and also unevenly distributed in space. These materials can be used to reconstruct social, economic, and even political aspects of the Late Bronze and Iron Ages. Finally, some excavations, primarily the more recent ones, have also yielded faunal and botanical data, enabling further investigation of economic practices, primarily with regard to the agricultural system of the region.

Given the long history of research in this area, effectively starting in earnest in the 1920s and 1930s with the excavations at Ras Shamra (Schaeffer 1931, 1932, 1933, 1934, 1935, 1936, 1937, 1938; Schaeffer and Dussaud 1929), Tell Nebi Mend (Pézard 1931), and Hama (Fugmann 1958; Riis 1948; Riis and Buhl 1990), the archaeological record is heterogeneous both in quantity and quality. Research interests and methodologies have varied over time and between projects. Therefore, recording standards, resolution, and accuracy vary between projects and publications, and not all types of data are equally available from every site.

4.2.1 Regional Scale Data: Survey Work

Settlement data from Late Bronze and Iron Age West-Central Syria was gathered at a regional level (**Appendix 1**). The database of known archaeological sites and settlements contains a total of 271 individual entries, including several well-known, excavated settlements, such as Ras Shamra, Tell Afis, Tell Mardikh, Hama, Tell Mishrifeh, and Tell Nebi Mend, but also incorporates a large number of sites that have only been surveyed to varying degrees of intensity (**Fig. 4.1**).

The locations of the sites were compiled from a variety of sources. For many of the best-known settlements it was possible to gather geographic locations either directly from published reports of from online sources. The locations of most smaller sites were acquired mainly from published and unpublished survey reports, but online resources were sometimes used to verify site positions. In several instances, there existed some overlap in the coverage of different survey projects. Sites that were included in more than one report played an important role in establishing site locations, in geo-referencing and rectifying survey maps, and in confirming the validity and accuracy of the localization. On the other hand, surveys sometimes provided contradictory or only very tentative information on the periodization of some sites. Therefore, it was decided to use the most up-to-date information available, which usually means that the dates given in the more recent publications were used.[60] Below, the individual survey projects and their contribution to this project's database will be presented.

An unpublished survey of archaeological sites across Syria was conducted by James Sauer of the American Center of Oriental Research in Amman, Jordan, in 1977 (Sauer nd). Access to the survey materials was kindly granted by Dr. Joseph Greene of the Harvard University Semitic Museum. During the approximately one-and-a-half months of survey work, 83 sites were visited across Syria and diagnostic artifacts were collected from 70 of these locations. Out of this total, 36 sites are located within the study area and belong to the periods of interest here. Thirty-two sites can

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[60] For a detailed discussion of archaeological chronology in Late Bronze and Iron Age Syria, see above (**§1.3**). The publications and reports used to compile the site list used in this project do not adhere to common standards concerning ceramic datings used. While some projects use only very general distinction, such as Late Bronze Age or Iron Age, others, especially Turri (2015) and Graff (2006) provide more detail, assigning certain sites to the Iron Age I and Iron Age II, for example. At this stage, the discrepancies in recording standards cannot be mitigated, since the dating criteria are not known for every single project, or because the results are not fully published yet. For the purpose of this thesis, sites that are assigned a general Iron Age date in the literature are considered to have been occupied in both the Iron Age I and the Iron Age II. Datings such as Iron Age I or Iron Age II are considered as single-period occupations.

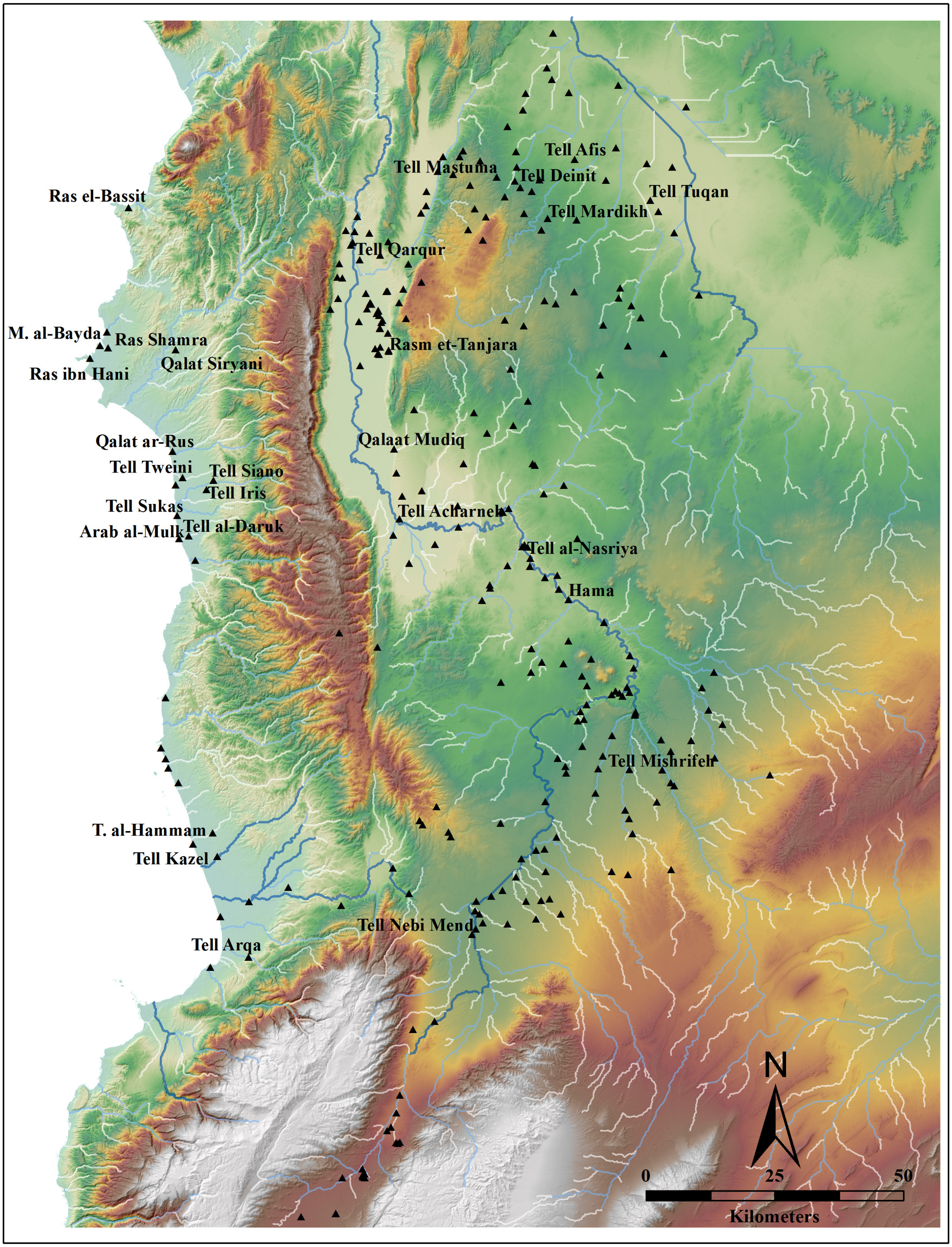

Fig. 4.1: Distribution of surveyed and excavated sites within West-Central Syria.

be assigned to the Late Bronze Age, whereas 31 sites provide evidence for Iron Age occupation. As there are only nine sites with evidence for single-period occupation, the degree of continuity between the two periods is rather high. Since the unpublished survey report does not list the geographic coordinates of the sites, these were acquired by integrating the information of the survey maps, site descriptions, and modern satellite imagery. As the report includes only very brief and cursory descriptions of the surveyed sites, site measurements were carried out in GIS, but should not be seen as authoritative.

Between 2003 and 2007, the *Deutsche Archäologische Institut* conducted several campaigns of intensive survey work in the Middle Orontes Valley (Bartl and al-Maqdissi 2005). During the survey, which covered approximately 600 km^2, a total of 175 individual find spots were mapped, including archaeological sites from the Early Paleolithic up to the Islamic and Ottoman periods (Bartl and al-Maqdissi 2014). Of the 34 sites of interest here, 25 are dated to the Late Bronze Age, whereas 29 are dated to the Iron Age. Only 14 of the surveyed sites are single-period settlements, again attesting to the considerable degree of settlement continuity in this area between the Late Bronze and Iron Ages. The exact geographic coordinates of these sites, as well as chronological information, were kindly provided by Dr. Karin Bartl.

Additional surveys were conducted to the west of Homs. Between 2004 and 2007, the Syro-Lebanese-Spanish mission to this region recovered a high number of archaeological sites in the Homs Gap and along the Syrian-Lebanese border (Haïdar-Boustani *et al.* 2005; Haïdar-Boustani *et al.* 2007; Ibañez *et al.* 2006, 2010). The survey covered all periods from the Paleolithic to the Islamic period, but only four sites were dated to either the Late Bronze or Iron Ages. Of these, only one belongs to the Late Bronze Age, whereas the remaining three belong to the Iron Age. The geographic locations of these sites were acquired by combining the information of the geo-referenced survey maps with satellite imagery. Yet, the rugged topographic terrain in this area made an exact localization of the sites difficult at times. As no information on site size was given in the reports, additional measurements were carried out in GIS, where possible.

In the Ghab Valley and the Rouj Basin, archaeological survey work already started in the 1960s and 1970s (Courtois 1972, 1973; Sauer 1979; van Liere 1963). The aims and methodologies of these projects were quite different. Van Liere relied primarily on aerial photographs to identify capital cities and citadels of the Bronze and Iron Ages. A similar focus on the most prominent tell sites of the region is evident in Courtois' work, who was mainly interested in the large tell sites dating to the 3rd and 2nd millennia BCE. The data recorded during the survey includes site size measurements and photographs of the sites, diagnostic ceramics, and lithic finds encountered during surface collection. Sauer's survey efforts focused primarily on the valley floors of the Ghab and the Rouj, using the results obtained by Courtois as a starting point. Again, the collected evidence included size measurements, site photographs, and surface collection of artifacts (cf., Graff 2006). In 2000, a new program of archaeological prospection, the Northern Ghab Regional Survey (NGRS), was started as part of the Tell Qarqur excavations, with a second season following in 2001. Around 100 archaeological sites, dating from the Paleolithic to the Islamic period, were mapped, using a combination of satellite data, topographic maps, and field walking. Site coordinates were recorded using a GPS and surface artifacts were collected (Graff 2006, 2008). Of the recorded sites, only 41 are of interest here, dating primarily to the Iron Age, especially the Iron Age II. Especially during the second field season, additional information was collected, including site size measurements, soil samples from the identified sites, and geological samples from several locations across the valley (Graff 2006, 2008). As a result, the NGRS is one of the few projects with a specific aim to study the archaeological data within their environmental context. However, the discussion of the survey results concentrates primarily on the 3rd millennium BCE (Graff 2006).

In the course of the excavations at Tell Mastuma, carried out by the Japanese mission between 1980 and 1995 (Iwasaki *et al.* 2009), the vicinity of the tell was also surveyed for additional archaeological sites in 1993. The survey concentrated exclusively on tell-type settlements. Although ceramics of all periods were collected, the focus of the survey work was placed on the Bronze and Iron Ages (Tsuneki 2009). The survey covered a radius of 15 km around Tell Mastuma and recorded a total of 22 tell-type settlements, 19 of which were occupied during the Late Bronze and Iron Ages. In fact, only one of the surveyed sites was dated to the Late Bronze Age, whereas all other sites belong to the Iron Age, suggesting a significant change in the regional settlement system between the two periods. The survey report provides detailed and accurate descriptions of the surveyed sites, including size measurements and topographic maps.

In his recent study, Turri (2015) compiled a substantial catalogue of excavated settlements and surveyed archaeological sites in the Orontes Valley. His study synthesizes several decades of archaeological research in the region and provides an extensive bibliography of archaeological survey activity in Western Syria. Importantly, he provides exact geographic coordinates for all the sites included in his discussion and in many instances additional information, such as site size measurements, are provided as well. From the sites catalogued by Turri, 96 lie within the boundaries of the study area used here and are dated to the Late Bronze and Iron Ages. Of these, 93 were occupied during the Late Bronze Age and 78 date to the Iron Age. Information on these sites beyond the published data was kindly provided by Prof. Daniele Morandi Bonacossi and Dr. Luigi Turri. Where site sizes were not provided, additional measurements were carried out in GIS.

The locations of 17 surveyed sites were compiled from the surveys around Tell Afis and Tell Tuqan in the north of the study area (de Maigret 1978). Seven of these sites are dated to the Late Bronze and 13 to the Iron Age. A few additional site locations in the far north of the study area were gathered from a regional survey conducted by the Tell Afis excavation team (Melis 2005). Site locations were acquired through the use of geo-referenced survey maps and satellite imagery. As site sizes were generally not included in the survey reports, additional measurements were carried out in GIS.

An additional 18 site locations, primarily in the coastal region and the adjacent mountain ranges, were collected from Lehmann's (2002) *Bibliographie der archäologischen Fundstellen und Surveys in Syrian und Libanon*. There is evidence for Late Bronze occupation for 13 of these, whereas Iron Age remains were recorded at eleven sites. The locations of the sites were established using a combination of the published maps and satellite imagery, whereas size measurements were carried out in GIS.

As already mentioned, different survey projects and publications provide different dates for sites in some instances. There also exists a wide discrepancy in the detail of the periodization schemes used. For example, the ACOR survey materials have not yet been properly published and were only recently examined in preliminary fashion.[61] The available data, thus, are quite sparse, and only differentiate broadly between Bronze and Iron Ages, without further subdivisions. On the

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[61] This information was kindly provided by Prof. Stephen Bourke in personal communication. At the time of writing, preparations for analysis and publication of these survey results are being made.

other end of the spectrum, Lehmann and Turri often identify sites as belonging to a specific subperiod, such as the Iron Age I or II, whereas the DAI survey, for example, only distinguished more generally between Late Bronze and Iron Ages.

In order to synchronize these quite disparate data, a sort of 'maximum' approach has been taken here. That is, all sites that were marked as belonging to the Bronze Age (in the case of the ACOR survey) or tentatively assigned to that period were treated as Late Bronze in date. Similarly, all sites with Iron Age data were considered to belong into that period, disregarding further subdivisions. Naturally, this approach means that the site catalogue currently contains sites which, in the future, will turn out to be misdated. Given the state of research, however, this approach currently constitutes the only feasible approach in integrating the available data. As more information becomes available, adjustments to the site catalogue and the periodization of individual sites need to be made.

4.2.2 Local Scale Data: Archaeologically Excavated Sites

Over the past decades, numerous archaeological excavations have taken place in West-Central Syria. For the most part, they have concentrated on large, prominent tell sites, but in some cases, smaller sites were also explored and excavated. In the following discussion, a broad overview over these excavation projects will be given, with a special emphasis on project goals and their usefulness for this thesis. The projects will be presented in geographical groupings, starting with the coastal plains before moving on to the inland regions of West-Central Syria (for a discussion of these geographical units, see below, **§5.4.2**).

4.2.2.1 The Northern Coast

The tell of Ras Shamra, the site of the ancient city of Ugarit, located about eleven kilometers north of modern Latakia, was initially excavated in the early 20th century CE after the accidental discovery of an ancient tomb (Schaeffer 1931, 1932, 1933, 1934, 1935, 1936, 1937, 1938; Schaeffer and Dussaud 1929) and have continued until recently (Yon 2006). Excavations have focused primarily on the architecture and urban layout of the city, uncovering fortification walls, domestic structures, sacral buildings, and a large royal palace. Historical analyses, on the other hand, have mainly focused on the rich textual documentation of the public buildings and private dwellings, which provide information on political, social, economic, and religious aspects of the Late Bronze Age.

In the excavations of several smaller sites on the Northern Coast, the connections between these settlements and the capital city of Ugarit have played a major role. In addition, much attention has been paid to the chronological development of later Greek influence, or even Greek occupation, in this region. At Ras al-Bassit, a small site about 50 km north of Latakia, excavations have been carried out between 1971 and 1984, uncovering both Late Bronze and Iron Age occupation levels. The results of these excavations have only been published in preliminary fashion (Braemer 1986; Courbin 1981, 1982, 1983, 1986, 1990, 1993; Darcque 2004). A few kilometers to the west of Ras Shamra, both Ras ibn Hani and Minet el-Beida were excavated with the aim of illuminating the settlement history of the kingdom of Ugarit. The soundings at Qal'at Siryani and Qal'at al-Rus (al-Maqdissi 2004a; Courtois 1963) and a study of the settlement history of the Northern Coast (Saadé 1990) were equally aimed at studying the settlement structure of the kingdom of Ugarit. The results of the Ras ibn Hani excavations were published in a series of preliminary reports (Badre 1983; Bounni 1982; Bounni *et al.* 1976, 1978; Bounni *et al.* 1979; Bounni *et al.* 1981; Bounni and Lagarce 2004; Lagarce and Lagarce 1988) and one monograph (Bounni *et al.* 1998), whereas for Minet el-Beida, only a few preliminary summaries of the earliest excavation seasons are available (Marchegay 2004; Schaeffer 1931, 1932, 1933; Schaeffer and Dussaud 1929; Yon 1993-1997).

Although faunal and botanical remains were collected during some of these excavations, only a few preliminary accounts have been published so far (Chahoud and Vila 2017; Courbin 1990; Vila 2004). A geomorphological and electrical resistivity survey carried out at Ras ibn Hani (Bounni *et al.* 1978) has concentrated on coastline morphology, but does not add significantly to an understanding of environmental processes during the Late Bronze and Iron Ages on the northern coastal plain. In fact, most research in this part of the study area has concentrated on chronological issues, including the development of Eastern Mediterranean influences in the ceramic corpus (e.g., du Piêd 2006-2007, 2011; Lagarce and Lagarce 1988; Rahmstorf 2011).

4.2.2.2 The Jableh Plain

In the Jableh Plain, excavations have mainly focused on two large, prominent tell sites, Tell Tweini and Tell Sukas, but several additional small excavations and soundings were carried out as well.

At Tell Tweini, excavations started in 1999 and continued until 2010. A primary goal of the project was to investigate the transition from the Late Bronze to the Iron Age in Western Syria, but also to study the Late Bronze Age levels in relationship to the findings from Ugarit, to which Tell Tweini was bound politically during that time period (al-Maqdissi *et al.* 2008; Bretschneider *et al.* 1999). Unlike most other projects in West-Central Syria, however, the excavations at Tell Tweini were conceived as an interdisciplinary project from the very beginning, considering both the archaeological and palaeoenvironmental record (Bretschneider *et al.* 2008, 33). As a result, not only have several preliminary reports on the faunal and botanical remains from Tell Tweini been published (Linseele 2008, 2010; Linseele *et al.* 2013; Vandorpe 1999), but the results of environmental, geophysical, and geo-archaeological studies have also been made available (al-Maqdissi *et al.* 2007; Baeteman 2010; Kaniewski *et al.* 2008; Kaniewski *et al.* 2010; Kaniewski *et al.* 2013). The excavations at Tell Tweini, augmented by geophysical prospection, have uncovered several Late Bronze and Iron Age occupation layers and succeeded in reconstructing much of the urban layout of the Iron Age settlement (al-Maqdissi *et al.* 2008; Bretschneider and Hameeuw 2008; Bretschneider and van Lerberghe 2008a; Bretschneider *et al.* 2008).

At Tell Sukas, a few kilometers to the south, excavations in the mid-20th century CE have uncovered the Bronze and Iron Age remains of an important harbor town, the primary goals being the investigation of Phoenician and Greek settlement in this region, as well as the acquisition of finds for the Danish National Museum (Riis 1970, 10). The results of the expedition have been published in a series of final reports (Abou-Assaf 1997; Buhl 1983; Lund 1986; Riis 1970, 1996). In both periods, mostly domestic contexts were excavated, but later building activities have caused considerable damage to these layers, whereas problems in stratigraphic control and recoding strategies cause issues for a functional analysis of these remains. In the course of the excavations at Tell Sukas, topographical studies in the Jableh Plain, as well as smaller soundings were also carried out (Oldenburg and Rohweder 1981; Riis *et al.* 2004), focusing on the settlement history of the coastal plain, but without much attention to palaeoenvironmental factors.

Small-scale excavations have also been conducted at Tell Siano and Tell Iris, with the primary aim of investigating the Late Bronze and Iron Age levels at these sites in light of the available historical record from those two periods (al-Maqdissi 2004b; al-Maqdissi and Souleiman 2004; Bounni and al-Maqdissi 1992, 1993, 1998).

4.2.2.3 The Akkar Plain

Excavations in the Akkar Plain have concentrated on two major mounds, Tell Kazel on the coast and Tell ʻArqa at the mouth of the Homs Gap. At both sites, Late Bronze and Iron Age occupation levels were uncovered, but the results show clear differences in the occupational sequence. For Tell Kazel, no final publications exist to date and the excavation results have been made available in a series of preliminary reports and specialized studies (e.g., Badre and Gubel 1999; Badre *et al.* 1990; Badre *et al.* 1994; Capet 2003; Capet and Gubel 2000; Dunand *et al.* 1964; Dunand and Saliby 1957). At Tell ʻArqa, the materials and documentation of the early excavations were mostly destroyed during the Lebanese Civil War and only two preliminary reports on these excavations exist (Thalmann 1978a, 1978b). The Bronze Age levels from the recent excavations, however, have been published in final form (Thalmann 2006, 2010). The small soundings at Tabbat el-Hammam and Tell Simiriyan (Braidwood 1940) have contributed only little evidence for the settlement history of the region.

Similar to the Northern Coast, research in the Akkar Plain has mainly focused on issues of chronology, ceramic typology, and evidence for foreign influence in the Late Bronze and Iron Ages (Badre 2003, 2006, 2011; Badre *et al.* 2005; Charaf 2004, 2007-2008, 2008, 2011; Jung 2007), and no environmental analyses have been conducted.

4.2.2.4 The Northern Plateau

On the Northern Plateau, archaeological excavations were first carried out at Tell Mardikh (ancient Ebla), and the nearby sites of Tell Afis and Tell Tuqan were explored in preliminary fashion as well (e.g., Matthiae 1979a, 1979b, 1983). Later, independent excavation projects were developed at Tell Afis (e.g., Cecchini and Mazzoni 1998; Mazzoni 1998) and Tell Tuqan (e.g., Baffi 2006, 2008, 2011b) and these three major sites were excavated in conjunction within the framework of an integrated research program (Matthiae 2014; Mazzoni 2014a). Chronological questions have provided the main focus of this research project and the Tell Afis excavations yielded one of the most complete and detailed occupational sequences of the Late Bronze and Iron Ages in West-Central Syria (see, for example, Cecchini *et al.* 2008; Ciafardoni 1987; Mazzoni 1990, 1992, 2000b, 2001b, 2005b, 2014b; Venturi 2000, 2007, 2010, 2011, 2013, 2014). Although the Matkh research program was specifically aimed at investigating environmental factors as well (Baffi and Peyronel 2014, 9), the published research has primarily focused on earlier occupation periods, especially the Early Bronze Age (Galiatsatos and Mantellini 2013; Mantellini 2015; Mantellini *et al.* 2013).

Additional excavations have been carried out at sites in the vicinity of Tell Afis. At Tell Mastuma, a small, rural settlement has been excavated and the results have been published in both preliminary (Egami 1988; Egami *et al.* 1988; Egami *et al.* 1984; Nishiyama and Yoshizawa 1997; Tsumoto 1997; Wada 1994; Wakita *et al.* 1995; Wakita *et al.* 1994; Wakita *et al.* 2000) and final (Iwasaki *et al.* 2009) form. In the context of the excavation, attention has also been paid to aspects of settlement structure (Tsuneki 2009) and environmental factors (Yasuda 1997). Ceramic analysis has primarily focused on the spatial distribution of vessel forms as an aid to architectural and functional reconstruction, thus lacking important chronological depth (Wada 2009c, 91). The small excavations at Tell Deinit have not provided much additional materials and have so far only been published in preliminary fashion (Shaath 1985, 2007, 2012).

4.2.2.5 The Lower Orontes Valley

At Tell Qarqur, initial excavations were carried out in the 1980s (Lundquist 1983) and then again from the 1990s onwards (Casana *et al.* 2008; Dornemann 1998a, 1998b, 2000, 2003a, 2008a, 2008b, 2008c, 2008d, 2008e, 2008f; Dornemann and Casana 2008a, 2008b; Dornemann *et al.* 2008). The monumental remains of an Iron Age citadel have been uncovered, but evidence for Early Iron Age and Bronze Age occupation levels has also been encountered. More importantly, the Tell Qarqur excavations were integrated into a regional study project, focusing on both the natural environment and the settlement system of the northern Ghab Valley. Geophysical and geoarchaeological studies have contributed to an understanding of landscape formation processes in this region (Graff 2006, 2008; Wieser 2012), but have mostly concentrated on earlier Bronze Age occupation periods.

At Tell ʻAcharneh, limited excavations have recently provided evidence for both Bronze and Iron Age occupation layers (Fortin 2000, 2001a, 2001b, 2003, 2006a, 2006b, 2006c, 2006d, 2006e; Fortin and Cooper 2013). In addition, the surrounding southern Ghab Valley has been surveyed, in an effort to illuminate the settlement history of this part of the study area (Fortin 2005; Fortin *et al.* 2005).

Salvage operations at Rasm et-Tanjara (Athanassiou 1977) provide further evidence for Iron Age occupation in the Lower Orontes Valley, although the materials come from very insecure contexts.

4.2.2.6 The Middle Orontes Valley

In the Middle Orontes Valley, several large and important sites were excavated: Hama, Tell Mishrifeh, and Tell Nebi Mend. All three have provided evidence for both Late Bronze and Iron Age occupation, albeit to differing degrees, and the small-scale excavations at Homs (King 2002; Moussli 1984) have provided further, albeit very limited evidence for occupation of the Middle Orontes Valley during these periods.

The early excavations at Hama uncovered the monumental remains of an Iron Age citadel, as well as the more fragmentary remains of an earlier Late Bronze Age occupation (Fugmann 1958; Riis 1948; Riis and Buhl 1990). However, limited stratigraphic control and reporting strategies make a functional interpretation of these remains difficult at times, and no particular attention was paid to environmental and economic aspects of the material record.

At Tell al-Nasriyah, a few kilometers northwest of Hama, an integrated archaeological and palaeoenvironmental research program was recently inaugurated (al-Maqdissi *et al.* 2009, 2010a, 2011; Parayre 2010). Geomorphological prospection has concentrated on disentangling the complex depositional history of the Orontes river and its river terraces (De Dapper 2010), whereas topographical, geomorphological, and geophysical survey has been employed at the site to investigate its settlement history and environmental context (Parayre 2010). The limited excavations have uncovered evidence for Iron Age II occupation (al-Maqdissi *et al.* 2009, 2010a, 2011; Parayre 2010), but have also uncovered a cremation cemetery evincing strong contacts to nearby Hama and the Aegean (Faivre 2010, 2013).

Tell Mishrifeh was also first explored in the early 20th century CE (du Mesnil du Buisson 1935) and again between 1999 and 2010 by a German-Italian-Syrian team (al-Maqdissi 2009). Late Bronze and Iron Age levels have been uncovered in different areas of the site, providing a detailed occupational sequence for these periods. Importantly, several studies have been devoted to the analysis of the faunal, botanical, palaeoclimatic, and geological data at the site (Fiorentino and Caracuta 2007; Morandi Bonacossi 2007b; Peña-Chocarro and Rottoli 2007; Riehl 2007; Valsecchi 2007; Vila and Gourichon 2007), providing a detailed record of socio-economic practices and the environmental context.

At Tell Nebi Mend, excavations were first conducted in the 1930s (Pézard 1931) and then again starting in the 1970s (Matthias and Parr 1989; Parr 1983). Late Bronze and Iron Age occupation sequences were uncovered in several areas of the main high tell and the results have been published in a series of theses and preliminary articles (Bourke 1991, 1993, 2012; Parr 2006-2008; Whincop 2003, 2007), as have the preliminary analyses of the faunal remains (Grigson 2015; Grigson *et al.* 2015).

4.3 PALAEOENVIRONMENTAL DATA

The second component of the Socio-Natural System concerns the natural environment. While topographic data are relatively easy to procure (see below, **§4.4**), palaeoclimatic and palaeoenvironmental data are not as widely available. Moreover, the nature of the data itself significantly complicates the acquisition process, as well their implementation into a GIS environment. Therefore, this aspect warrants special attention.

4.3.1 Palaeoclimatic Research in the Eastern Mediterranean

As already discussed in Chapter 2, environmental and climatic explanations for cultural change were already developed in the early and mid-20th century CE (e.g., Carpenter 1966; Huntington 1915, 1917; Issar 1990). For the most part, however, scholars were unable to produce sound scientific data to support their hypotheses, a situation which changed dramatically in the 1960s and 1970s, as large quantities of newly gathered data became available for the first time (Issar and Zohar 2007, 5). Early palaeoclimatic studies were conducted in Western Iran (van Zeist 1967; van Zeist and Wright 1963; Wasylikowa 1967), southeastern Turkey (van Zeist *et al.* 1968), western Syria (Niklewski and van Zeist 1970), and Israel (Gat and Dansgaard 1972).

Since then, palaeoenvironmental research in the Eastern Mediterranean has risen in popularity. In the Northern Levant, this includes a series of drill cores from the Ghab Valley (van Zeist and Bottema 1991; van Zeist and Woldring 1980; Yasuda *et al.* 2000), Cyprus (Kaniewski *et al.* 2013), the Syrian coast (al-Maqdissi *et al.* 2007; Kaniewski *et al.* 2008; Kaniewski *et al.* 2010); palynological analysis from the Rouj Basin in the vicinity of Tell Mastuma (Yasuda 1997); and a charcoal survey from Syria, especially the southern parts of the country (Wilcox 1992, 1999). In the Southern Levant, palaeoenvironmental data have been obtained primarily from the speleothems from the Soreq (Bar-Matthews *et al.* 1997, 1998; Bar-Matthews *et al.* 1999; Bar-Matthews *et al.* 1993; Kaufman *et al.* 1998) and Jerusalem caves (Frumkin *et al.* 1999), as well as the various studies conducted on the sediments and depositional history of the Dead Sea (Bartov *et al.* 2006; Baruch 1990; Begin *et al.* 1985; Bookman [Ken-Tor] *et al.* 2004; Bookman *et al.* 2006; Enzel *et al.* 2003; Frumkin 1997; Frumkin *et al.* 1991; Kagan *et al.* 2015; Klein and Flohn 1987; Klinger *et al.* 2003; Langgut *et* *al.* 2014; Litt 2005; Litt *et al.* 2012; Migowski *et al.* 2004; Migowski *et al.* 1999; Migowski *et al.* 2006; Neev 1964; Neev and Emery 1967; Neev and Hall 1977; Neumann *et al.* 2007a; Stein 2001; Stein *et al.* 1997). Additional studies have been carried out in central Anatolia (Kaniewski *et al.* 2007; Woldring and Bottema 2001-2002), at Lake Van in eastern Turkey (Lemcke and Sturm 1997; van Zeist and Woldring 1978; Wick *et al.* 2003), in western Iran (van Zeist and Bottema 1977; Wasylikowa 1967), at Lake Kinneret, Lake Huleh, the Golan Heights, and in the Negev in Israel (Baruch 1986, 1990; Baruch and Bottema 1999; Goodfriend 1991; Neumann 2005; Neumann *et al.* 2007a; Schwab *et al.* 2004), the Nile Delta (Bernhardt *et al.* 2012; Fontugne *et al.* 1994; Hassan 1981), in the Mediterranean (Cheddadi *et al.* 1991; Schilman *et al.* 2002; Schilman *et al.* 2001), and on the Arabian Peninsula (Lézine *et al.* 2010). Outside of the Near East, studies on climatic and vegetational change have been conducted in Spain and France (e.g., Bogaard *et al.* 2016; Ferrio *et al.* 2005).

Unfortunately, however, the utility of these studies for environmental reconstruction and especially modeling is curtailed by several issues and problems. Significant differences in the quantity, quality, and comparability of the data indicate that many interpretations offered are far from conclusive. The highest degree of agreement between different studies and researchers apparently exists with regard to very broad, general trends, especially for the earliest periods of investigation. Climatic changes at the transition from the Pleistocene to the Holocene, marked by momentous climatic shifts and considerably increased global temperatures (Issar *et al.* 1989; Stein *et al.* 1997), are fairly well established in the literature and generally agreed upon. In comparison, the mid- and late-Holocene is characterized by less severe climatic and environmental change, despite a general long-term trend towards a more arid environment punctuated by several short-term episodes of increased precipitation (Rambeau and Black 2011, 94). This long-term drying trend is well attested at Soreq Cave (Bar-Matthews *et al.* 1997, 1998; Bar-Matthews *et al.* 1999; Bar-Matthews *et al.* 1993), in the Wadi Muqat in northern Jordan (Abboud 2000), in the Eastern Mediterranean (Schilman *et al.* 2002; Schilman *et al.* 2001) and in the Negev (Goodfriend 1991).

However, there is no clear agreement on the exact starting point for this trend. For example, differences in $\delta^{18}O$ and $\delta^{13}C$ values of the Soreq speleothems, which act as indicators of temperature, rainfall, and vegetation regime (Bar-Matthews *et al.* 1998, 207-208), have been interpreted as evidence for major changes in precipitation patterns. Indicative of these changes are diminishing rainfall levels, starting around 7,500 BP, as well as rising temperatures, starting around 7,000 BP. These results are in agreement with the findings of Schilman *et al.* (2002; 2001), who identify a drying trend in the isotopic composition and properties of deep-sea marine sediments off the coast of Israel. On the other hand, evidence from the Wadi Muqat suggests the onset of drier conditions at around 5,000 BP, while the oxygen isotope data obtained from land snail shells by Goodfriend (1991) supports an argument for enhanced aridity around 5,800-5,200 BP (cf., Rambeau and Black 2011). Although a warming trend throughout the Holocene is clearly suggested by the data, estimations for its starting point and duration can vary considerably, sometimes up to two-and-a-half millennia.

These differences become even more pronounced in the historical periods, particularly from the Middle Bronze Age onwards (Rambeau and Black 2011, 99). Whereas the Soreq Cave and Eastern Mediterranean marine sediment datasets continue to exhibit a considerable degree of agreement, suggesting the onset of increasingly drier conditions around 3,100 or 3,000 BP, palynological data from Anatolia (Kaniewski *et al.* 2007), the Syrian coast (al-Maqdissi *et al.* 2007; Kaniewski *et al.* 2008; Kaniewski *et al.* 2010), and Lake Van (Lemcke and Sturm 1997; Wick *et al.* 2003) indicate a much earlier start of increasing aridity, somewhere between 4,200 and 3,500 BP.

Most severe, however, are the discrepancies observable in the interpretations of the Dead Sea record. As already noted by Rambeau and Black (2011, 99), some of the studies conducted there differ not only in some minute details, but in fact reach directly contradictory conclusions. For example, based on their analysis of the sedimentary record, Migowski *et al.* (2006) reconstruct ancient levels of the Dead Sea to be comparatively high between 7,000 and 3,500 BP, and rather low between 3,500 and 2,150 BP, indicative of more humid and arid phases, respectively. To some degree, their findings are consistent with the pollen and sediment data discussed by Neumann *et al.* (2007a), where a relatively humid climate is identified for the Middle Bronze and Early Iron Ages, whereas increased aridity is indicated during the Late Bronze and later Iron Ages. These arguments, however, stand in direct opposition to other research conducted in the Dead Sea area. Frumkin (1997), Frumkin *et al.* (1991), and Klinger *et al.* (2003) all argue for a completely different scenario, with more arid conditions prevailing until ca. 3,600-3,450 BP, followed by a slightly moister period between 3,450 and 3,150 BP. This interpretation is also corroborated by the work by Bookman [Ken-Tor] *et al.* (2004) and Kagan *et al.* (2015), the latter of which identify a dry phase during much of the Late Bronze and a humid period during the Iron Age. Again, however, there is no exact agreement on the precise starting point or the duration of these climatic phases. Equally contradictory environmental and climatic reconstructions have been offered for the Golan Heights (Neumann *et al.* 2007b; Schwab *et al.* 2004) and the Lake Kinneret region (Baruch 1986, 1990). While the former two studies argue for the regeneration of deciduous oak forests and low anthropogenic interference from the Middle Bronze to the Iron Age, the latter identifies widespread forest clearing and olive cultivation around the Dead Sea and in Northern Israel (cf., Rambeau and Black 2011, 99).

In part, these differences can be attributed to the types of materials analyzed, that is, whether cave speleothems, sediments and pollen, snail shells, or even historical records are studied, and where these materials were gathered, for example, whether pollen data is derived from lake or marine sediments. In arid zones, terminal lakes such as the Dead Sea provide natural climatic gauges and lake levels can be taken as indicators of climatic change, as their water content and chemical composition are largely determined by water input and evapotranspiration (Klein and Flohn 1987, 151; Lemcke and Sturm 1997, 654). On the other hand, deep-sea sediments offer a broad regional scope, at the expense of temporal resolution (Cheddadi *et al.* 1991, 54). The origin of the sample materials, thus, has an influence on their utility for palaeoclimatic studies, although in some instances it is possible to link these diverse types of evidence (see, Roberts *et al.* 2011; Roberts *et al.* 2004; Roberts *et al.* 2010).

But discrepancies in analysis results also exist in instances where similar materials and data sets are studied, as is the case with many palynological studies. In general, it is recognized that pollen diagrams constitute an appropriate way to study past climates and vegetation regimes. However, Cappers *et al.* (1998) have also argued that interpretation and comparison of pollen diagrams is often impeded by dating issues, not only making it difficult to correlate pollen records among each other, but also with the archaeological record (Cappers *et al.* 1998, 160). The authors cite two aspects which contribute to this situation: On the one hand, drill cores do not always include the necessary numbers of carbonized remains that can be accurately dated, resulting in chronological gaps. On the other hand, carbon concentrations in the samples may be contaminated with materials from older sediments (Cappers *et al.* 1998, 160). Consequently, Cappers *et al.* (1998, 168) have argued that correlations of some Eastern Mediterranean pollen diagrams, especially those of the Ghab Valley, Lake Hulah, and Eski Açigöl, are questionable, given that the radiocarbon dates proposed for the Ghab core are too few and generally questionable.

In addition, discrepancies between the different studies are introduced by advances and developments in analytical techniques and analysis procedures. In fact, these changes have necessitated frequent re-evaluations of older results, as well as completely new sampling operations in previously covered areas. The drill cores obtained at Lake Zeribar in Western Iran in the 1960s and 1970s (van Zeist and Bottema 1977) were recently re-studied by Wasylikowa (2005), whereas the Lake Van data obtained in the 1970s (Kempe and Degens 1978; van Zeist and Woldring 1978) had to be augmented with additional sediment cores, due to severe errors in the chronological scheme of the sediment record (Wick *et al.* 2003, 670). In the Ghab Valley in Syria, the original drill core published by Niklewski and Zeist (1970) did not provide much data on the Holocene, necessitating further investigation (van Zeist and Woldring 1980). Yet, the results of these renewed studies have been called into question on chronological grounds, as the influence of dissolved carbonates within the groundwater (hard-water effect) was not accounted for, necessitating even further research (Yasuda *et al.* 2000, 129). Both the Ghab Valley and Lake Hulah studies have been criticized for their methodology (Meadows 2005), severely curtailing the usefulness of these materials. Similar doubt has been cast on the validity of some of the sediment chronologies proposed for the Dead Sea (e.g., Begin *et al.* 1985; Frumkin 1997; Neev 1964; Neev and Emery 1967; Neev and Hall 1977).

A similar conclusion is reached by Finné *et al.* (2011) in their recent survey of the available palaeoenvironmental and palaeoclimatic data from the Near East. The authors particularly note the wide range of dating techniques employed, including radiocarbon, uranium series, dendrochronology, sediment varve counting, and others. While all of these techniques individually can produce useful results, the different constraints of these methods severely compromise comparability across various studies (Finné *et al.* 2011, 3154). As a consequence of these limitations, they consider only 18 out of the almost 80 studies cited in their review as qualitatively sufficient to warrant closer comparison and statistical analysis. Concluding their synthesis, the authors note a general consensus that the period of 3,400-2,800 BP (ca. 1450-850 BCE) was drier than before, although considerable variability existed between individual regions. In contrast, no coherent picture appears to emerge for the period after 2,800 BP.

Yet, through their survey, Finné and colleagues also highlight an important problem that is only rarely acknowledged but has a significant impact on palaeoclimatic reconstructions in the Eastern Mediterranean: The immense variability in geographical coverage and even an almost complete absence of any sort of palaeoclimatic proxy data from some of the archaeologically most important areas of the Near East (Finné *et al.* 2011, 3166). This observation is mirrored in **Fig. 4.2** which shows the geographic distribution of the climate studies discussed above in relation to the study area used here. Although this map does not constitute a comprehensive overview over all the palaeoclimatic studies conducted within the Near East, it does include those that are most commonly cited in the literature, and their distribution serves as a good indicator of a general trend within palaeoclimatic research in the region. As can be easily seen, studies that focus on the Northern Levant, particularly Northern Syria, are fairly low in numbers and concentrate within the northwestern-most corner of the study area. This can, at least to some degree, be considered an artifact of the history of archaeological exploration in this region, since most early excavations did not collect environmental samples, whereas the results of the more modern excavations, for example at Tell Qarqur or Tell Nebi Mend, are not yet available in final form. This stands in contrast to the situation observed in the Southern Levant, where samples are widely available and more evenly distributed. By far the most studies have been concerned with the Dead Sea evidence, far outn-

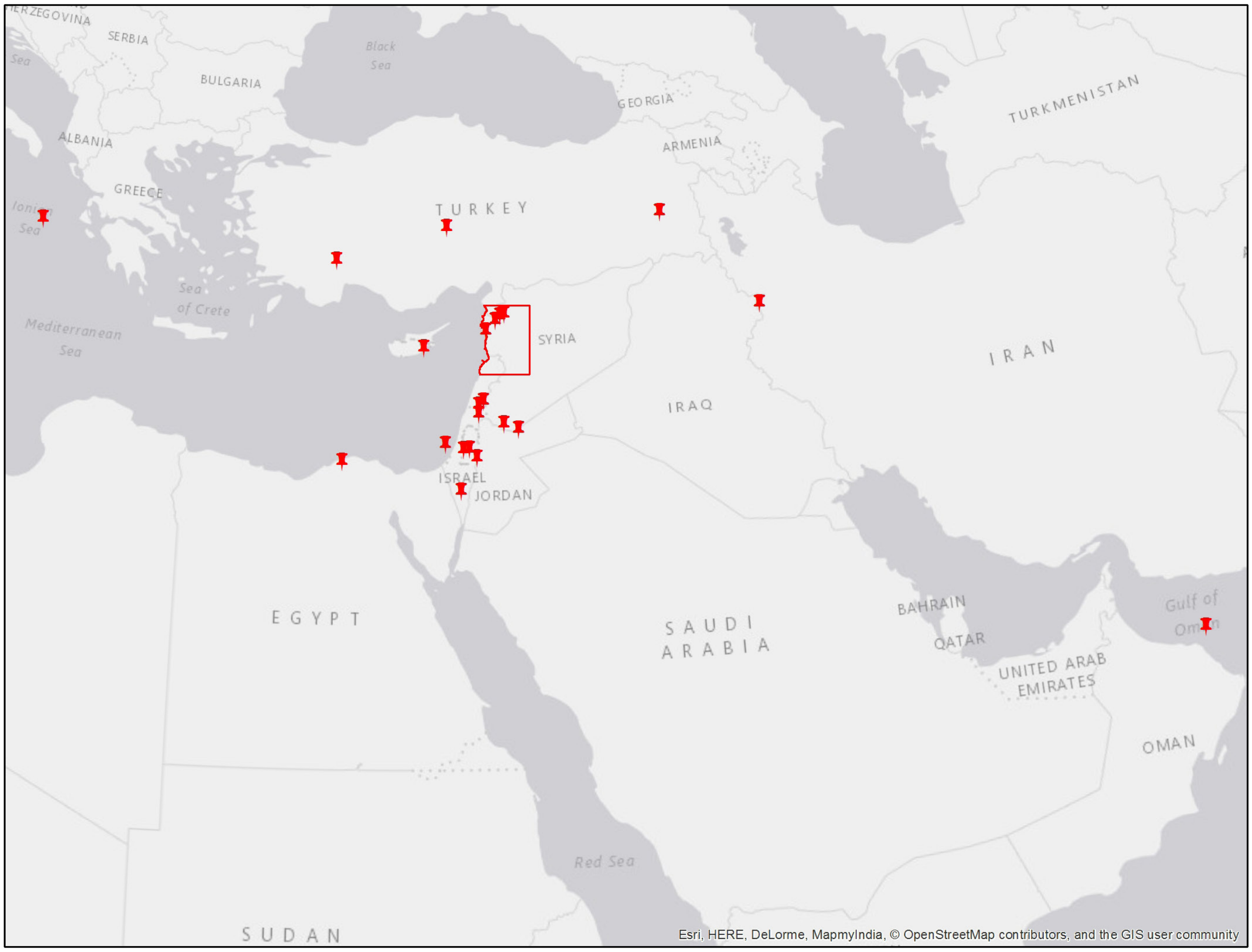

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Fig. 4.2: Distribution of palaeoclimatic proxy studies discussed in the text in relation to the study area.

umbering all other study sites by a significant margin. Considering, however, that these studies sometimes directly contradict each other, the prominence of these studies within palaeoclimatic reconstruction should be regarded with due caution.

This situation is not significantly changed through the inclusion of archaeobotanical samples. Riehl and colleagues (Riehl 2008, 2009a, 2009b, 2011, 2012, 2014; Riehl *et al.* 2008; Riehl and Nesbitt 2003; Riehl *et al.* 2014) have studied the ubiquity of certain plant taxa, but have also analyzed stable isotope ratios of charred plant remains. These studies differ significantly from the ones discussed so far in one important aspect: Their data, which consist of botanical samples, have been collected during archaeological excavation, in contrast to the other environmental research, which has been conducted on a variety of natural landscape features. As a result, the data used by Riehl and colleagues are much more closely associated with cultural remains and the changes observed within them. Therefore, their analyses and conclusions warrant special attention.

In their earliest study, Riehl and Nesbitt (2003) compared the distribution of field and horticultural crop seeds across 39 sites in the Aegean and the Near East during the Late Bronze and Iron Ages. Their evidence was drawn from the published excavation records, but the authors immediately acknowledged a conspicuous lack of consistently sampled and published archaeobotanical remains from the Iron Age levels across the region (Riehl and Nesbitt 2003, 305). Still, as the available data suggests, there appears to be only little change in the distribution of wheat and barley crops during the Late Bronze and Iron Ages, whereas small-seeded millet is introduced in the Near East in the Iron Age, when it becomes quite common (Riehl and Nesbitt 2003, 306). Unsurprisingly, horticultural fruits like olive, grape, and fig are already well established in the Near East well before the beginning of the Iron Age, which are supplemented later by the introduction of almond and pomegranate (Riehl and Nesbitt 2003, 307). These changes lead the authors to suggest that a significant change occurred within the agricultural system of the Iron Age Near East, which also stands in contrast to the development in the Aegean, where changes are already observable in the preceding Late Bronze Age.

In another distribution study, Riehl (2009a) observed several changes in the ubiquity and prominence of both drought-tolerant and drought-susceptible crop species. During the Early Bronze Age, proportions of both drought-resistant (barley, free-threshing wheat) and drought-susceptible (olive, lentils) crops are high, but diminish over the course of the Middle Bronze Age. In the Late Bronze and Iron Ages, the proportions of barley and wheat remain largely stable, whereas olives witness a continuous intensification across the two periods, and lentils, the most drought-susceptible crop included in the analysis, reappear in Northern Mesopotamia only during the Iron Age (Riehl 2009a, 100-107). This pattern is significant insofar as the different capabilities of the various crops to withstand prolonged episodes of aridity can function as an indicator for changes in regional climates and environments. Consequently, Riehl suggests that the abandonment of less drought-tolerant crop species, such as lentils, during certain periods was caused by a decrease in mean annual rainfall within the region. However, as she also recognizes, this stands in contrast to the apparent intensification of water-demanding crops, like grapes and olives, which would have required the widespread application of irrigation techniques to sustain them (Riehl 2009a, 112).

To some extent, these findings were later confirmed by stable isotope analyses conducted on botanical remains (Riehl *et al.* 2014). More than a thousand samples from 33 archaeological and 13 modern sites were analyzed for changes in the values of δ^{13}C, which acts as a drought-stress signal due to reduced rainfall during the grain-filling period within the plant growing cycle (Riehl *et al.* 2014, 12348). Very high levels of water supply were recognized by the authors for the early and mid-Holocene periods, with considerably higher precipitation rates than today, a finding which is consistent with that of other palaeoclimatic proxy analyses. More importantly, though, climatic fluctuations were identified for the succeeding historical periods. A process of aridification was recognized to begin in the Early Bronze Age, continuously increasing before reaching its climax during the Middle Bronze Age. During the Late Bronze Age, however, variations in δ^{13}C indicate a series of more humid episodes, before the renewed onset of increased aridity during the Iron Age. The highest levels of drought stress, as indicated by the isotope values, occurred during the Middle Bronze Age, while both the Late Bronze and Iron Ages suffered less severely from increased aridity.

Isotopic analysis of archaeologically excavated botanical remains, therefore, has been able to reproduce and confirm many of the climatic and environmental patterns already observed in other types of environmental proxy data, including a significant drop in rainfall levels after the mid-Holocene, a continuous drying trend throughout the latter part of the Holocene, as well as variation and fluctuation of climatic stress over time and space. Yet, it should not be forgotten that archaeobotanical studies are affected by similar limitations as some of the palaeoenvironmental studies mentioned above. Most importantly, the dataset is highly dispersed and the distribution of archaeological sites that have provided samples shows severe gaps in the coverage of coastal Levantine and inland West-Central Syrian sites (**Fig. 4.3**). Only five sites are located within the study area and of these, only two, Tell Tweini and Tell Mishrifeh, are directly relevant to this study, as the samples from the other three date to the Neolithic, the Early Bronze, and the modern period,

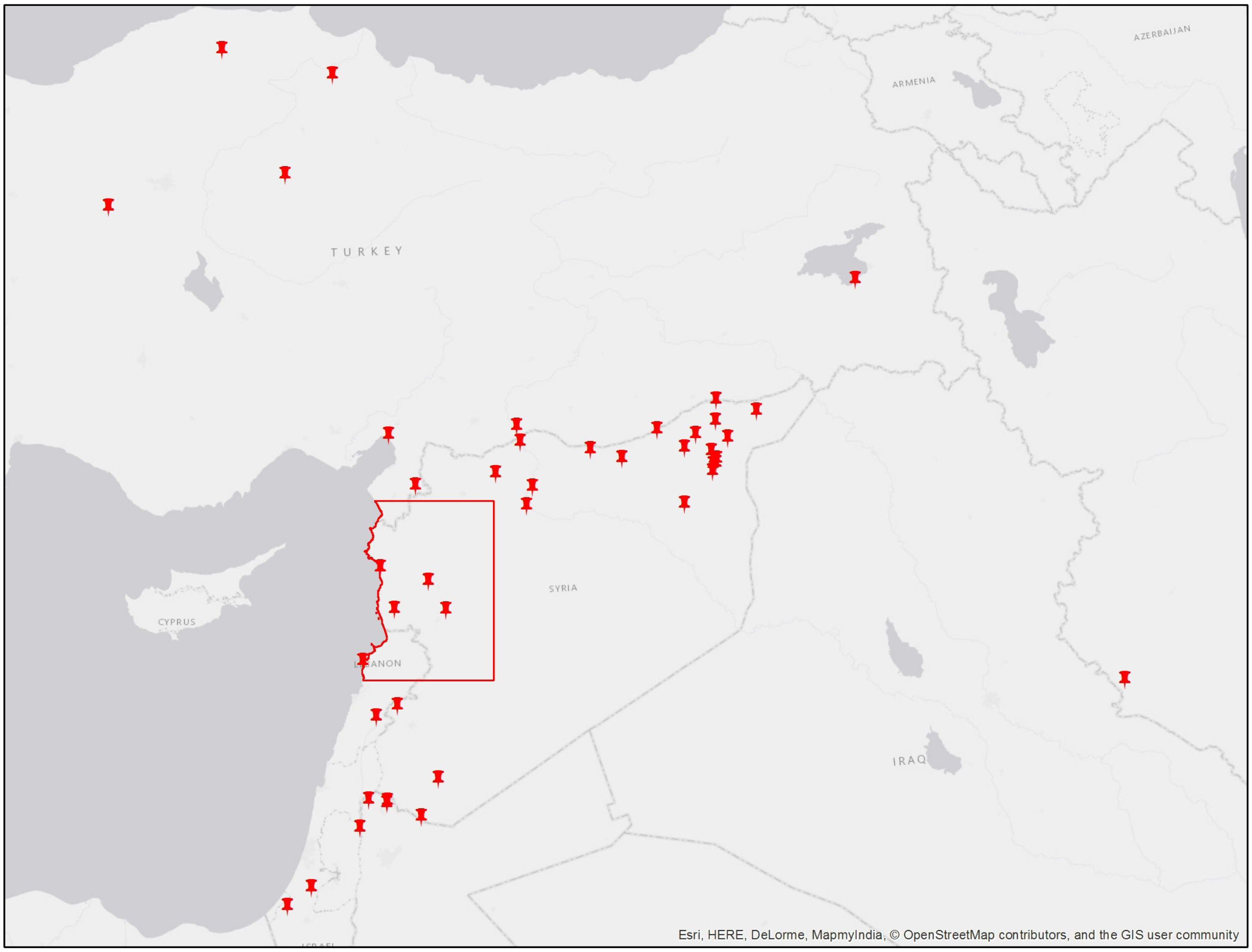

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Fig. 4.3: Distribution of archaeobotanical samples discussed in the text in relation to the study area.

respectively. Although Tell Mishrifeh has provided the highest quantities of botanical samples from a single location, around 140, the overwhelming majority of samples has been collected in Upper Mesopotamia, both in total number of specimen and number of sites sampled. Out of a total of some 1,037 isotope samples, only 76 (ca. 7 %) are dated to the Late Bronze and 152 (ca. 15 %) are dated to the Iron Age.[62]

Another issue that has so far severely hampered a comprehensive reconstruction of climatic and environmental changes in the Near East concerns the oftentimes different time spans these studies cover, as well as their main periods of interest.[63] Several studies, particularly those that have produced long series of uninterrupted climate records, have tended to focus on the earliest recorded

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[62] In a recent dissertation (Smith 2005), similar archaeobotanical analyses were carried out to investigate ancient agricultural practices and changes therein through time and space. The analysis relies on 99 new samples from Tell Qarqur in addition to the published materials from 59 sites dispersed across the entire Levant. The study is able to identify clear differences in strategies of crop production and plant use, reflecting differences in local economic systems and in regional climatic and environmental contexts. However, as the study compares two non-consecutive chronological periods, the Early Bronze and the Iron Age, no inferences about short-term climatic change, especially during the Late Bronze/Iron Age can be made. This highlights a recurring problem, that is the lack of available data specifically focusing on the transition from the Late Bronze to the Iron Age.

[63] These issues are also acknowledged by Riehl *et al.* (2009b) in the context of archaeobotanical analyses. To alleviate this issue, they propose to focus on a comparison of a narrow range of main crop plants to be able to make generalized statements about regional and global environmental changes. While this approach works for botanical samples, it is probably much more complicated in cases where other types of palaeoclimatic proxies are studied. It would have to be proven that isotopic composition of, for example, cave speleothems and land snails, are in fact comparable and not differentially affected by environmental factors.

instances of dramatic climatic change, for example the transition from the Pleistocene to the Holocene, or similarly marked events (cf., Finné *et al.* 2011). Thus, the currently available palaeoclimatic and -environmental data, while marking a significant step towards the analysis of the effects of climate change on agricultural regimes and social systems, does not provide adequate data on West-Central Syria in the Late Bronze and Iron Ages. Often, the data discussed pertain only to very early periods of human history, or utilize resolutions and time scales that do not afford sufficient detail on small time intervals relevant to archaeological research in historical periods, for example individual centuries. Consequently, they are of little use in trying to reconstruct climatic change during the 2nd and 1st millennia BCE, as intended here.

And even in cases where data on this period exist or have been specifically studied, there are often issues of resolution involved that make a comparison between different datasets difficult. Already Enzel *et al.* (2003, 263) lamented a severe lack in "[...] independent, age constrained, high-resolution records of Near East Holocene climates [...]." Indeed, this lack of high-resolution data has had a significant impact on earlier environmental reconstructions, as low-resolution records masked many significant, yet short-lived and less prominent, fluctuations within climates, effectively creating the false impression of a relatively uneventful climate history throughout the Holocene (Schilman *et al.* 2001, 158). This, of course, contrasts with the quite volatile, unstable, and short-lived climatic phenomena that are now thought to characterize much of the late Holocene, particularly the Bronze Age (Bar-Matthews *et al.* 1999; Issar and Zohar 2007; Kaniewski *et al.* 2008; Mayewski *et al.* 2004; Schilman *et al.* 2001; Staubwasser *et al.* 2003; Staubwasser and Weiss 2006). To complicate things even further, the dividing line between purely natural causes for climatic change and the effects of anthropogenic alterations to the natural environment tend to become increasingly blurred in the later Holocene (Rambeau and Black 2011, 94), making it more and more difficult to clearly identify instances of dramatic climatic change, as opposed to the degradation and destruction of the landscape through human occupation and exploitation.

Notwithstanding these differences in resolution and scope of the data, shortcomings in analytical methodology, or the differences in interpretations drawn from the data, there have been several attempts to relate palaeoclimatic patterns observed in the proxy data to instances of social, political, or cultural change identified in the archaeological record (see, Chapters 2 and 3). In many instances, however, there is no clear-cut methodology, with which climatic proxy data and archaeological evidence can be related to each other. Cultural transformations are interpreted as caused by climatic change, based on isochronisms between the observed phenomena. In this regard, changes in Dead Sea levels have been associated with episodes of socio-cultural transformation (Bookman [Ken-Tor] *et al.* 2004; Enzel *et al.* 2003), as have other climatic events (deMenocal 2001; Migowski *et al.* 2006). In some rare instances, a direct link has even been proposed between climatic changes and the migration of (presumably) historically attested population groups, such as the Sea Peoples (Kaniewski *et al.* 2013). Another approach has been to compare the development of settlement patterns, including settlement sizes and aggregated settlement areas, to patterns of climatic change observed in the palaeoclimatic proxy record of Soreq Cave and Lake Van (Lawrence *et al.* 2016).

Although such comparisons often yield interesting results, for example the observation that a divergence of settlement trends and environmental conditions can be observed in the Near East after ca. 2000 BCE (Lawrence *et al.* 2016, 11), it actually remains to be proven that climatic and environmental changes did indeed cause, or at least contribute to, changes in social structure (cf., Kuniholm 1990).

4.3.2 Palaeoclimatic Modeling in the Eastern Mediterranean

In a few instances, scholars have attempted to use computer models to analyze past climates and environments in the Eastern Mediterranean, along with their effects on human societies. These approaches, however, rely on the availability of appropriate climate models, which have only recently become available. Hence, only a select few studies have attempted to make use of these models and approaches.

One notable study is the one conducted by Soto-Berelov *et al.* (2005), in which the authors study the effects of major droughts and vegetation changes on the social development in the Bronze Age Southern Levant. By combining topographical, geological, and climatic parameters in a modeling environment, the authors investigate changes within the vegetational regimes of the Southern Levant during a 2,500-year period, between 5,500 and 3,000 BP. Analyzing the relationship between environmental parameters and vegetational changes, the authors suggest that major shifts occurred in the distribution of certain plant regimes, and that these changes were significantly correlated with fluctuations in mean annual precipitation volumes (Soto-Berelov *et al.* 2005, 106-107). In this instance, predictive environmental modeling of plant regions is used to investigate the underlying causes of social changes, primarily the recession of urban life at the end of the Early Bronze Age, observed in the archaeological record.

Whereas Soto-Berelov and colleagues made use of the Macrophysical Climate Model (MCM), a climatological model capable of estimating past climatic parameters on a fairly small local scale (see below, **§4.3.3**), other attempts have been made to utilize some of the many complex global climatological models that have been developed over the past couple of years. For example, Brayshaw *et al.* (2011) created a series of time-slice climate simulations for the past 12,000 years. For each of the modeled time-slices, which are separated by two-millennia intervals, environmental responses to specific changes within global climate forcings, such as solar radiation, green-house-gas emissions, and ice sheet cover, were analyzed with the HadSM3 model. Based on the model outcome, the authors argue that the Mediterranean, and particularly the Levant, experienced high levels of rainfall during the early Holocene, followed by a pronounced drying trend in the middle and late Holocene, again followed by a gradual recovery of rainfall levels during the pre-industrial period (Brayshaw *et al.* 2011, 45).

In a different approach, Black *et al.* (2011) combined information from topographical models with rain gauge measurements. These data were integrated with climatic simulations carried out with the HadSM3 model and five time-slices between 12,000 and 2,000 BP were analyzed and the results compared to the palaeoenvironmental proxy record. Both environmental modeling and proxy analysis register a general, long-term drying trend throughout the Holocene, leading the authors to conclude that Regional Climate Models (RCMs), such as the one employed in this instance, are generally capable of replicating patterns of climatic change observed in the actual record (Black *et al.* 2011, 108-111).

These studies show how global climate models, primarily employed to investigate and predict future climate change, can be used in archaeological and palaeoenvironmental research. By now, there exist various projects dedicated to collecting, coordinating, synthesizing, and evaluating the different climatological modeling efforts conducted within the past few decades. Of these, the *Paleoclimate Modelling Intercomparison Project* (PMIP3) and the *Coupled Model Intercomparison Project* (CMIP5) are the most widely known, providing a platform to coordinate model experiments and compare the output data of different climatological model applications.

The development of PMIP dates back to the 1980s, originating from two parallel projects focusing on modeling climatic change. Its specific aim was to provide a platform by which palaeoclimatic modeling efforts could be coordinated, different models checked, and the mechanisms of climate change investigated (Braconnot *et al.* 2012). While the first incarnation of PMIP concentrated on General Circulation Models (GCMs) for atmospheric variables only, PMIP2 introduced additional models for ocean-atmosphere and ocean-atmosphere-vegetation interactions as well. The current installment, PMIP3, offers the full range of experiments established by CMIP5, a platform for the coordination of twenty different climate modeling groups with a total of more than fifty different climatic models (Taylor *et al.* 2012), in addition to several time steps not included within the CMIP5 routine. Overall, PMIP3 offers palaeoclimatic modeling standards for five distinct time steps, including the mid-Pliocene (ca. 3.3-3 mya), the Last Interglacial (ca. 125 kya), the Last Glacial Maximum (ca. 21 kya), the mid-Holocene (ca. 6 kya), and the last millennium (ca. 800 AD to present) (Braconnot *et al.* 2012, 422). Within the PMIP3 experiment setup, particular focus is given to climatic sensitivity, that is, global temperature variability as an effect of differential concentrations of carbon dioxide in the atmosphere (Braconnot *et al.* 2012, 421).

A similar approach was taken by CMIP5. Again, one of CMIP's primary aims is to provide common standards and experimental procedures, with which different models and differences in their output can be compared (Taylor *et al.* 2012, 485). In contrast to PMIP, however, CMIP experimental design focuses on the evolution of the climate in the 21st century CE and only includes simulations on the Last Glacial Maximum, the mid-Holocene, and the last millennium (Braconnot *et al.* 2012, 417). In general, CMIP climate simulations use two basic types of model scales, either long term (centuries) or near-term (10-30 years; also known as 'decadal'). Long-term simulations are generally based on pre-industrial environmental conditions, whereas short-term models utilize a range of observed environmental factors (Taylor *et al.* 2012, 487). In both cases, atmosphere-ocean global climate models provide the standard for all modeling processes, although full-scale Earth System Models (ESMs), integrating biochemical components for a complete carbon cycle, exist as well (Taylor *et al.* 2012). The inclusion of many different modeling groups and an even higher number of individual climate simulation frameworks means that CMIP5 models together cover an enormous 421 different atmospheric, oceanic, and terrestrial parameters which can be sampled at an annual, monthly, daily, or even hourly time scale, depending on the model used (Taylor *et al.* 2012, 491).

However, this discussion also highlights one of the major constraints imposed by these climatological models, both within the CMIP5 and PMIP3 environments. All of the available models concentrate primarily on episodes of extreme and easily identifiable climate change on a global scale, but are quite inadequate when it comes to modeling the comparatively small differences and fluctuations that have characterized local climates of the past approximately 6,000 years (Black *et al.* 2011), especially since most of the late Holocene is completely omitted from the simulation timeframe. Their coarse spatial resolution also makes them of rather limited use for archaeological problems, as modeling and comparison on a sub-continental scale is rather difficult.[64] Furthermore, studies that have used some of the CMIP/PMIP models have experienced inconsistent results when attempting to analyze mid-Holocene climate change, calling the utility of these models into

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[64] Black (2009) notes that most global climate models operate on a scale of approximately 2.5° of horizontal resolution, that is, around 280 km at the equator. This scale, however, is completely inadequate when attempting to model climatic change in a topographically diverse region, such as West-Central Syria (Black 2009, 193). Even when the detail of the data is significantly enhanced through post-processing operations, model resolutions are still in the range of 40-50 km (Black 2009; Brayshaw *et al.* 2011).

question (Black *et al.* 2011, 105). These inconsistencies are most probably caused by differences in the structures and underlying assumptions that characterize each individual model, as well as the specific range of environmental parameters considered in the different models.

4.3.3 The Macrophysical Climate Model (MCM)

Due to these data and model limitations, it was decided to follow a different approach to modeling past climatic variables in Late Bronze and Iron Age West-Central Syria. The Macrophysical Climate Model (MCM) offers a viable alternative to both proxy data and continental-scale climatological simulations. The MCM, developed by meteorologists at the University of Wisconsin-Madison since the 1990s, was conceived as an alternative to general circulation models (GCMs), whose large geographical and temporal scales make them less useful for the social sciences and other disciplines (Bryson and DeWall 2007, 3). General circulation models, which are widely used in climatological research, are complex models that use a bottom-up approach, which means that processes are modeled at a macrophysical scale, which are then combined into a global simulation through iterative procedures (Bryson and Bryson 2000, 77). In contrast, the MCM uses a somewhat simpler approach in which large-scale global phenomena are used to estimate climatic patterns on a much smaller, local scale. Instead of using weather phenomena to infer climatic conditions, the MCM first establishes the general boundary conditions which determine individual weather patterns and uses these to reconstruct local conditions (Bryson and Bryson 2000; Bryson and DeWall 2007). These boundary conditions are determined by so-called 'centers of action,' which include subtropical highs, the jet stream, or the Intertropical Convergence (ITC; also called Intertropical Convergence Zone [ITCZ]). Based on the assumption that basic

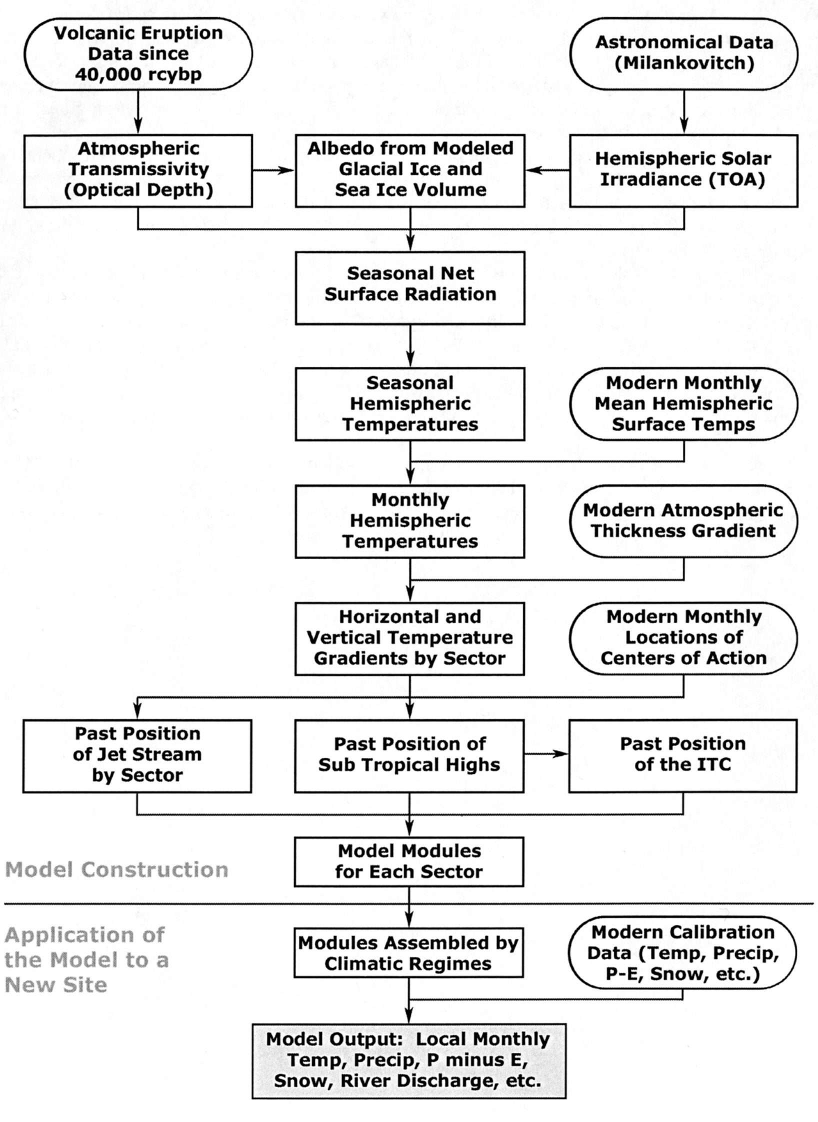

Fig. 4.4: Overview over the Macrophysical Climate Model components (Bryson and DeWall 2007, fig. 1.2).

atmospheric physics, that is, the relationships between these centers of action, the topography, and monthly weather variables (i.e., temperature or precipitation) have not changed since the late Pleistocene, past monthly weather patterns can be calculated from the modeled positions of these centers of action (Bryson and DeWall 2007, 4). Although it might be argued that such an approach is not as accurate as the more complex GCMs, one advantage of the MCM is that it does not require expensive, specialized hardware and software to run.

Similar to other climatological simulations, the MCM consists of several individual modules and components which together make up the complete model. Atmospheric parameters, such as volcanic aerosols and solar irradiance, are used to model parameters like surface radiation, temperature, and the position of action centers in a step-by-step approach, which are combined into site-specific models applicable to certain geographic zones (**Fig. 4.4**).[65] Using modern calibration data, each model can be used to calculate monthly temperatures, precipitation, evapotranspiration, snow cover, or river discharge for any location of interest (Bryson and DeWall 2007, 3-10). Due to these characteristics, the MCM is "[...] in essence, a heat-budget model predicated on orbital forcing, variations in atmospheric transparency, and the principles of synoptic climatology" (Bryson and DeWall 2007, 6).

In a comparison of four different climatological models, Ruter *et al.* (2004) conclude that the accuracy of the MCM is generally comparable to that of many GMCs, although some differences exist. However, compared to the more complex, global GCMs, the MCM offers several benefits, such as high temporal and spatial resolution, including the ability to model climatic variation at the century scale and for specific sites of interest, easy comparability in relation to actual field data, and user-friendliness without the need for expensive equipment (cf., Bryson and DeWall 2007; Ruter *et al.* 2004). And given that solar variability has been recognized as one of the most important forcing mechanisms in paleoclimates (Mayewski *et al.* 2004; Staubwasser *et al.* 2003), it can be suggested that the MCM, which assigns special importance to solar irradiance and its variability, constitutes an adequate tool to model palaeoclimatic variability during the Holocene.

Of course, Bryson's MCM is not unopposed within the scientific community. One of its main problems is the exclusive reliance on only two climatic variables, volcanism and orbital forcings, thus utilizing a reduced set of variables when compared to other climatological models (Arıkan 2015, 161; cf., Bryson and DeWall 2007). Furthermore, the exact parameters of the regressions on which the model is based are essentially unknown and unavailable for further analysis and evaluation, making the MCM modeling parameters a kind of 'black box' (Arıkan 2015, 162). Since the model has not been further developed to address these issues, and the modeling parameters have not been made public, the MCM has not been fully accepted by the community of climate scientists and its main area of application remains archaeological research (Riehl, pers. com.). However, it should be noted that the results of the MCM have repeatedly been compared to the results of other palaeoclimatic models, somewhat mitigating the lack of statistical parameters to accurately assess the modeling procedures and results (Arıkan 2015, 162).

Especially its ability to model climatic variables at small scales makes the MCM particularly useful for archaeological studies of climate change and social adaptation. The model has been used to simulate ancient precipitation patterns for eastern and central Anatolia (Arıkan 2012, 2014, 2015; Arıkan *et al.* 2016; White 2014), the Wadi al-Hasa in Jordan (Arıkan 2011; Barton *et al.* 2010b), or

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[65] These geographical zones are called 'climatic regimes,' of which there are twelve in total. Each climatic regime's model consists of four to six modules that are specific to that particular regime. In the case of West-Central Syria, the model for Europe and Central Asia has to be used.

the Southern Levant (Soto-Berelov *et al.* 2005). Where modeled climatic data was checked against data recovered from palaeoenvironmental studies, a high degree of correspondence between simulated and observed values or trends could be recognized (Arıkan 2015; Arıkan *et al.* 2016; Barton *et al.* 2010b).

Hence, it was decided to utilize the MCM for the present study. Required modern input values were acquired through the Food and Agriculture Organization of the United Nations (FAO), which maintains a database of weather stations around the world. The data were downloaded through the FAOClim Agroclimatic Database (FAO 2001), a global database of some 30,000 weather stations recording a variety of climatic parameters. The data for 54 stations located within or in close proximity to the study area, 48 from Western Syria and six from Northern Lebanon, were downloaded. The data acquired include 14 different parameters, most importantly values for monthly mean, maximum, and minimum temperature and mean monthly precipitation, but also additional data such as evaporation or wind speed, among others (**Appendix 2**). However, the data recorded at these stations differ in their comprehensiveness. The complete range of parameters, most importantly precipitation, temperature, and evaporation, was included only for 23 of these stations, whereas the remaining ones only provide records of temperature and/or precipitation. The data were downloaded as time series, that is, as monthly and annual averages during the climate normal (1961-1990), according to the requirements of the MCM (Bryson and DeWall 2007).

Using these values, the statistical regressions of the MCM were used to calculate monthly precipitation and temperature means at 100-year intervals until 16,000 BP. Where possible, evaporation was calculated in the same way. The output of the MCM model consists of time-series tables, as well as graphs for each variable (**Appendix 3**), along with statistical data on the accuracy of the regression and the correspondence between observed and calculated values. The data show a quite complex and variable evolution of the three climatic parameters over the past several millennia. In general, it can be observed from the graphs that the late Holocene was characterized by significant volatility in temperature, precipitation, and evaporation, including the period analyzed here. Furthermore, the model output data suggests that these fluctuations did not occur uniformly and geographical differences are clearly observable. Furthermore, the data suggest that discrepancies existed between different seasons. For example, it can be observed in several instances that winter and summer temperatures and precipitation levels developed along diverging trends, rather than showing a simple, uniform progression in one direction. These differences, it might be suggested, are significant and will be discussed and analyzed further later.

4.3.4 Climate Surface Interpolation

The MCM was used to calculate precipitation, evaporation, and temperature values for the time period used here. Seven consecutive 100-year time intervals, from 1350 BCE to 750 BCE, were modeled, thus spanning the Late Bronze, the Iron Age I, and most of the Iron Age II period, according to Mazzoni's (2000c) well-known chronological scheme. MCM output values were then linked to the geographical point data of the FAO weather stations (**Fig. 4.5**) and then used to interpolate continuous surfaces for each of the five time slices.

Theoretically, several interpolation methods are available in GIS to generate continuous surfaces from point data. They can broadly be categorized into deterministic models (e.g., average distance, Thiessen polygons, Inverse Distance Weighting, Spline), and geostatistical models (e.g., Kriging, polynomial regression trend surface) (Hartkamp *et al.* 1999; Keblouti *et al.* 2012; Mair and Fares 2011). Methods of the first family are relatively simple and base their measurements primarily on the values of surrounding points. The latter family contains methods that rely on statistical models, for example spatial autocorrelation, to evaluate the relationships between different points.[66]

Precipitation, temperature, and evaporation values were interpolated for the entire study area. As not all climate stations included records for each of the three variables, surfaces were interpolated using a different number of points. One of the stations, Safita (CS45), had to be entirely eliminated from the sample, since precipitation values calculated by the MCM were either zero or even negative, and therefore not usable as model input. The remaining 53 stations provided 53 precipitation records, 28 temperature records, and 25 records for evaporation.

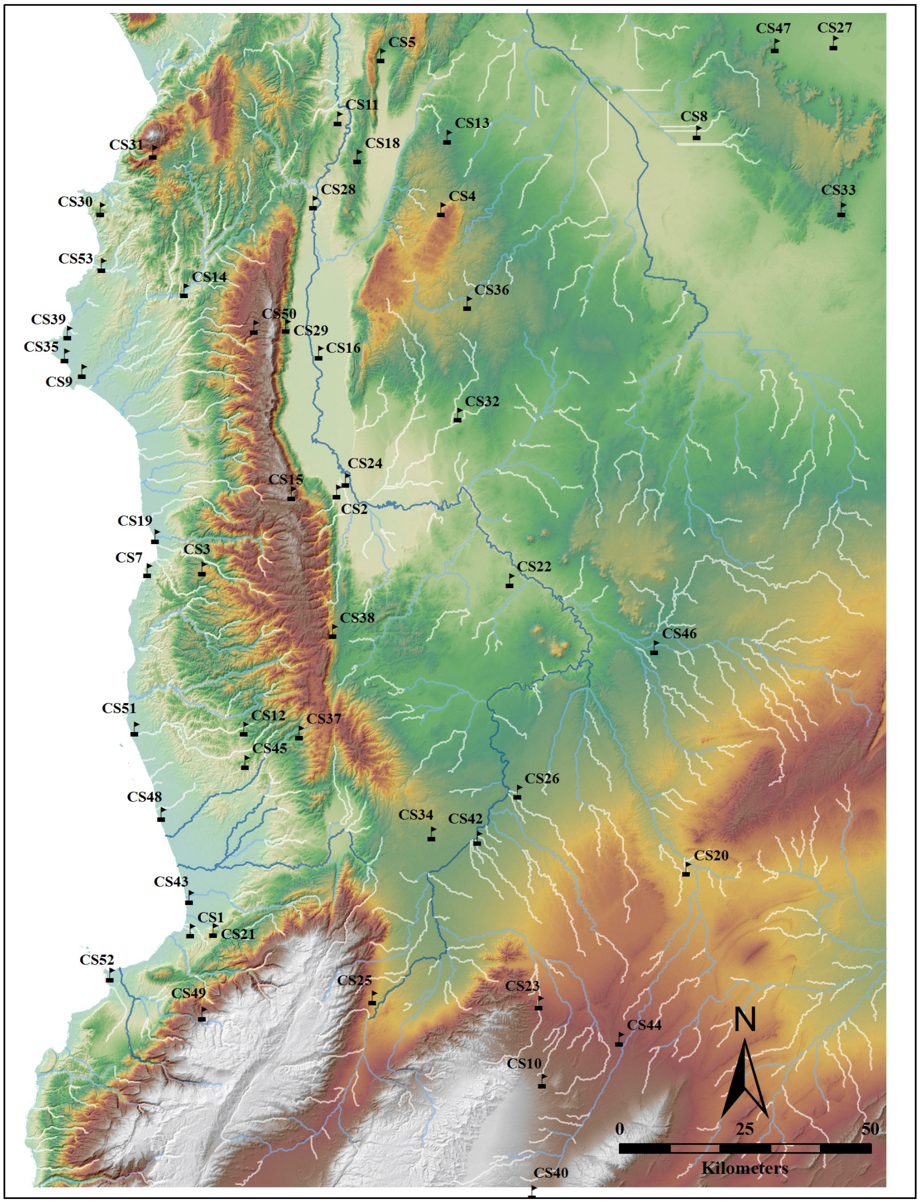

Fig. 4.5: Distribution of FAO climate stations within West-Central Syria.

For interpolation, Spline Interpolation with Tension was used. This method uses a mathematical function to minimize surface curvature, which is defined as

$$S_{(x,\,y)} = T_{(x,\,y)} + \sum_{j=1}^{N} \lambda_j \, R(r_j)$$

with N being the number of points, λ_j are coefficients of linear equation, and r_j is the distance from a point to another point at location j, whereas T and R differ depending on what type of spline in-

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[66] While some researchers have suggested that geostatistical interpolation methods produce more accurate results for the interpolation of climate data (e.g., Goovaerts 2000; Hartkamp *et al.* 1999; Mair and Fares 2011; Naoum and Tsanis 2004; Taesombat and Sriwongsitanon 2009), others have favored deterministic methods, such as Inverse Distance Weighted (IDW) interpolation (e.g., Keblouti *et al.* 2012; Noori *et al.* 2014). One deterministic method in particular, Spline Interpolation, has become particularly popular for climate surface interpolation and has consequently been applied in several studies (Hofierka *et al.* 2002; Mitáš and Mitášová 1988; Mitášová and Mitaš 1993; Rehfeldt 2006). Lately, they have also been successfully employed in archaeological applications of climate interpolation (e.g., Arıkan 2014).

terpolation is used (Franke 1982; Mitáš and Mitášová 1988). For spline interpolation with tension, which is used here, *T(x,y) = a1*, where *a1* is a coefficient that results from the solution of linear equations, whereas *R* is defined as

$$R(r) = -\frac{1}{2\pi\varphi^2}\left[\ln\frac{r\varphi}{2} + c + K_0\,(r\varphi)\right]$$

with *r* being the distance between point and sample, *φ2* the weight parameter, *K0* the modified Bessel function, and *c* a constant with the value of 0.577215 (Franke 1982; Mitáš and Mitášová 1988).

The advantage of using this interpolation technique is that it minimizes surface curvature and thus produces smooth surfaces that incorporate every single input value (Arun 2013). The stiffness of the surface, the thin plate, is reduced by introducing first-derivative terms into the equation, the influence of which is determined by the weight parameter, φ^2. A higher weight parameter results in a less rigid plate that is made to intersect with the input data points, but also results in slightly coarser output surfaces (Mitášová and Mitaš 1993). Spline interpolation with tension is commonly used for phenomena that exhibit gradual variation, such as climatic phenomena, and this method has been proven to perform well in topographically heterogeneous regions (Hofierka *et al.* 2002), making it particularly suitable for a variegated study area such as West-Central Syria.

4.3.5 Comparison of Climate Models

To illustrate the differences between the different climate models, mid-Holocene data from two models of the CMIP/PMIP modeling family were acquired as well. Output data for these two models, the CNRM-CM5 and HadGem2-ES models, were acquired free of charge through the *WorldClim* website (www.worldclim.org) at a spatial resolution of 30 arc-seconds (ca. 1 km).[67]

Both models consist of several modeling components for a variety of atmospheric, terrestrial, and oceanic parameters. In the case of the HadGem2 model, these include the troposphere, land surface, hydrology, stratospheric aerosols, ocean and sea ice, the terrestrial carbon cycle, and oceanic biochemistry (Jones *et al.* 2011; Martin 2011). Whereas the HadGem2 is classified as a true Earth System Model (ESM), primarily due to the inclusion of the carbon cycle, the CNRM is categorized as a General Circulation Model (GCM). Both models, albeit primarily focusing on current climates and future climatic predictions, are capable of carrying out Last Glacial Maximum, mid-Holocene, and last millennium simulations, as required by the CMIP5 procedures (Jones *et al.* 2011; Voldoire *et al.* 2013). Both models are calibrated through a control run using historical parameters from the mid-19th century CE (Jones *et al.* 2011).

For both models, raster files containing mean monthly precipitation values were integrated into the GIS. For each model, the raster files were combined in order to calculate mean annual values that can be compared with the modeling output from the MCM. The resulting files thus represent mean annual precipitation during the mid-Holocene (ca. 6,000 BP), as modeled by the CNRM-CM5 and HadGEM2-ES models.

Comparison was carried out through statistical analysis. A set of 200 randomly distributed sampling points were generated for the study area. For each point location, the values for each of the three model outputs were extracted from the rasters and appended to the point data. For the MCM, the model values for 1250 BCE were used in the comparison (**Fig. 4.6**; **Appendix 4**).

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[67] The procedures used to reach this level of resolution, which involve calibration through the use of climate data from weather stations and interpolation algorithms, are described in detail in Hijmans *et al.* (2005).

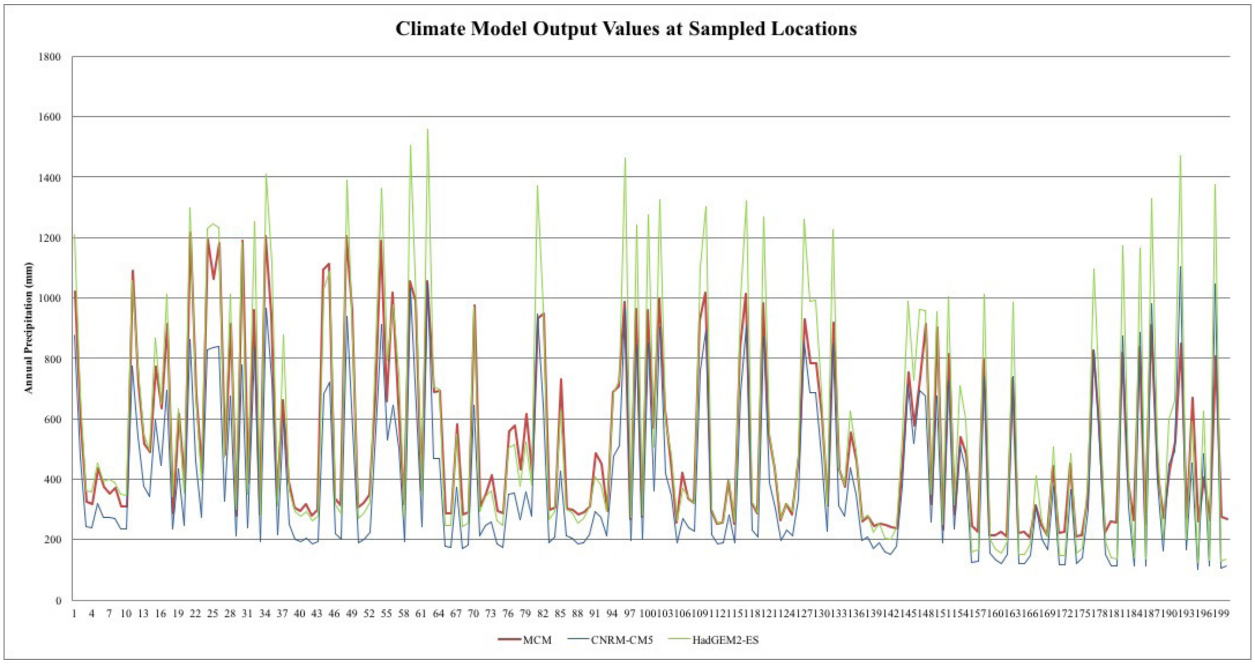

Fig. 4.6: Annual precipitation values at sampling locations.

Some differences, but also some similarities, between the three models are easily perceptible. Overall, it can be observed that the values for all three models follow the same general geographical pattern, that is, peaks and troughs appear at the same locations. This suggests that the three data outputs, despite differences in amplitude, essentially attest to the same general geographical trends within the modeled data.

However, it can also be seen that the three models return oftentimes quite different values at the same locations. The CNRM-CM5 consistently returns very low values when compared with the other two models, both in areas where values peak, as well as in the region where low values prevail. These differences are quite significant and can be as high as 410 mm, as is the case at point CS44 on the northern coast. Conversely, the HadGEM2 returns rather high values, especially in peak areas. The MCM apparently occupies a middle ground between the two.

These findings are also confirmed by statistical analysis (**Tab. 4.1**). Precipitation values modeled by the CNRM are characterized by low minimum, low maximum, and low mean values. It also has the lowest standard deviation of all three models, indicating that its values are clustered fairly close together. In contrast, the HadGEM has both the highest maximum value, as well as the highest mean value, indicating that it tends to return very high precipitation values. In addition, the HadGEM is characterized by the highest standard deviation, indicating that its values are spread over a wider range than the other models.

	MCM	**CNRM-CM5**	**HadGEM2-ES**
Minimum	208.42	103	126
Maximum	1215.25	1103	1558
Mean	524.85	403.88	573.89
Standard Deviation	290.94	265.77	389.37

Tab. 4.1: Summary statistics for climate model values.

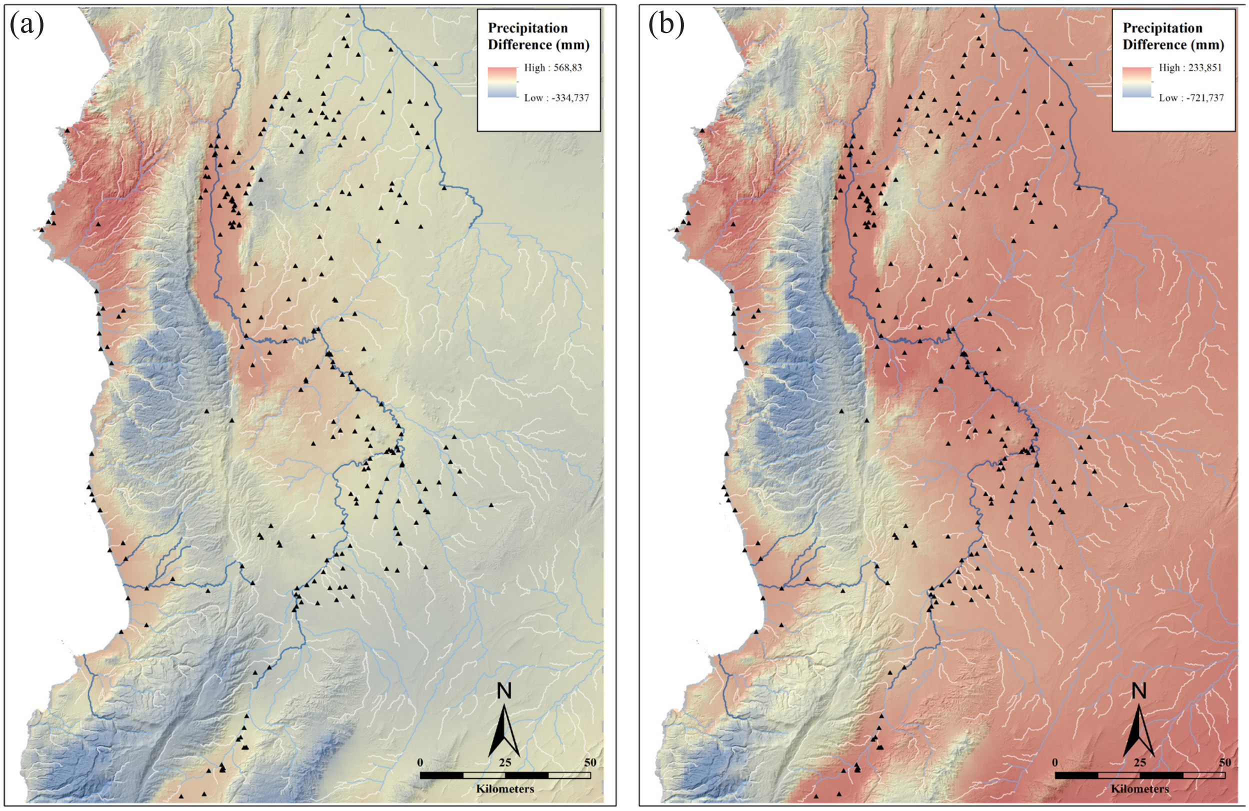

Fig. 4.7: Differences in annual precipitation values between (a) MCM and CNRM-CM5, and (b) MCM and HadGEM2-ES.

The geographic distribution of these differences is quite telling. Differences were calculated by subtracting the values of either the HadGEM or the CNRM from those computed by the MCM (**Fig. 4.7**). In both cases, red colors denote a positive difference in precipitation values, meaning that the CNRM or the HadGEM2 model drier conditions in these areas, whereas blue colors denote regions where the two models return higher precipitation values, that is, model more moist conditions.

In the case of the CNRM, significantly drier conditions are modeled along the coast, especially in the north. Drier conditions are also predicted for the Ghab Valley and parts of the Middle Orontes Valley, whereas values roughly similar to those of the MCM are modeled for inland areas. The HadGEM, on the other hand, consistently models considerably drier conditions across the entire region. Areas of extreme dryness exist on the northern coast, in the Ghab Valley, and in areas of the Orontes river and the far south-eastern corner of the study area. In both instances, however, considerably wetter conditions are modeled for large portions of the coastal mountain ranges.

Not surprisingly, the choice of an appropriate climatological model, thus, constitutes an important aspect of environmental modeling and has significant ramifications for the modeling results. Of course, the CNRM and the HadGEM, both of which model mid-Holocene conditions, cannot be used to analyze late-Holocene contexts, as has been discussed above. Comparison and analysis of the three models suggests that severe differences in modeled climatic parameters exist. These differences, both in their magnitude and their spatial patterning, strongly suggest that the use of an appropriate, period-specific climatological model is an integral aspect of modeling and analyzing past environments. Notwithstanding its limitations, the MCM, with its ability to model century-scale time intervals at geographically small scales, constitutes the most feasible tool with which climatic parameters in Late Bronze and Iron Age West-Central Syria can be modeled.

4.4 TOPOGRAPHICAL DATA

Topographical factors constitute a major element of the natural environment and influence human behavior by restricting social interactions, for example movement or visibility. In addition, topographical variables have been recognized as having a major influence on agricultural practices and crop husbandry strategies. As such, landscape features such as terrain elevation and slope constitute an important aspect in modeling socio-natural interactions and an integral part of the material required to develop an environmental model with which these interactions can be scrutinized.

4.4.1 Acquisition of Digital Elevation Model (DEM) Data

Although there exist a variety of historical topographic maps of the study area, such as the ones created in the 20th century CE by the British and German militaries (Great Britain 1924; Heer 1942),[68] software requirements and time constraints make their digitization and integration into the GIS extremely labor intensive and prohibitive (Conolly and Lake 2008, 103-107; Harrower 2010, 1148). Therefore, digital topographical data, primarily derived from satellite instruments, were used instead.

Four different Digital Elevation Models (DEMs) were acquired free of charge through the *Earth-Explorer* website (earthexplorer.usgs.org) of the United States Geological Survey (USGS) and integrated into the GIS. Each of these datasets is characterized by variations in global coverage, spacing of data postings, horizontal and vertical accuracy, the number of individual datasets used to create the DEM, and the number of scenes (or tiles) necessary to cover the study area of this project (**Tab. 4.2**).[69]

The GTOPO30 dataset was developed in 1996 by the USGS (**Fig. 4.8: a**). It was compiled from eight different data sources, including Digital Terrain Elevation Data (DTED) provided by the National Geospatial-Intelligence Agency (NGA) and a variety of topographic maps at a scale of 1:1,000,000. It found wide application for hydrological, climatological, geomorphological, and military research on a scale ranging from regional to global, and offers a horizontal resolution of 30 arc-seconds for the entire global land surface between 90 °N and 90 °S (Danielson and Gesch 2011; Yastıklı *et al.* 2006). For two of its main components, the DTED and the USGS DEM, vertical accuracy is given as 30 m linear error at the 90 % confidence level, which corresponds to a Root Mean Square Error (RMSE) of 18 m (Yastıklı *et al.* 2006). However, due to the inclusion of a variety of different data sources in the model, there actually exist noticeable discrepancies in the data quality (Danielson and Gesch 2011). Accordingly, vertical accuracy of the GTOPO30 model

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[68] This is only a very short and incomplete list of existing topographic maps of West-Central Syria. Similar maps were also created by French, Soviet, and Syrian authorities at scales ranging between 1:10,000 and 1:5,000,000. For a complete list and discussion, see Mantellini *et al.* (2013).

[69] Global elevation datasets invariably include more-or-less severe errors which cannot be avoided (Alatawi and Abushandi 2015). For example, both ASTER and SRTM satellite data both register features other than the bare earth, such as buildings, trees, and other objects that protrude above ground level (Rexer and Hirt 2014). Usually, such issues can be addressed and mitigated against through ground trothing which, however, is currently not feasible given current access limitations to Syria. Therefore, at least for the time being, digital elevation data has to be used 'as is' and additional rectification and accuracy enhancement has to be postponed.

Dataset	Data Provider	Data Components	Coverage	Resolution	Scene IDs	Acquisition Date
SRTM 1arc-sec	NASA, NGA	SRTM	60°N - 56°S	1 arc-sec	n34e035_1arc_v3 n34e036_1arc_v3 n34e037_1arc_v3 n35e035_1arc_v3 n35e036_1arc_v3 n35e037_1arc_v3 n36e035_1arc_v3 n36e036_1arc_v3 n36e037_1arc_v3	06/13/2016
ASTER GDEM v2	NASA, METI	ASTER	80°N - 83°S	1 arc-sec	ASTGTM2_N34E035 ASTGTM2_N34E036 ASTGTM2_N34E037 ASTGTM2_N35E035	02/12/2015
GMTED2010 (7.5 arc-sec)	USGS, NGA	1: SRTM (DTED 2) 2: Antarctica satellite radar and laser altimeter DEM 3: DTED 1 4: CDED3 5: CDED1 6: Greenland satellite radar altimeter DEM 7: National Elevation Data - Alaska 8: SPOT 5 Reference 3D 9: GTOPO30 10: National Elevation Data 11: GEODATA 9-sec DEM v2	84°N - 56°S 84°N - 90°S	7.5 arc-sec	30n030e_20101117_gmted_mea075	06/07/2016
GTOPO30	USGS	1: DTED 2: DCW 3: USGS 1-degree DEM 4: Army Map Service 1:1,000,000 maps 5: International Map of the World 1:1,000,000 maps 6: Peru 1:1,000,000 map 7: New Zealand DEM 8: Antarctic Digital Database	90°N - 90°S	30 arc-sec	gt30e020n40	06/07/2016

Tab. 4.2: Overview over the different DEM datasets and their respective characteristics.

can vary considerably, with RMSE ranging from anywhere between 9 m and 304 m, according to the documentation file provided with the data download. One scene of GTOPO30 data was downloaded and clipped to fit the extent of the study area used here.

The Global Multi-Resolution Terrain Elevation Data 2010 (GMTED2010) model (**Fig. 4.8: b**) was developed by NASA and the NGA as a replacement for GTOPO30, made possible by the improved availability of modern, high-resolution data sets on a global scale (Danielson and Gesch 2011). GMTED2010, which is derived from a total of eleven individual sources, provides three different resolutions of 30-, 15-, and 7.5 arc-seconds, that is, 1 km, 500 m, and 250 m ground resolution at the equator, respectively (Danielson and Gesch 2011, 1-2). Most component datasets provide a global coverage between 84 °N and 56 °S, whereas some elements cover from 84 °N to 90 °S. Due to the patchwork character of the model, only the 30 arc-second data is available on a truly global scale (Danielson and Gesch 2011, 2). Raster- and control point-based accuracy assessment of GMTED2010 shows a RMSE of 25-42 m at 30 arc-seconds, 29-32 m at 15 arc-seconds, and 26-30 m at 7.5 arc-seconds, which constitutes a significant improvement over GTOPO30 data, with a combined global RSME of around 66 m (Danielson and Gesch 2011, 22). For this study, the 7.5 arc-second DEM was downloaded, as it offers the highest spatial resolution, and clipped to the study area.

One of the most widely known and used sources for topographic data is provided by the Shuttle Radar Topography Mission (SRTM), carried out by the Space Shuttle *Endeavor* in 2000 (**Fig. 4.8: c**). It constitutes the first near-global data set of land surfaces created entirely from remotely sensed data. The data was collected using an array of two radar antennas, C-band Spaceborne Imaging Radar (C-band) and the X-band Synthetic Aperture Radar (X-SAR), scanning the Earth's surface between 60 °N and 56 °S (Rexer and Hirt 2014, 215). The C-band antenna operated on 5.6 cm wavelength and covered a swath of 225 km on the ground, whereas the X-band used a 3 cm signal covering a 45 km swath. Data collected by the C-band antenna has an absolute vertical accuracy of 16 m, a relative vertical accuracy of 10 m, and a horizontal accuracy of 20 m at the 90 % confidence level. The X-SAR antenna, on the other hand, has 16 m absolute and 6m relative accuracy, again at the 90 % confidence level (Yastıklı *et al.* 2006). Since the completion of the mission, a variety of DEMs has been generated from the data, including 1-, 3-, and 30 arc-second versions (ca. 30 m, 90 m, and 1 km, respectively).[70] SRTM-data is available as a non-void filled product, with only minimal post-processing, and as void-filled data, where missing information has been added with the help of interpolation algorithms or additional elevation data from different sources. According to Rexer and Hirt (2014, 216), absolute vertical error of SRTM data is often below 9 m, attesting to its high accuracy. In the same study, SRTM elevations were compared against a large set of ground control points in Australia, suggesting an offset of around 2.7 m over bare ground (Rexer and Hirt 2014, 225). Lately, SRTM data has been used in a variety of capacities in archaeological studies (e.g., Barry 2014; Casana and Cothren 2008; Galiatsatos *et al.* 2008) oftentimes in order to validate other remotely sensed data or to fill in the voids of another DEM. For the present study, SRTM data with 1 arc-second resolution was downloaded in the form of six individual tiles, which were integrated into the GIS, combined into a mosaic, and clipped to the study area extent.

In 1999 NASA launched the *Terra* satellite, which carries the ASTER (Advanced Spaceborne Thermal Emission and Reflection Radiometer) instrument assembly (**Fig. 4.8: d**). Data collection started in 2000 with fourteen different bands, including visible light, near infrared, short-wave infrared, and thermal infrared. In 2009, the first version of the Global Digital Elevation Model (GDEM) was published by NASA and the Ministry of Economy, Trade, and Industry (METI) of Japan. A second version, the ASTER GDEM v2, followed in 2011. The original ASTER GDEM v1 provided coverage of land surfaces between 83 °N and 83 °S with horizontal postings spaced at 1 arc-second intervals, that is, around 30 m at the equator (Tachikawa *et al.* 2011, 3). The exact procedures by which ASTER data are extracted, validated, and compiled into a coherent topographic model are described by several studies (Chrysoulakis *et al.* 2003; Falkowski *et al.* 2005; Guha *et al.* 2014; Yastıklı *et al.* 2006). The initial assessment study (Team 2009) reported several issues and artifacts within the data, while independent studies estimated the effective ground resolution of GDEM v1 at 120 m (Crippen 2009; Tachikawa 2009). While GDEM v2 is based on the same data structure and postings, the inclusion of additional scenes and improvements to the data processing methods resulted in a significantly enhanced product (Tachikawa *et al.* 2011). Accu-

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[70] According to Rexer and Hirt (2014, 214), the data are provided by two different agencies, the USGS and the NGA. Each provider uses slightly different terminology for their products. Models provided by the USGS are usually simply denoted as SRTM, whereas NGA models are designated Digital Terrain Elevation Data (DTED). Ultimately, both SRTM and DTED are derived from the exact same data generated by the space shuttle mission.

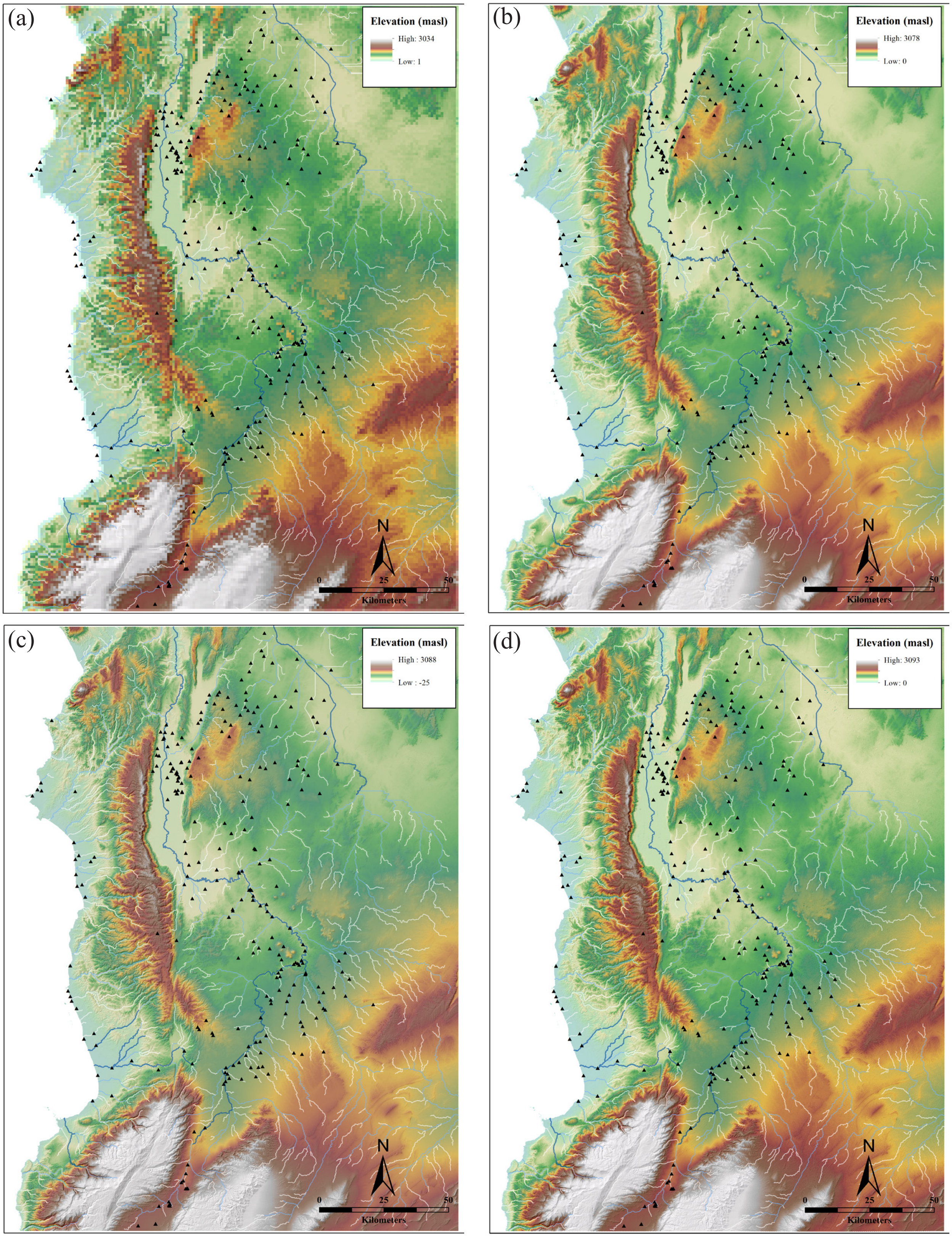

Fig. 4.8: Digital Elevation Models: (a) GTOPO30, (b) GMTED2010, (c) SRTM, (d) ASTER.

racy assessment studies, carried out by various teams in different regions of the world, suggest a horizontal resolution of around 70-82 m, as compared to the 114-121 m accuracy of GDEM v1, in addition to a significantly reduced RMSE of 8.68 m, compared to 9.34 m (Tachikawa *et al.* 2011, 21-23). Due to its high resolution, global coverage, and accessibility, ASTER has been recognized as a valuable resource for topographic studies, especially for the representation of terrain surfaces and the mapping of drainage networks (Alatawi and Abushandi 2015), disaster monitoring, hydrological modeling and analysis, or stereoscopic visualization (Arefi and Reinartz 2011). In addition, ASTER has also found wide application in archaeological studies (Altaweel 2005, 2008b; Arıkan 2010, 2011, 2015; Barry 2014; Barton *et al.* 2010a; Harrower 2010; White and Barber 2012).[71] For this study, a total of four ASTER GDEM v2 tiles were downloaded, combined into a mosaic, and clipped to the study area's extent.

4.4.2 Comparison of Digital Elevation Models

At first light, there does not appear to exist much difference in the four available Digital Elevation Models. Quite obviously, the coarser resolution of GTOPO30, at about 90 m compared to the 30 m of the other three, has an effect on the DEM and elevations are not represented with the same level of detail as is possible with higher-resolution data. But there are also less readily apparent differences between the four models. Each of the models is characterized by a different range of elevation levels, sometimes with significant differences. For example, both GMTED2010 and ASTER data are very close to each other, with GMTED values between 0 and 3,078 m, while ASTER values range between 0 and 3,093 m. The most apparent difference is observed in the SRTM dataset, which is the only one to include negative values, where elevations range between -25 and 3,088 m.

To investigate these differences further and, more importantly, in a statistically more robust way, a systematic sampling strategy was employed. As before, a (different) set of 200 randomly placed sample points was generated for the study area and the elevation values at these locations for all four of the DEMs were extracted and appended to these points (**Appendix 4**). A minimum distance of 1,000 m between points was specified to achieve better spatial coverage and minimize clustering. The sampling points are well distributed throughout the study area, covering the entire range of topographic zones. Thus, the sample values extracted from these points do cover regions of both intense settlement activity and those where no settlement activity has been recorded so far.

Comparing the four different datasets through a plot of the elevation values at each sampling location, several similarities and differences between the DEMs can be highlighted **(Fig. 4.9**). Overall, there appears to exist a reasonable fit between the data. For the most part, the graphs exhibit the same general trends and patterns. However, in several instances, there also exist some significant differences between the elevation values recorded. For example, for GTOPO30 the elevation value of point TC3 is recorded as 390 m, about 100 m lower than for the other three models. On the other hand, point TC36 has a value of 388 m, which is more than 200 m higher than the values for the other three models. In several instances, the three more modern datasets, particularly GMTED and SRTM record quite high values, resulting in easily identifiable peaks within the chart. Quite often, the values recorded for the SRTM dataset appear to occupy sort of a middle ground when compared to the others.

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[71] Harrower (2010) also discusses a methodology to extract elevation data at higher resolutions, at ca. 15 m, from ASTER imagery. His methodology, however, requires the use of accurate ground control points and is therefore not feasible in the context of this study.

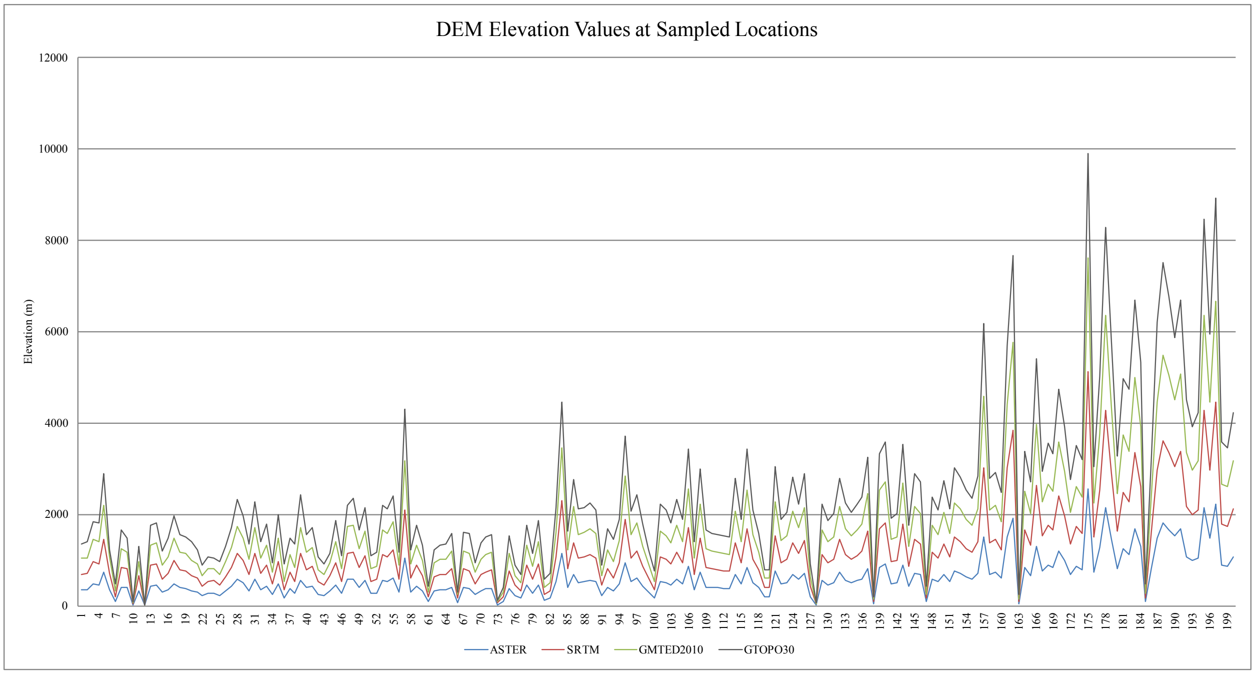

Fig. 4.9: Elevation values at sampling locations.

These observations are also confirmed by statistical analysis. Standard summary statistics were calculated for the point series for each individual dataset (**Tab. 4.3**). The results show several similarities between GTOPO30 and GMTED on the one, and ASTER and SRTM on the other hand, both in terms of their minimum and maximum values, as well as their mean values and standard deviation. But whereas SRTM has the highest maximum elevation value of the entire sample range, its mean elevation is located between the higher GTOPO30 and GMTED2010 and the lower ASTER values. Overall, this does to some degree confirm the observation that ASTER appears to systematically underestimate terrain heights, whereas SRTM tends to record slightly higher values (Arefi and Reinartz 2011; Rexer and Hirt 2014). Based on their analysis of topographic data across Australia, Rexer and Hirt (2014, 225) have estimated that ASTER values tend to be around 4.2 m below their actual values, where SRTM elevations tend to be 2.7 m too high. On other hand, research conducted in Saudi Arabia suggests that ASTER data tend to be higher than the heights recorded on topographic maps and through GPS ground survey (Alatawi and Abushandi 2015, 2-3). And in Greece, SRTM data has been shown to tend to underestimate elevations in several instances (Nikolakopoulos *et al.* 2006).

	SRTM	**ASTER**	**GMTED2010**	**GTOPO30**
Minimum	5	6	3	1
Maximum	2569	2556	2492	2286
Mean	606.31	599.94	607.17	610.07
Standard Deviation	436.33	436.87	431.65	431.15
RSME	-	8.80	18.99	64.54

Tab. 4.3: Summary statistics for DEM data sets.

To further analyze the differences between the four datasets, the Root Mean Square Error (RMSE), a standard measurement to calculate the difference between modeled and observed values, was calculated (**Tab 4.3**). Usually, calculating the RMSE requires the existence of accurate observations, such as ground control points (GCPs) in the case of topographic data. However, as such an approach is not feasible at the moment, it was decided to use SRTM data as the 'observed' value, or baseline, against which the other model data could be compared. It was decided to use SRTM as the baseline, because studies have indicated its high level of accuracy in relation to GCPs, as well as its superior performance in relation to some national elevation datasets and in non-mountainous terrain (cf., Arun 2013; Rexer and Hirt 2014; Yastıklı *et al.* 2006), which comprises the majority of the terrain within the study area used here.

The RMSE calculated for ASTER, GMTED, and GTOPO clearly show some significant differences. Most importantly, ASTER values, with an RMSE of 8.8 m, again, are shown to be very close to those of SRTM. The highest discrepancy, with an RMSE of 64.54 m, is found between SRTM and GTOPO30 data, suggesting that the old GTOPO30 is severely outperformed by newer datasets. The GMTED2010, with its RMSE of 18.99 m, lies somewhere in the middle. The reason for these quite significant differences between ASTER and SRTM on the one hand and GMTED on the other might be the inclusion of a wide variety of different data sources within the GMTED model, including the older GTOPO data, which has been shown to introduce significant inaccuracy (Danielson and Gesch 2011).

Differences between SRTM and ASTER data, although less severe, still exist and are likely to have an effect on the overall accuracy of environmental modeling and spatial analysis. However, neither a plot of sampled elevation points, nor their statistical analysis, provides sufficient data to evaluate the significance of these differences. Overall, SRTM elevation values tend to be slightly higher than those recorded by ASTER. But where do these differences occur? And are they limited to certain parts of the study area, or are they distributed evenly across the region?

These issues can be properly addressed when elevation differences between the two datasets are analyzed for their geographic distribution. The total elevation difference between the two was calculated by subtracting ASTER from SRTM values. The results are quite interesting, especially the spatial patterning of the observed differences (**Fig. 4.10**). As becomes clear, ASTER values are significantly higher especially in mountainous areas, but also in the coastal areas. Especially in the south and east, elevation differences can be quite severe, almost 300 m higher than SRTM, shown by red colors. On the other hand, in other areas elevations are recorded as significantly lower, which is denoted by blue colors. Often, areas where ASTER values are much higher are situated immediately adjacent to areas of extremely low values, which is particularly prevalent in the east of the study area, as well as in the *Jebel al-Nusayriyah* in the north-west.

The comparatively higher elevation extremes, and presumably also more extreme terrain slopes observed in the ASTER data from West-Central Syria, are expected to have a significant impact on the analysis of agricultural suitability. Therefore, it has been decided to use the SRTM data as the topographical based data for this project.

4.4.3 Hydrology

The Digital Elevation Model was also used to create a hydrology layer, in order to delineate rivers and streams in the study region. Creation of this layer followed the procedures outlined in Maidment (2002). In this approach, surface water flow is modeled based on the topographic relief of the area, defining flow direction as moving from higher to lower elevations, usually using an 8-direction pour point model (Harrower 2010, 1449).

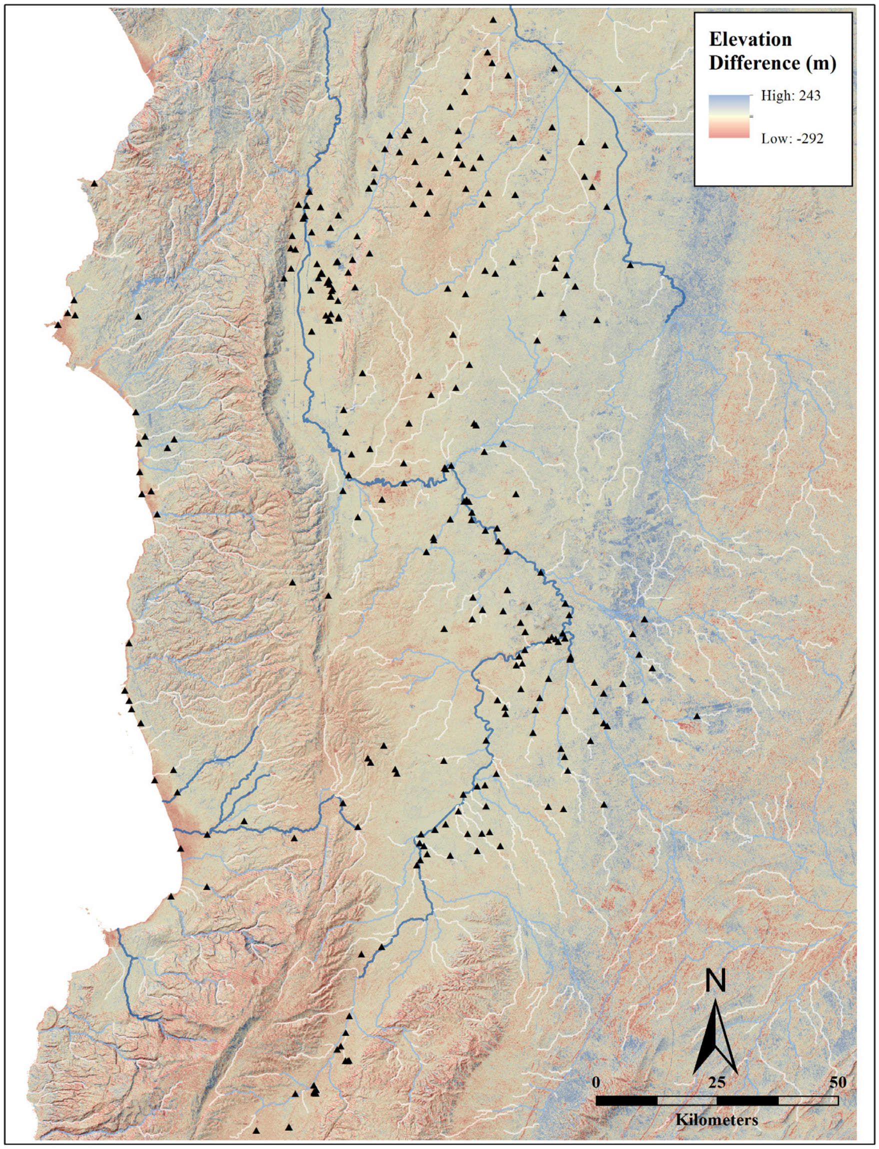

Fig. 4.10: Differences in elevation values between SRTM and ASTER data.

From the resulting raster, a stream network is created by applying a threshold on the number of contributing raster cells. Often a threshold of 5,000 cells is used (Harrower 2010), but for this study a threshold value of 20,000 was used, in order to conform to the large scale of the analysis region.

The resulting streams were classified according to the scheme proposed by Strahler (1957), and divided into three categories: perennial/large, intermittent/moderate, and wadi/small. The water courses were checked against satellite imagery and topographic maps and, where necessary, adjusted with the help of the information contained in *Inventory of Shared Water Resources in Western Asia* (UN-ESCWA and BGR 2013).

4.5 Soil Data

Another major constraining parameter for agriculture is the character and the quality of the soils present. The characteristics of the soil, including its texture, mineral content, pH-range, salinity, groundwater level, and drainage, have a significant impact on the suitability of a location for planting crops.

Most often associated with Mediterranean-type environments are Red Mediterranean Soils, also called Terra Rossa soils, whose common characteristic is their high fertility and their red color (Allen 2001; Durn 2003; Yaalon 1997). Although not solely confined to the Mediterranean region, Terra Rossa soils are particularly prevalent in this part of the world, forming primarily on highly permeable limestones and dolomite outcrops, with deposits ranging between a few centimeters to several meters in thickness (Allen 2001; Durn 2003). Other frequently encountered soils include brown and yellowish-brown ('cinnamon') soils. The former occur on non-calcareous or decalcified rocks in areas with less severe summer droughts and with high winter precipitation, whereas cinnamon soils are characteristic of low-rainfall regimes (Allen 2001, 84-85).

These Mediterranean soils are often referred to as zonal soils, whose main characteristics and geographical distribution are defined by climatic, rather than topographic or geological, factors (Allen 2001, 85). However, this assumption has been criticized by several authors and soil surveys have identified a much more complex distribution of soils and sediments within Mediterranean-type environments (Allen 2001; de la Rosa 1984; Durn 2003; Verheye and de la Rosa 2005; Yaalon 1997). In addition to not being used anymore as distinct categories in most modern soil classification schemes (Durn 2003), this broad and coarse categorization of soils into red, brown, or yellowish-brown Mediterranean soils is problematic from a modeling point of view, as small-scale, localized differences between soil types and their physical and chemical properties are masked.

Due to the nature and location of the study area in Western Syria, information on the majority of soil characteristics cannot be gathered in the field at the moment. And although modern geographic and satellite data have made it possible to create detailed soil maps with the help of remotely sensed data (e.g., Boettinger *et al.* 2008; Lagacherie 2008), such an approach usually requires at least some minimal ground truthing to ensure the validity of the results (Aksoy *et al.* 2009; Nanni *et al.* 2012). Since such an approach is currently not feasible, it was necessary to rely on rather coarse soil classifications available in already published soil maps from Syria.

The Soil Taxonomy system developed by the United States Department of Agriculture (Staff 1999) is a widely used system, organized hierarchically (orders, sub-orders, great groups, sub-groups, etc.) based on well-defined soil horizons and specific soil properties (Verheye and de la Rosa 2005). Within this system, Mediterranean soils are found at the sub-order level and are part of several distinct classes, such as Alfisols, Ultisols, Inceptisols, and Mollisols (Durn 2003).

These USDA categories constitute the basis for a soil map of Syria and Lebanon at the scale of 1:1,000,000 ('Illaywi 1985). The primary classes present within the study area are aridisols, entisols, inceptisols, and mollisols, thus covering a range of Mediterranean and desert soil types. Although these categories are associated with certain characteristics (e.g., Masri 2006; Riehl 2009a), links to agricultural use and other types of land use practices are rather tentative and ill-defined. In addition, the USDA system, originally being developed for the continental United States, incorporates a variety of soil types that do not occur in the arid and semi-arid environments of the Near East, and the rather broad distinctions between the soil categories present within the study region do not afford a sufficient degree of detail.

Therefore, a different soil map (Straub 1988a, 1988b), published as part of the *Tübinger Atlas des Vorderen Orients*, was used. Although this map utilizes a coarser map scale of 1:8,000,000, it was generated from a detailed study of a variety of more detailed soil maps (Straub 1988a). Instead of using the USDA Soil Taxonomy, this map also relies on the soil classification scheme developed by the Food and Agriculture Administration of the United Nations (e.g., FAO 1977; FAO and UNESCO 1974). Even though the FAO system derives significant inspiration from the work of the USDA, it has the advantage of being developed specifically with the aim of synchronizing and harmonizing different national classification schemes into one single framework (Verheye and de la Rosa 2005). In addition, the FAO classification has been repeatedly updated (e.g., FAO 1998, 2006, 2015), and can therefore be related to modern conceptions of soil mapping and classification (Zech *et al.* 2014).

As a result of the large map scale, the typology used by Straub (1988b) relies on the establishment of soil communities, defined by the primary soil type and several subordinate soil classes, as well as other factors, such as texture and relief, resulting in a total of 14 different soil communities (**Fig. 4.11**). For discussion, these can be roughly grouped into 5 groups, based on the most prominent soils within these communities.

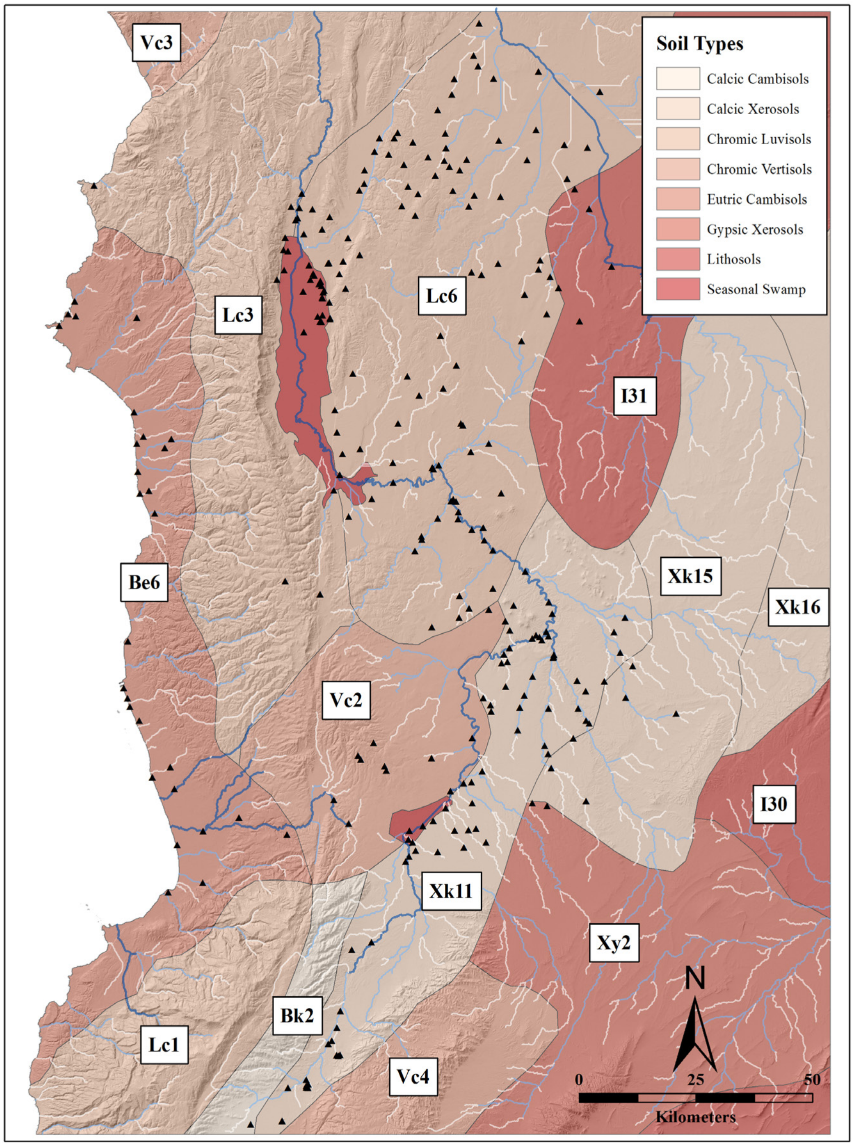

Fig. 4.11: Distribution of soil classes within West-Central Syria.

To the first group belong some of the most fertile and productive soils of the world, Cambisols. These are generally relatively young and well drained, contain moderate to high levels of nutrients, and are neutral or slightly acidic, with a pH-value of around 5-7 (Zech *et al.* 2014). Cambisols are low in organic matter, aluminum and iron concentrations, and are used extensively as agricultural soils, either for food crops in the alluvial plains, or for annual and perennial crops, or livestock grazing, in more hilly terrain (FAO 2006). Especially Eutric Cambisols are well suited for intensive agriculture (Zech *et al.* 2014, 28) and some Red Mediterranean Soils belong to this category (Durn 2003, 85). Within the study area, Cambisols occur either as Eutric Cambisols associated with Calcic Cambisols, Chromic Luvisols, or Eutric Regosols (map unit: Be6), or as Calcic Cambisols, associated with Vertic Cambisols (map unit: Bk2).

The second group comprises three communities whose primary characteristic is the presence of Chromic Luvisols. According to the FAO classification, Luvisols are very fertile soils, with high permeability, good potential for water storage, and a slightly acidic pH-value around 4-6 (FAO 2006, 2015; Zech *et al.* 2014). Luvisols, especially Chromic Luvisols, are generally fertile agricultural soils that are widely used for wheat cropping and other agricultural uses on low inclines, whereas steeper terrains are often used for herd grazing or tree crops. On higher slopes, erosion control measures are often required (FAO 2006), whereas extended summer dryness can constitute a limiting factor unless supplemental irrigation is applied (Zech *et al.* 2014). Some Terra Rossa soils fall under this category (Durn 2003, 85). Within West-Central Syria, Chromic Luvisols are associated with Cambisols and Rendzinas, (map unit: Lc1), Calcic Cambisols and Lithosols (map unit: Lc3), or Calcic Xerosols and Calcic Luvisols (map unit: Lc6) and occur on either undulating or sometimes even steep terrain.

Vertisols, clay rich soils with a relatively poor topsoil layer, constitute a third major group. These soils are generally low in permeability and badly drained and tend to fracture and harden during the dry season. With a pH-value between 6.5 and 8, they can range between slightly acidic and slightly basic. Their characteristics make them prone to erosion. Although some crops can be grown with the application of fertilizers, Vertisols are not desirable as agricultural soils and are therefore mostly used for livestock grazing (Zech *et al.* 2014). In West-Central Syria, Chromic Vertisols occur in association with Calcic and Vertic Cambisols (map unit: Vc2), Calcic Cambisols and Mollic Gleysols (map unit: Vc3), or Vertic Cambisols and Chromic Luvisols (map unit: Vc4), mostly on terrain with relatively low inclines.

The remaining soil communities and categories are generally unsuitable for cultivation. Xerosols, also called desert soils, are mostly unconsolidated deposits with a vegetation regime dominated by xerophytic shrubs and trees and ephemeral grasses, although crops can be grown under heavy irrigation. Consequently, Xerosols, which occur mostly in association with other types of Xerosols in West-Central Syria (map units: Xk11, Xk15, Xk16, and Xy2) are largely used for animal husbandry (FAO 2006). The last major category includes Lithosols, also called Leptosols, which are shallow soils with rock outcrops close to or directly at the surface. Erosion is common on these soils and they are primarily used for livestock grazing during the wet season (FAO 2006). They occur in the study area associated with other Lithosols and Xerosols (map unit: I30), and sometimes also Vertisols (map unit: I31). Finally, two remnant groups, Regosols, weakly developed mineral soils common in arid and semi-arid regions, and Gleysols, wetland soils in need of drainage, are both of poor agricultural use and occur within the study area only as subordinate soil classes associated with the more prevalent groups (FAO 2006).

As outlined in Chapter 1 (**§1.2**), some portions of West-Central Syria, especially in the Ghab depression and also some parts of the Middle Orontes Valley around Lake Qattineh, were covered by seasonal swamps in the past. Consequently, large portions of the Ghab Valley, although today characterized by fertile soils and under intensive cultivation, can be considered as quite unsuitable for intensive agriculture in ancient times. Therefore, the outlines of the marshlands, as recorded on military maps of mid-20th century CE (Great Britain 1924), were also traced in GIS and used to adjust the results of the soil survey. Together, both soils and marshes were traced as polygons and converted to raster format.

Although this approach, relying on large-scale maps and simplified soil classifications without ground control, is less desirable than a more detailed and accurate field study of soil distributions, the general soil characteristics within the study area can be established. The FAO classification system, on which the underlying soil map is based, has been established and validated through extensive global research and makes it possible to utilize the available data for an analysis of agricultural potential and environmental change.[72]

4.6 HYDROGEOLOGICAL DATA

One final element pertaining to the study of agricultural potential in the context of climatic and environmental change pertains to the availability of groundwater throughout the study area. According to Pustovoytov and Riehl (2016), archaeological studies of climate change have only paid little attention to this aspect, rarely considering the influence of aquifers and their distribution on environmental processes and the agricultural system (but see, Wilkinson 1999; Wilkinson 2003).

Poehls and Smith define an aquifer, the main source of groundwater, as "a water-bearing or saturated formation that is capable of serving as a groundwater reservoir supplying enough water to satisfy a particular demand, as in a body of rock that is sufficiently permeable to conduct groundwater and to yield economically significant quantities of water to wells and springs" (Poehls and Smith 2009, 15), whereas Domenico and Schwartz simply define it as "a rock unit sufficiently permeable to supply water to wells." (1998, 16).

Aquifers have been recognized as one of the most important freshwater sources around the world and especially in semi-arid and arid environments (Alley *et al.* 2002; FAO 2003; Pustovoytov and Riehl 2016; Scanlon *et al.* 2006). Aquifers occur in unconsolidated (sands, silts, gravel, etc.) and consolidated (sandstones, limestones, and other rocks) formations (Poehls and Smith 2009, 15) and constitute an important component of the hydrological cycle, feeding streams, lakes, and wetlands (Alley *et al.* 2002, 1985), as has been remarked already in Chapter 1 in the context of the Orontes river.

Importantly, aquifers constitute a freshwater resource largely independent of fluctuations within climates and precipitation patterns, and can function as buffer stores of rainfall water during dry seasons (Pustovoytov and Riehl 2016). As Alley *et al.* (2002, 1990) note, surface and groundwater systems operate at considerably different temporal and spatial scales, although climatic fluctuations at inter-annual, decadal, or millennial time scales can have potentially different effects on aquifer recharge rates (Scanlon *et al.* 2006, 3354).

In many arid regions of the world, the groundwater stored in aquifers today was recharged during periods with much wetter conditions, such as the last Ice Age (Alley *et al.* 2002), and the residence time of groundwater, that is, the time elapsed between recharge and discharge (Kazemi *et al.* 2006), can range from anywhere between sixty and several million years (Gassiat *et al.* 2013;

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[72] In contrast, Barton *et al.* (2010a), in their study of landscape development in the Wadi al-Hasa in Jordan, have decided to classify all soils as Mediterranean Terra Rossa. The authors argue that such an approach is more accurate than attempting to extrapolate soil parameters, like texture or composition, from soil maps that lack the appropriate resolution and detail (Barton *et al.* 2010: 373). However, their study focuses exclusively on the issue of soil erodibility, as they analyze the impact of agricultural and pastoral practices on the landscape through degradation of ground cover and vegetation, and hence its impact on soil erosion and soil degradation. For the present study, however, such an approach is not feasible as the differences in soil characteristics and their suitability for wheat cropping are the main focus here. Classifying all soils within the study area as one particular type would eliminate the differences in suitability of various locations, effectively making the soil data useless for the analysis.

Kazemi *et al.* 2006; Pustovoytov and Riehl 2016). For example, isotope analysis of groundwater samples in the Eastern Desert of Egypt yielded groundwater ages of 18 kya, 80 kya, and 100 kya (Dabous *et al.* 2002), whereas in the Arava Valley of Israel, aquifer ages of 24 kya, 25 kya, and 30 kya were reported by Burg *et al.* (2013). Similar ages, dating to the Last Glacial Period, have been indicated by Issar (1990) for the aquifers of the Sinai Peninsula and the Negev Desert. Further to the north, explorations in northern and southern Jordan have dated groundwater reserves to the early-mid Holocene and the Pleistocene-Holocene transition, respectively (Bajjali and Abu-Jaber 2001). In the Dead Sea region, analyses have suggested a groundwater age of several thousand years, although methodological constraints prevent a more precise conclusion (Avrahamov *et al.* 2010).

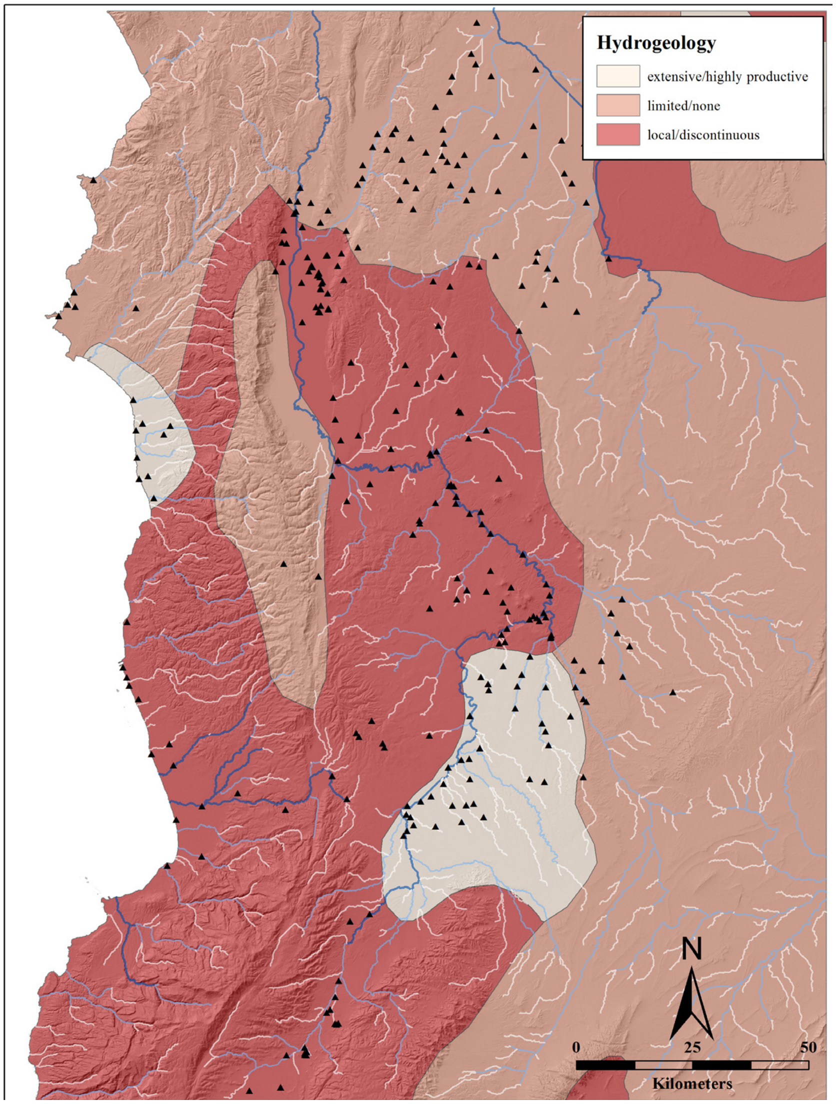

Fig. 4.12: Distribution of hydrogeological features (aquifers) within West-Central Syria.

Together, this evidence suggests that most of the groundwater in semi-arid and arid regions, especially in the Near East, is of considerable age, in many instances having formed during the last Glacial Period (Scanlon *et al.* 2006). In areas where rainfall amounts to less than 200 mm per year, precipitation can be considered negligible for aquifer recharge (Scanlon *et al.* 2006, 3336), especially since most precipitation water does not enter the groundwater cycle (Alley *et al.* 2002, 1987). The depletion of groundwater resources, thus, is considered a significant threat to modern agricultural systems around the world (Alley *et al.* 2002). This applies particularly to the Near East, where water resources are highly sensitive to drought stress (FAO 2003).

Given the importance of groundwater, especially in arid environments like the Levant, it can be suggested that the availability of groundwater reservoirs played an important role in the sustenance of agriculture in the past, often constituting the only perennial sources of freshwater available (Eichmann and Klimscha 2012). Furthermore, given the generally high groundwater ages identified in the Levant and the Near East in general, it can also be suggested that the distribution of aquifers in the region during the Late Bronze and Iron Ages was essentially similar to modern times.[73]

For the purposes of this project, the aquifer distribution across the study area was established with the help of a hydrogeological map from the *Tübinger Atlas des Vorderen Orients* (Schöler 1990). Although the map scale, at 1:8,000,000, is rather large, this map provides the most comprehensive inventory of groundwater resources in the Near East. Aquifers were categorized according to three basic categories - extensive and highly productive, local or discontinuous, and limited or no groundwater – without further distinguishing between intergranular and fissured types (cf., Pustovoytov and Riehl 2016). The locations of the aquifers were traced from the geo-referenced map in GIS and converted to raster format (**Fig. 4.12**).

4.7 Conclusion

This chapter has presented and evaluated the data available to conduct an analysis of socio-environmental interactions according to the principles outlined in Chapter 3. The available data consist of different types of archaeological, climatic, and environmental records. Yet, as the discussion has also shown, the availability of a variety of datasets and data sources also necessitates a detailed analysis and evaluation of accessible materials.

This is not only true for topographic data, such as DEMs, of which several are theoretically available, but especially for climatic data. As has been shown, palaeoenvironmental proxy data from the Eastern Mediterranean and adjacent regions have increased in both quantity and quality over the past ecades. Yet, despite this proliferation of data, these types of evidence are still somewhat problematic with respect to regional palaeoclimatic and palaeoenvironmental reconstruction. On the one hand, inconsistencies in materials analyzed and the methods employed have resulted in discrepancies in interpretation, to the point of yielding directly opposing results, as is the case with some of the Dead Sea records. On the other hand, the spatial distribution of these palaeoenvironmental studies is highly uneven. Whereas some regions, especially the Southern Levant, have been intensively surveyed, other areas, especially West-Central Syria, have only received comparatively little attention. This makes it not only difficult to compare and correlate the results of these analyses with each other, but it is also highly problematic from the point of view of modeling in a GIS framework. With only a handful of data points from the study area itself, extrapolation and modeling of climatic variables, such as precipitation or temperature, is severely complicated, if not made outright impossible. As Bryson and Padoch (1980) argue, proper analysis of climatic change and its effects on human society requires the use of quantitative data. And while instrumental records and actual observational data is always to be preferred, the authors also stress that "[...] one cannot [...] use whatever record happens to be available *somewhere*" (Bryson and Padoch 1980, 587; italics in original). Granted, Bryson and Padoch were primarily concerned with climatic differences on the scale of countries, continents, or even hemispheres. Yet, the same principle can be applied to much smaller study areas, like West-Central Syria, since climatic variables can oftentimes vary over relatively short spatial distances and within relatively short time intervals. Even within circumscribed geographic units, climatic signals can reflect different temporal and spatial

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[73] A similar assumption is made by Pustovoytov and Riehl (2016) for the Early and Middle Bronze Ages in Mesopotamia, Anatolia, and the Levant.

developments, without necessarily contradicting each other (Bryson and Padoch 1980, 589). This is especially true for environmentally highly variegated regions, such as the Levant and West-Central Syria, with its fissured topographic relief and complex sedimentary deposition history.

To implement climatic data into the analysis, it is therefore necessary to rely on retrodictions of climatic variables offered by the Macrophysical Climate Model. Although this model is not without its problems, or opponents, as discussed above, and even though the resulting values are at least at one remove from actual instrumental observation, it nonetheless for the time being affords the only feasible option to model important climatic variables with a temporal and spatial resolution appropriate for an archeological investigation centered on a few centuries in the Late Bronze and Iron Ages.

Archaeological data, obtained from both surveys and excavations, furnishes a wealth of data on settlement patterns and processes, as well as socio-economic factors. Equally important, several excavation projects have paid special attention to environmental processes as well, greatly facilitating a comparison of the palaeoclimatic modeling results with the actual palaeoenvironmental proxy record. However, as only a handful of projects have concentrated on these issues, or published data on the Late Bronze and Iron Ages, the available materials are highly fragmentary and geographically confined.

The following chapter will rely on the data presented here in order to develop an initial model of agricultural suitability for West-Central Syria in the Late Bronze and Iron Ages. The results of this model will be used to identify and visualize the chronological and spatial dimensions of climatic change throughout the period of interest, but also to provide a basis for further investigation.

CHAPTER 5
INVESTIGATING CLIMATE AND SOCIAL CHANGE: GIS MODELING AND GEOSPATIAL ANALYSIS

5.1 INTRODUCTION

According to Scholz (2011), every investigation into Socio-Natural Systems (SNS) necessarily has to begin with a thorough analysis of environmental factors. Only when environmental processes and responses to climatic change are understood in detail is it possible to discuss social and environmental aspects in relation to each other. Environmental analysis, hence, constitutes an integral part of SNS analyses, as it defines the 'background' against which potential social, economic, and political changes can be evaluated and understood.

With the help of the components and datasets described in the previous chapter, past climatic and environmental conditions can be modeled and integrated into an analysis of socio-natural interactions in Late Bronze and Iron Age West-Central Syria. This modeling process consists of several stages. The first entails the extrapolation of retrodicted climatic variables, such as temperature and precipitation data, to the entire study area. Through comparison of the resulting climate surfaces, broad chronological and geographical trends in climatic change can be identified. By comparing the results of these procedures to the palaeoclimatic proxy data from the study area and its immediate surroundings, the validity of these modeling results, observable in generally similar long-term trends and climatic events, can be ascertained.

In a second stage, a predictive model of agricultural suitability for wheat crop husbandry, based on a range of environmental and climatic variables, will be developed. This model provides a base line with which the effects of Late Bronze and Iron Age climate change can be analyzed and understood. This will be achieved by moving through a series of analytical scales, from a regional perspective to an analysis of the surroundings of archaeological sites. Considering social aspects as well, the inclusion of the immediate surroundings of sites, site-catchment territories (see, **§3.3.3**), marks the transition from a purely environmental analysis to an investigation of socio-natural interactions on a local scale.

In a third stage, developments and changes within the settlement system of West-Central Syria will be investigated. The spatial patterning of archaeological sites will be studied with the help of geostatistical analysis tools, as outlined above (**§3.3.4**). In addition, further statistical analyses will be conducted in order to investigate the relationship not just between sites, but also between sites and their respective environments, that is, important topographic and climatic variables that might have influenced site locations and long-term settlement trends.

Throughout all of these stages, analysis and evaluation will begin with a broad perspective, initially focusing on a regional analysis. The analysis scale will then be successively narrowed down to a sub-regional level, considering certain parts of the study area in isolation, and then move on to an analysis on a local level, defined by individual archaeological sites. This tacking between different analytical scales will make it possible to detect small-scale, geographically and chronologically discrete processes and developments within the data, enabling a more detailed description of late 2nd and early 1st millennium BCE climate change than would be possible from a regional perspective alone.

5.2 MACROPHYSICAL CLIMATE MODEL RESULTS IN CONTEXT

The use of the Macrophysical Climate Model (MCM), as described in the previous chapter, has made it possible to model climatic variables like precipitation, evaporation, and temperature for the Late Bronze and Iron Ages and extrapolate them to the entire study area. On the one hand, the results of these procedures can be analyzed for the patterns they exhibit, providing valuable information on the development of climatic factors throughout the periods of interest. On the other hand, these results can (and need to) be checked against the available palaeoenvironmental and archaeobotanical record.

5.2.1 Macrophysical Climate Model Results: Annual Precipitation

Continuous precipitation surfaces for seven century-long time intervals between 1350 and 750 BCE were created with the help of the MCM. The results show a general pattern of high rainfall volumes in the coastal areas, especially on the northern coast and the coastal mountain range, with precipitation levels gradually decreasing on the eastern mountain flanks and the inland areas (**Fig. 5.1**). Moderate rainfall levels prevail in some coastal areas, the Lebanon mountains, parts of the Homs Gap, and areas of the Ghab Valley and Rouj Basin in the north of the study area. Low rainfall levels, on the other hand, are especially common in the southern and eastern portions of the study area, as well as some sectors of the Middle Orontes Valley.

This overall pattern does not change significantly over time. At all modeled time-steps, coastal areas receive more precipitation than those regions further inland. Nonetheless, some temporal changes in the data can be observed, particularly with regard to maximum and minimum values of precipitation. Around 1350 BCE, mean maximum rainfall peaks at about 1780 mm per annum, with minimum precipitation around 151 mm, the highest minimum value for the entire period analyzed. By 1250 BCE, maximum rainfall has dropped to around 1745 mm, whereas minimum values have only diminished slightly, to about 150mm. At 1150 BCE, however, annual precipitation values rise again, to about 1789 mm, the highest value observed within the modeled time frame, with minimum values dropping further to about 144 mm per year. In 1050 and 950 BCE, maximum precipitation volumes decrease first to around 1746 mm and then to 1688 mm, the lowest maximum value modeled. During the same time period, however, minimum values increase slightly, to 146 mm and 149 mm, respectively. From around 850 BCE onwards, maximum precipitation values increase again until 750 BCE, while minimum precipitation drops again to 142 mm and then to 137 mm.

Rather than suggesting a constant, linear drying trend in West-Central Syria, the modeled data furnishes evidence for a series of more-or-less pronounced fluctuations in rainfall patterns and volumes through time. To investigate and understand these fluctuations in more detail, especially from a geographical standpoint, it is useful to consider the differences in precipitation levels between different time-steps. To achieve this, raster values for consecutive modeling steps were subtracted from each other. The results attest to considerable variability in the pattern of precipitation differences over time, with red colors indicating areas of reduced rainfall, whereas blue colors indicate more moist conditions (**Fig. 5.2**). Between 1350 and 1250 BCE, the central coastal plain and the northern parts of the Ghab Valley are especially affected by dropping precipitation levels, decreasing by almost 50 mm per annum, with other parts of the coastal plains being affected to a lesser degree. This trend is reversed between 1250 and 1150 BCE, when those regions previously affected by diminishing precipitation levels now receive more rainfall, whereas rainfall volumes otherwise decrease throughout the entire study area, in some areas, like the northern coast, quite severely. Between 1150 and 1050 BCE, this trend reversed again, with some coastal areas receiving less precipitation, whereas levels otherwise increase slightly throughout West-Central Syria. In contrast to earlier times, however, the Lebanon mountains in the south, as well as areas of the coastal mountains in the north of the study area, are now also affected by increasing drought. This trend continues between 1050 and 950 BCE. Diminishing rainfall levels spread across the central coastal mountains and into the western-most areas of the Middle Orontes Valley, while the Lower Orontes Valley, in the northern regions of the Ghab Valley, experience a significant reduction in precipitation values, around 100 mm per annum. The following time interval, from 950 to 850 BCE, witnesses a general drying trend throughout most of the region, although more moist conditions are also suggested for parts of the Ghab Valley and the coastal mountains. Finally, precipitation levels exhibit a spatially discontinuous pattern of expansion and reduction between 850 and 750 BCE, with parts of the northern and central coasts and the Ghab Valley witnessing dryer conditions, while other regions of the coastal plains and the coastal mountains experience higher rainfall levels.

Fluctuations in rainfall between individual time intervals do not follow a linear pattern and the magnitude of precipitation changes oscillates over time. At times, these fluctuations can be quite limited in scale, for example between 1350 and 1250 BCE, when precipitation increases in some areas by about 13 mm per annum. At other times, for example, precipitation changes can be quite significant, as suggested by differences of up to 100 mm and more in some periods.

5.2.2 Macrophysical Climate Model Results: Annual Temperature

Temperature constitutes the second climatic variable of specific interest here. As described before, continuous surfaces for mean annual temperatures were generated with the help of the MCM in the same way that precipitation surfaces were.

Overall, an investigation of the chronological development of temperatures in West-Central Syria in the Late Bronze and Iron Ages reveals a significant degree of stability, with maximum temperatures usually around 20 °C, whereas minimum annual temperatures stay around 11 °C (**Fig. 5.3**). Patterns within temperatures do not only remain fairly constant over time, but also exhibit a marked degree of geographical stability, with some areas of the northern coastal mountains and areas in the far south-east of the study area consistently returning the lowest temperature values.

Despite the rather stable chronological and geographical pattern evident in the temperature modeling results, a more detailed consideration of differences between individual time-steps helps to understand this aspect of climatic change more fully. As before, differences were calculated by subtracting the raster values of two consecutive time-steps (**Fig. 5.4**). For the most part, the differences are minute and negligible, with temperature differences in most instances below even 0.1 °C. Yet, two important exceptions to this general trend exist. Between 1350 and 1250 BCE, temperatures increase up to 0.7 °C per year in the far south-west of the study area, and to a lesser degree also in the south-east and east. Between 1250 and 1150 BCE, however, these areas experience a reduction in temperatures at about the same magnitude as before.

Unlike precipitation, which fluctuates throughout the time period analyzed, temperature levels in West-Central Syria remain fairly constant throughout the Late Bronze and the Iron Ages. In this

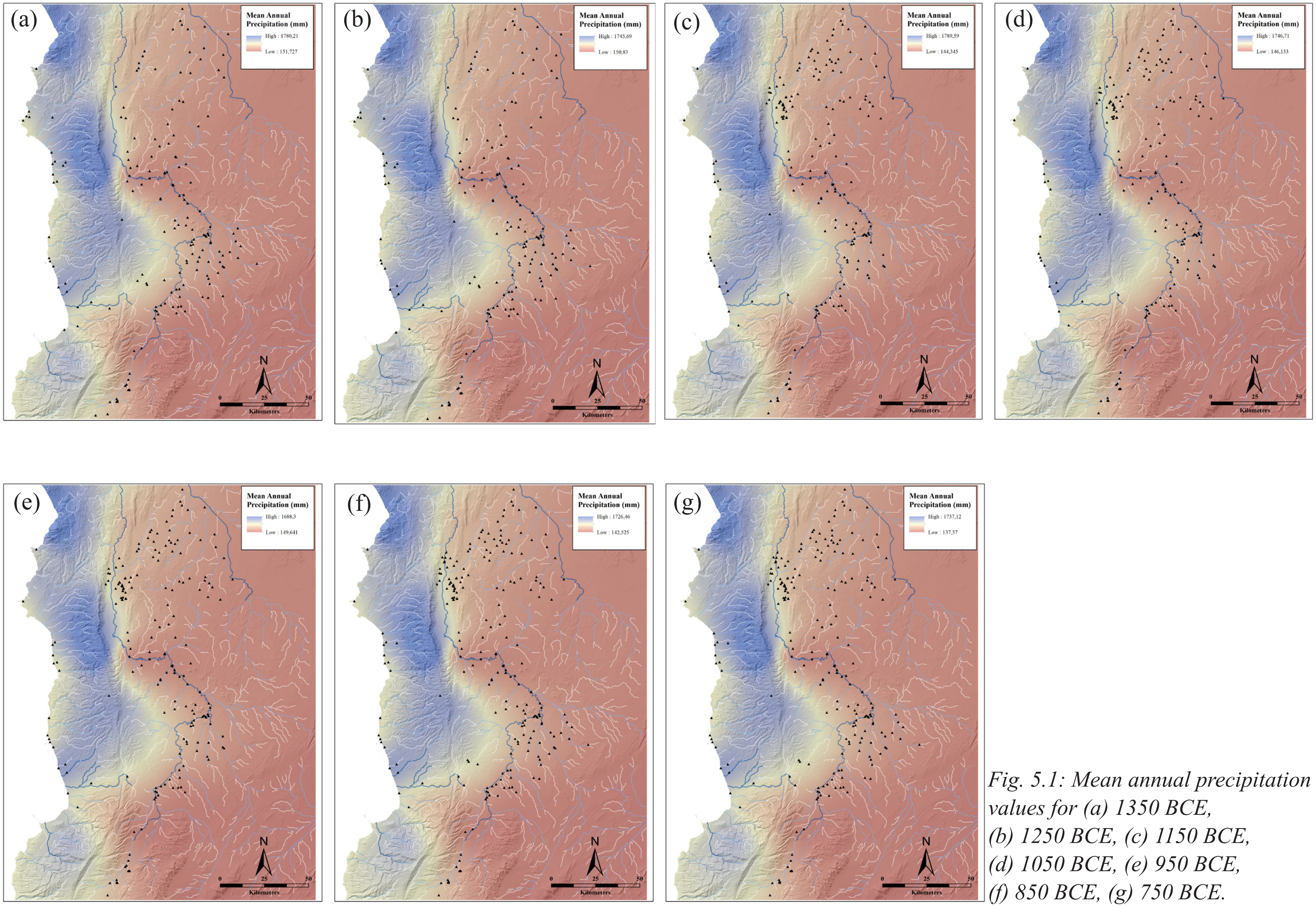

Fig. 5.1: Mean annual precipitation values for (a) 1350 BCE, (b) 1250 BCE, (c) 1150 BCE, (d) 1050 BCE, (e) 950 BCE, (f) 850 BCE, (g) 750 BCE.

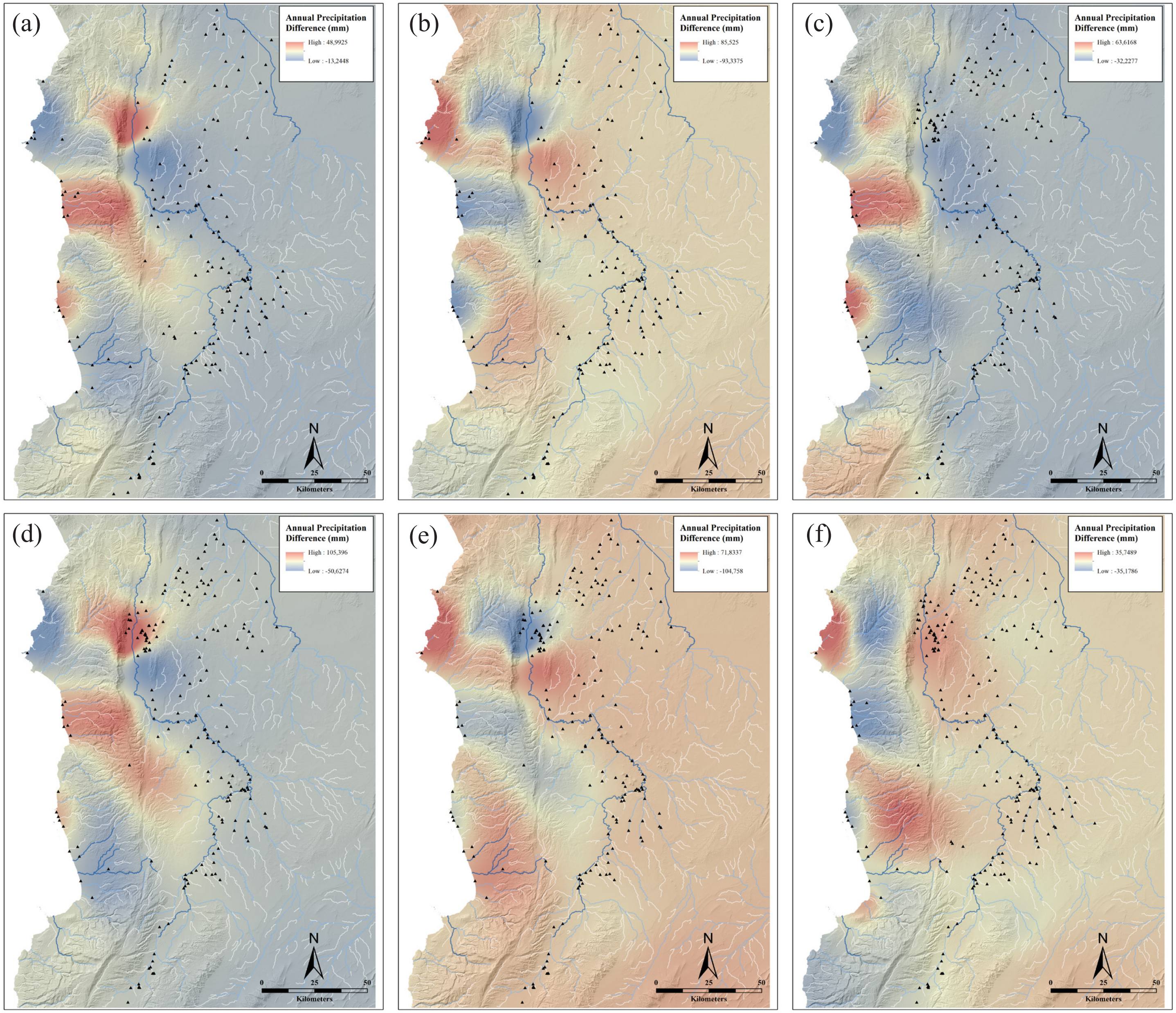

Fig. 5.2: Geographical distribution of differences in mean annual precipitation values for
(a) 1350-1250 BCE,
(b) 1250-1150 BCE,
(c) 1150-1050 BCE,
(d) 1050-950 BCE,
(e) 950-850 BCE,
(f) 850-750 BCE.

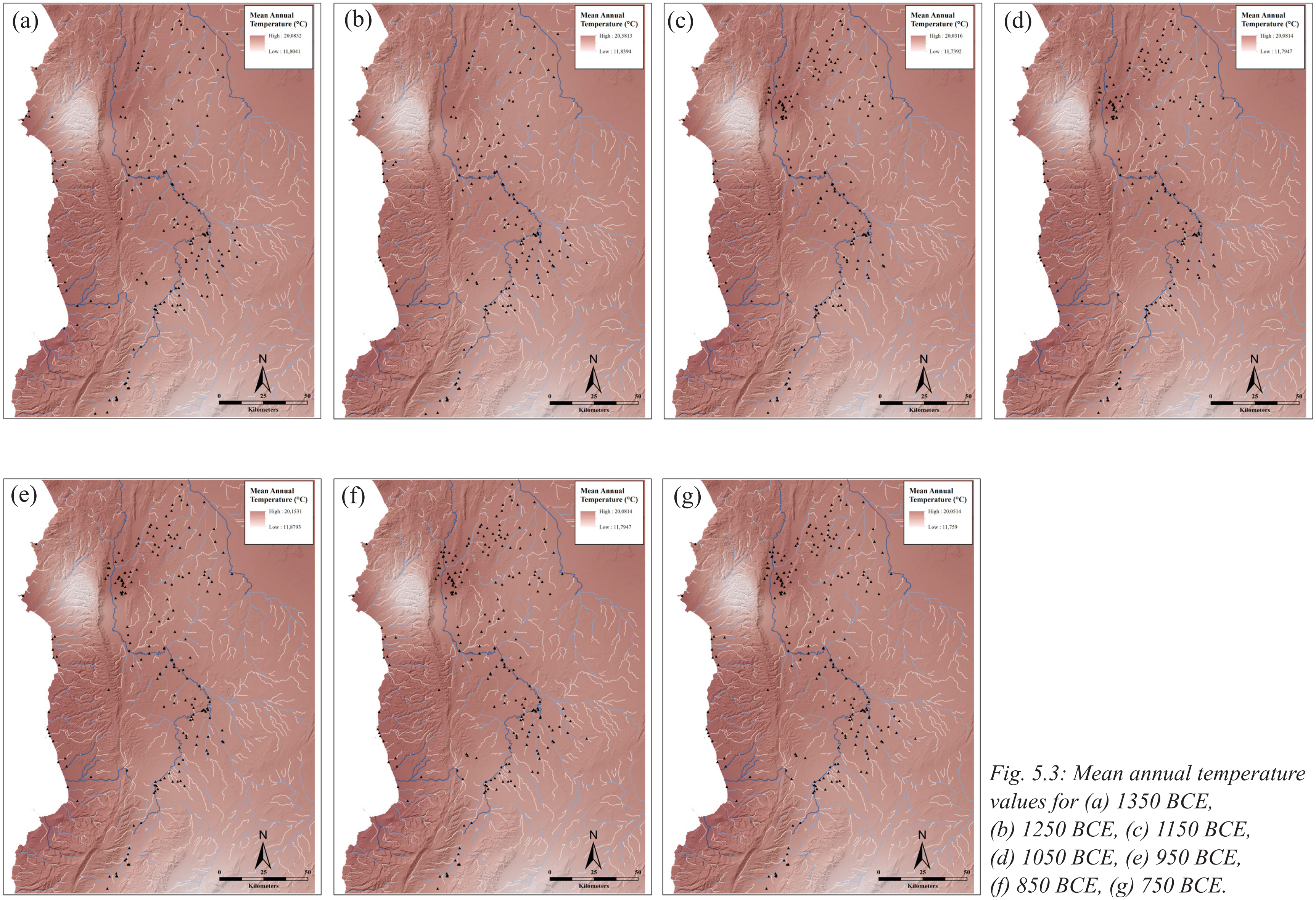

Fig. 5.3: Mean annual temperature values for (a) 1350 BCE, (b) 1250 BCE, (c) 1150 BCE, (d) 1050 BCE, (e) 950 BCE, (f) 850 BCE, (g) 750 BCE.

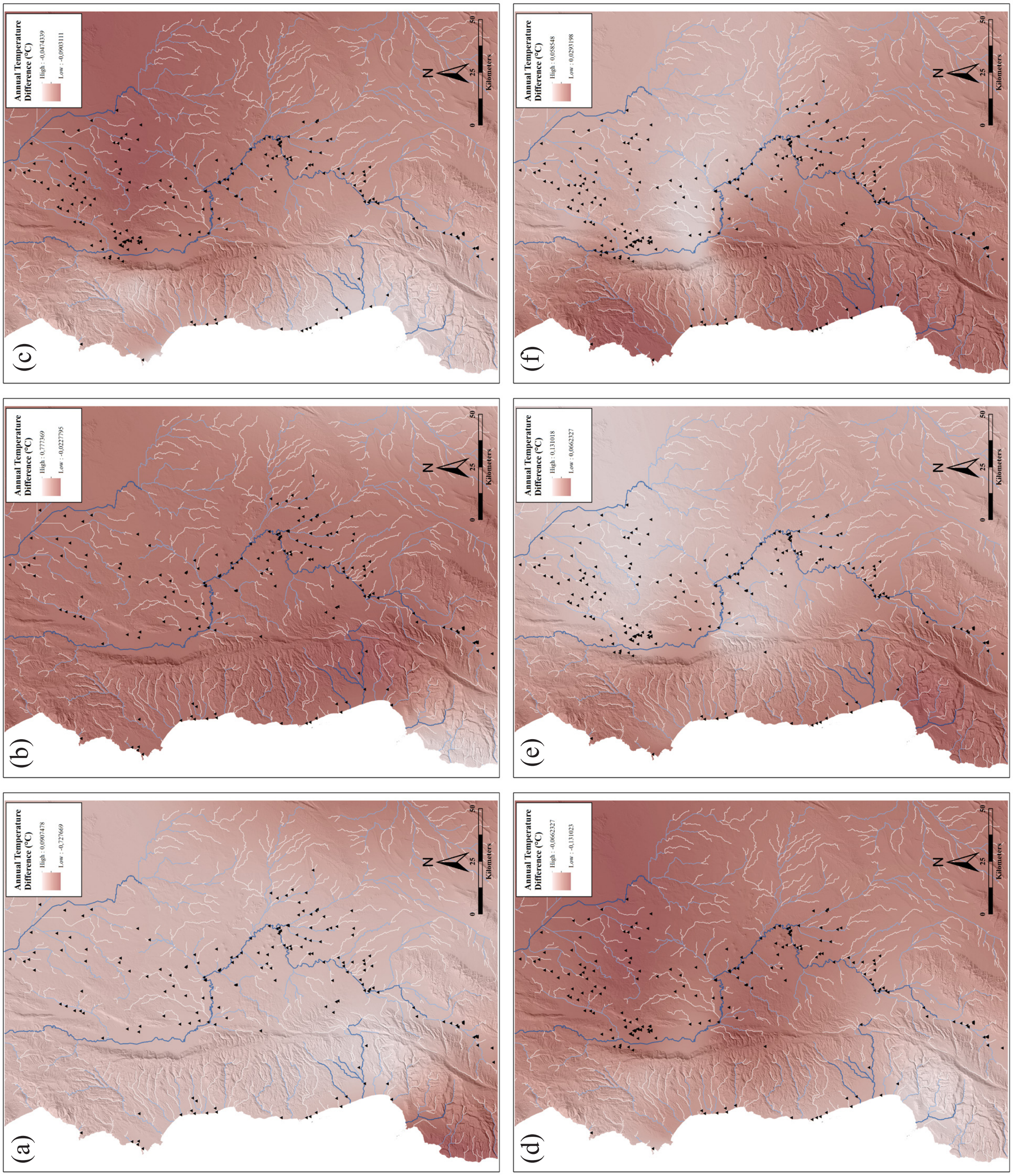

Fig. 5.4: Geographical distribution of differences in mean annual temperature values for (a) 1350-1250 BCE, (b) 1250-1150 BCE, (c) 1150-1050 BCE, (d) 1050-950 BCE, (e) 950-850 BCE, (f) 850-750 BCE.

regard, the results of GIS modeling not only support the identification of climatic fluctuations at the end of the 2nd millennium BCE, but also provide a much more nuanced and detailed picture on the chronological and temporal aspects of climate change and environmental transformation.

5.2.3 Understanding the Effects of Precipitation and Temperature Changes

The modeling results presented above suggest different patterns of chronological and geographical change for precipitation and temperature regimes in Late Bronze and Iron Age West-Central Syria. These results notwithstanding, it should be remembered that these general trends in temperature and precipitation might conceal more minute and short-lived climatic changes. According to Bryson and Padoch:

> "[…] an often overlooked fact about climatic data is that small differences in the mean temperature might mean significant differences in the frequency of occurrence of extreme values. Even in the midwestern United States, a change of mean July temperatures of 2-3°F may be associated with change in frequency of the extreme which are stressful to crops by a factor of five to ten. In Iceland a decrease of annual temperature of 1°C reduces the growing degree days by 27 percent, illustrating that small changes may be critical in marginal areas." (Bryson and Padoch 1980, 589)

Hence, a more detailed analysis and consideration of patterns within the MCM data is necessary to more fully understand the effects that changes within these climatic variables might have had on both the environment and on human society.

Plotting maximum, minimum, and mean temperature values for the entire study area across all analyzed time periods (**Fig. 5.5**) illustrates that both minimum and maximum temperatures fluctuate only very little over time. Changes in mean temperature, on the other hand, are slightly more pronounced over time, with differences between time-steps being on the order of 0.1 °C or even

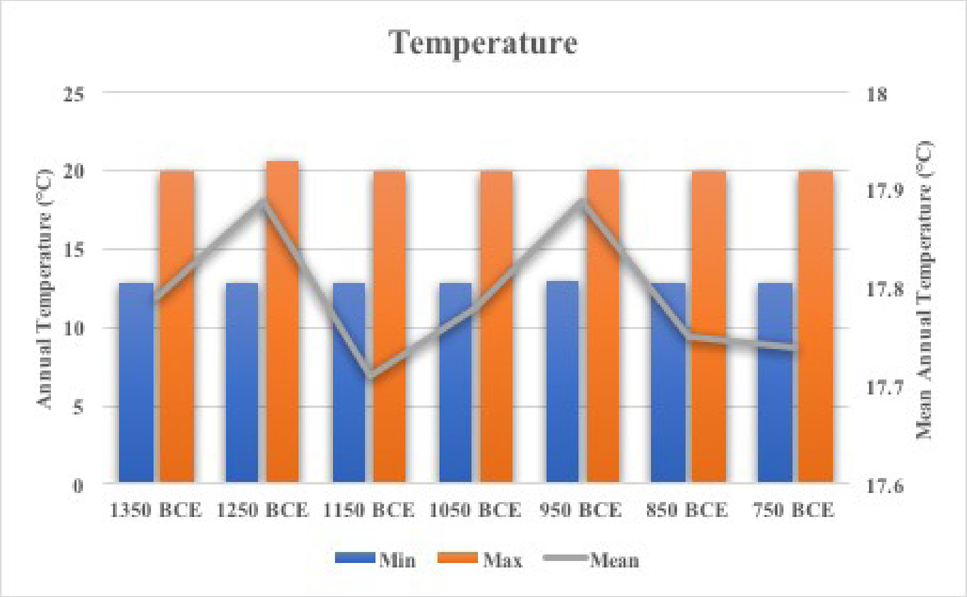

Fig. 5.5: Development of minimum (blue), maximum (orange), and mean (grey) annual temperature values between 1350 BCE and 750 BCE.

slightly more. At first glance, these changes appear minute and insignificant in scale. Yet, considering that these temperature changes of 0.1 °C are similar to the contribution of natural forcings (between -0.1 and 0.1 °C) to modern climatic change identified by the *Intergovernmental Panel on Climate Change* (IPCC) in their latest report (IPCC 2013, 17), the potential effects of even such small-scale changes becomes more apparent. Even more so, as temperature changes of up to +/- 0.7 °C between 1350 and 1250 BCE and 1250 and 1150 BCE, as described above, are very close to the 0.8°C-threshold when "[…] dangerous climate change impacts are already being experienced […]" (Shaw 2013, 569). This increase is also comparable in scale to the temperature increase of 0.78 °C, identified by the IPCC for the period from 2003-2012 relative to the period 1850-1900 (IPCC 2013) and which is causing concern in the scientific community.

These more severe temperature changes are limited to a period of about two centuries in the Late Bronze and Early Iron Ages. At the same time, they appear to be confined primarily to the far south-west of the study area. At this point it is difficult to ascertain what the effect of these changes might have been, especially since they appear to constitute an isolated instance within the data. Their existence, however, might suggest that parts of the Levant, especially those parts to the south of the study area used here, experienced more pronounced climatic shifts over comparatively short periods of time at the end of the Late Bronze Age. Extending this investigation to areas outside of the study area, however, is not feasible within the confines of this study and additional research will be necessary to further illuminate this issue.

A similar plot for precipitation values suggests a more linear development of climatic change, although still relatively minute in scale (**Fig. 5.6**). For the period between 1350 and 950 BCE, a steady downward trend in maximum precipitation levels can be observed. A similar long-term downward trend in minimum precipitation levels between 1350 and 750 BCE, however, is punctuated by a number of minute fluctuations. This general aridification trend is also observable in annual mean precipitation levels, which not only show a gradual, yet slightly fluctuating decline, but also attest to a significant reduction in rainfall levels between the Late Bronze Age and the late Iron Age I, by as much as 20 mm per year.

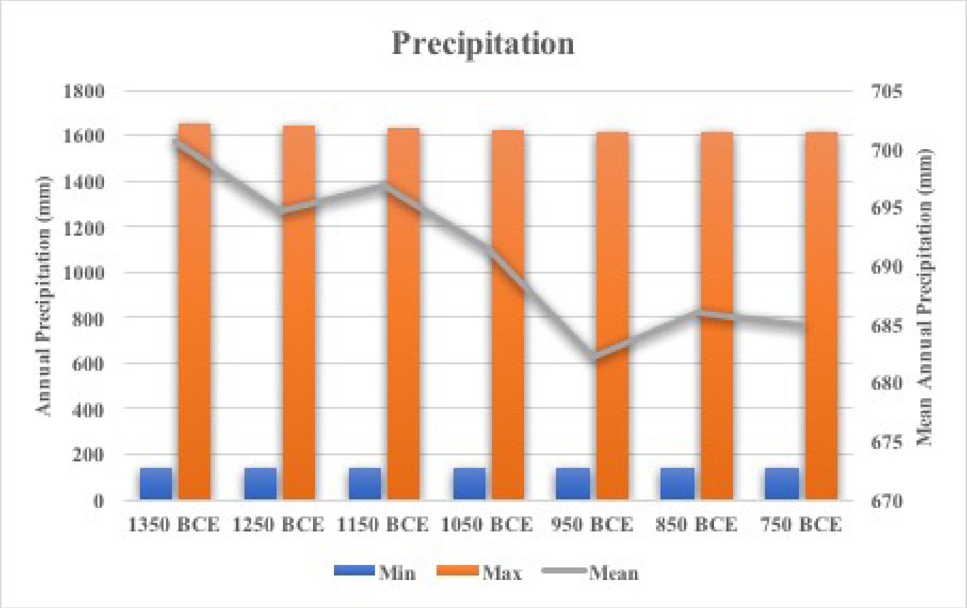

Fig. 5.6: Development of minimum (blue), maximum (orange), and mean (grey) annual precipitation values between 1350 BCE and 750 BCE.

Taken together, the data generated by the MCM suggest an overall, long-time decrease in precipitation levels over the course of the Late Bronze and Iron Ages. Temperatures, on the other hand, do not attest to a similarly unequivocal downward trend. Instead, while both maximum and minimum temperatures remain virtually stable, mean temperatures tend to fluctuate slightly over time.

However, as already mentioned above, the data also confirms the existence of geographical patterning within climatic variables and climatic change within West-Central Syria, with the most pronounced differences existing between coastal and inland regions. Yet, even geographical patterning is more complex than a simple coast-inland dichotomy might suggest. A plot of modern precipitation time-series data suggests that climatic correlations exist between certain areas, but not others (**Fig. 5.7**). As the graphs show, correlation of rainfall data is strongest between Hama and Aleppo[74] (r^2=0.53), followed by Hama and Tripoli (r^2=0.42), indicating that climatic patterns in inland West-Central Syria tend to be correlated to those of the southern coast. Conversely, correlation between Hama and Lattakia, that is, between the Middle Orontes Valley and the Northern Coast, is very low (r^2=0.03). Interestingly, correlation between Lattakia and Tripoli, the northern and southern coastal areas of the study area, is similarly low (r^2=0.24), indicating that it cannot be easily assumed that all coastal areas are (and were) affected by climatic changes in a uniform way. As these correlations might suggest, inland areas and the southern coastal plains might be affected similarly by climatic changes, such as droughts, whereas the Northern Coast might not be affected

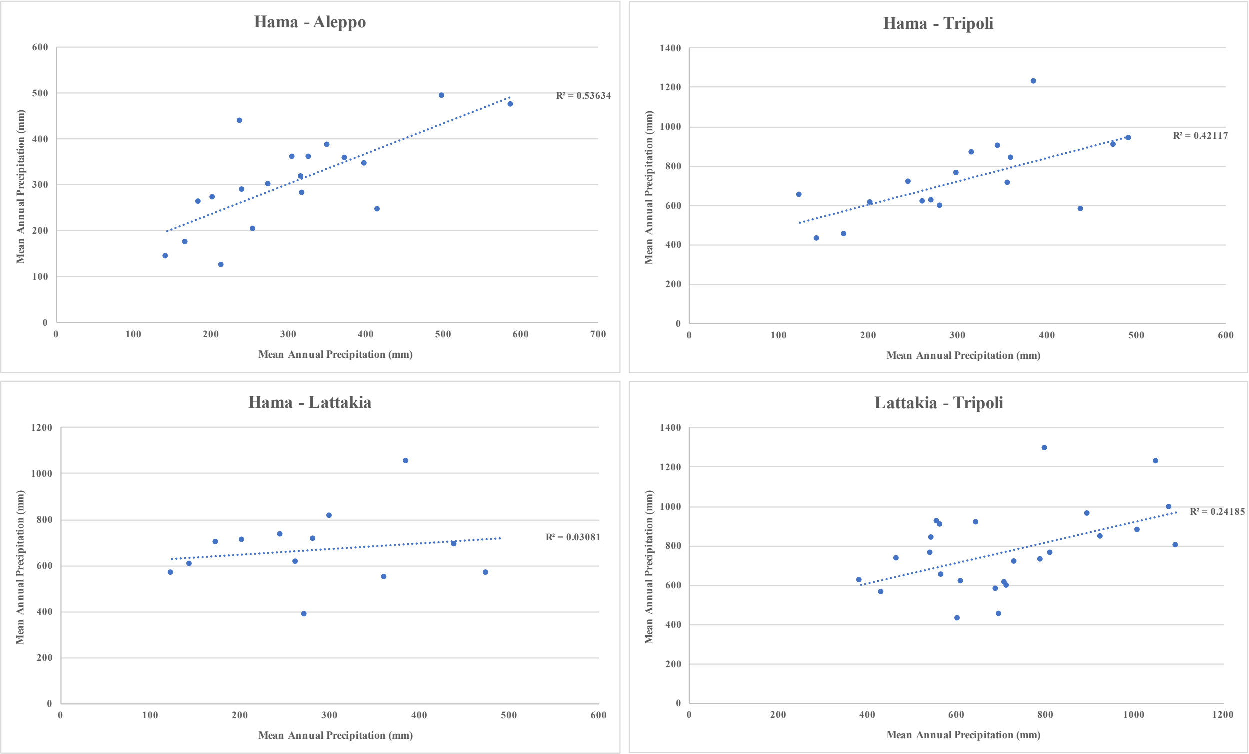

Fig. 5.7: Correlation of modern precipitation values for (a) Hama-Aleppo, (b) Hama-Tripoli, (c) Hama-Lattakia, (d) Lattakia-Tripoli.

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[74] Unfortunately, time-series data for precipitation levels is not available from any of the climate stations within the study area. Therefore, a direct comparison between the inland regions of West-Central Syria, namely the Orontes Valley and the Northern Plateau, is not possible with the available data. Hence, precipitation records for Aleppo have been used as an approximation for the inland area in the north of the study area.

by the same perturbations at the same time. This could potentially exacerbate the effect of droughts and other climatic events within West-Central Syria, as multiple regions might be affected at the same time (cf., Wilkinson and Hritz 2013).

5.2.4 Comparison of Palaeoenvironmental Proxy Data with Modeling Results

The climate of the period between 1350 and 750 BCE, that is, the terminal Late Bronze Age, the Iron Age I, and the Iron Age II, did not remain static over time. In addition, geographical differences between various sub-regions of the study area existed as well, as indicated by both modern observational records, as well as modeled palaeoclimatic data.

The modeled precipitation data suggests some interesting developments. Maximum rainfall levels initially decline between 1350 and 1250 BCE, after which they briefly recover, only to decline steadily until ca. 950 BCE. Afterwards, maximum precipitation levels slightly rebound. Mean precipitation values suggest a similar development, with a particularly noticeable decline evident between 1150 and 950 BCE. Minimum precipitation levels, on the other hand, are at a global low in 750 BCE, with both 1150 and 850 BCE exhibiting rather low minimum values as well. Decreases in precipitation values appear to primarily affect coastal areas and parts of the Lower Orontes in the beginning, but later also start affecting areas further inland, such as the Middle Orontes Valley or the Northern Plateau.

Fluctuations in modeled temperature values are more minute and less readily discernable. While both maximum and minimum values do not change significantly over time, mean temperatures fluctuate repeatedly, being particularly low at ca. 1150 BCE. However, the data does not suggest that extreme monthly differences occurred in regional temperature levels. Nonetheless, especially the precipitation data suggest that even within a single study area, spatial and temporal variability exists in the pattern and scale of climatic changes.

But how do these findings compare to the results of previous palaeoenvironmental and archaeobotanical studies? As already discussed in the previous chapter (**§4.3.1**), palaeoenvironmental proxy studies have provided evidence for climatic change at the end of the Late Bronze Age. Particularly the increased $\delta^{18}O$ values recorded in the sediment cores from the Eastern Mediterranean (Schilman *et al.* 2002; Schilman *et al.* 2001) and in the speleothems of Soreq Cave (Bar-Matthews *et al.* 1999) suggest the onset of increasingly arid conditions at that time (cf., Kaniewski *et al.* 2008, 13941).

Additional and more detailed data were recently published. They consist of the two Tell Tweini drill cores (al-Maqdissi *et al.* 2007; Kaniewski *et al.* 2008; Kaniewski *et al.* 2010; Kaniewski *et al.* 2012), another drill core from the vicinity of Hala Sultan Tekke on Cyprus (Kaniewski *et al.* 2013), and a pollen diagram from the vicinity of Tell Mishrifeh (Valsecchi 2007). In the Tell Tweini cores, the authors have identified a significant positive deviation of the PdB (pollen-derived biome) scores for the period 1175-800 BCE, trending towards the establishment of hot desert (HODE) and warm steppe (WAST) environments, thus indicating an episode of increased aridity (Kaniewski *et al.* 2008, 13942). A similar trend towards aridification has been recognized in an increase in xerophytic wood and shrub (XERO) environments at the expense of warm mixed forest (WAMX) biomes, with an intense peak around 900 BCE (Kaniewski *et al.* 2008, 13942-13943). Kaniewski *et al.* have also identified some smaller fluctuations within this general trend, indicated by negative deviations of the PdB scale around 1250-1175 BCE, 1000-950 BCE, and 800-600 BCE, suggesting moister conditions (Kaniewski *et al.* 2008, 13942-13944). Similar evidence for slightly more amenable conditions has been obtained from the Tell Mishrifeh pollen and sediment data, which indicate the regeneration of the small lake on the northwestern edge of the site between 1110 and 980 BCE and again around 800 BCE (Valsecchi 2007, 113), which the authors have compared to lake level changes in the Dead Sea region (e.g., Bookman [Ken-Tor] *et al.* 2004; Enzel *et al.* 2003).

Overall, the Tell Tweini cores provide significant information on the development of regional climatic factors, indicating a series of small-scale shifts and fluctuation within a general drying trend (see also, Kaniewski *et al.* 2010; Kaniewski *et al.* 2012). In the Hala Sultan Tekke core, a positive PdB signal is recorded for the period of 1200-850 BCE, again indicating the onset of more arid conditions at the end of the Late Bronze Age. This drought period, according to the evidence from Cyprus, lasts until the 9th century BCE, after which wetter conditions prevail again (Kaniewski *et al.* 2013).

These findings correspond well to the results obtained by the Macrophysical Climate Model discussed above. The relatively moister conditions recorded in the drill cores from Tell Tweini are mirrored in the relatively high precipitation values calculated for the period of 1350 to 1150 BCE. After this period, the MCM results show a steady and significant reduction in rainfall, which corresponds with the development of HODE, WAST, and XERO biomes identified for the same period by the core pollen. This trend peaks in 950 BCE according to the MCM data, which is fairly close to the peak identified around 900 BCE by Kaniewski and colleagues. Between 950 and 850 BCE, precipitation values calculated by the MCM increase, again corresponding to the findings of both the Tell Tweini and the Hala Sultan Tekke cores, which provide evidence for increasing moisture levels around 800 and 850 BCE, respectively.

In addition, these findings correspond to some degree with the isotope analyses conducted by Riehl *et al.* (2014) on archaeobotanical samples from the Levant. The authors note an increase in the $\Delta^{13}C$ values from grains from Late Bronze Age layers, indicating generally favorable agricultural conditions. At the same time, they notice a decrease in $\Delta^{13}C$ values for the Iron Age, suggesting increased aridity during that period. Although the samples discussed by Riehl and colleagues come from secure archaeological context, and can therefore be dated with considerable precision, it is important to note that samples are unevenly distributed among specific centuries in the late 2nd and early 1st millennia BCE, again making it difficult to use these data points for detailed geographic modeling.

Overall, the modeling results correspond quite well with the findings of palaeoenvironmental research, as already suggested by other authors (e.g., Arıkan 2014, 2015; Arıkan *et al.* 2016). Admittedly, some differences between the results exist. For example, the MCM is not capable of identifying extremely short-lived climatic fluctuations, such as the one identified by Kaniewski *et al.* (2008) between 1000 BCE and 950 BCE, mainly because the model's century-scale output does not account for such small time intervals. In addition, the MCM suggests that increased moisture levels started again around 850 BCE, whereas the Tell Tweini core suggests a date of about 800 BCE. Again, this might very well be a result of the modeling scale on which the MCM operates, but might also be attributed to the inaccuracies inherent in relying on data retrodicted from modern observations.

The severity of climatic change suggested by the MCM is also somewhat at odds with the results obtained by palaeoclimatic research. As Kaniewski *et al.* (2008) have argued, periods of increased aridity identified in the pollen record are fairly marked and characterized by dramatic vegetation responses. The MCM model output, on the other hand, might be taken to suggest less severe and more gradual changes within regional climates of the Late Bronze and Iron Ages. These differences, however, might be (at least) in part be attributed to the different scales with which the MCM and pollen analysis operate. Whereas the MCM returns absolute values, in this case precipitation volumes, the results of the pollen analysis are discussed primarily in relative terms, indicating either higher or lower levels of aridity, without actually quantifying its magnitude in absolute terms.[75]

This raises an important question, which has so far not been answered adequately: Was climatic change at the end of the Late Bronze and throughout the Iron Age actually significant enough in scale to have a negative effect on the environment? Similarly, were these environmental changes severe enough to adversely affect the agricultural system, as suggested by Kaniewski *et al.* (2013)? And what areas of the Levant, and particularly West-Central Syria, did the detrimental effects of these changes have the most severe impact on the environment and human society?

5.3 A Predictive Model of Agricultural Suitability

Relying on the palaeoenvironmental proxy record alone, these questions cannot be sufficiently answered at the moment. Therefore, a different, and complementary, approach is taken here, utilizing the predictive modeling capabilities of GIS. By modeling not just climatic change, as done with the MCM, but also its effects on the environment and agricultural suitability, it will be possible to assess how severe climatic changes at the end of the Late Bronze and throughout the Iron Age actually were, and what their effects on the socio-economic and socio-political sphere might have actually been.

5.3.1 Defining the Model Parameters

Both Late Bronze and Iron Age agricultural systems were extremely complex. Archaeobotanical samples provide evidence for a diverse subsistence economy, including the staple crops of wheat and barley, but also fruits like olives, grapes, and figs, among others. In addition to agriculture and horticulture, animal husbandry, especially of cattle and sheep/goats, played a significant role. Evidence for the cultivation of wheat and barley has been found in prehistoric contexts in southern Mesopotamia and southwestern Iran (Wilkinson 2003). Both crops have been closely associated with the development of the earliest forms of irrigation agriculture in this area of the Ancient Near East, but have remained the predominant agricultural crops throughout most of Mesopotamian history (van Zeist and Bottema 1999; Wilkinson 2003). In the Syrian Jazirah and especially in Western Syria, where conditions were moister than in southern Mesopotamia, wheat and barley continued to play an important role in rain-fed crop husbandry strategies, whereas the more favorable environmental conditions also allowed for the cultivation of lentils, vines, and olives (Wilkinson 2003, 100).

This impression, based on archaeological data, is also corroborated by textual sources. For West-Central Syria, documents from Early Bronze Age Tell Mardikh indicate that both field crops, such as wheat and barley, and horticultural plants, such as olives and grapes, played a vital role in the local economy (Wilkinson 2003, 123). A similar picture emerges from Iron Age textual sources, for example the Neo-Assyrian campaign reports. Shalmaneser III, in the earliest version of his annals, lists precious metals, furniture, purple wool, elephant ivory, various types of garments

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[75] A similar argument has been made by Wallace *et al.* (2013) for isotope studies of plant remains, which generally record their results in relative terms, for example the ratio $\delta^{13}C$, rather than using absolute measurements, such as $\Delta^{13}C$, which indicates a plant's water status as a calibrated absolute value (cf., Bogaard *et al.* 2016; Vaiglova *et al.* 2014; Wallace *et al.* 2015).

along with agricultural products such as wine, oxen, sheep, and ducks among the lists of tribute and loot acquired during his campaigns in Western Syria (Grayson 1996, A.0.102.1). In a later text (Grayson 1996, A.0.102.2), more detailed descriptions are given, listing large quantities of precious metals and linen garments, 20 talents of purple wool, 500 oxen, and 5000 sheep received from the kingdom of Pattina in the Amuq Plain, in addition to the metals, oxen, and sheep received from Bit-Agusi in Northern Syria (Grayson 1996, A.0.102.2: ii, 18b-24a, 27b-30a). Tiglath-Pileser III, one of the few Neo-Assyrian kings to specifically mention the kingdom of Hamath in his campaign reports, lists metals, hides, ivory, garments, linen garments, purple wool, wood, sheep, birds, horses, mules, oxen, goats, and camels among other objects and goods received as payment (Tadmor and Yamada 2011, #28, #32). These lists of tribute and booty extracted from the kingdoms of Syria, while not necessarily exact in the volumes and amounts recorded, nonetheless give a good indication of the complexity of the economy of these kingdoms, as well as their apparent prosperity and economic productivity.

Given the scale and complexity of these economic systems, it is impossible to develop a comprehensive model that integrates all these different aspects into a single framework. Therefore, crop cultivation, specifically for winter wheat, is used here as a ‘base line’ with which the effects of climatic change on the agricultural system can be approximated and analyzed. Wheat was one of the most widely distributed, and probably most important, subsistence crops in the Ancient Near East. It has been closely associated with economic prosperity, suggesting that it can be used as an indicator of agricultural production and social stability (Riehl *et al.* 2014, 12348), with the suitability of a certain area for growing crops strongly related to a number of environmental and climatic factors. In this context, wheat is preferred over barley as the crop type on which the model will be built, since it is more dependent on climatically and environmentally favorable conditions than the latter (van Zeist and Bottema 1999, 30-31), and is therefore expected to be more sensitive to small-scale climatic changes.

Although predictive modeling has recently become fairly popular in archaeological research, suitability analysis remains a little explored field, a few exceptions notwithstanding (e.g., Dorshow 2012). However, they are more commonly applied in other social and natural sciences, including geography, agricultural science, environmental science, and disaster management. Predictive modeling has been used to monitor and study aspects of landscape dynamics (Sarma *et al.* 2013), agricultural development (Shanan and Peleg 1980), land-use mapping (Ceballos-Silva and Lopez-Blanco 2003), and vegetation development (Jin *et al.* 2008; Stage and Salas 2007). Although each application differs slightly in the methods and parameters used in the analysis, they can all be classified as a form of “hierarchical geospatial analysis” (Dorshow 2012, 2099), in which multiple independent parameters are combined and weighted against each other. In GIS, such a hierarchical analysis can be achieved by overlaying multiple raster surfaces containing information on a range of variables, such as topography or climate, to create a new surface indicating the likelihood of a given area to be amenable for certain activities or for the occurrence of specific natural phenomena, such as agricultural production or the presence of certain plant species.

For the analysis of wheat crop suitability in Western Syria, a predictive modeling framework was developed that is based on a set of five key environmental factors: mean annual precipitation, water deficit during the growing season,[76] soil type, terrain slope, and the availability of groundwater.[77]

Each of these factors constitutes a major influence on the suitability of an area for successful wheat cultivation. Each of these parameters was transformed into a model component and integrated into a single, comprehensive modeling framework. Although these components are based on the raster data discussed in the previous chapter, they had to be re-classified according to a common suitability scale, in order to be integrated into a single model. This classificatory scheme consists of five different classes, ranging from a value of 1 (very low) to 5 (very high) (cf., Ceballos-Silva and Lopez-Blanco 2003).

5.3.2 Mean Annual Precipitation Parameter

The importance of total annual precipitation for vegetation development and agriculture has long been recognized and extensively discussed in ecology and agricultural management. In addition to the Food and Agriculture Organization of the United Nations (Doorenbos and Pruitt 1977; Steduto *et al.* 2012), which considers water availability as the main limiting factor for crop development, several agronomic studies consider water shortages and droughts as one of the major constraints, if not the most important one, to agricultural production. Especially in the case of wheat crops, water stress can have significant effects on plant development and crop yield, particularly in those

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[76] In this context, 'growing season' refers specifically to the developmental stage of winter wheat. In the Mediterranean region, the growing season primarily spans the months from March to May, although in some instances it can also extend into early June (e.g., Ilbeyi *et al.* 2006). For the purposes of the analysis presented here, precipitation values have been averaged across the months from March to May, in order to arrive at a general representation of growing season conditions.

[77] Of course, these parameters are not all-inclusive and a variety of other factors could justifiably be cited. For example, in their case study on rain-fed dryland agriculture on Hawaii, Kurashima and Kirch (2011) use slope, elevation, precipitation, substrate age, and distance from the coast as modeling parameters. Harrower *et al.* (2012) identify geology, climate, geomorphology, and hydrology as the generally most important influences on subsistence systems in their case study in the Arabian Peninsula, whereas Altaweel (2008a) has used soil evolution, hydrology, evapotranspiration, plant phenology, and daily weather conditions as the defining parameters of his agent-based social model of barley cultivation in Iron Age Northern Mesopotamia (cf., Wilkinson and Hritz 2013). Another important natural factor for the successful cultivation of wheat is temperature during the growing season. Although Riehl (2008) and others (e.g., Angus and Moncur 1977) have argued that in arid environments temperature plays a less significant role in wheat agriculture than precipitation, other scholars have pointed out the importance of temperatures for proper plant development and adequate agricultural yields (Bagherzadeh and Daneshvar 2014; Farooq *et al.* 2011; Ilbeyi *et al.* 2006; Oweis *et al.* 1999). According to Farooq *et al.* (2011), wheat is highly sensitive to high temperatures, which can cause damage to the plant during the growing stage. According to them, the optimum mean temperature during this period lies between 12-22 °C, whereas Steduto *et al.* (2012) consider temperatures of 15-23 °C as optimal. Above this range, considerable reductions in crop productivity can occur and temperatures of more than 30 °C can lead to complete plant sterilization and crop loss (Farooq *et al.* 2011). On the other extreme, low temperatures can also effect plant health. Below 10-12 °C, the hazard of crop failures increases noticeably, whereas a minimum mean temperature of 5 °C is considered the bare minimum for growth (Steduto *et al.* 2012). Yet, modeling of growing seasons temperatures (which has not been included in the detailed discussion) does not suggest that this aspect played a significant role in wheat crop suitability in the Late Bronze and Iron Ages in West-Central Syria. On the contrary, with only a few minor exceptions, temperatures were found to be within the optimal zone for growth, without either spatial or temporal variation, which also caused some problems for the construction of the suitability model. Therefore, growing season temperatures were not included in the modeling process. In addition, the list provided above consists (almost) exclusively of natural parameters, excluding numerous socio-cultural factors that could have an effect on suitability for cultivation, for example a farmer's training, technical equipment, or use of fertilizers, as suggested by Hassan *et al.* (2010). However, these factors are less easily represented in a GIS and would also require a much more precise knowledge of farming practices in the Ancient Near East, especially during the 1st millennium BCE. Due to these limitations, the focus of this analysis rests entirely on natural limitations to crop suitability, which is also supported by a number of recent studies, which have stressed the importance of natural factors in the development of plant regimes and for agricultural potential (see following discussion).

areas of the Near East characterized by a Mediterranean climate regime (Angus and Moncur 1977; Bagherzadeh and Daneshvar 2014; Boutraa *et al.* 2010; Ilbeyi *et al.* 2006; Khan and Naqvi 2011; Zhang and Oweis 1999).[78]

In the Mediterranean, water demand for agricultural crops is primarily satisfied with rainwater, as soil water is usually depleted by the characteristic hot and dry summers (Zhang and Oweis 1999, 205). According to FAO guidelines, an average of 450 mm to 650 mm of precipitation is necessary to achieve high wheat yields. Whereas in some instances, rainfall of only 250 mm can already be sufficient to reach crop maturity, supplementary irrigation is strongly recommended below 300 mm (Zhang and Oweis 1999, 209). In today's Syria, the overwhelming majority of cropland is found in areas receiving between 250-450 mm of rain per year (Oweis *et al.* 1999, 255).

This importance of precipitation for wheat agriculture has also been recognized from an archaeological point of view, especially with regard to the Ancient Near East. Wilkinson and Hritz (2013, 11) have argued that the agriculture of Northern Syria relied heavily on adequate rainfall levels. More generally, Wilkinson has commented on the particular importance of rainfall for intensive agriculture, arguing for a "[…] broad correspondence between areas of higher rainfall and high population densities" (Wilkinson 2003, 18). The Eastern Mediterranean in particular, due to its variegated topography, is highly sensitive to changes and differences in precipitation. In general, rain-fed agriculture is possible in areas of at least 300 mm of annual precipitation, but becomes significantly more hazardous below this threshold (Wilkinson 2003, 17). Although the cultivation of some crops, for example barley, is possible with as little as 200 mm per year, most large archaeological sites are located north of the 300 mm isohyet (Jursa 2013), suggesting that marginal areas of low or unreliable precipitation were not able to support large-scale settlement (cf., Lewis 1949, 280). But variability in rainfall is not only dependent on topographical variables, as inter-annual and inter-seasonal differences in rainfall patterns contribute to an increased instability of agricultural systems in those marginal areas as well (Wilkinson 2003). This argument is also adopted by Riehl (2008, S43), who maintains that precipitation constitutes a more significant limitation on agriculture and land-use than does temperature.

Hence, annual precipitation can be considered a main limiting factor for the successful cultivation of wheat crops in West-Central Syria. Variability in rainfall can be assumed to have had major effects on agricultural production, especially since the study area is characterized by significant spatial variability in precipitation levels (see, Wilkinson 2003, Fig. 2.1). Based on the foregoing discussion, the raster values of mean annual precipitation, modeled by the MCM and extrapolated across the study area, were re-classified into five different categories of suitability (**Tab. 5.1**) for integration into the common modeling framework.

Range (mm)	**Suitability Score**
< 200	1
200 - 250	2
250 - 300	3
300 - 450	4
> 450	5

Tab. 5.1: Suitability scale for mean annual precipitation parameter.

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[78] The importance of water availability has also been recognized for other cultivars, such as maize and potatoes (Ceballos-Silva and Lopez-Blanco 2003), and other non-agricultural plants, albeit only indirectly (Stage and Salas 2007). In contrast, a study by Jin *et al.* (2008) has argued that rainfall is only of secondary importance to vegetation development, with other environmental and topographical factors being seen as more important.

5.3.3 Mean Growing Season Water Stress Parameter

In addition to annual precipitation, seasonal fluctuations in rainfall can be considered of critical importance to wheat cultivation. Water availability is especially critical during the flowering stage of the growing season, as water deficits during that period can lead to significant reductions in crop yield.

Several studies have stressed the importance of drought stress for wheat crops and several scholars consider drought as the most significant environmental hazard to agriculture worldwide. Water stress during the growing season is considered especially problematic, affecting plant development even more than during other stages (Ilbeyi *et al.* 2006; Zhang and Oweis 1999). Modern agronomic research indicates that serious water deficits during this period can lead to a reduction in plant biomass, its tillering ability, and the size and quantity of grains developed (cf., Boutraa *et al.* 2010; Khan and Naqvi 2011). As the nutritional quality of wheat is in large parts defined by kernel weight and size, a reduction in these characteristics potentially has enormous repercussions on subsistence strategies and the economy in general (Araus *et al.* 2007, 2). Importantly, damage incurred by crops during this period cannot be recovered through supplementary irrigation during later stages of plant development, rendering the growing season a critical episode of agricultural production.

In ancient Western Syria, grains were primarily grown as winter crops (Jursa 2013), meaning that the growing period would occur in late spring. For Mediterranean winter crops, such as bread wheat (*Triticum aestivum L.*), this critical period starts around March or April, depending on weather conditions, and lasts until at least May (Cooper and Gregory 1987; Zhang and Oweis 1999). In a recent archaeological study, White (2014, 167-174) identified deteriorating climatic and environmental conditions in Late Bronze Age Anatolia, resulting in markedly increased water stress during the months of April and May, suggesting that frequent seasonal droughts constituted a considerable threat to agricultural production. Hence, it is not sufficient to just regard annual precipitation as the only water-related variable in determining agricultural suitability and productivity. Seasonal fluctuations in rainfall, and especially the potential of significantly rising levels of water stress, should be considered in the suitability model as well.

Thus, seasonal drought, that is, serious water deficits during the growing season, was also incorporated into the suitability model as a parameter. Following the literature, the growing season for wheat was defined as the period from March to May, incorporating the vegetative, flowering, and yield formation periods of crop development. This is based on the assumption that winter wheat varieties would have been cultivated in West-Central Syria, which would have been more resistant to the dry and hot summer conditions of the region (cf., White 2014).

To operationalize water stress as a model parameter, crop evapotranspiration had to be calculated, which can be achieved through the formula

$$ET_c = ET_0 \text{ x } K_c$$

where ET_c is crop evapotranspiration under normal circumstances, ET_0 is the reference evapotranspiration value, and K_c is the crop coefficient, which is specific to the particular type and growing stage of the plant analyzed. Values for ET_0 were obtained through the MCM. Evaporation data from the FAO climate stations were used to model monthly and annual evaporation values for the seven time-slices analyzed here. Then, the mean value for the period between March and May, the main growing season of winter wheat, was calculated. The K_c value for winter wheat during the mid-season stage of plant development is given as 1.2, according to FAO data (Allen *et al.* 1998).

In a second step, water stress during the growing season was computed. The calculated crop evapotranspiration value ET_c was subtracted from mean precipitation values during the same period. The results of these calculations can be found in the corresponding data table (**Appendix 5**).[79] The computed values were then used to interpolate continuous surfaces for water stress during the growing season, as described in the previous chapter (**§4.3.4**).

To integrate this parameter into the suitability model, water-stress values had to be re-classified. Unfortunately, the available literature on this issue does not provide a clear indication of the level of water stress that might be considered detrimental to wheat crop development, or how much water deficit might still be considered acceptable, although some scholars argue that full irrigation is not always required to secure high crop yields (Oweis *et al.* 1999; Zhang and Oweis 1999). In those instances where water stress is explicitly quantified, different methods to determine the level and severity of water deficits are used, for example by calculating percentages of field water capacity (Boutraa *et al.* 2010) or by relying on the results of isotopic analysis (e.g., Bogaard *et al.* 2016; Ferrio *et al.* 2003; Vaiglova *et al.* 2014; Wallace *et al.* 2013; Wallace *et al.* 2015).

Such an approach, however, is not feasible within the confines of this project and with the data available. Hence, a different approach was taken. Keeping in mind that crop plants are capable of enduring moderate levels of water stress, the calculated ranges of water deficit were divided into the five suitability classes, using equal intervals (**Tab. 5.2**).

Range (mm)	Suitability Score
< -100	1
-100 - -50	2
-50 - 0	3
0 - 50	4
> 50	5

Tab. 5.2: Suitability scale for mean growing season water stress parameter. Numbers represent approximate range as values differ slightly between modelled time intervals.

5.3.4 Soil Type Parameter

According to the FAO, wheat can be grown on a wide variety of soil types. Yet, soil characteristics can have significant effects on crop cultivation and therefore soils can be regarded as a "[…] structuring element of agrarian societies" (Salisbury 2012, 179). The importance of favorable soil characteristics has been highlighted in a number of different studies (Ashraf and Normohammadan 2011; Bagherzadeh and Daneshvar 2014; Ceballos-Silva and Lopez-Blanco 2003; Jin *et al.* 2008).

Mediterranean soils, as discussed in the previous chapter, are generally highly fertile. Their moisture regime is xeric, meaning that most of the rainfall occurs during the winter months, whereas their temperature regime is thermic (soil temperatures between 15-22 °C), or sometimes mesic (temperatures around 8-15 °C). Together with their favorable chemical properties, these characteristics make many Mediterranean soils highly suitable for cultivation (Verheye and de la Rosa

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[79] These calculations only represent a rather simplistic approximation of the various physical and chemical dynamics that define evapotranspiration and crop water uptake, especially since a precise estimation of crop evapotranspiration is considered very difficult, even with more complete data (cf., Steduto *et al.* 2012, 9). For example, the computational model used by the FAO to estimate evapotranspiration for various types of crops uses a range of parameters, including climate, crop type, soil, and management characteristics (Steduto *et al.* 2012). Similarly, Boutraa *et al.* (2010) have associated water stress not only with deficits in the amount of rainfall, but also with factors such as cold and heat, soil salinity, acidity, and alkalinity. Also, see Ilbeyi *et al.* (2006) for other parameters affecting crop production. Thus, the water stress parameter, as presented here, is only a rather simplistic adaptation of the interrelated and complex processes that define crop water requirements in the real world. However, in the context of this study, it can be suggested as a reasonable approximation of these various physical and chemical processes.

2005). While it is not possible to evaluate the full range of potentially important chemical soil characteristics in West-Central Syria, the data presented in Straub (1988b) is detailed enough to allow for the inclusion of soil texture and pH-value into the evaluation of agricultural suitability.

Soil erosion, on the other hand, currently constitutes a major constraint on mapping and modeling soil properties and soil suitability in West-Central Syria. It has long been recognized that Mediterranean soils are characterized by a long history of deposition, erosion, and re-deposition, which scholars have attributed to either natural (e.g., Bintliff 1977; Vita-Finzi 1969, 1976) or anthropogenic (Chester and James 1991; Wagstaff 1981; c.f., Yaalon 1997) causes (c.f., Allen 2001). As a result of the oftentimes steep slopes of the Eastern Mediterranean topography, soil erosion is a widespread phenomenon (Yaalon 1997), occurring especially frequently on marl slopes and in areas where Lithosols are prevalent (Allen 2001). In addition to these topographical and environmental factors, anthropogenic influences, in the form of vegetation removal, cultivation, and soil compaction, have been cited as negatively affecting soil erosion rates across the Mediterranean (Allen 2001; van der Zanden 2011). Whereas certain forms of cultivation, such as olive horticulture, or vegetation regimes, like shrub lands, might positively affect soil erosion rates, other forms of land use, particularly cereal cultivation and livestock grazing, have been recognized to contribute to sediment loss (Allen 2001).

The problem of soil erosion in the Mediterranean, along with its natural and anthropogenic causes, has long been recognized (Allen 2001; Lewis 1949; van der Zanden 2011). In Syria, large portions of the country are affected by soil degradation (van der Zanden 2011), and some scholars have estimated that up to 50 % of the country's soils are under severe threat of erosion today (Haktanir *et al.* 2004). As the soils on many slopes and in upland areas have become very shallow, or were entirely removed, only the valleys and lowlands preserve soil profiles of considerable depth (Yaalon 1997). Due to the long history of both natural and anthropogenic land degradation, few regions of the Mediterranean, and the Levant in particular, can be considered as pristine, and are therefore better understood as semi-natural in origin (Allen 2001, 10).

Soil Type (TAVO)	**Suitability Score**
Eutric Cambisols (Be6)	5
Calcic Cambisols (Bk2)	5
Chromic Luvisols (Lc1)	4
Chromic Luvisols (Lc3)	4
Chromic Luvisols (Lc6)	4
Chromic Vertisols (Vc2)	4
Chromic Vertisols (Vc3)	3
Chromic Vertisols (Vc4)	3
Xerosols (Xk11)	2
Xerosols (Xk15)	1
Xerosols (Xk16)	1
Xerosols (Xy2)	1
Lithosols (I30)	1
Vertisols (I31)	1
Swamp and Marshland	1

Tab. 5.3: Suitability scale for soil type parameter.

Owing to this complex history of soil erosion in West-Central Syria, along with its interrelated topographical, environmental, climatic, and anthropogenic aspects, the evaluation of the effects of soils on Late Bronze and Iron Age agriculture can be little more than a reasonable approximation. A more accurate representation of the distribution of soils throughout the region during these periods would require the use of complex (agent-based) computational models to retrodict the effects of human land use, as done by a few scholars (e.g., Arıkan 2012; Arıkan *et al.* 2016; Barton *et al.* 2010a; Barton *et al.* 2010b; Wilkinson *et al.* 2013).[80] Since such

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[80] Note, however, that even these sophisticated models have to rely on some necessary generalizations in the model development process, such as classifying all soils as Mediterranean Terra Rossa, as done, for example, by Barton *et al.* (2010b).

an approach is not feasible within the confines of this project, the distribution of soils in Late Bronze and Iron Age West-Central Syria will be based on the data published in the TAVO map (Straub 1988a, 1988b).

Soils were classified according to the common suitability scale (**Tab. 5.3**). Re-classification of the soil communities is based primarily on the main soil types, although other factors, such as associated soil classes, texture, and terrain slope were also considered.

5.3.5 Terrain Slope Parameter

Terrain characteristics have been widely cited as important factors governing the development of vegetation regimes and the suitability for agricultural production (Ceballos-Silva and Lopez-Blanco 2003; Jin *et al.* 2008; Sarma *et al.* 2013; Stage and Salas 2007). Especially Jin *et al.* and Sarma *et al.* have emphasized the importance of topographical parameters, including elevation, slope, and aspect (slope direction) of the terrain. In contrast, Bagherzadeh and Daneshvar (2014) have found no statistically significant correlation between elevation and wheat/barley suitability in their study of Northwest Iran, suggesting that only certain aspects of topography play a role in crop suitability.

In this context, especially terrain slope can be considered as a major variable determining agricultural suitability, as the steepness (or flatness) of the topography determines, or at least significantly affects, surface runoff and susceptibility to erosion, the latter of which has been recognized as a significant element in suitability for cultivation (Bagherzadeh and Daneshvar 2014). Yet, terrain slope is not only significant as a component of the natural environment, but also constitutes an important sociocultural factor. In the Wadi al-Hasa in Jordan, a sharp decline of settlement densities above 20° (36.4 %) of terrain slope has been recognized (Arıkan 2010, 2012), suggesting that cultivation above this threshold becomes increasingly difficult and unsustainable, limiting agricultural activities, such as ploughing, sowing, or harvesting.[81]

Based on these considerations, DEM-derived slope values were re-classified into five suitability categories, representing the detrimental effects of increasing slope on crop cultivation (**Tab 5.4**). As quantifiable data on suitable terrain slopes are mostly missing from the literature, the slope categories outlined by Dorshow (2012) were adhered to. The only adjustment has been made to the lower threshold of the suitability scale, which has been set as 36 % slope, as indicated by observations made by Arıkan (2010, 2012) during archaeological work in the Southern Levant.

Range (%)	Suitability Score
0-10	5
10-15	4
15-20	3
20-36	2
>36	1

Tab. 5.4: Suitability scale for terrain slope parameter.

5.3.6 Hydrogeology Parameter

The distribution of hydrogeological features, that is aquifers, constitutes the final parameter considered in the modeling process. As already discussed in the previous chapter **(§4.6)**, groundwater can be considered an important source of irrigation water, and therefore constitutes an important factor in the sustenance of agricultural systems in semi-arid and arid environments, such as the Mediterranean and the Near East (Allen 2001, 56).

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[81] In comparison, in the context of maize farming at Chaco in the southwestern United States, a slope of 16 % has been suggested as a threshold beyond which farming would have been rather unlikely to occur (Dorshow 2012; Kirkby 1973).

In West-Central Syria, particularly the limestone and marl formations of the Orontes river valley have been recognized as major sources of groundwater (Allen 2001; Lewis 1949) and Pustovoytov and Riehl (2016) have recently proposed an interesting way to include the distribution of aquifers into an analysis of climatic and environmental change and social adaptation.

Yet, although the importance of groundwater for agriculture is fairly well established for modern agriculture, the use of these groundwater sources in ancient times is less well understood. In his survey of groundwater use in ancient Israel-Palestine, Issar (2001) stated that the arid character of the Eastern Mediterranean compelled its inhabitants to access groundwater sources through the digging of wells. Indeed, the existence of wells and water systems is attested at numerous sites, for example Arad, Beersheba, Gezer, Gibeon, Hazor, Jerusalem, Lakish, Megiddo, and Taanach (Issar 2001; Schmidt 2015). While the well at Arad can be attributed to the Early Bronze Age (Issar 2001), the water systems at Hazor, Megiddo, and Gibeon have been dated to around the 10th-9th centuries BCE, based on stratigraphic evidence (Schmidt 2015, 438). At the Hittite capital of Hattusha in Anatolia, similar waterworks have been identified. To date, a total of about eleven such installations, consisting of eight ponds and two basins in the Upper City and another large basin in the Lower City, have been identified (Schachner and Wittenberg 2012; Seeher 2010). Some of these installations were used for the collection of rain water, but in several instances their cutting into the groundwater table clearly indicates the intent to access subterranean freshwater reserves, leading scholars to propose that the inhabitants of Hattusha relied on groundwater for storage, agriculture, and livestock rearing (Schachner and Wittenberg 2012; Seeher 2010). In Syria, however, the situation is less clear. Recently, Kühne (2012) argued that Neo-Assyrian agriculture in the Jezirah relied on a combination of precipitation, surface water, and groundwater, for which the primary evidence consists of the dense network of canals identified in the area. In West-Central Syria, very little is known about the construction and use of water systems. The only example of such structures is the large well excavated in conjunction with the Royal Palace at Tell Mishrifeh (Schmidt 2015), which constitutes the sole example of water systems in the region.

That not all of these structures were intended to access groundwater sources has been argued by Weinberger *et al.* (2008). Nonetheless, hydrological engineering was a common practice in the Levant throughout the Bronze and Iron Ages and the use of groundwater sources is unequivocally attested in Syria at Tell Mishrifeh, as well as at Anatolian sites, such as Hattusha. While the exact ways in which groundwater was used are not entirely understood, especially in West-Central Syria with its limited archaeological evidence, aquifers can nonetheless be considered an important source of freshwater In addition, wells dug to reach the groundwater can be assumed to constitute a way in which human populations secured their subsistence in arid environments (c.f., Eichmann and Klimscha 2012).

To account for the importance that groundwater resources play in arid environments, the distribution of aquifers in West-Central Syria has also been considered in the development of the predictive model of agricultural suitability. Different suitability scores were assigned to areas with no groundwater, with only sporadic or seasonal groundwater, and with extensive groundwater resources, without further internal subdivisions (**Tab. 5.5**).[82]

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[82] This approach differs slightly from the one taken by Pustovoytov and Riehl (2016), who have combined both extensive and irregular aquifers into a single category. No distinction between intergranular and fissured aquifers has been made in their study as well.

Aquifer Type (TAVO)	Suitability Score
Extensive and highly productive	5
Local or discontinuous	3
Limited or no groundwater	1

Tab. 5.5: Suitability scale for hydrogeology parameter.

5.4 Modeling Results

The suitability model was created by combining the different parameters in a weighted overlay. The overlay was performed for each of the seven time slices between 1350 and 750 BCE (**Fig. 5.8**). Water availability, indicated by precipitation and water stress, is generally considered the most important factor for wheat crop cultivation, especially in the semi-arid environment of Northern Syria. A higher relative weight was thus assigned to these factors, which was also necessitated by the focus of the analysis lying on chronological change and the effects of altering climatic and environmental conditions. Static parameters - soils, topography, and hydrogeology - were assigned lower relative weights (**Tab. 5.6**).

Model Parameter	Relative Weight (%)
Annual Precipitation	30
Growing Season Water Stress	30
Terrain Slope	15
Soil Type	15
Hydrogeology	10

Tab. 5.6: Weighting scale for the suitability model.

Despite the higher relative weight of the chronologically variable parameters, geographical variation constitutes the most pronounced difference observable in the suitability maps. The coastal plains and the western slopes of the coastal mountains are marked by generally high suitability scores, particularly on the Jableh Plain. Other regions of high agricultural suitability include parts of the Ghab Valley in the north, the western fringes of the Northern Plateau, and sections of the Middle Orontes Valley. The Upper Orontes and the eastern parts of the Middle Orontes Valley, as well as the majority of the Northern Plateau, are only moderately suitable for agriculture, whereas the eastern fringes of the study area are characterized by generally low suitability values. In addition to these stable spatial patterns, there are also some temporal fluctuations observable in the data. Expansions of moderately suitable land at the expense of more favorable areas on the coast occurs primarily in the northern and southern parts. In addition, both the Middle and Lower Orontes Valleys and the Northern Plateau experience some more-or-less pronounced fluctuations in agricultural suitability and, in a few isolated areas, even the development of areas of low suitability. Most noticeable, however, is the expansion of low suitability areas in the eastern fringes of the Northern Plateau and the Middle Orontes Valley.

Visual inspection of the modeling results alone suggests both spatial and temporal variability in the effects of changing climates on the agricultural system of Late Bronze and Iron Age West-Central Syria. To investigate these patterns further, statistical analysis of the distribution of suitability classes across the study area was conducted on three different analysis scales, moving from large (regional) to small (site-dependent) resolution.

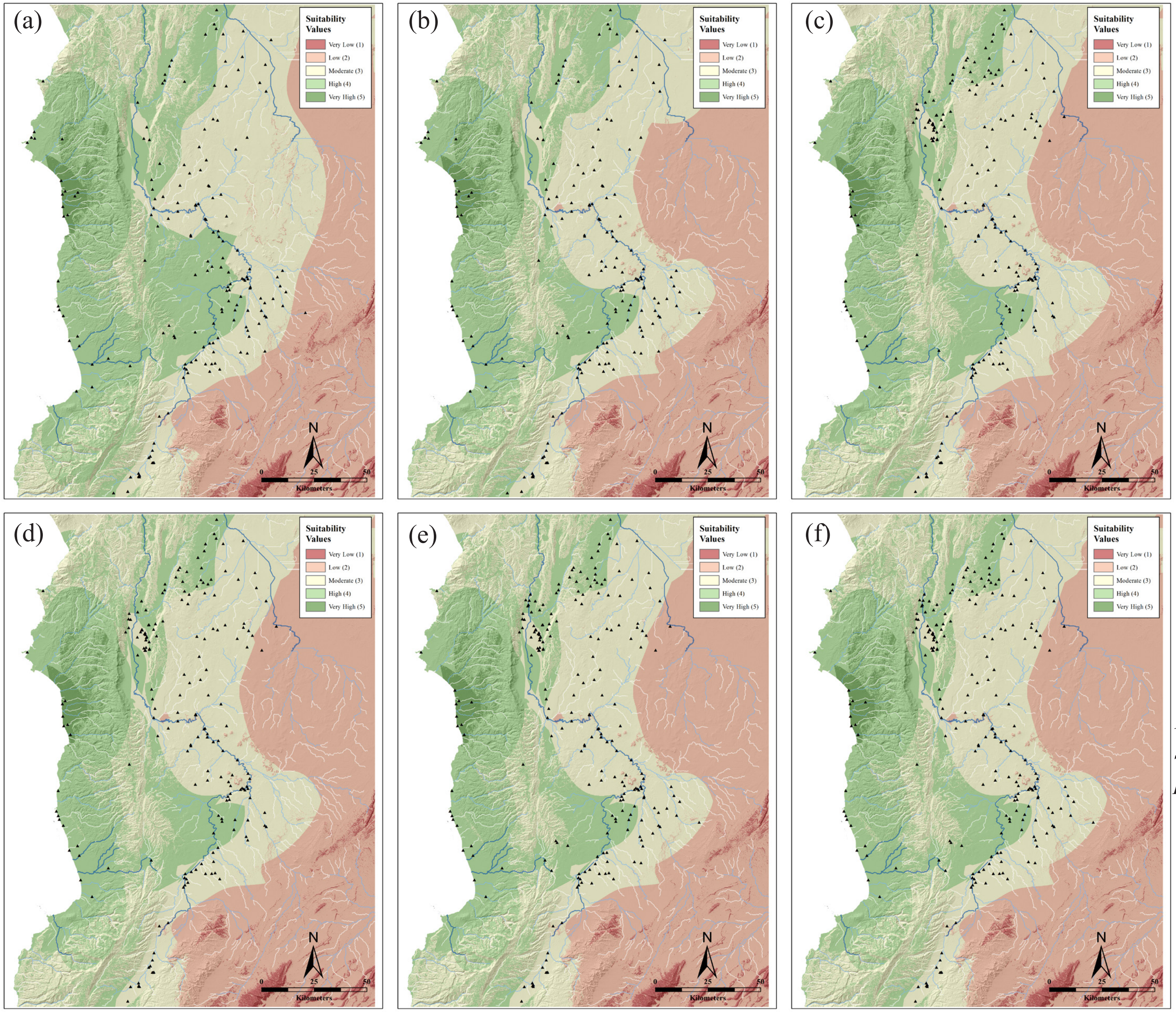

Fig. 5.8: Suitability scores calculated by the predictive model for (a) 1350 BCE, (b) 1250 BCE, (c) 1150 BCE, (d) 1050 BCE, (e) 950 BCE, (f) 850 BCE, (g) 750 BCE.

5.4.1 Regional Analysis

In a first step, the distribution of suitability classes was investigated at the regional level, considering the entire study area as a whole (**Fig. 5.9**). One obvious characteristic of agricultural suitability at this scale is the fairly small role played by areas of either very low or very high suitability. The very small portions that these two classes constitute of the entire sample, around 1-2 % each, can be explained by their geographical distribution. Whereas areas of very high suitability are largely confined to the Jableh Plain on the coast, very low values occur primarily in the eastern steppe and desert fringes. Conversely, areas of lowq, moderate, and high agricultural suitability constitute over 96 % of the entire sample.

But chronological developments become apparent as well. Around 1350 BCE, moderate and high suitability areas make up for 36.8 % and 30.8 % of the entire area, respectively. Areas of low suitability, on the other hand, constitute a slightly lower portion, at 29.1 %. This changes in 1250 BCE, when the low areas make up 32.4 %, whereas high areas decrease to 26.3 % of the total sample. This trend continues afterwards as well, with areas of low suitability accounting for 35.2 % in 750 BCE, whereas the percentage of highly suitable land has decreased to only 24.5 %.

Considering the entire study area, it appears that climatic change did indeed have an effect on the development of agricultural suitability in the study area over time. Towards the end of the Late Bronze Age, the proportion of less favorable areas increases at the expense of more suitable ones. To some degree, this trend continues into the Iron Age as well, as a further decrease in the proportions of highly suitable areas might suggest. Yet, climatic fluctuations during the Iron Age also do not follow a clear trajectory, as some minor temporal variations in the relative proportions of suitability classes might suggest.

It appears that by considering the entire regional sample for West-Central Syria at once, the effects of more subtle and small-scale temporal and spatial trends are obscured. Moreover, by taking the

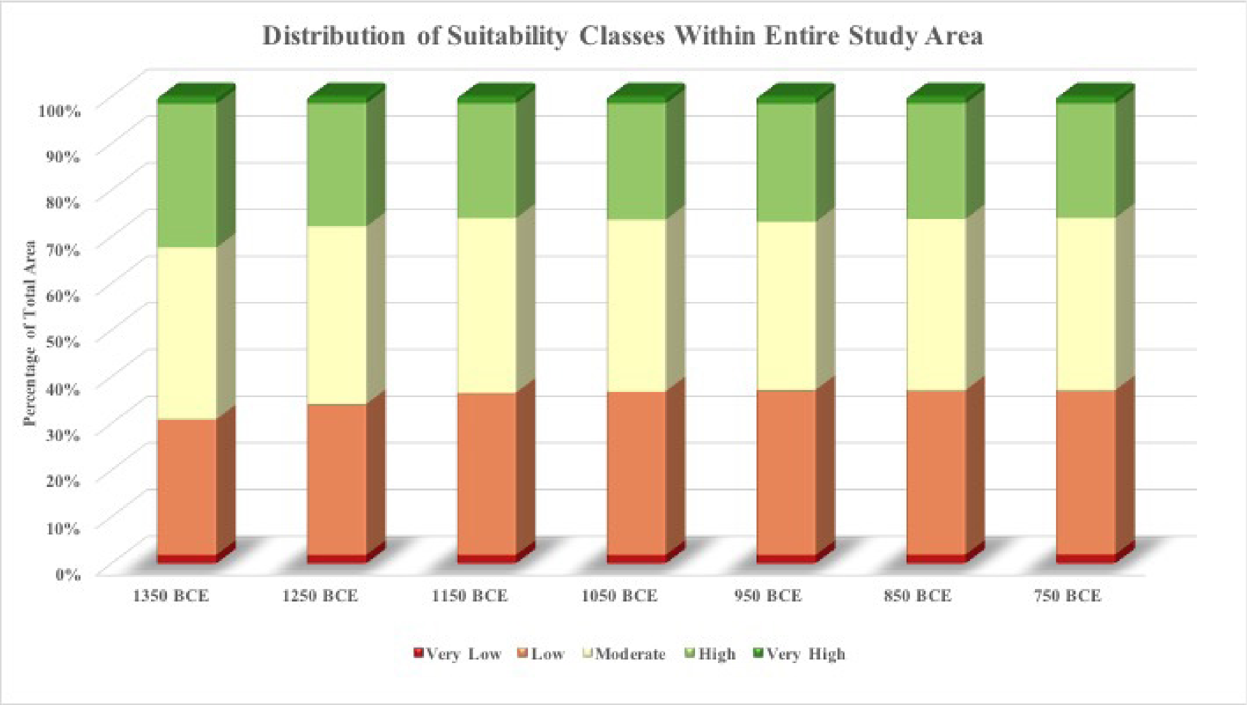

Fig. 5.9: Distribution of suitability scores within the entire study area.

entire regional sample into account, the analysis also includes regions of the study area that are far removed from the main settlement areas of West-Central Syria, which were of little (or no) importance to the sustenance of agricultural production during these periods.

5.4.2 Sub-Regional Analysis

To investigate the potential influence of minuscule, and probably less obvious, temporal and spatial patterns in the data, six analysis zones were defined in order to conduct further analysis on a smaller, sub-regional scale (**Fig. 5.10**). These regions, the Northern Coast, the Jableh Plain, the Central Coast, the Akkar Plain[83], the Northern Plateau, and the Orontes Valley, correspond to the main areas of settlement activity. These regions were defined in a data-driven way. Using the topographical data as the basis, hydrological basins were delineated according to the procedures outlined in Maidment (2002). As such, these regions effectively denote drainage basins and their contributing upland areas and can be considered discrete, contiguous ecological sub-systems.

The Mediterranean coast is generally marked by the complete absence of both low and very low suitability classes. On the Northern Coast, the high class clearly dominates the sample, ranging between 75 and 80 % of the total area (**Fig. 5.11**). The remaining areas are made up of moderately and very highly suitable land, the former being approximately twice as common as the latter. The sub-region experiences a slight drop in overall suitability between 1350 and 1150 BCE, observable in an increase in the moderate category, concomitant with a decline in both the high and very high classes. Between 1150 and 950 BCE, this trend reverses, but from 850 BCE onwards, overall suitability again starts to drop.

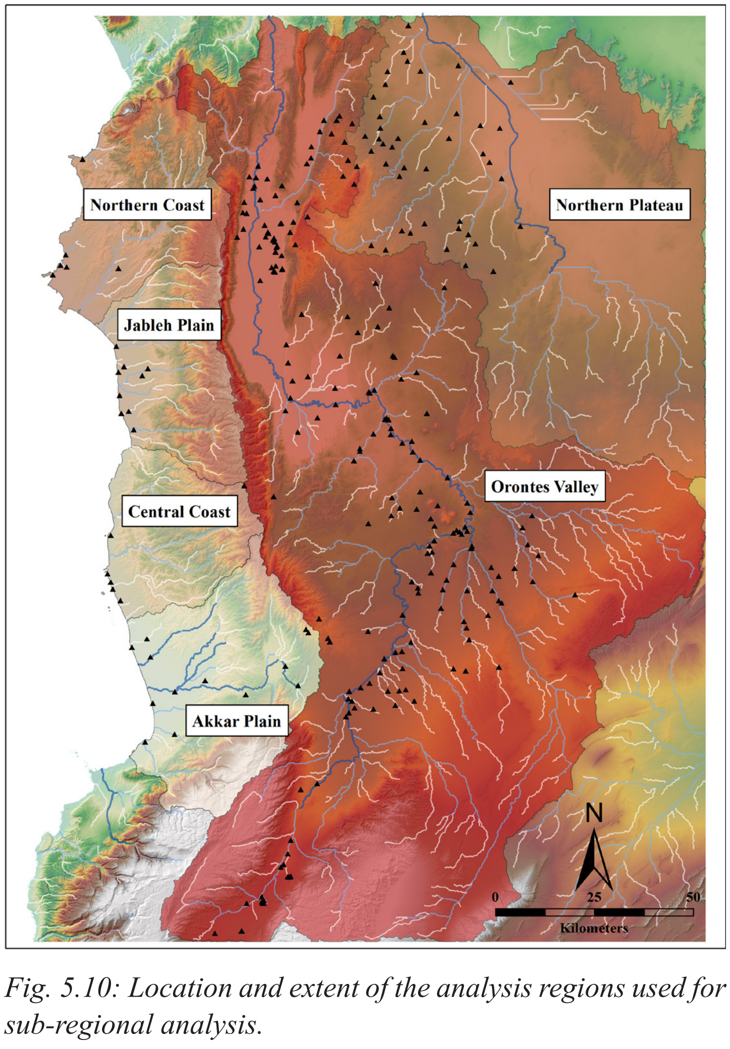

Fig. 5.10: Location and extent of the analysis regions used for sub-regional analysis.

As only alluded to above, the Jableh Plain constitutes the most fertile sub-region of the entire study area (**Fig. 5.12**). Here, unlike in any other part of West-Central Syria, the very high suitability class makes up around 30 % of the total area. While the overwhelming majority of this sub-region consists of highly suitable land (ca. 66-68 %), only a small fraction is made up of moderately suitable areas. Yet, even here small chronological changes can be observed. These

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[83] In fact, the region designated here as 'Akkar Plain' entailed both the coastal area of the Akkar Plan proper, as well as the adjacent Homs Gap, which links the coastal plain to the Orontes Valley further inland. For the sake of brevity, the term 'Akkar Plain' will be used in the following discussions to designate the area encompassing both the Akkar Plain and the Homs Gap.

are most prominent between 1350 and 1250 BCE, when the proportion of moderately suitable areas increases from below 1 % to over 2 %. A few minor temporal oscillations (far below 1 % of the total area) notwithstanding, this sub-region exhibits a remarkable degree of stability in agricultural suitability over time.

A similarly stable situation can be observed on the Central Coast (**Fig. 5.13**). The high suitability class constitutes the highest proportion of the total area, always above 80 %. The share of moderately suitable land, on the other hand, does fluctuate slightly over time, between roughly 14-18 %. Again, a long-term decrease in overall suitability can be observed between 1350 and 1150 BCE, when the proportion of both the high and very high classes diminishes. This trend is reversed between 1150 and 950 BCE, when suitability increases slightly, but conditions again become slightly more unfavorable after 950 BCE.

Finally, the data from the Akkar Plain exhibits some marked chronological variability (**Fig. 5.14**). Between 1350 and 1150 BCE, the proportions of moderately suitable land expand at the expense of highly suitable areas. This change in proportion, from around 17 % to over 32 % is quite significant in scale. Until 950 BCE, suitability again increases slightly, before receding again in 850 BCE and, to a lesser degree, in 750 BCE.

On the Northern Plateau, the distribution of suitability classes follows a very different pattern, especially from a chronological point of view (**Fig. 5.15**). Whereas about half of the sub-region consists of moderately suitable areas in 1350 BCE, this proportion drops to about 29 % around 1150 BCE, after which fluctuations are rather minute in magnitude. At the same time, the sub-region experiences a progressive expansion of less suitable areas. Whereas the low class makes up 41 % of the area in 1350 BCE, it increases to over 66 % in 950 BCE, concomitant with a decline in highly suitable areas and an almost negligible increase in areas of very low suitability (on the order of about 0.1 %). Quite interestingly, though, while the decline of highly suitable areas follows a linear pattern, both moderate and low categories oscillate slightly through time, with the expansion of unsuitable land reaching its high point in 950 BCE, after which it recedes again slightly.

The Orontes Valley is not only the largest of these regions, but also constitutes the archaeologically most important one, due to its high settlement density (**Fig. 5.16**). The highest proportion of this region consists of moderately suitable areas, which cover between 44 % and 50 % of the sub-region. Areas of low and very low suitability make up around 27-30 % and 1-2 % of the sample, respectively, which is just below the average for the entire region. Highly suitable areas fluctuate between 19-27 %, whereas the very high class is entirely absent from the data. As a result, the Orontes Valley appears largely as an area of moderate suitability, but with significant portions of both lowly and highly suitable land as well. Again, chronological differences are perceptible, for example in the expansion of both low and moderate proportions between 1350 and 1150 BCE. The most severe drop in suitability occurs between 1350 and 1250 BCE, when the proportion of highly suitable land drops from 27 to 20 %.

In summary, it becomes clear that the effects of climatic change on agricultural suitability operate on different scales in the coastal and inland areas. Whereas the coastal plains, and especially the Jableh Plain, exhibit generally high values of agricultural suitability, the inland areas are characterized by considerable proportions of less suitable, even unfavorable, land. Yet, in moving beyond regional analysis, it can also be shown that subtle, and quite important, differences exist between individual sub-regions, both in terms of spatial and chronological variability. The most obvious example is the Northern Plateau, which witnesses a major rise in the proportion of low suitability values over time. The only other sub-region where equally strong chronological changes are appa-

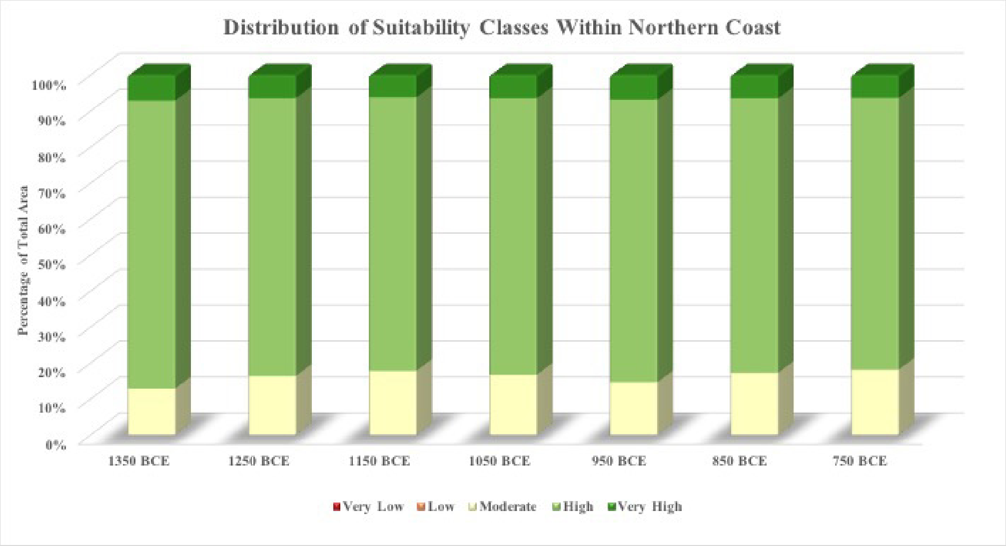

Fig. 5.11: Distribution of suitability scores on the Northern Coast.

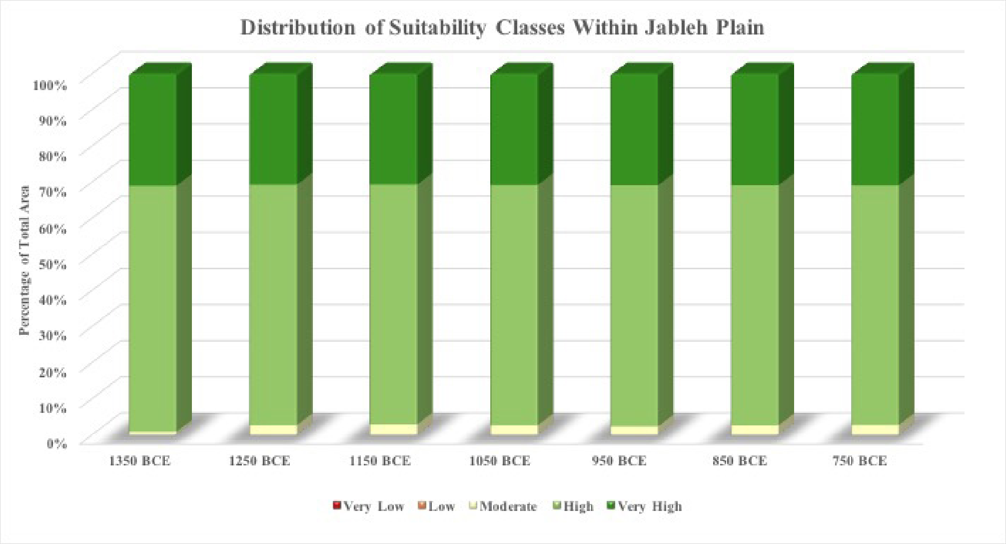

Fig. 5.12: Distribution of suitability scores within the Jableh Plain.

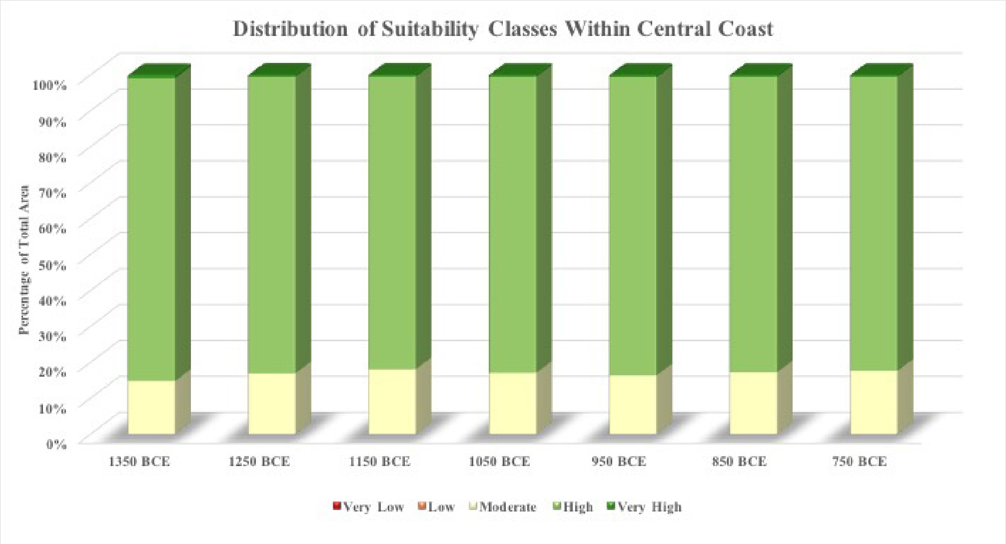

Fig. 5.13: Distribution of suitability scores on the Central Coast.

Fig. 5.14: Distribution of suitability scores within the Akkar Plain.

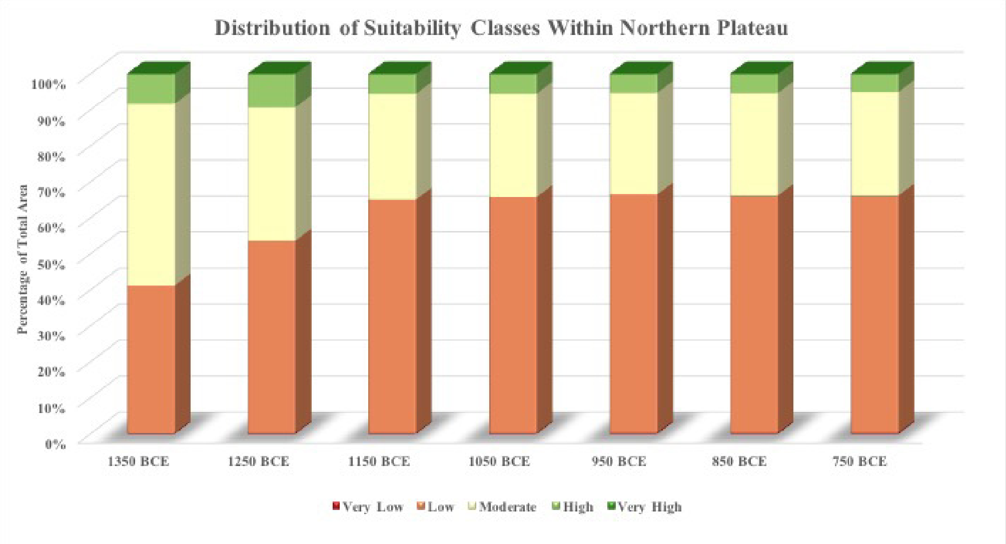

Fig. 5.15: Distribution of suitability scores on the Northern Plateau.

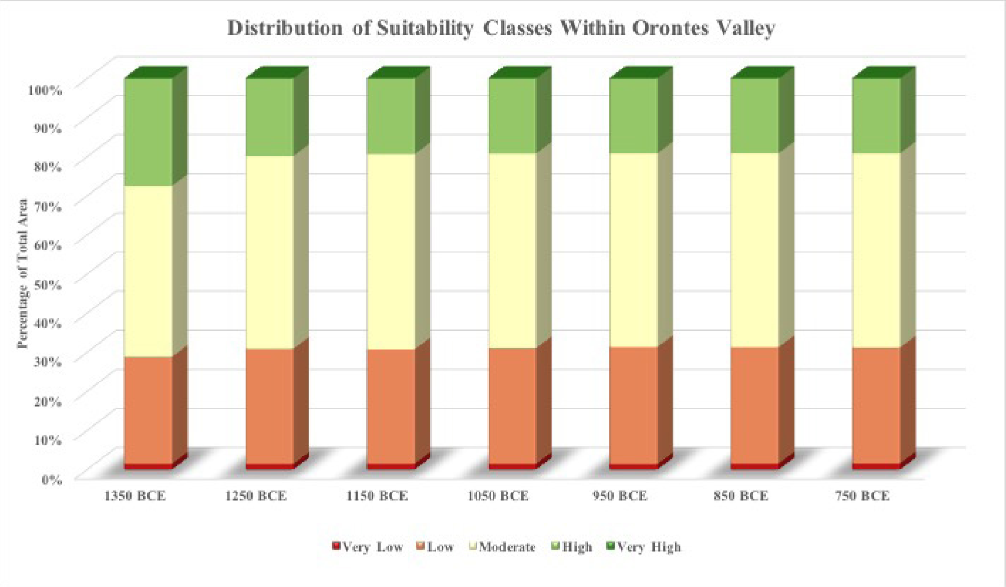

Fig. 5.16: Distribution of suitability score within the Orontes River Valley.

rent is the Akkar Plain, where moderately suitable areas expand at the expense of more favorable ones. Apart from these easily identifiable patterns, these data also provide evidence for some spatially and temporally confined fluctuations. Especially in the coastal areas, minor fluctuations in the proportions of suitability classes are perceptible, with an initial drop in overall suitability, followed b slightly more amenable conditions, before finally declining again. In contrast, the Orontes Valley as a whole remains fairly stable over time, with the most noticeable change in suitability occurring at the start of the period analyzed here.

5.4.3 Site-Dependent Analysis

Examining the development of wheat crop suitability between 1350 and 750 BCE on a regional and sub-regional scale makes it possible to identify chronological and geographic variation in the effects of climatic change.

These observations, however, are solely related to environmental factors. As even the sub-regions defined above incorporate large areas that are far removed from the main areas of settlement activity, they do not adequately account for the significance these climatic and environmental changes would have had for the communities living in the region. In fact, only a fraction of the entire study area would have been located in the immediate vicinity of both Late Bronze and Iron Age settlements in the region and would, thus, have been directly relevant to agricultural production. Analyzing environmental change solely on a regional, or even sub-regional, scale, it is possible that processes and developments at smaller scales, and in close vicinity to ancient settlements, are inadvertently obscured. It is thus both useful and necessary to further narrow the scope of the analysis to an investigation of the immediate surroundings of archaeological sites in both the Late Bronze and the Iron Age.

5.4.3.1 Application of Site-Catchment Analysis to West-Central Syria

As suggested in Chapter 3 (**§3.3.3**), there exist a variety of approaches to site-catchment analysis and the delineation of catchment territories. But while simplistic models, such as simple linear measurements, are inadequate and overly deterministic, complex models, such as the ones employed by Wilkinson and colleagues, require certain kinds of data (both archaeological and non-archaeological) that are currently not available for West-Central Syria.

It has been repeatedly argued by several scholars that time constitutes one of the most important factors in agricultural activities (e.g., Chisholm 1962; Vita-Finzi and Higgs 1970) and human travel (e.g., Livingwood 2012). Hence, it was decided to utilize a time-based approach to the delineation of catchment territories as a shorthand for modeling the potential extent of agriculturally exploitable territories within the study area. Following the argument of Vita-Finzi and Higgs (1970), territories were drawn at a one hour's distance from archaeological sites for the Late Bronze, Iron Age I, and Iron Age II periods (**Fig. 5.17**).

Catchment areas were created as anisotropic (directionally dependent) distance surfaces, using the *PathDistance* function in ArcMap. In this procedure, the cost of traversing a raster cell is defined by the surface raster, in this case the Digital Elevation Model (DEM), as well as a range of potential additional horizontal and vertical parameters, or impedances. This model, like many other archaeological applications of path modeling, only considers the effects of topography on movement through space. Thus, only vertical friction was considered in the calculation, which was provided by the well-known Tobler hiking function (Tobler 1993), implemented according to the guidelines

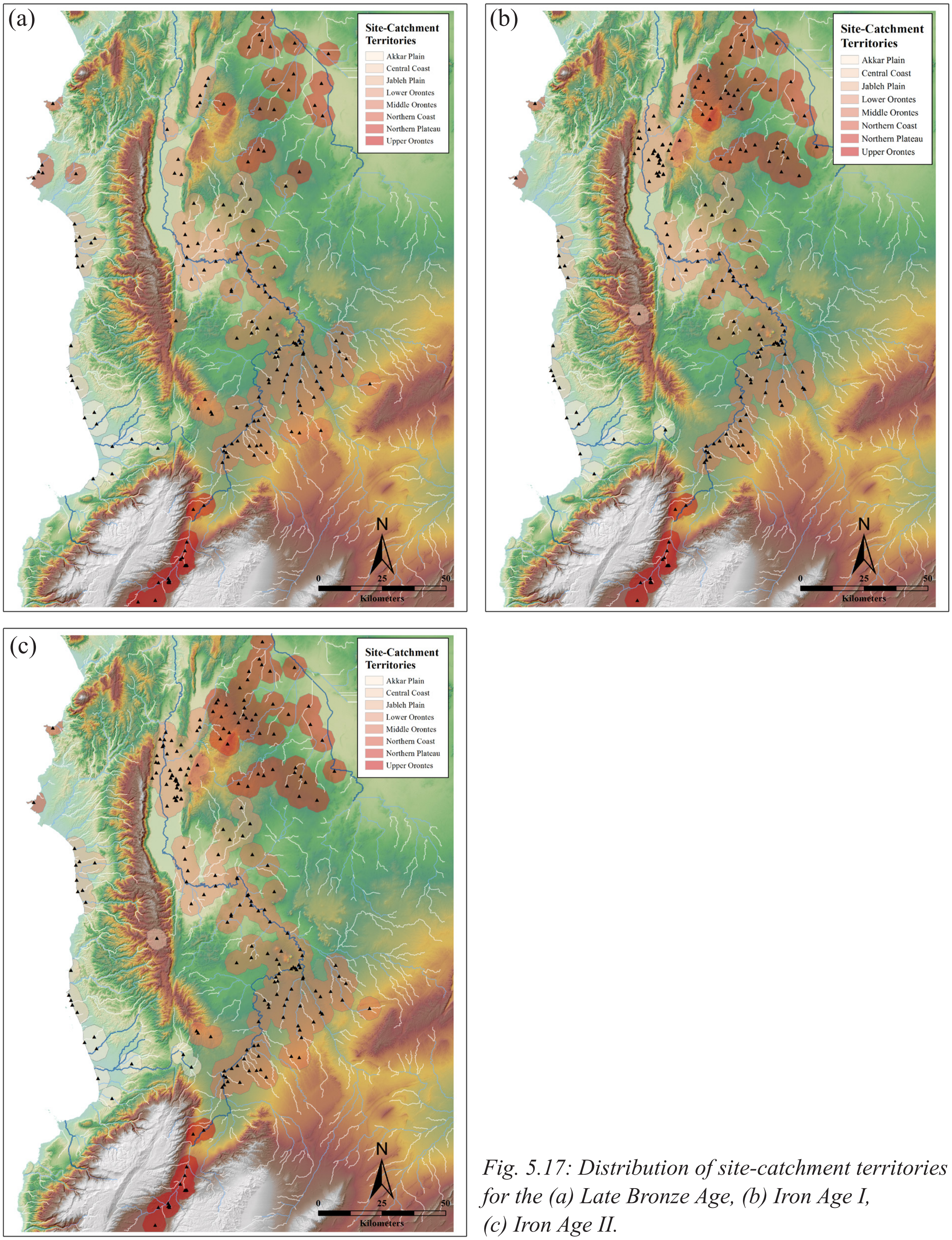

Fig. 5.17: Distribution of site-catchment territories for the (a) Late Bronze Age, (b) Iron Age I, (c) Iron Age II.

presented by Tripcevich (2009).[84] Although this approach relies on a number of assumptions concerning the movement of people through space, and although it cannot rely on archaeological and textual data in the same way as the models employed by some scholars, the results compare well with the size of site-catchment territories identified in Upper Mesopotamia. Being dependent on geography, and therefore variable in size and geometry, these catchment territories in practice vary between ca. 1-5 km, depending on the steepness of the terrain. This compares well with the range of ca. 1-6 km established by Wilkinson and others (e.g., Widell *et al.* 2013a; Wilkinson 1994, 2005), but also with the suggested territory diameter of about 3 km provided by the Hollow Way features identified by Casana (2013) in Northern Syria.

5.4.3.2 Agricultural Suitability within Site-Catchment Territories

As before, these catchment territories were used to analyze the distribution of suitability classes, again providing evidence for both spatial and chronological variability in the data.

When the catchment-territories of all the sites within the study area are considered, areas of moderate suitability clearly constitute the highest proportion of available land, around 60 % and more (**Fig. 5.18**). Areas of high suitability constitute another significant portion of the sample, whereas both very high and low categories constitute only minor fractions of the total area. Yet, these proportions change over time. Whereas areas of very high suitability remain fairly stable over time (between 2.2 % and 2.6 %), a steady decrease in highly suitable land is evident over time, from 36.2 % in 1350 BCE to 26.5 % in 750 BCE. At the same time, both moderate and low suitability classes expand, but also show some fluctuation over time, for example a continuous expansion of unfavorable (low) areas until ca. 950 BCE, followed by a slight decline afterwards.

This picture changes again, when the territories of sites within individual sub-regions are considered in isolation. Again, the coastal areas exhibit a different pattern of agricultural suitability distinct from the inland areas of West-Central Syria, although differences exist between different parts of the coastal areas as well. On the Northern Coast (**Fig. 5.19**), areas within site catchments are highly fertile throughout the entire period analyzed. The proportions of the very high and high suitability classes are particularly high during the Late Bronze Age, together accounting for over 90 % of the total area. At the start of the Iron Age around 1150 BCE, however, some noticeable changes occur. While areas of very high suitability do not lie within site-catchment territories anymore, moderately suitable areas experience a rise, from around 9 % to 26 % of the area. After this initial change, this distribution remains stable throughout the Iron Age I and Iron Age II. To some degree, this pattern is mirrored in the Central Coast (**Fig. 5.20**), where a substantial expansion of moderately suitable areas occurs at the transition from the Late Bronze to the Iron Age, between ca. 1250 and 1150 BCE. Again, this pattern remains largely stable throughout the Iron Age, with fluctuations within the proportions being minute, ranging between 0.1 % and 0.5 % in magnitude.

The Jableh Plain, as has already benn noted above, constitutes the most fertile sub-region of West-Central Syria. This becomes even more apparent if site-catchment territories are considered (**Fig. 5.21**). Here, very highly suitable areas constitute over 90 % of the total area. In the Late Bon-

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[84] The Tobler function is not free of criticism, given that it is exclusively slope-dependent and uses time as the preferred measurement unit. Furthermore, critics point out that this function is based on modern conceptions and observational data, rather than proper experiments and ethnographic research (see, for example, Herzog 2013b; Kantner 2012). Despite these shortcomings, the Tobler function can be regarded as a useful estimate, one of the reasons it has enjoyed widespread popularity in archaeological research.

ze Age, this proportion is even as high as 98.5 %, but it decreases to about 91 % at the beginning of the Iron Age. As is the case with many of the coastal areas, these proportions remain virtually stable throughout the Iron Age.

The only exception to this rule is the Akkar Plain (**Fig. 5.22**), where some pronounced fluctuations are observable. These occur both within individual periods, such as an expansion of moderately suitable land in the Late Bronze Age between 1350 and 1250 BCE, but also between periods. For example, after the initial decrease in overall suitability in 1250 BCE, highly suitable areas again expand around 1150 BCE and remain almost stable until 850 BCE, after which they decrease again slightly during the later Iron Age.

On the Northern Plateau (**Fig. 5.23**), some small changes in agricultural suitability are evident in the Late Bronze Age, with the percentage of high suitability areas expanding from around 22 % to about 26 % between 1350 and 1250 BCE. At the same time, however, some areas of low suitability develop as well. The Iron Age witnesses the progressive expansion of unfavorable areas over time, reaching a high point of ca. 10.4 % towards the end of the Iron Age I, around 950 BCE. At the same time, the proportion of highly suitable areas remains fairly stable. The development of considerable portions of unsuitable land within the potential catchment territories of Iron Age sites constitutes one of the unique characteristics of the Northern Plateau region.

In the Lower Orontes Valley, several fluctuations in the proportion of suitability classes are apparent over time (**Fig. 5.24**). After an initial contraction within the Late Bronze Age, the proportion of highly suitable areas in the site-catchment territories of this sub-region expands again in the Iron Age I, increasing from ca. 27 % to just over 33 %. Some minor variation notwithstanding, the proportion of high and moderate suitability classes remains rather stable throughout the Iron Age and areas of low suitability constitute only a minor fraction of the sample.

Already in the Middle Orontes Valley, a different situation presents itself (**Fig. 5.25**). Here, the most significant temporal change occurs already within the Late Bronze Age, between 1350 and 1250 BCE, when the proportion of highly suitable land declines from over 33% to just above 18% of the total area. Unlike in the Upper Orontes region, the proportion of suitability classes remains mostly stable throughout the Iron Age I period and only changes again noticeably at the transition from the Iron Age I to the Iron Age II.

In the Upper Orontes Valley (**Fig. 5.26**), the overwhelming majority is made up of moderately suitable areas (around 80 % as above), whereas both high and low categories make up a much smaller fraction of the total area. The most significant chronological change is observable in the proportion of highly suitable areas, which contracts from 12.6 % in the Late Bronze Age to about 5.8 % in the Iron Age. Whereas the proportions of high suitability remain virtually stable within each period, minor fluctuations in the percentage of moderate and low areas can be observed throughout the Iron Age, especially the Iron Age I period (for example, the percentage of the low class expands from 5.8 % in 1150 BCE to over 7 % in 950 BCE, after which it declines again).

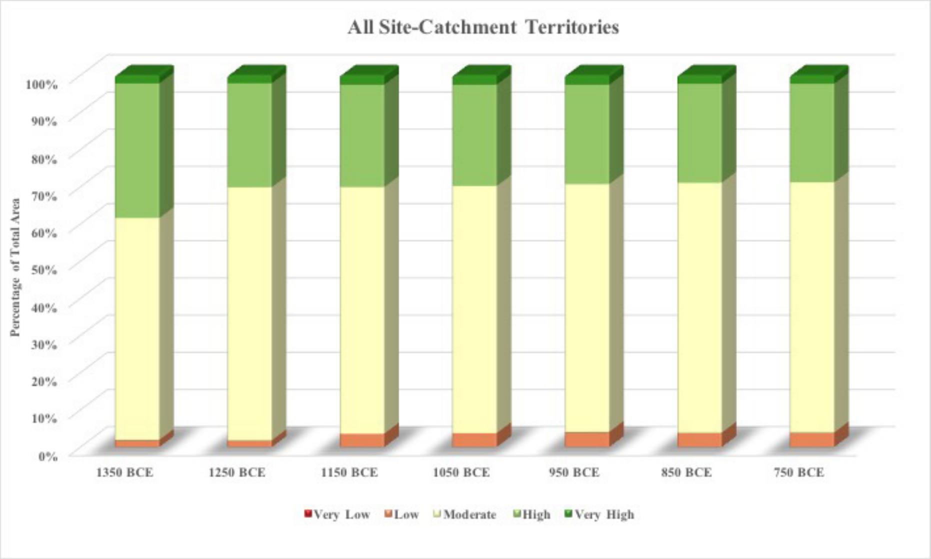

Fig. 5.18: Distribution of suitability scores within all site-catchment territories.

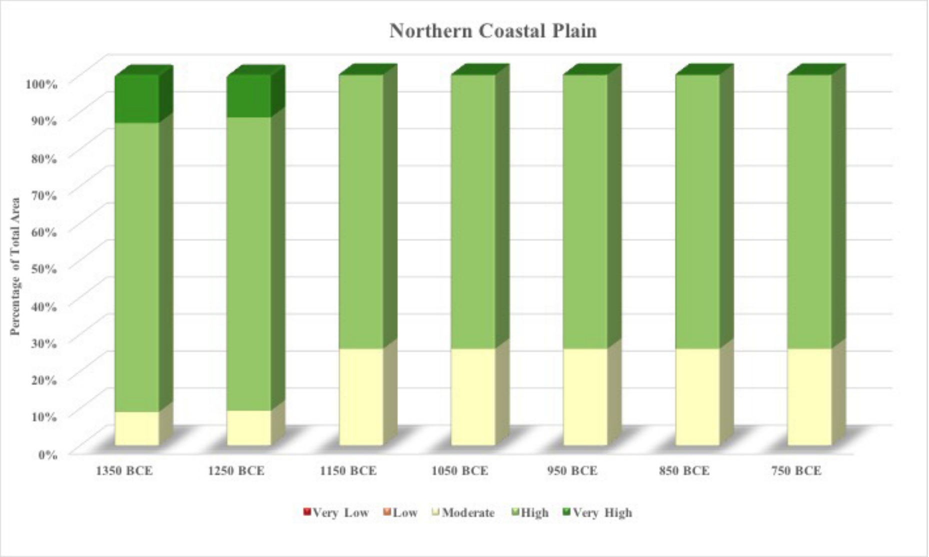

Fig. 5.19: Distribution of suitability scores within site-catchment territories on the Northern Coast.

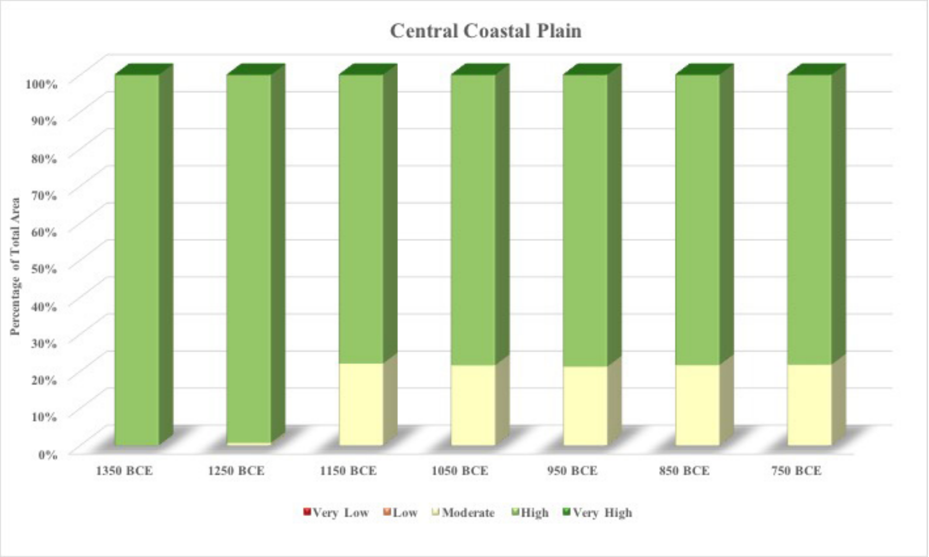

Fig. 5.20: Distribution of suitability scores within site-catchment territories on the Central Coast.

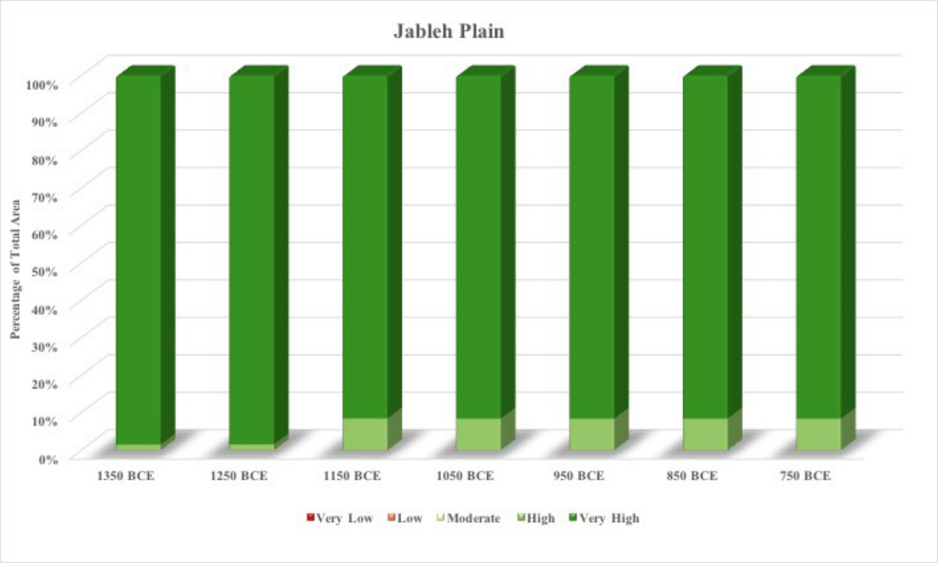

Fig. 5.21: Distribution of suitability scores within site-catchment territories in the Jableh Plain.

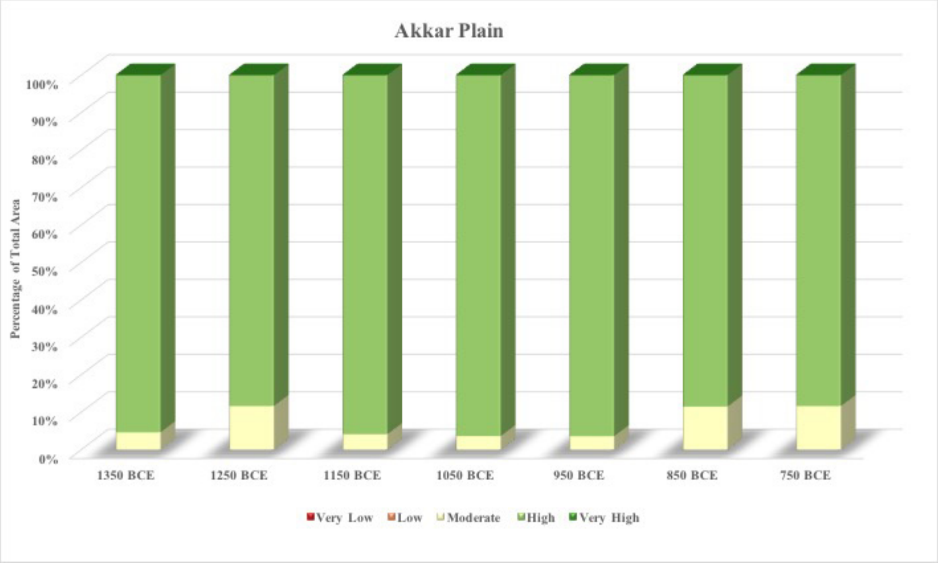

Fig. 5.22: Distribution of suitability scores within site-catchment territories in the Akkar Plain.

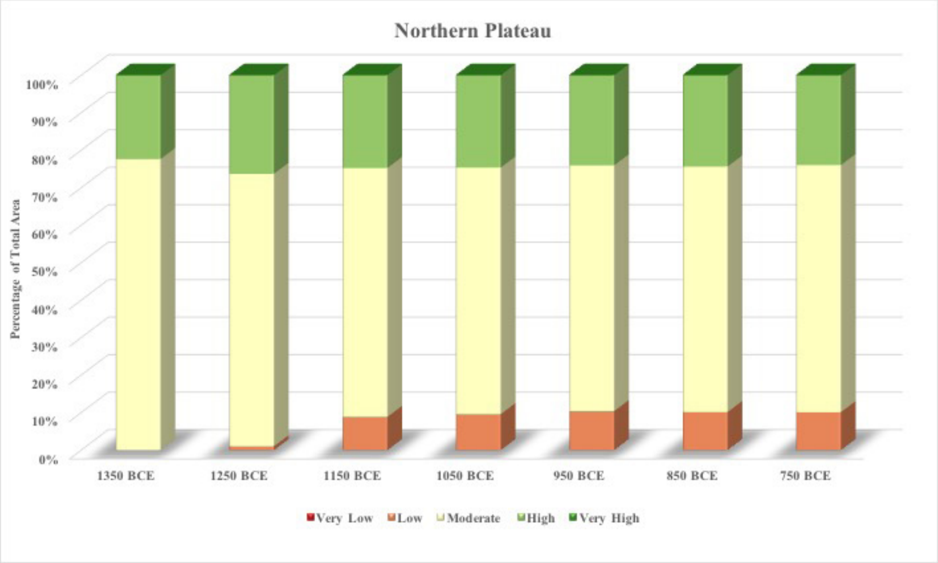

Fig. 5.23: Distribution of suitability scores within site-catchment territories on the Northern Plateau.

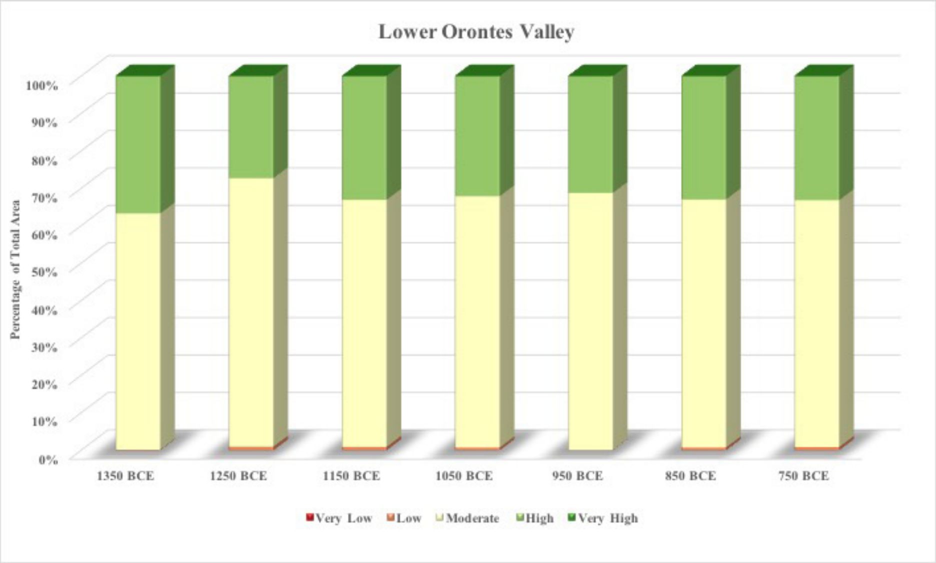

Fig. 5.24: Distribution of suitability scores within site-catchment territories in the Lower Orontes Valley.

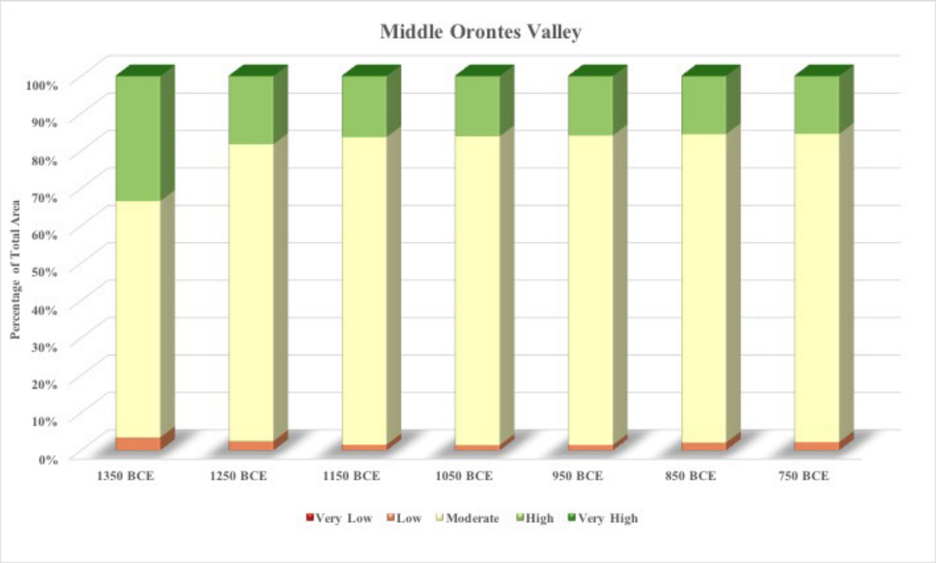

Fig. 5.25: Distribution of suitability scores within site-catchment territories in the Middle Orontes Valley.

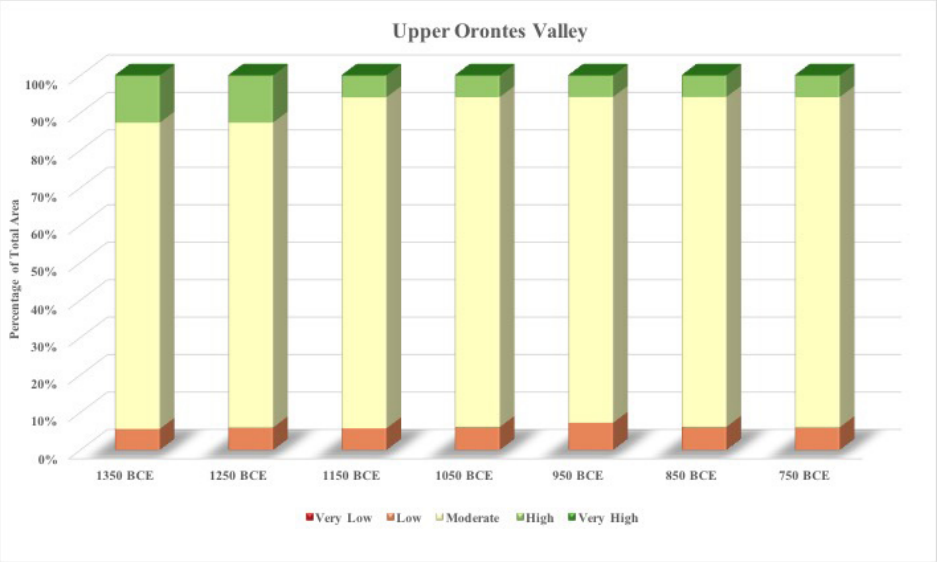

Fig. 5.26: Distribution of suitability scores within site-catchment territories in the Upper Orontes Valley.

5.5 SUMMARY OF THE MODELING RESULTS

Modeling the potential suitability for wheat crop cultivation and analyzing the results across various scales facilitates a more nuanced understanding of the spatial and chronological dimensions of climate change. Some of these processes have already been noted by other studies, for example the identification of deteriorating environmental conditions indicated by palaeoenvironmental and archaeobotanical research.

More importantly, though, the application of GIS modeling, for the first time makes it possible to quantify, analyze, and assess the effects these climatic changes had not just on the environment in general, but also on the social system - in this particular case, the agricultural potential and subsistence base of Late Bronze and Iron Age communities in West-Central Syria.

Although the analysis presented here is based on modeled data, as opposed to observational records, the output data obtained from the Macrophysical Climate Model are generally comparable to the results attained from actual palaeoenvironmental research. The general temporal development of modeled climatic variables, especially precipitation, resembles the processes of vegetation development observed in the sediment cores from the study area, particularly from Tell Tweini, suggesting that these models and algorithms can be employed in cases where actual data are either missing or too few to enable a regional analysis.

What is more, the use of the Macrophysical Climate Model and GIS applications makes it possible to extrapolate these values to an entire study area with considerable spatial precision. As a result, predictions of ancient rainfall and temperature levels cannot only be analyzed for the temporal variability they exhibit, but also for geographical variation. As the data shows, differences between coastal and inland areas are quite pronounced, the former consistently receiving more rainfall than the latter. Yet, there also exist noticeable differences on a smaller scale, for example rainfall levels differing across the length of the Orontes Valley, or between the river valley and the Northern Plateau.

5.5.1 Trends of Environmental Change

Through the use of the predictive model, the effects of these changes and differences can be observed. When the entire study area is considered, it becomes apparent that low, moderate, and highly suitable areas are represented at roughly equal proportions, although a subtle trend towards deterioration can be observed.

Yet, regional analysis alone obscures several small-scale, heterogeneous trends within the data, which becomes obvious once the entire dataset is sub-divided into smaller units at different analysis scales. Moving from a regional to a sub-regional perspective, it becomes clear that different regions of the study area exhibit diverging long-term trends of environmental response to climatic shifts. In the Orontes Valley, the primary temporal change consists of the expansion of moderately suitable land at the expense of areas more favorable to agricultural production, whereas regions less favorable for cultivation (that is, low suitability) experience only a minor rise in proportion. That this trend cannot be understood as exemplary for all areas of inland West-Central Syria is clearly shown by the data from the Northern Plateau. Here, a significant expansion in the proportions of unfavorable (low) areas occurs first within the Late Bronze Age and again at the beginning of the Iron Age, seemingly at the primary expense of moderately suitable land, as opposed to highly suitable areas. On the one hand, this development indicates a significant deterioration of environmental conditions for agriculture in this area. On the other hand, the data might be taken to suggest that this process of environmental deterioration happens mostly at the expense of areas that are already not among the most favorable ones of the region. In other words, rather than large swathes of formerly highly desirable agricultural land suddenly turning into economically disadvantageous waste land, climatic deterioration on the Northern Plateau at the end of the Late Bronze Age appears to primarily affect marginal lands that might already be considered under some environmental stress.

As far as the coastal areas are concerned, all four sub-regions, the Northern Coast, the Jableh Plain, the Central Coast, and the Akkar Plain, all exhibit a general pattern of agricultural favorability. Moreover, all four sub-regions provide evidence for slight fluctuations of suitability levels over time. This is particularly observable on the Northern Coast and the Akkar Plain, where an initial high point of suitability around 1350 BCE is followed by a period of small, but steady, decline until 950 BCE, again followed by an expansion of more favorable land around 850 BCE. Although less strongly pronounced, this pattern is also observable in the Jableh Plain and on the Central Coast.

5.5.2 Environmental Change and Site Territories

When the surroundings of archaeological sites, that is, those areas that potentially constituted the basis of their subsistence economy, are considered, some interesting trends emerge a well.

In the Lower Orontes Valley, the proportion of moderately suitable areas within site territories expands between the Late Bronze and the Early Iron Age, after which it largely remains stable over time, some minor fluctuations notwithstanding. In the Middle Orontes Valley, a slightly different trend is observable. Here, a major contraction of highly suitable land occurs already within the Late Bronze Age, between 1350 and 1250 BCE, suggesting that this area experienced some degree of environmental deterioration during that period. This trend also continues into the Iron Age I period, albeit to a lesser degree, after which the proportions of suitability classes essentially stabilize and do not change significantly any more. In the Lower Orontes Valley, an initial contraction of the proportions of highly suitable land occurs already within the Late Bronze Age, between 1350 and 1250 BCE. However, contrary to the situation observed in other parts of the river valley, the proportion of favorable areas within site-catchment territories expands again during the Iron Age I, and again over the course of the Iron Age II. Given that the proportions of suitability classes within site-catchment territories are directly dependent on the number and position of the sites on which they are centered, it might be suggested that this pattern is indicative of a deliberate attempt to seek out more favorable areas. On the Northern Plateau, an initial slight expansion of highly suitable land can be discerned during the Late Bronze Age. Yet, in the Iron Age, considerable portions of land within site territories become unfavorable for agriculture. As the proportion of highly suitable land remains fairly stable during that time, it might be suggested that this deterioration mainly affected areas of already rather marginal agricultural potential.

In the coastal areas, the most noticeable chronological trend is the contraction of agricultural favorable areas between the Late Bronze Age and the Iron Age I, which can be observed both on the Northern Coast, as well as the Central Coast. Another significant trend is the fluctuation of agricultural suitability over time in the Akkar Plain. After an initial deterioration of conditions at the end of the Late Bronze Age, agricultural suitability is at its highest throughout the Iron Age I period, but declines again during the Iron Age II. Again, it can be suggested that this pattern is predicated on developments within the settlement system during these periods. The Jableh Plain experiences only a slight reduction in suitability and remains the most fertile region of West-Central Syria across the entire period analyzed.

5.6 SETTLEMENT PATTERN ANALYSIS

Survey work provides a large corpus of data with which the relationships between social processes, observable in the spatial patterning of archaeological sites, can be analyzed. Visual inspection of the distribution of sites within the study area already reveals a certain degree of spatial patterning. Some regions, such as the Middle Orontes Valley or the Northern Plateau, are much more densely occupied than others. While archaeological practices, such as survey intensity and recording practices, undoubtedly had an effect on these patterns, it might also be suggested that the distribution of sites in Late Bronze and Iron Age West-Central Syria reflects some underlying processes of spatial patterning.

These underlying patterns, in particular the relationships between site locations and environmental parameters, are of significance for the interpretation of the settlement system and its diachronic development. The form of the spatial pattern, e.g., distributed or clustered, provides important information on the structure of the settlement system, as does the spatial scale at which these processes occur. In this regard, the tight clustering of settlements within an area might be the result of close interrelations and might indicate a tendency towards increased socio-economic or political integration. Similarly, changes in site size can be indicative of changing patterns of social organization, closely linked to processes of population aggregation or dispersal, or the type of subsistence strategies employed (Arıkan 2010, 4). Similarly, changing relationships to environmental factors, for example topographic features or climatic conditions, can be interpreted as indicative of changing relationships between societies and their environments, especially from the standpoint of a largely agriculture-based economy.

These underlying patterns can be investigated with the help of spatial statistics, a collective term applied to a variety of tools used for the analysis of patterns and relationships within spatial data. Spatial statistics have long been a staple in archaeological research and have been applied in a variety of contexts (e.g., Blankholm 1990; Hill 2006; Hodder and Orton 1979; Kintigh 1982; Kintigh and Ammerman 1982; Maschner and Stein 1995).

Rather than solely concentrating on the basic characteristics of archaeological sites, such as occupation periods, site size, or site location, the following analyses will also analyze and describe the spatial patterning of the archaeological site data. What is more, through the use of statistical tools, such as the chi-squared (x^2) test and bivariate regression analysis, the relationships of these sites to their respective environments and important climatic variables will be investigated, following the arguments of Bevan and Conolly (2006), Bevan *et al.* (2013), Verhagen (2007), and Williams (2004), all of which have called in some form for the inclusion of different statistical methods and a consideration of different resource types in any effort to investigate the relationships between archaeological sites and their surrounding environments.

As before, the data will be discussed according to the geographical groupings of the analysis regions used before. For the purpose of clarity, the raw data used for the x^2-test and the bivariate regression analysis graphs can be found in **Appendix 6**. It should be pointed out, however, that differences in data variability did not always make it possible to properly analyze the relationships between sites and environmental factors in all instances to a similar degree. Therefore, both the discussion presented below as well as the data tables in the appendix will only refer to those instances where the available data permits statistical analysis and has provided sufficient results.

5.6.1 General Regional Trends

It has been noted before that the character of the settlement system of West-Central Syria, and the entire Levant in general, changed considerably between the Bronze and the Iron Ages. For example, Liverani (2014) has argued that the early Iron Age in Syria witnessed the abandonment of large cities and a general dispersal of the population across the region. According to him, the large, urban centers of the Late Bronze Age contracted in size, with settlement activity primarily confined to the well-fortified, yet small, citadel mounds (Liverani 2014, 395). Overall, settlement sizes decreased and a new system of small, mostly rural settlements developed, spreading into the formerly unoccupied hinterland of urban centers, as well as highland areas (Liverani 2014, 435).

This general impression is confirmed by the quantitative data from the surveys (**Fig. 5.27**). As can be clearly seen, between the Late Bronze Age and the Iron Age II, the number of sites in West-Central Syria increases continuously. Whereas during the Late Bronze Age 180 sites were occupied, this number increases to 197 in the Iron Age I and even further to 231 during the Iron Age II. This constitutes an overall increase in site numbers of 9.4 % between the Late Bronze Age and the Iron Age I and 17.3 % between the Iron Ages I and II, and a full 28.3 % increase from the Late Bronze Age to the Iron Age II. The increase of settlement numbers is thus especially pronounced during the Iron Age II. At the same time that site numbers increase, their average sizes decrease notably. Whereas average site size is around 6.2 ha during the Late Bronze Age, it decreases to 5.5 ha in the Iron Age I and to 5.3 ha in the Iron Age II. This amounts to a decrease in average site size of 11.8 % between the Late Bronze Age and the Iron Age I and of 4.3 % between the Iron Ages I and II, whereas for the entire Late Bronze-Iron Age period considered here, this amounts to a decrease of over 16 %.

Taken together, these developments point to a general trend towards the dispersal of smaller settlements within West-Central Syria. Yet, again, this trend is not chronologically uniform. The rise in overall site numbers is most pronounced in the Iron Age II, whereas the most severe decrease in average site size already occurs between the Late Bronze and the Early Iron Age. Considering these developments, it might be suggested that major *qualitative* changes to the settlement system occurred in the Iron Age I, whereas during the Iron Age II mainly the *quantitative* characteristics of this new system changed and developed further.

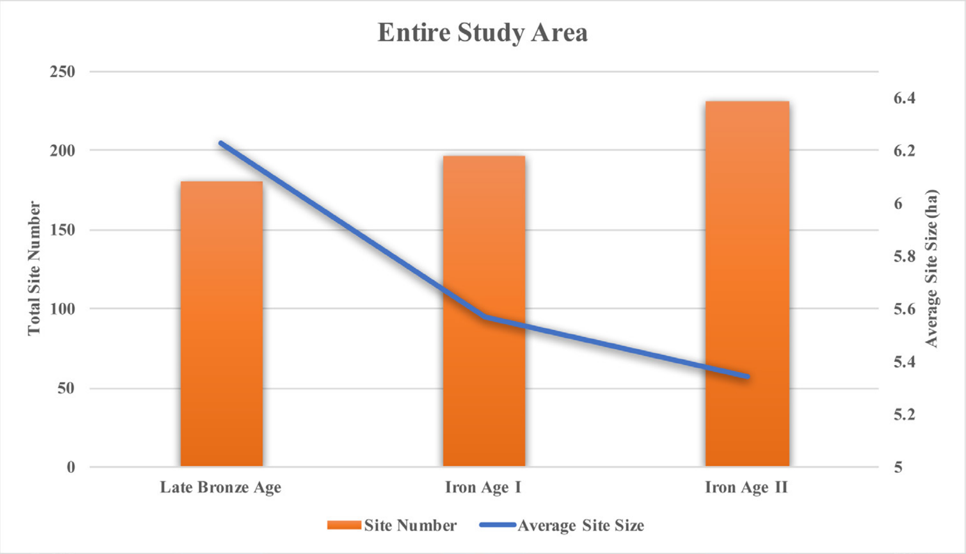

Fig. 5.27: Numbers and average sizes of archaeological sites in entire study area.

The observed trend towards smaller settlement sizes, however, is not necessarily indicative of a trend towards region-wide depopulation. Comparing the total occupied settlement area of all three periods (**Fig. 5.28**), it becomes apparent that the occupied area remains almost stable between the Late Bronze Age and the Iron Age I, increasing only minimally from 891 ha to just over 892 ha, an increase of less than one percent. Between the Iron Age I and the Iron Age II, on the other hand, the total occupied area steeply increases by 11.3 % to over 993 ha. At the same time, the total area of site-catchment territories, those areas around sites potentially used for agricultural production, initially decrease slightly by 4.3 %, before expanding by 13.2 % between the Iron Age I and the Iron Age II. Especially the initial decrease of catchment territories between the Late Bronze Age and the Early Iron Age is interesting to note, as it indicates that sites were placed closer together, their territories thus overlapping to a significant degree.

This trend of spatial clustering of settlements can be clearly identified, and quantified, through spatial analysis. As can be seen in **Fig. 5.29**, changes in the spatial distribution of settlements within West-Central Syria can be observed between the Late Bronze and Iron Ages. In general, sites of all three periods tend to be more clustered at smaller distances, but tend to become more dispersed as distances increase. In the Late Bronze Age, clustering can be primarily observed at smaller distances, with the threshold between clustering and dispersal at ca. 35 km, after which the pattern is more dispersed. Clustering is particularly evident around 10-15 km distance, whereas dispersal is most pronounced between 40-45 km. Yet, the Observed K only approaches the higher and lower confidence envelope at these distances, but does not transcend these thresholds. Thus, although some evidence exists that the distribution of sites in the Late Bronze Age is subject to processes of spatial clustering and dispersal, these developments are not statistically significant enough to fully reject the null-hypothesis of spatial randomness. In other words, in the Late Bronze Age both clustering and dispersal are not distinctive.

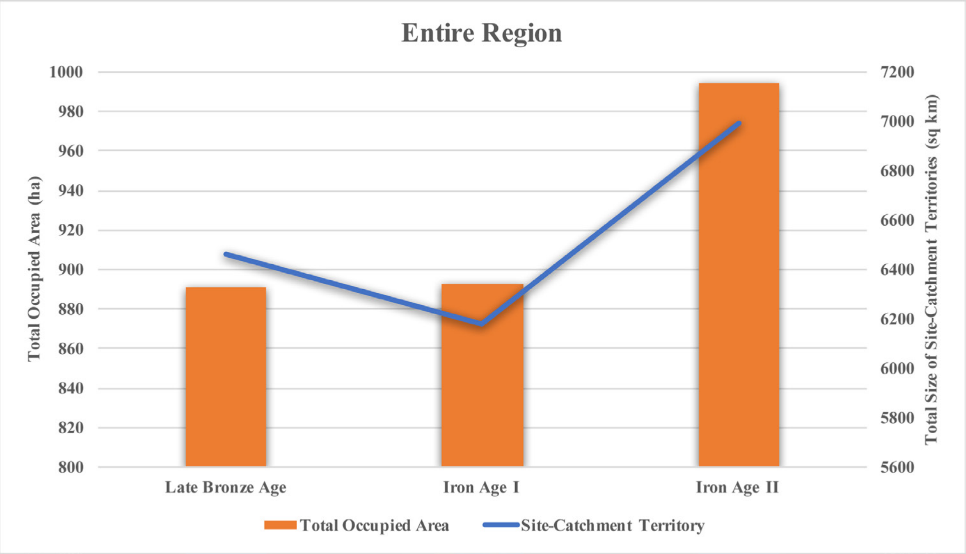

Fig. 5.28: Total occupied area and catchment-territory sizes in entire study area.

During the Iron Age I, on the other hand, spatial clustering occurs up to a distance of around 37 km, after which a trend towards dispersal can be observed. Whereas spatial clustering is found to be statistically significant up to a distance of about 18 km, the pattern of dispersal at high distances

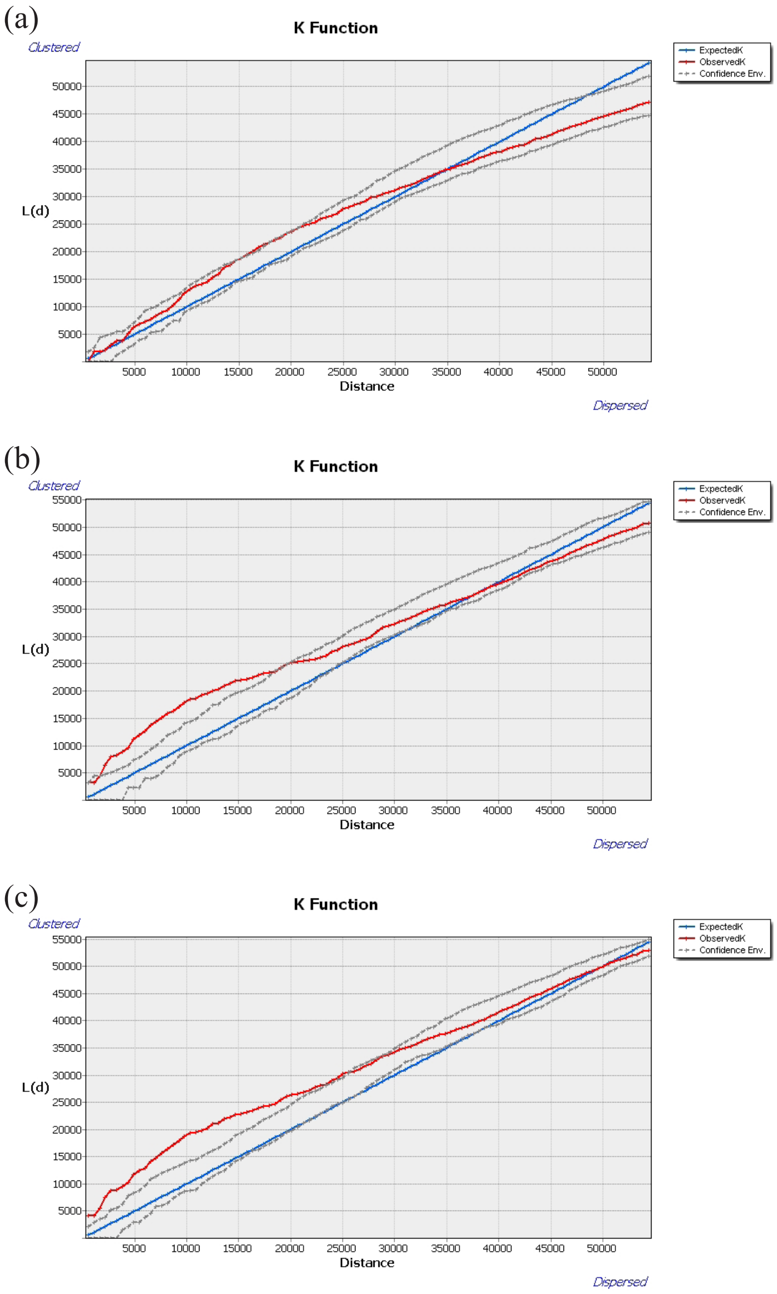

Fig. 5.29: Spatial statistics (Ripley's K) output graph for entire study area: (a) Late Bronze Age, (b) Iron Age I, (c) Iron Age II.

is not significant, nor does it approach the lower confidence envelope. This pattern suggests that during this period, changes within the settlement system resulted in the development of settlement clusters, significantly altering the relationships between individual sites.

This trend continues into the later Iron Age II. Again, clustering is evident at smaller distances, whereas some evidence for dispersal exists at larger scales. In this particular instance, the threshold between clustering and dispersal is located at about 47 km and clustering is significant at distances of up to around 23 km. Settlement dispersal, on the other hand, is not statistically significant. As was the case with the Early Iron Age, this suggests that the settlement system of the Iron Age II was characterized by well-defined settlement clusters. In comparison to the preceding period, however, the distances up to which clustering occurs increased, suggesting that more settlements (and hence larger areas) than before were integrated into these clusters. While it can be suggested that this development is the result of a general increase in site numbers during this period, it still highlights the point that the most significant break in the settlement system of West-Central Syria occurred between the Late Bronze Age and the Iron Age I, whereas the Iron Age II constituted a further development and articulation of this process.

As many of the newly established sites of the Ion Ages I and II appear to have been rather small in size, it might be suggested that they were primarily rural in character. Therefore, in order to understand these processes of settlement dispersal and clustering in more detail, it is also necessary to investigate the relationships of these sites to their natural environment and a variety of environmental variables, such as elevation, terrain slope, soil type, availability of water courses and hydrogeological features, or precipitation volumes.

In an initial step, x^2-tests for dependence were carried out in order to identify the relationship between archaeological sites and important climatic and environmental variables, including precipitation, hydrogeology, and water courses.[85] The results of this test indicate that site locations and rainfall volumes are related to each other. A similar relationship can be established when groundwater sources are being considered. On the other hand, a similar statistical relationship between site locations and environmental parameters cannot be as easily defined for water courses. Therefore, the results of the x^2-test suggest that the spatial distribution of archaeological sites within the study area is strongly influenced by rainfall levels and the presence of certain aquifer types within the immediate vicinity of sites. However, this test does not provide any information on the character of this relationship. Whereas overwhelming proportions of site-catchment territories consist of land receiving very high and high levels of precipitation, most sites appear to have been established in areas without, or with only limited access to, groundwater sources.

While the x^2-test can be used to establish some general relationships between site locations and environmental parameters, it is necessary to use additional tools and methods to analyze these relationships in more detail. Therefore, bivariate regression analysis was used to analyze site densities in relations to aggregated (or 'binned') value ranges of important natural features.[86]

When precipitation is concerned, it becomes apparent that throughout most of the Late Bronze and Iron Ages, site densities are highest within areas of relatively high rainfall, consistently peaking around 400-450 mm of annual precipitation. Interestingly, the only exception to this general pattern occurs at the very end of the Iron Age II, when site densities are highest in areas of around 250-300 mm per annum, although site densities in regions with high rainfall are still about as high as in previous centuries. As for hydrogeology, most sites are located in areas with access to regular groundwater sources, which is interesting to note considering that extensive and highly productive aquifers constitute only a relatively minor portion of all the aquifer types available in West-Central Syria.

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[85] Similar to the methodology outlined by Pustovoytov and Riehl (2016), these analyses were carried out by calculating the importance of certain types of water sources within site-catchment territories. For both precipitation and aquifers, the total land area belonging to the five suitability categories (very high, high, moderate, low, very low) defined in Chapter 4 was calculated for each period. For water courses, the total lengths of the three stream types, perennial/large, intermittent/moderate, and wadi/small, within site-catchment territories were calculated. The distribution of these values across the Late Bronze and Iron Ages was then subjected to statistical analysis using the x^2-test for independence using a 99 % confidence level, as described in Chapter 3.

[86] The natural features analyzed here are precipitation, hydrogeology, topographic elevation, terrain slope, and soil class. Due to the different nature of these phenomena, value ranges were aggregated differently for each of the five variables. For precipitation, the suitability ranges established in Chapter 4 were used. For hydrogeology and soils, on the other hand, discrete categories were used, whereas both slope and elevation were divided into regular intervals.

In addition, parameters such as topographic elevation, terrain slope, and soil types were considered for analysis. Throughout the Late Bronze and Iron Ages, site densities tend to be higher at low and moderate elevations and also tend to concentrate in areas of rather gentle and moderately terrain, with steeper and more elevated regions generally less intensely settled. The relationship between site locations and soil types, on the other hand, is much more ambiguous, with site densities generally more evenly distributed between the different soil classes. However, it is interesting to note that peaks in site density occur on both rather unsuitable soils, like Xalcic Xerosols and seasonal swamps, but also on highly productive soils, such as Eutric Cambisols. Especially the high peak of site density on the seasonal marshlands of the Lower Orontes Valley is notable and can be explained by their relative small size relative to the size of the study area, as well as the massive expansion of settlement activity occurring in the Lower Orontes Valley during the Iron Ages I and II.

Yet, as the analysis also shows, site intensities are related to different climatic and environmental parameters to different degrees throughout different periods. During the Late Bronze Age, for example, precipitation volumes appear not to be a particular good indicator of site densities (r^2 = 0.48 and 0.45), similar to elevation (r^2 = 0.43), terrain slope (r^2 = 0.35), and especially soil type (r^2 = 0.07), as opposed to hydrogeology, which appears to be a very strong indicator (r^2 = 0.96). During the Iron Age I, on the other hand, precipitation (r^2 = 0.65, 0.66, and 0.67), elevation (r^2 = 0.68), and slope (r^2 = 0.58) are much stronger indicators as before. And whereas soil type continues to be a particularly weak indicator of site intensity (r^2 = 0.26), hydrogeology appears to remain the strongest indicator of site location (r^2 = 0.99). Finally, in the Iron Age II, both elevation (r^2 = 0.67) and slope (r^2 = 0.59) continue to be moderately good indicators, whereas precipitation appears to be only a reasonable indicator during the early part of this phase (r^2 = 0.66). As before, soil type constitutes only a weak indicator of site density (r^2 = 0.26), whereas site locations continue to be strongly related to aquifer geography (r^2 = 0.98).

Apart from these general trends, differences in the relationships between site locations and environmental conditions surely existed on smaller scales as well. Therefore, it is necessary to narrow the discussion down to more localized, sub-regional contexts, where the relationships between the settlement system and the natural environmental can be analyzed in more detail. As before, the discussion will adhere to the same framework of sub-regional analysis used before. However, as data limitations do not permit to use every analysis type in every single context (for example, cluster analysis requires a certain minimum number of site locations to perform correctly), the following sections will eschew completeness and instead focus on only the most interesting and statistically most significant patterns.

5.6.2 Sub-Regional Trends

5.6.2.1 The Northern Coast

Throughout the period analyzed here, the Northern Coast is characterized by a relatively low density of archaeological sites. It is also the sub-region of West-Central Syria where a decrease in settlement activity is the most pronounced (**Fig. 5.30**). Whereas a total of six sites were occupied during the Late Bronze Age, this number decreases to just two during the Iron Age. Concomitant with this decrease in site numbers is a stark reduction of average site sizes, from 10.2 ha in the Late Bronze Age to just 1.9 ha during the Iron Age. These changes amount to a reduction of 81.3 % in site size and 66.6 % in site numbers. At the same time, the total occupied area decreases by over

90.6 %, from 40.7 ha to 3.8 ha, and the size of site-catchment territories decreases by 65 %. After the initial decrease in settlement activity between the Late Bronze and Early Iron Ages, no further changes to the settlement system occur throughout the remainder of the Iron Age, since only two sites have been recorded for the Iron Age in this part of the study area.

Apart from a quantitative decrease in settlement activity, the archaeological data also reflects a qualitative decrease in the settlement of the Northern Coast. At both Ras ibn Hani and Ras al-Bassit, the only sites that have furnished evidence for Iron Age occupation in this part of West-Central Syria, well-planned urban settlements were replaced by a more ephemeral, probably rural occupation. The architecture uncovered at these sites testifies to a decrease in prosperity during the Iron Age I, as do the ceramic materials, which attest to the cessation of outside trading contacts. While this situation can probably at least in part be attributed to the current state of research, the sharp decline in settlement activity on the Northern Coast of West-Central Syria between the Bronze and Iron Ages is certainly also the result of distinct social, political, and economic processes, especially the destruction and abandonment of the prime political and economic center of Ugarit.

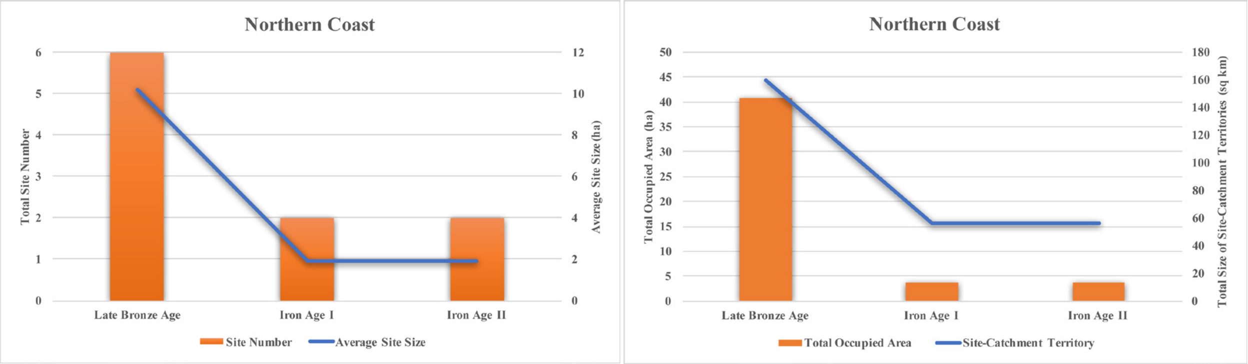

Fig. 5.30: Statistics for archaeological sites on Northern Coast: (a) site numbers and average site size, (b) total occupied area and catchment territory sizes.

This low number of sites also makes it difficult to assess the relationships of site locations to climatic and environmental variables. In both the Late Bronze and Iron Ages, sites on the Northern coast are located within a zone of generally very high rainfall levels, but do not have access to groundwater resources and only limited access to water courses. Due to lacking variability in the data, x^2-test could only be performed with regard to the availability of water courses, but a relationship between site locations and water sources is not indicated by the results. Similar limitations apply to an investigation of site densities in relation to topographical factors.

5.6.2.2 The Jableh Plain

Since almost all the known Late Bronze and Iron Age settlements in the Jableh Plain have been either excavated (Tell Tweini, Tell Sukas) or at least briefly probed (Tell Siano, Tell Daruk, Arab al-Mulk, Qal'at ar-Rus, Tell Iris), it is possible to reconstruct the settlement history of this subregion with quite some detail. It becomes immediately apparent that settlement activity in this area develops on a very different trajectory from what can be observed on the Northern Coast. Between the Late Bronze and the Early Iron Age, sites initially decrease both in numbers and average size, by 25 % and 22.8 %, respectively (**Fig. 5.31**). But whereas the total occupied area decreases from 34.2 ha to only 13.2 ha (decease of 61.4 %), the total area of site-catchment territories decreases to a much smaller degree. This development indicates that Iron Age I sites in the Jableh Plain were much more dispersed geographically, as site territories did not overlap as much as in the preceding Late Bronze Age. Between the Iron Age I and Iron Age II, site numbers increase again, as do average site size and total occupied area. The most pronounced development is the increase in total occupied area, which expands by over 143 % between the Iron Age I and Iron Age II, whereas site-catchment territories only increase moderately in total area, by about 16.8 %.

This development closely resembles the information gained from excavation. In the Late Bronze Age, the settlement system of the Jableh Plain is clearly dominated by the two large sites of Tell Tweini and Tell Siano. At least at Tell Tweini, a dense urban agglomeration attests to the prosperity of these cities, whereas the smaller villages, for which Tell Sukas is indicative, were less densely occupied and generally rural in character. During the Early Iron Age, the apparent decrease in site numbers and sizes, as well as total occupied area, can be attributed especially to the temporary abandonment of Tell Siano. At Tell Tweini and Tell Sukas, despite unquestionable evidence for continued occupation, the data point towards diverging developments at the two sites. At Tell Sukas, a small, rural settlement of flimsy domestic structures continues to exist during the transition from the Late Bronze to the Iron Age, whereas at Tell Tweini, the prosperous urban settlement of the Late Bronze Age was replaced by a much impoverished, and probably smaller, rural settlement during the 12th century BCE. It was only later in the Early Iron Age that urban occupation at Tell Tweini expanded again, reaching an extent similar to that of the Late Bronze Age town.

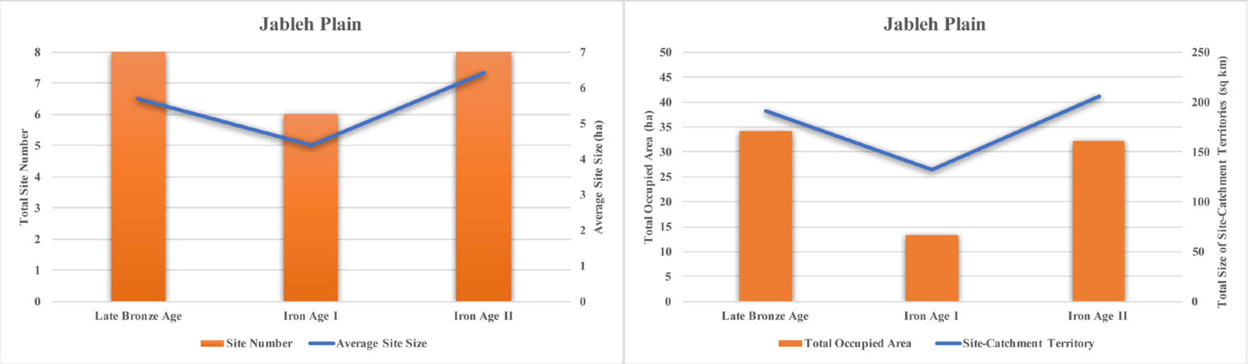

Fig. 5.31: Statistics for archaeological sites in Jableh Plain: (a) site numbers and average site size, (b) total occupied area and catchment territory sizes.

The settlement system of the Jableh Plain developed in a very favorable natural environment. Not only were all sites in this region located in an area of very high rainfall levels, but sites also had ample access to dependable groundwater resources and a variety of streams and rivers, although of mostly small and moderate size. The data permits statistical testing of the relationship between site locations and hydrogeology and water courses, but in both instances does not suggest a significant relationships between them.

5.6.2.3 The Akkar Plain

So far, a total of eight sites has been recorded for the Late Bronze Age Akkar Plain, which decreases to seven in the Early Iron Age, and then increases again to eight in the Iron Age II (**Fig. 5.32**). At the same time, however, average site sizes decrease continuously and uninterruptedly, from 4.7 ha in the late Bronze Age to 4.1 ha in the Iron Age I and then to 3.8 ha in the Iron Age II, constituting a decrease of 12.8 % and 7.3 %, respectively. Total occupied area and total area of site-catchment territories follow a pattern similar to that observed for site numbers, with an initial reduction between the Late Bronze and Early Iron Ages, followed by a subsequent increase in the Iron Age II. But whereas total occupied area in the Iron Age does not reach the same level as in the Late Bronze Age, the area of site-catchment territories in the Iron Age II is actually larger than in any of the preceding periods, suggesting that sites are spaced further apart with less overlap between their immediate agricultural territories. In the Iron Age, the Akkar Plain continued to be characterized by the same system of small, mostly rural communities that already characterized the Late Bronze Age in this part of West-Central Syria (cf., Thalmann 2010).

This long-term development towards a less intense urban occupation in the Akkar Plain is also mirrored in the archaeological data. At Tell ‘Arqa, this process of ruralization is already perceptible in the Late Bronze Age and the data from small-scale soundings and excavations point to a settlement pattern dominated by small, rural settlements in this area (see, Thalmann 2010, 100). This process continues into the Iron Age, with Tell ‘Arqa being only sporadically occupied. The flourishing Late Bronze Age site of Tell Kazel, characterized by intensive trading contacts with the Eastern Mediterranean, was reduced to a small, impoverished settlement during the Early Iron Age, with some parts of the site temporarily being abandoned.

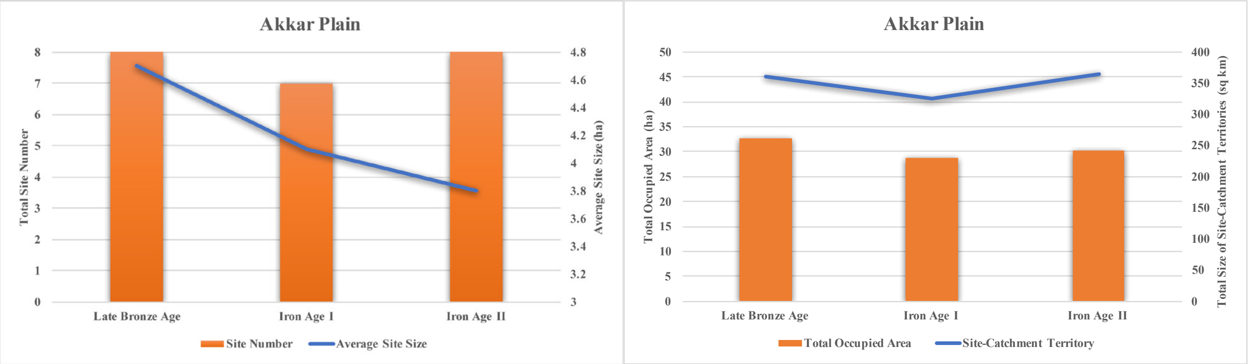

Fig. 5.32: Statistics for archaeological sites in Akkar Plain: (a) site numbers and average site size, (b) total occupied area and catchment territory sizes.

Throughout the Late Bronze and Iron Ages, the Akkar Plain is not only characterized by high levels of annual rainfall, but sites also had access to a variety of other water sources, including several larger rivers and streams, as well as at least irregular groundwater sources. Only the relationship between site locations and water courses could be analyzed with the x^2-test but does not indicate a significant relationship between the two. Analysis of site densities in relation to topographical variables was also only possible for elevation and terrain slope, but the results do not provide evidence for significant changes in the relationships between site locations and the topography of the surrounding territory, which might be indicative of stable socio-environmental relationships in this part of West-Central Syria.

5.6.2.4 The Northern Plateau

The survey data from the Northern Plateau indicates a considerable transformation of the settlement system over time (**Fig. 5.33**). During the Late Bronze Age, only 20 sites were occupied, with an average site size of 2.3 ha, a total occupied area of 63.8 ha, and a total combined site-catchment territory of 1,144 km^2. In the Early Iron Age, site numbers have increased to a total of 43, an increase of 115 %, whereas site sizes increase by about 43.5 %, total occupied area by around 83.5

%, and site-catchment areas by about 43.2 % compared to the Late Bronze Age. This development clearly attests to a substantial expansion of settlement activity during the Early Iron Age, resulting in a very different settlement structure. Between the Iron Age I and the Iron Age II, changes in the settlement system are rather small in comparison, although a continued increase in site numbers, total occupied area, and catchment territories is perceptible. Interestingly, though, average site sizes during this period remain unaltered, signifying a primary expansion of small and modest-sized sites in the area, rather than the development of large, central settlements, for example.

Chronological changes in the settlement pattern of the Northern Plateau are not only observable in site characteristics, but also in their spatial distribution (**Fig. 5.34**). During the Late Bronze Age, sites are for the most part dispersed within the sub-region, the strongest evidence for dispersal existing at distances of 5 km and 11.5 km, although not in a statistically significant way. During the Early Iron Age, evidence for dispersal exists at very small distances, up to ca. 3.8 km, whereas between 3.8 km and ca. 10 km a slight indication for clustering is given. At higher distances, a trend towards dispersal can again be observed. However, as before, these trends are not statistically significant. Finally, in the Iron Age II, indications for clustering at distances between ca. 3.8 km and 10.8 km are slightly stronger than before and even transcend the confidence threshold at about 9.8 km. Although the evidence is somewhat ambiguous, it might be suggested that a slight trend towards spatial clustering can be observed in the settlement data from the Northern Plateau.

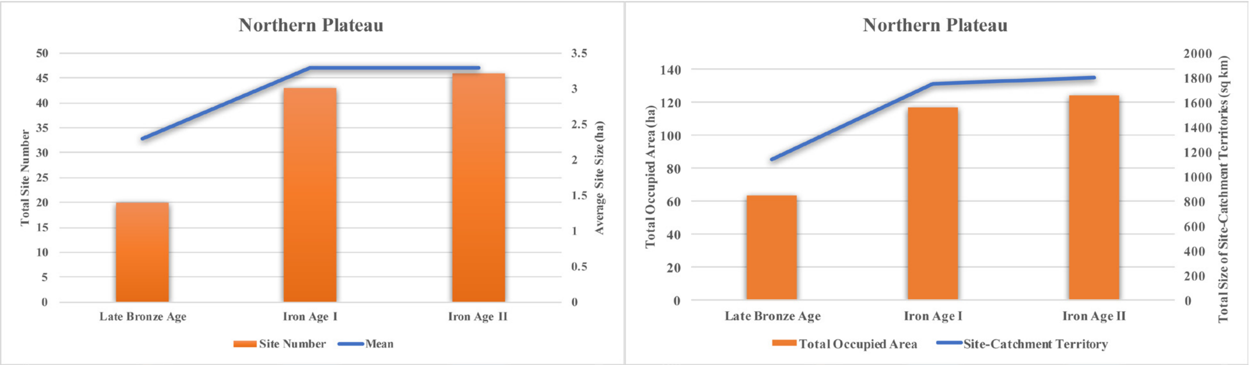

Fig. 5.33: Statistics for archaeological sites on Northern Plateau: (a) site numbers and average site size, (b) total occupied area and catchment territory sizes.

The x^2-test indicates that in this part of West-Central Syria, site locations appear to be related significantly to precipitation volumes and water courses, but a relationship between sites and groundwater reservoirs cannot be established. Whereas the Northern Plateau was characterized by relatively high rainfall levels throughout the Late Bronze and Iron Ages, access to other water sources was generally limited. The strong relationship between site locations and precipitation volumes on the Northern Plateau is also indicated by regression analysis, with the site densities being generally highest in those areas that receive high amounts of annual rainfall. In general, site densities and rainfall levels are strongly positively correlated, except for 1250 BCE, when site densities are higher in areas receiving less precipitation. Not only might this be indicative of shifting rainfall patterns, with more settlements now being located in areas receiving less rainfall than before, but also a subsequent adaptive process, as Iron Age sites are again located primarily in areas receiving higher levels of precipitation.

At the same time, sites on the Northern Plateau tend to cluster more heavily at higher elevation ranges, the correlation between site location and elevation being much stronger throughout the Iron Age than was the case in the Late Bronze Age. In general, sites on the Northern Plateau tend

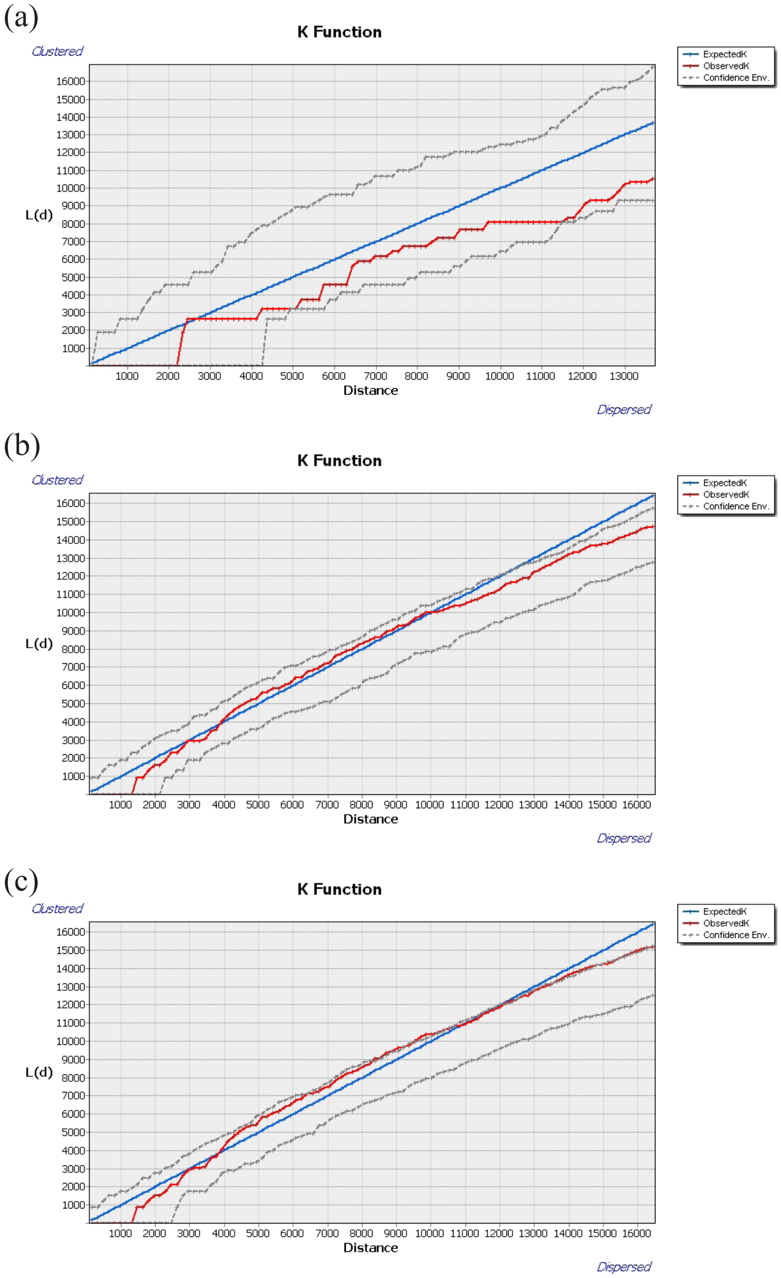

Fig. 5.34: Spatial statistics (Ripley's K) output graph for Northern Plateau: (a) Late Bronze Age, (b) Iron Age I, (c) Iron Age II.

to favor relatively steep terrain slopes, which might indicate a preference for horticultural crops, such as olives or grapes, rather than a reliance on staple crops, like barley or wheat. The data also indicates some temporal shifts in the relationships between site locations and terrain slopes, correlations between the two being higher in the Late Bronze Age and the Iron Age II, but noticeable weaker in the Early Iron Age.

5.6.2.5 The Orontes Valley

Excavation data from the Late Bronze and Early Iron Age levels from sites in the Lower Orontes Valley are still rather scarce. Nonetheless, a similar continuous, uninterrupted expansion of settlement activity as in the Northern Plateau is observable in the survey data (**Fig. 5.35**). Site numbers increase substantially between the Late Bronze and Early Iron Ages, from 26 to 50 sites, and increase of about 92.3%. This number increases even further, by another 20 %, in the Iron Age II, up to a total of 60 sites. At the same time, average site sizes decrease continuously, first by ca. 32.1 % between the Late Bronze Age and the Iron Age I, and then again by ca. 2.7 % between the Iron Ages I and II. At the same time, total occupied area increases by 18.4 % between the Late Bronze and Early Iron Ages, and again by ca. 9.1 % during the Iron Age, with site-catchment territories increasing by ca. 21.2 % and ca. 5 %, respectively. Despite these changes, considerable evidence for settlement continuity has been identified as well, especially in the southern Ghab Valley, in the vicinity of Tell ʻAcharneh, where all Late Bronze Age sites continue to be inhabited in the Iron Age as well (Fortin and Cooper 2014).

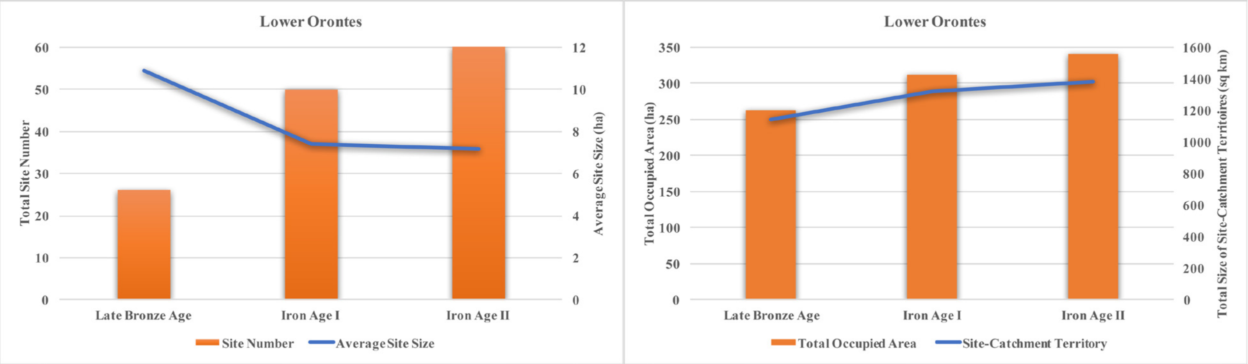

Fig. 5.35: Statistics for archaeological sites in Lower Orontes Valley: (a) site numbers and average site size, (b) total occupied area and catchment territory sizes.

Again, the development of site characteristics in the Lower Orontes Valley suggests a qualitative difference between the settlement system of the Late Bronze Age and the Iron Age I, whereas the Iron Age II witnesses the further development and quantitative expansion of this particular pattern of spatial organization. This difference can also be seen in the spatial patterning of sites (**Fig. 5.36**). During the Late Bronze Age, sites tend towards dispersal at small distances, up to about 4.5 km, with some minimal indications of clustering at distances of up to about 7 km distance, and again a much stronger tendency towards dispersal at large scales. These trends, however, are not statistically significant. This stands in strong contrast to the obvious and statistically highly significant pattern of site clustering during the Iron Ages I and II. Again, the strongest difference between the internal structure of the settlement system occurs during the transition from the Late Bronze to the Iron Age I.

The settlement system of the Middle Orontes Valley exhibits a chronological development quite different from other regions of West-Central Syria (**Fig. 5.37**). During the Late Bronze Age, this area was especially densely settled, with a total of 92 sites recorded for this period. With an average site size of 5.9 ha, these appear to have been mostly of modest size. In the Iron Age I, however, site density decreases notably by ca. 27.2 %, whereas average site size increases to 6.9 ha, an increase of about 16.9 %. In the Iron Age II, site numbers increase again to 87, whereas average site size decreases to 6 ha. Total occupied area and total site-catchment territory follow the same

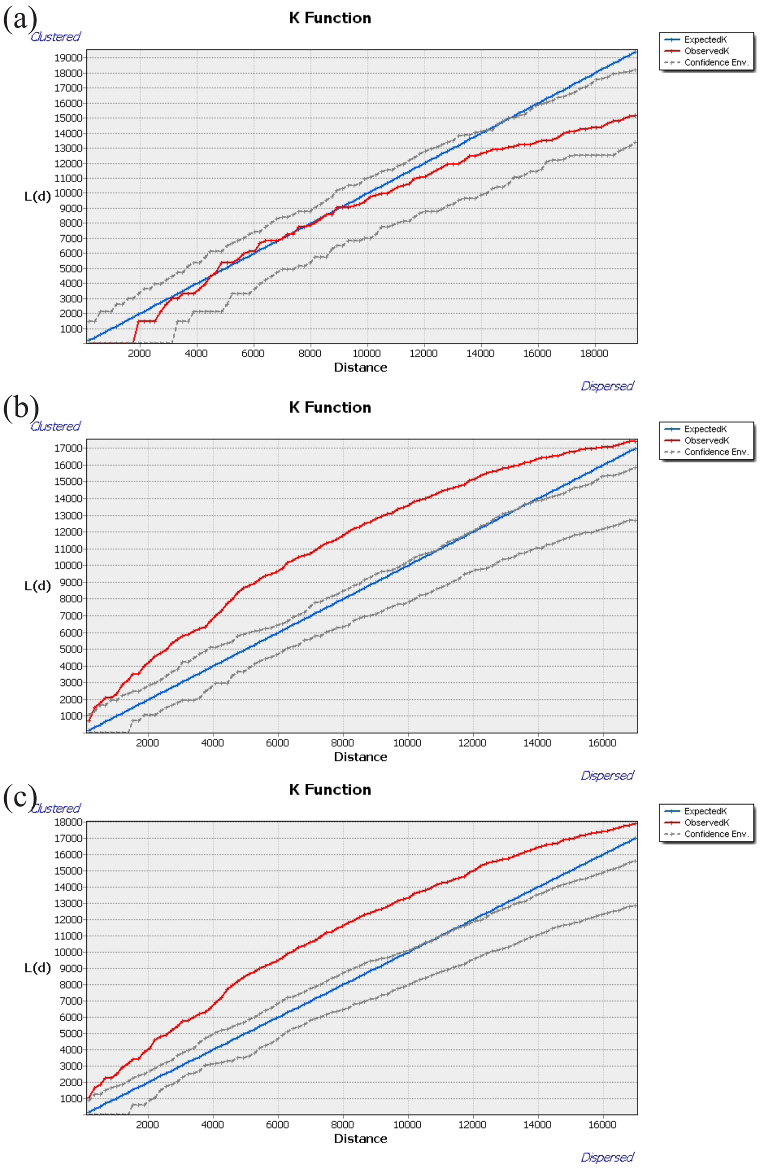

Fig. 5.36: Spatial statistics (Ripley's K) output graph for Lower Orontes Valley: (a) Late Bronze Age, (b) Iron Age I, (c) Iron Age II.

general trend, initially decreasing between the Late Bronze Age and the Early Iron Age, before expanding again over the course of the Iron Age. However, despite the renewed expansion of settlement activity between the Iron Ages I and II, the same levels of total site number, site size, total occupied area, and catchment territories as in the Late Bronze Age are not reached again.

The strongly aggregated (clustered) settlement system of the Late Bronze Age changes in character during the Early Iron Age, when clustering is only apparent at scales of up to 14 km, whereas at larger scales a slight (yet statistically insignificant) trend towards dispersal is apparent (**Fig. 5.38**). In the Iron Age II, however, the settlement system of the Middle Orontes Valley again reverts back to a strongly clustered distribution, again indicating a change in the relationships between settlements during this time period. Notwithstanding the presence of several larger sites within this sub-region, especially Tell Mishrifeh, Tell al-Nasriyah, Hama, and Tell Nebi Mend, the settlement system of the Middle Orontes Valley is primarily characterized by small and moderately sized sites. This

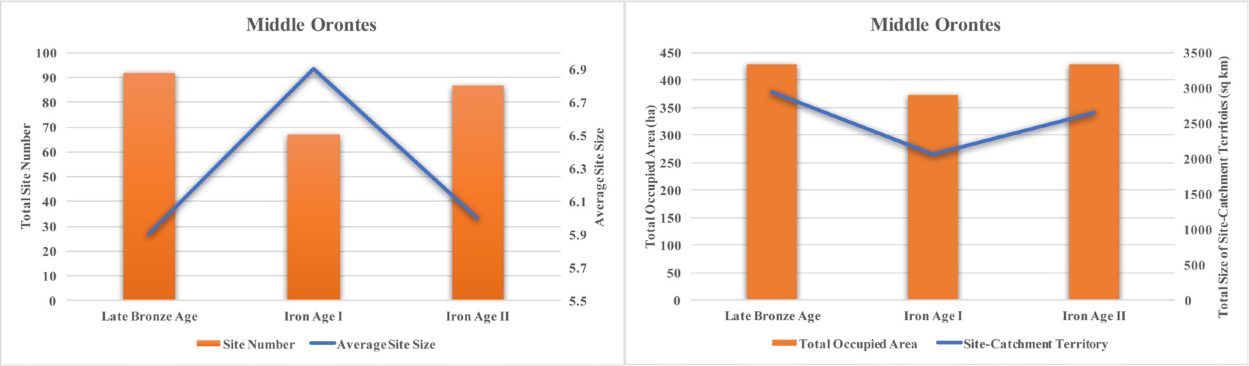

Fig. 5.37: Statistics for archaeological sites in Middle Orontes Valley: (a) site numbers and average site size, (b) total occupied area and catchment territory sizes.

spread of rather small, agricultural villages across the landscape is especially well attested in the vicinity of Tell Mishrifeh, where 21 sites existed in the Iron Age, as compared to the eleven sites of the Late Bronze Age (Morandi Bonacossi 2006, 101-104).

The settlement system of both the Lower and Middle Orontes Valleys is strongly related to the availability of water courses and hydrogeological features, whereas a relationship between site locations and precipitation volumes can only be established for the Lower Orontes Valley. Within the entire Orontes Valley, sites tend to cluster primarily in areas of low and moderate elevations, and in areas of low and moderate slopes, but occur on a variety of soils. This preference for more gentle, low-lying terrain might indicate an agriculture centered around the cultivation of staple crops, such as wheat and barley.

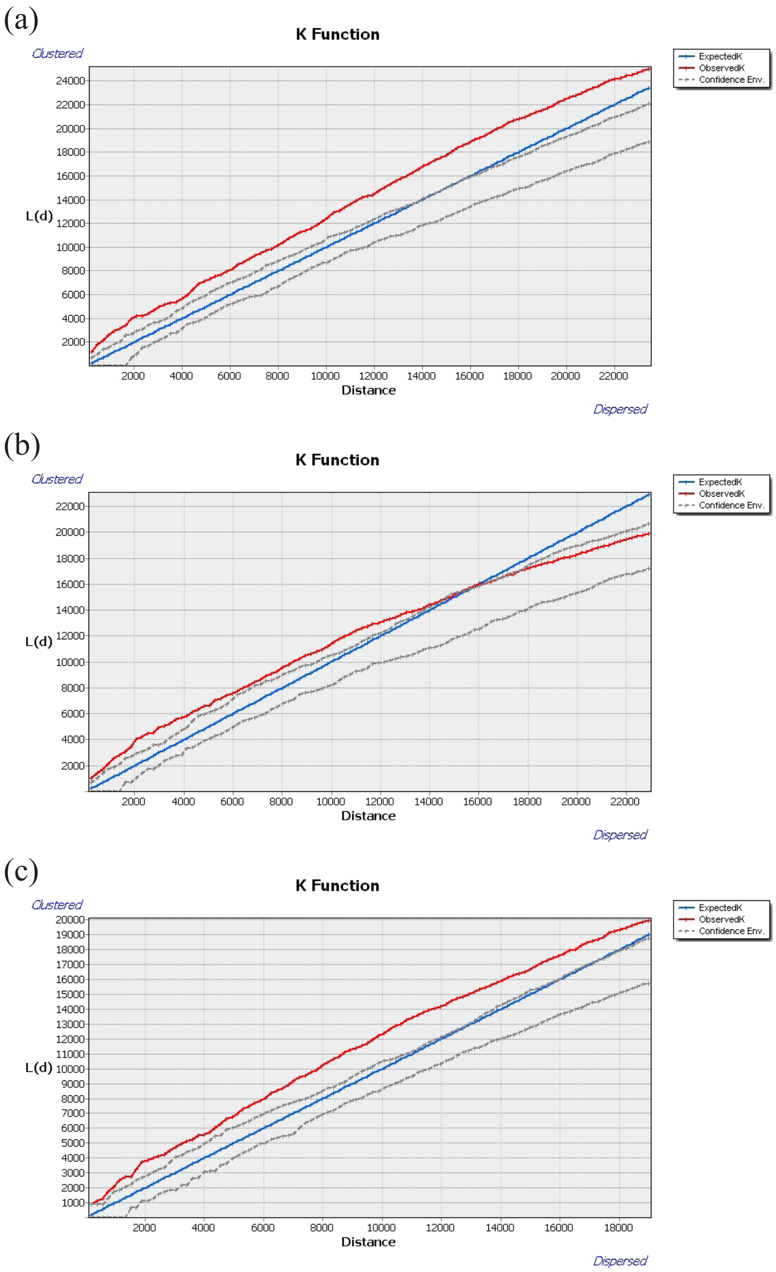

Fig. 5.38: Spatial statistics (Ripley's K) output graph for Middle Orontes Valley: (a) Late Bronze Age, (b) Iron Age I, (c) Iron Age II.

5.7 CONCLUSION

To some degree, the data analyzed support some of the hypotheses made by other scholars concerning the role of environmental change in the transition from the Late Bronze to the Iron Age in West-Central Syria. Based on modeled data, it can be suggested that the region experienced some environmental deterioration during the Late Bronze and Iron Ages, primarily observable in falling precipitation levels and some minor fluctuations in annual temperatures.

Apart from these general correlations with environmental proxy data, the modeling results also enable a more nuanced discussion on the development and patterning of these changes, as well as their effects. As has been discussed, both geographical and chronological variability becomes more apparent once the data is queried and analyzed at various scales. The analysis shows that different regions, even within this relatively confined study area, were affected to differing degrees by these changes and no single development can be assumed for the entire study area. What is more, the inclusion of social variables, in the form of site-catchment territories, in the discussion has shown that potential interactions between the environment and its inhabitants had an influence on the degree to which these changes were felt. Not only do the proportions of suitability classes differ sometimes considerably from those of the entire study area or even sub-regions, but the development of the settlement pattern also had an effect on the distribution of suitability classes within these territories. This is observable in both the Akkar Plain, and, to a slightly lesser degree, in the Lower Orontes Valley, where the proportions of agricultural suitable (or unsuitable) land within site territories shift between archaeological periods. However, as some regions also exhibit environmental variability within periods, it becomes clear that some sites must have been affected by changing climatic conditions.

Geospatial analysis has also shown that the settlement system of West-Central Syria exhibits some marked diachronic change. Site numbers, site sizes, total occupied area, and site-catchment territories fluctuate from period to period, with a general trend towards settlement intensification evident especially in the inland areas. At the same time, the spatial patterning of sites within the study region changed considerably over time, especially between the Late Bronze and the Early Iron Age, when a pronounced trend towards settlement aggregation is observable, which continues into the later Iron Age II. However, as the analysis has also shown, these trends in settlement development were not geographically uniform and, similar to climatic and environmental factors, differed sometimes considerably between individual sub-regions. Again, this highlights the importance of analyzing both social and environmental data at various scales in order to differentiate between broad, regional processes on the one hand and small, local developments on the other.

CHAPTER 6

COMPLEX INTERACTIONS, DIVERGING TRAJECTORIES: AN INTEGRATED DISCUSSION OF SOCIO-NATURAL INTERACTIONS IN WEST-CENTRAL SYRIA

6.1 Introduction

In this chapter, which constitutes the final step of the SNS analysis, all the available data on social and environmental change in Late Bronze and Iron Age West-Central Syria will be brought together in an integrated discussion. This includes the evidence from palaeoclimatic research, climatic modeling, and agricultural suitability analyses, but also entails the results obtained from archaeological survey, excavation work, and archaeobotanical and zooarchaeological studies, as well as the data contained in historical documents. The archaeological data used in the discussion is summarized in **Appendix 7**, where an overview over the major archaeological materials and their chronological distribution is given.

Placing a special focus on the analysis and explanation of diachronic change and transformation, the discussion will be subdivided chronologically, discussing the Late Bronze Age, the Iron Age I, and the Iron Age II in sequence. In keeping with the principles of Socio-Natural Systems thinking, the discussion will tack between different scales of analysis, moving between broad regional perspectives and small-scale, local contexts. In addition, a thematic ordering is introduced into the discussion by grouping together those sub-regions that furnish evidence for similar, or at least comparable, development trajectories. Considering that these geographic similarities can differ from period to period, these groupings will not be static but specific to the period discussed and the evidence available.

However, two sub-regions, the Central Coast and the Upper Orontes Valley, will not be discussed in detail. With the sole exception of survey data, no archaeological or environmental evidence is available from these two regions. This lack of data makes it impossible to link climatic and environmental processes to actual evidence of social transformation. Yet, settlement data or the results of environmental modeling in these two sub-regions will be sporadically alluded to, in order to compare and contrast trends of environmental change and social transformation in West-Central Syria.

6.2 The Late Bronze Age: Early Signs of Socio-Environmental Change

6.2.1 Flourishing Economies in a Stable Environment

That the kingdom of Ugarit was one of the prime political and economic centers of West-Central Syria is not only demonstrated by the rich textual and archaeological documentation available from the capital city, but also indicated by the archaeological record of numerous sites on the Northern Coast and in the Jableh Plain, which constituted the kingdom's territory. That this territory was densely settled during the final decades of the Late Bronze Age is clearly indicated by economic records, which provide evidence for the existence of around 150-192 settlements under the control of the kings of Ugarit (Buchholz 1999; Sommer 2016; Yon 1992). Although only about 14 of these settlements are archaeologically known, including Tell Siano which at that time most probably was the center of an independent minor kingdom, the available evidence attests to the existence of a flourishing urban culture on the northern coast of West-Central Syria.

The most important urban centers on the Northern Coast include not only the capital city of Ugarit itself, but also Ras ibn Hani, with its two large palaces and administrative functions, and Minet el-Beida, a densely settled urban center acting as the kingdom's primary commercial harbor. Conversely, in the southern territories of the kingdom, in the Jableh Plain, only one large urban center existed at Tell Tweini, ancient Gibala, whereas the majority of settlements in this part of the coastal plains were of only moderate size. This difference in the character and scale of the urban occupation in these two sub-regions is also evident in differences in average site size and total occupied area, both of which are considerably higher on the Northern Coast than in the Jableh Plain.[87]

Unfortunately, not much is known archaeologically about the non-commercial, agricultural economy of the kingdom of Ugarit and the existing textual records are somewhat ambiguous in this regard. For example, Yon (1992, 113) considers the agricultural potential of the kingdom's territory as the basis for its economic wealth, a position shared by Buchholz (1999), who considers the northern coastal plains capable of supporting the local population. On the other hand, Sommer (2016, 31) considers the local topography and edaphic characteristics of this region as unconducive for agricultural surplus production.[88] Furthermore, according to Sommer (2016, 34), the fact that only 31 out of the almost 200 settlements within the territory of Ugarit are mentioned as grain producers should be seen as indicative of the low level of agricultural potential afforded by the natural environment of the northern coastal regions.

In the final decades of the Late Bronze Age, the coastal regions of West-Central Syria experienced some climatic fluctuations, although the different types of data show somewhat diverging trends. Between 1350 and 1250 BCE, the modeling results indicate an overall, region-wide reduction in precipitation volumes, followed by a brief recovery between 1250 and 1150 BCE. However, if geographical differences are taken into account, it appears that not all coastal areas were affected

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[87] Although the Jableh Plain belonged in large parts to the kingdom of Ugarit, another small kingdom, the kingdom of Siyannu-Ushnatu existed in the area as well. The kingdom's political and administrative center was located at Siyannu, with which Tell Siano has been identified. However, the limited archaeological finds made so far at Tell Siano (al-Maqdissi 2004b; Bounni and al-Maqdissi 1992, 1993, 1998) stand in contrast to the historical record, where Siyannu is frequently mentioned in the Ugaritic, Egyptian, Hittite, and even Neo-Assyrian and biblical sources (Bounni and al-Maqdissi 1992, 129). In the texts found at Ras Shamra, the kingdom appears several times, both in letters and official treaties. In a short treaty between the kings of Ugarit and Amurru (RS 19.69), which might be dated before the Hittite conquest of Syria (Janowski and Wilhelm 2005, 163), the kingdom of Siyannu-Ushnatu is assigned to the sphere of influence of the king of Ugarit. It remains under Ugaritic dominance until the Hittite king Mursili II (1321-1295 BCE) places it under the jurisdiction of the Hittite viceroy at Carchemish, evidenced by RS 17.355, RS 17.368, RS 17.380, and RS 17.382 (Janowski and Wilhelm 2005; Singer 1999). As a result, a border between the two kingdoms is established across the fertile agricultural plains, leading to repeated border disputes (RS 17.235; Vita 1999) and conflict over agricultural land and resources (Singer 1999, 662). Thus, the textual evidence provides valuable information for an economic history of this part of the coastal plain, for which the excavations at Tell Siano have not yet furnished any archaeological evidence.

[88] It should be noted, however, that Sommer's position on this issue is apparently based exclusively on the maps and materials compiled by Wirth (1971). Wirth's study constitutes a comprehensive, holistic environmental, economic, and cultural overview over Syria around the middle of the 20th century CE. The data used in the study appear to have been compiled from a variety of sources, including population statistics and economic reports, but are also to a significant degree based on individual, subjective observations as the author admits: "Der Geograph muß in Syrien noch echte Pionierarbeit leisten. Es bleibt ihm nichts anderes übrig, als die Ärmel hochzukrempeln, sich im Lande umzusehen und mit den >konventionellen< geographischen Methoden an die Arbeit zu gehen. Mehr oder minder zufällige Einzelinterviews, mehr oder minder zufällige eigene Beobachtungen und Felduntersuchungen, Kartierungen und das neuerdings so verlästerte geographische Fingerspitzengefühl erfüllen zwar nicht die Exaktheitsansprüche der >modernen< Wissenschaftstheorie. Sie sind in Entwicklungsländern aber nach wie vor unentbehrliches Handwerkszeug geographischer Arbeit; in Verbindung mit einer möglichst guten eigenen Landeskenntnis führen sie hier viel weiter als zwar ausgefeilte, aber nicht anwendbare moderne Methoden" (Wirth 1971, 4).

by these fluctuations in rainfall in the same way. Between 1350 and 1250 BCE, both the Jableh Plain and the Central Coast further south received slightly less precipitation than before. Between 1250 and 1150 BCE, the Northern Coast was affected by diminished rainfall levels, whereas the Jableh Plain again received slightly more rainfall. The onset of slightly moister conditions is also indicated by the Tell Tweini pollen data (Kaniewski *et al.* 2010; Kaniewski *et al.* 2012).

Though, the results of the environmental modeling, especially the suitability analyses, also indicate that these climatic changes did not constitute a significant threat to the agricultural potential of this part of West-Central Syria. On both the Northern Coast and the Jableh Plain, modeling results show an overwhelming dominance of highly suitable areas, especially in the Jableh Plain, where large portions of the available land belong to the very high suitability class. This is even more apparent when the immediate vicinities of Late Bronze Age sites are considered and especially in the Jableh Plain conditions remained highly favorable to agricultural production during the terminal Late Bronze Age. To a certain degree, the existence of agriculturally favorable conditions within the territory of Ugarit is acknowledged by Sommer (2016, 136), who considers the environment of the kingdom of Ugarit as not susceptible to drought.

Faunal and botanical data, although rather scarce and only recorded at a handful of sites, might be taken to support an image of a diversified and generally productive agricultural economy. Sheep, goat, and cattle remains have been identified at both Ras Shamra (Vila 2004, 2008) and Tell Tweini (Linseele 2008, 2010; Linseele *et al.* 2013), whereas pigs and wild animal species are represented in only minor quantities. In this context, the relatively high percentages of cattle bones in the assemblages, around 30 % at Ras Shamra and about 37 % at Tell Tweini, not only suggest that these animals played an important role in the production of meat for consumption (Vila 2008, 173), but also indicate that environmental conditions were overall favorable for sustaining large cattle herds. As far as botanical data is concerned, pollen analyses at Ras al-Bassit provide evidence for land clearance and cereal cultivation within the immediate vicinity of the site (Courbin 1990, 503), whereas the Field A Tell Tweini samples are dominated by einkorn and emmer wheats, while barley and bread wheats were less frequently encountered (Vandorpe 1999).[89] The predominance of wheat over barley at Tell Tweini might be indicative of generally favorable agricultural conditions, as wheat is considered more susceptible to environmental stress than barley. Furthermore, considerable quantities of olive remains in the Tell Tweini samples attest to an intense horticultural production, which is also supported by textual sources from Ugarit, such as RS 18.042, RS 20.01, and RS 20.168, which record shipments of oil and other commodities to Cyprus and Egypt (Sommer 2016, 31).

This evidence for generally favorable agricultural conditions, however, stands somewhat in contrast to the textual sources from Ugarit, which record severe food shortages within the kingdom and adjacent regions. The solution to this conundrum, which has been hinted at by Sommer (2016, 110), might be Ugarit's focus on a mercantile and service-oriented economy, which might have led to relatively few people directly involved in the cultivation of staple crops, instead focusing on other economic activities. Although the territory of the Ugaritic kingdom was mostly fertile and suitable for intensive agricultural production, this potential might not have been exploited to the

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[89] One problem in the analysis of the faunal and botanical samples from these coastal areas is the rather preliminary fashion in which these data have been published so far. The faunal remains of Ras Shamra have only been treated in cursory fashion, with a more complete analysis expected to be available in the near future (Chahoud and Vila 2017), although it was not available to the author at the time of writing. The faunal remains from Tell Tweini have been published in more detail (Linseele 2008, 2010; Linseele *et al.* 2013). On the other hand, botanical data from the northern coastal areas is mostly unavailable, the only available data being a preliminary report on the Tell Tweini materials (Vandorpe 1999), as well as an oblique reference on materials from Ras al-Bassit (Courbin 1990), which lacks sufficient detail.

fullest extent. Instead, as the textual records illustrate, grain and other agricultural commodities were often procured from other localities in inland West-Central Syria (cf., Klengel 1990; Sommer 2016). In this regard, Courtois (1990) has discussed a number of administrative documents from the South Palace (House of Yabninu) at Ugarit. These texts (see, Nougayrol 1970) contain the names of several cities and villages located in the eastern districts of the kingdom of Ugarit, presumably to the east of the Orontes Valley, which are listed as the origin of a range of agricultural products, for example barley, shipped to the city of Ugarit.

6.2.2 Ruralization and Social Decline

Whereas the repercussions of Late Bronze Age climatic shifts were not strongly felt by communities on the Northern Coast and in the Jaböeh Plain, other areas of West-Central Syria provide evidence for either the existence or the development of less favorable environmental conditions during this period. The Central Coast was not just generally less favorable for agricultural cultivation, reflected in the complete lack of areas of extremely high suitability and significant proportions of less suitable land, but also exhibits some minor temporal changes throughout the Late Bronze Age, indicating slightly less favorable conditions around 1250 BCE. A similar situation prevailed on the Akkar Plain, which shows clear evidence for a deterioration of environmental conditions already during the Late Bronze Age, observable in the expansion of moderately suitable areas at the expense of more fertile land. Apart from Tell Kazel, which provides evidence for a dense, urban occupation during this period, the settlement system of the Akkar Plain was characterized by a rather low number of settlements of only modest size. As the remains of Tell ʻArqa (Level 11) indicate, settlement activity in this part of the study area was already in decline by the start of the period analyzed here and continued over time.[90] Whether this decline can be attributed to environmental causes, however, is highly questionable, given that site-territories in the Akkar Plain remain highly suitable for agricultural exploitation throughout the Late Bronze Age. Unfortunately, no botanical or faunal data is available to further investigate this development, but the currently available evidence appears to indicate that the causes of the settlement decline on the Akkar Plain during the Late Bronze Age should better be attributed to social or political factors, rather than climatic and environmental ones.

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[90] The limited archaeological evidence from Tell ʻArqa can be contrasted with the historical record on the city of Irqata, with which Tell ʻArqa is commonly identified (Thalmann 2010, 86). The city is mentioned several times in the el-Amarna correspondence, especially in a series of letters from Rib-Hadda, king of Byblos, who complains to his Egyptian overlord about ongoing conflicts with Abdi-Ashirta and his son Aziru in the context of the establishment of the kingdom of Amurru (e.g., EA 75, EA 88; Knudtzon 1915). Irqata is also mentioned in a letter by Abdi-Ashirta (EA 62; Knudtzon 1915) and two letters by Aziru (EA 139, EA 140; Knudtzon 1915). Although these letters do not provide any direct evidence for the position of Irqata within the regional settlement system (Thalmann 2010, 100), these references still suggest that the city played a role in the political and military struggles that characterized the region during the Late Bronze Age. Yet, an almost complete absence of the city's name from Hittite and Ugaritic documents (Hawkins 1976-1980) illustrates that the city's importance had declined during the latter part of this period, which might be correlated to the apparent urban decline observed in Level 11 at Tell ʻArqa.

6.2.3 Small-Scale Production in a Marginal Environment

According to the results of the MCM modeling, the Northern Plateau experienced some climatic fluctuations during the Late Bronze Age, with conditions becoming slightly moister and a little cooler between 1350 and 1250 BCE, before experiencing a noticeable drop in precipitation and a slight increase in temperatures between 1250 and 1150 BCE. These developments suggest slightly deteriorating conditions towards the end of the Late Bronze Age. But were these changes actually significant enough to effectuate an economic downturn in this area?

If the development of agricultural suitability is considered for the entire sub-region, it becomes apparent that large portions of the Northern Plateau are indeed unsuitable for intensive cereal cultivation, as suggested by the very high proportion of unsuitable land in this part of West-Central Syria. What is more, the proportion of these unsuitable areas increases significantly over the course of the Late Bronze Age, expanding from 41 % in 1350 BCE to over 53 % in 1250 BCE. Yet, when the immediate surroundings of archaeological sites, that is, site-catchment territories, are considered, it becomes apparent that conditions on the Northern Plateau were not so bleak after all. Areas within the agricultural territories consisted primarily of moderately suitable land and between 1350 and 1250 BCE, the proportion of favorable land actually increased noticeably, from around 22 % to over 26 % of the total area. Although almost no botanical or faunal remains are currently available to substantiate this claim (see, Minniti 2014), the modeling data might be taken to indicate that settlements on the Northern Plateau were not affected by deteriorating environmental conditions during the Late Bronze Age. Instead, major environmental changes appear to be confined to the mostly uninhabited areas on the eastern fringe of the study area.

As far as the archaeological evidence is concerned, a relatively high number of small sites indicate a predominance of rural settlements, the only exception being Tell Afis.[91] During the final part of the Late Bronze Age, the urban layout of Tell Afis underwent some important transformations. The large Residence F of the 14th and early 13th centuries BCE (Phase VII) was first replaced by a short-lived industrial complex (Phase VI) and the area later covered by several residential buildings in the late 13th century BCE (Phase Vb) (Baffi and Peyronel 2014; Venturi 2014). This final Late Bronze Age phase provides a detailed view of storage activities at Tell Afis, with a variety of large pithoi, medium-sized krater-jars, and fusiform jars providing evidence for the medium- and short-term storage of foodstuffs and their distribution (Venturi 2015). Based on the ceramic assemblage and the associated small-finds, Venturi (2015, 86) has argued that Buildings A and E were used for public or communal storage purposes, whereas Building B probably was more domestic in character (Venturi 2015, 84). This arrangement of storage activities at 13th and early 12th-century BCE Tell Afis has been interpreted as the vestiges of a Late Bronze Age administrative system (Venturi 2015, 92), although some tendencies towards the dissolution of centralized control over storage activities are already apparent during the 13th century BCE.

6.2.4 Complex, Heterogeneous Patterns

Taken as a whole, the Orontes Valley exhibits a complex pattern not just of environmental and climatic change, but also with regard to social organization.

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[91] Scanty Late Bronze Age remains have been uncovered at Tell Tuqan (Phase IVb), where some kind of occupation is indicated in the Lower Town (Baffi 2011a; Baffi and Peyronel 2014), as well as at Tell Mardikh, where evidence for Late Bronze Age squatter occupation and an impoverished settlement has been excavated in several areas of the site (Baffi and Peyronel 2014; Matthiae 2006; Peyronel 2007).

Between 1350 and 1250 BCE, parts of the northern Ghab Valley around Tell Qarqur were affected by a substantial decrease in precipitation volumes, whereas other parts of the river valley, for example the southern areas of the Lower Orontes or large parts of the Middle Orontes Valley experienced a slight increase in annual rainfall. In the period between 1250 and 1150 BCE, on the other hand, most areas of the Orontes Valley, particularly the southern portions of the Lower Orontes, received less precipitation than before, illustrating a gradual, but spatially and chronologically non-contiguous process of aridification.

These geographical differences are also observable in the results of the suitability model. For the entire Orontes Valley, a slight increase in lowly suitable land is observable between 1350 and 1250 BCE, concomitant with a reduction in highly suitable areas. Sites in the Upper Orontes Valley, however, were not significantly affected by these developments, as the proportions of suitability classes within site-catchment territories remained virtually stable between 1350 and 1250 BCE. On the other hand, in the Middle Orontes Valley a degradation of agricultural land is evident, observable in the expansion of moderately suitable areas, mostly at the expense of areas of high suitability. Since the proportion of unsuitable land in the Middle Orontes Valley also decreases slightly during the same time period, this development is not indicative of the general development of agriculturally unfavorable conditions in this area, but should perhaps be understood more as a progressive trend towards the marginalization of previously attractive land. A similar trend might be identified in the Lower Orontes Valley, where a reduction in highly suitable land, concomitant with an increase in the proportions of the low suitability class, is apparent between 1350 and 1250 BCE.

Again, it is difficult to compare the modeling data to other types of environmental proxy data and substantiate the results obtained through GIS analysis. In the Lower Orontes Valley, Late Bronze Age levels have barely been sampled so far and the Tell Qarqur evidence comes exclusively from Iron Age levels (Arter 2003). The botanical samples from the Royal Palace (Area G) of Tell Mishrifeh show a predominance of barley over wheat, but also indicate sizeable quantities of olive remains. Grapes, however, are only represented in fairly low numbers, whereas lentils are entirely missing from the samples (Riehl 2007). Similarly, the few Late Bronze Age samples from Area J, analyzed by Peña-Chocarro and Rottoli (2007), indicate that barley was slightly more common than wheat, but also attest to the significance of olive cultivation during this period. Again, the preference of barley over wheat, which has been noted at other Near Eastern sites as well (Riehl and Nesbitt 2003), as well as the absence of water-dependent crops like lentils, might indicate the preference for more drought-resistant crops and might therefore indicate an economic strategy adapted in order to cope with the adverse effects of climatic change during this period (Riehl 2007, 147). At the same time, the faunal remains from Tell Mishrifeh and Tell Nebi Mend suggest that proportions of steppe-habitat animals were particularly high in the Middle Orontes Valley during the Late Bronze Age (Grigson *et al.* 2015; Vila and Gourichon 2007), which have been interpreted as the result of landscape changes and the onset of increasingly arid conditions, lasting into the Early Iron Age (Grigson *et al.* 2015, 182).

Despite these apparent trends towards environmental deterioration, the archaeological evidence points to a dense occupation of the Middle Orontes Valley during the Late Bronze Age. This can be observed in the very high number of small- and medium-sized settlements centered around a handful of larger administrative centers, such as Hama and Tell Nebi Mend. The remains of Hama Period G consist of the well-preserved remains of a large structure in Square I-10, comprised of at least ten rooms, several of which provided evidence for large-scale storage activities, as evinced by the large numbers of storage jars still found *in situ* (Fugmann 1958, 119). Both the architectural features of this building, as well as the evidence for centralized storage, have led the excavators to propose an identification as a palace (Fugmann 1958, 122). At Tell Nebi Mend, two large, public structures have been excavated in Trenches II and III, of which the former probably served an administrative purpose, whereas the latter was potentially of cultic or religious function (Bourke 1993; Grigson 2015; Parr 1991). However, no evidence for large-scale stockpiling of foodstuffs, similar to Hama, was encountered at Tell Nebi Mend. Following the destruction of its palatial complexes already in the 14th century BCE, Tell Mishrifeh developed into a small, predominantly agricultural village (al-Maqdissi 2002; Da Ros 2015; Luciani 2002, 2003, 2006; Morandi Bonacossi 2006, 2013; Shabo 2015). Despite the apparent decline of royal authority at Tell Mishrifeh during the final stages of the Late Bronze Age, the evidence from several areas of the Upper and Lower Towns attests to a continued, yet reduced occupation at the site (Morandi Bonacossi 2007a, 82).

In contrast to the Middle Orontes Valley, which was characterized during the Late Bronze Age by a high number of relatively small sites, the settlement system of the Lower Orontes Valley was more compact, distinguished by a high average site size and a high total occupied area, although no statistically significant evidence for spatial clustering during this period exists. In archaeological terms, this sub-region is only very badly understood. The excavations at Tell Qarqur have furnished only limited ceramic evidence of the 13th and 12th centuries BCE (Dornemann 2008c, 93). At Tell ʻAcharneh, the remains of a large structure, encountered on the southern flank of the northwestern mound, constitutes the only unequivocal evidence of a Late Bronze Age occupation at this site, apart from small quantities of Late Bronze Age ceramic sherds (Cooper 2006; Fortin 2006a). Yet, the 22 large storage jars that were set into the floors clearly mark the large building on the acropolis as an important structure (Fortin and Cooper 2013, 158), suggesting the centralized storage of agricultural produce.

Historical sources do not provide much information with which the archaeological data could be augmented. In the 14th century BCE, Qatna/Tell Mishrifeh was part of the kingdom of Nuhashshi (Richter 2006), a political entity located on the western fringes of the Syrian steppe (Klengel 1969). Following the destruction of its palatial centers, Qatna disappeared form the historical documentation. The position of Hama, which is not attested in the historical sources prior to the 1st millennium BCE, is not entirely clear and the city might have been part of the kingdoms of Nuhashshi, Nija, or Tunip, which were located within the general area of the Middle Orontes Valley (cf., Hawkins 1972-1975; Klengel 1969). The identification of Tell Nebi Mend with ancient Qadesh was already proposed a long time ago (see, Klengel 1969; Parr 1983; Pézard 1931) and has been confirmed by the renewed excavations and additional textual finds (Parr 1991). In the Lower Orontes Valley, Tell Qarqur has been identified with ancient Qarqar (*^{uru}qar-qa-ra*), whereas recently an identification of Tell ʻAcharneh with ancient Tunip (*^{uru}Tu-ni-ip*) has become well-accepted (Fortin 2006b; Frayne 2006). The city of Tunip appears several times in the textual record of the period, for example in a 15th century BCE treaty (AlT 2; Wiseman 1953) between king Ir-Addu of Tunip and king Niqmepa of Mukish, which regulates the cross-border exchange of people between the two polities (Dietrich and Loretz 1997), and a treaty (CTH 135; Laroche 1971) between the Hittite Great King and the king of Tunip, which ensures the return of formerly lost territories to the king of Tunip (van Soldt 2014).

Although these textual sources allow for the general localization of the major Late Bronze Age kingdoms, and facilitate an investigation of their political and military relationships, most of the kingdoms' internal structure and economy remain in the dark. The fact that high site densities in the Late Bronze Age Orontes Valley are observable particularly on low and moderate elevations, as well as on low and moderate slopes, might indicate a diversified agricultural economy relying on a variety of crops and livestock. The apparent statistical relationship of both Lower and Middle Orontes Valley sites to water courses and hydrogeological features within site territories might indicate that proximity to water resources constituted a constraining factor on settlement development and distribution.

6.3 The Iron Age I: The Qualitative Transformation of a Settlement System

6.3.1 A Local Trend Towards Sustained Depopulation?

Population dynamics between the 12th and 10th centuries BCE resulted in various changes to the social, economic, and political structure of West-Central Syria, which is especially notable in the significant decrease of settlement activity on the Northern Coast. In this sub-region, site numbers decrease by over 66 % between the Late Bronze and the Early Iron Age, while average site sizes drop by over 80 % and total occupied area by 90 %.

The current archaeological data suggest a considerable decrease in population levels in this part of West-Central Syria, despite some unequivocal evidence of continued occupation and the apparent survival of topographical names even until recent times (see, Caubet 1992). An immediate, albeit ephemeral, re-occupation phase is evident at Ras Shamra, especially in the western part of the site, where the 'Armorer's House' and the 'House with the Portico' provide evidence for the re-use and spatial alteration of the Late Bronze Age residences (Callot 2008; Margueron 1977; Yon 1992). Similarly, at Ras ibn Hani, following the partial destruction and abandonment of the site in the early 12th century BCE, small houses separated by narrow streets were erected directly on top of the ruins of the Southern Palace (Bounni *et al.* 1976; Bounni *et al.* 1979; Bounni *et al.* 1981; Bounni and Lagarce 2004; du Piêd 2006-2007, 2011), while a more ephemeral occupation appears to have occurred in the area of the former Southern Palace (du Piêd 2006-2007). A comparable re-occupation phase, consisting of modest architectural remains on top of the abandoned Late Bronze Age buildings, is attested at Ras al-Bassit, suggesting a virtually uninterrupted settlement at the site (Courbin 1986, 1990; Darcque 2004; du Piêd 2006-2007). These buildings were associated with relatively large silos, with an approximate storage capacity of 6 m^3, potentially indicating that they were meant to satisfy the storage requirements of an extended social group (Courbin 1990, 503; cf., Venturi 2015).

This development is particularly striking in comparison to the high degree of settlement activity and prosperity that this area enjoyed during the Late Bronze Age. More importantly, the depopulation of the Northern Coast during the Early Iron Age (and beyond) cannot be explained based on climatic and environmental factors, at least not as far as modeling results are concerned and when relying solely on the environmental conditions of the Northern Coast. The modeled precipitation data point towards a significant reduction in rainfall levels between 1250 and 1150 BCE, followed by two centuries of slight increases in precipitation, followed again by a strong trend towards aridification after 950 BCE. Despite these climatic changes, and their effects on the wheat crop suitability, large parts of the Northern Coast, as well as the territories on which settlements depended, remain highly suitable for agriculture. Thus, it remains questionable whether or not these climatic changes entailed the large-scale deterioration of the environment and deprived local communities of their subsistence base.

6.3.2 Long-Term Environmental Degradation and Social Adaptation

Whereas the Northern Coast experienced a stark reduction in settlement activity during the Early Iron Age, site numbers on the Northern Plateau increased by 115 % relative to the preceding period, with the total occupied area increasing by more than 83 % and average site size increasing by over 43 %.

Tell Afis provides practically the only available archaeological data on this period, as Early Iron Age layers at Tell Tuqan are almost non-existent (Baffi and Peyronel 2014; Fiorentino 2014) and only very fragmentarily preserved at Tell Mardikh (Mazzoni 1990, 1992).[92] After the destruction of the final Late Bronze Age occupation at Tell Afis (Phase Vb),[93] the site was quickly resettled in the late 13th and early 12th centuries BCE (Phase Va). This was followed by a new permanent settlement in the mid-12th to the mid-11th centuries BCE (Phase IVc-a), which consisted of two small houses in Area E on the acropolis (Venturi 2013, 2015). One of the characteristic features of this phase is the extensive use of storage facilities, which consisted of numerous pits and silos in both private and public spaces (Venturi 2015). Between Phase IVc and IVa (**Fig. 6.1**), that is, between the late 12th and early 11th centuries BCE, a progressive shift occurred away from the private storage of foodstuffs on an individual household level towards communal storage practices (Venturi 2015, 89).

Fig. 6.1: Development of storage activities at Tell Afis during the Early Iron Age: (a) Phase IVc, (b) Phase IVa (Venturi 2015, figs. 7-8).

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[92] Unfortunately, much of the Late Bronze and Iron Age materials from Tell Mardikh remain largely unpublished today and only very little information on these periods is available (Lehmann 2013, 268). Renewed analyses of these materials are expected to be published in the near future (Matthiae and Pinnock 2017), but were unavailable to the author at the time of writing.

[93] The general phasing system for Tell Afis has been first outlined in Venturi (2007) and has been adhered to in subsequent publications (e.g., Venturi 2011, 2013, 2014, 2015) as well as in the present discussion.

Between the mid-11th and mid-10th centuries BCE (Phases IIId-a), the beginnings of an urbanization process are apparent, resulting in the progressive build-up of formerly open spaces and even further collectivization of storage facilities for agricultural products and other foodstuffs (Venturi 2015, 90). At the same time, two superimposed temple structures, Temples AIII.2 and AIII.1 were erected in the center of the mound (Mazzoni 2010a, 2010b, 2012b, 2014a, 2014b; Soldi 2009), providing further evidence for this gradual process of urbanization.

The proliferation of storage facilities is one of the hallmarks of the Iron Age I of Tell Afis and provides evidence for a consistently high degree of agricultural production and the prosperity of the agricultural economy of the Northern Plateau during this period (Venturi 2015, 92). That this development was not necessarily the result of a process of socio-economic and socio-political integration might be suggested by the currently available settlement data, as the spatial distribution of Iron Age I sites does not indicate a tendency towards settlement aggregation (or dispersal, for that matter). Instead, geostatistical analysis suggests that the small- and medium-sized sites of the Early Iron Age were more-or-less evenly distributed across the region. Perhaps, the need for increased storage capacities and the progressive move towards the collectivization of storage activities might instead be interpreted as an adaptive strategy in reaction to deteriorating environmental conditions? Although the palaeoclimatic data is somewhat ambiguous in this regard,[94] suitability analysis indicates that climatic changes during the Early Iron Age had a noticeable effect on wheat crop suitability within this sub-region. For the entire plateau region, a significant increase in the proportions of low suitability values is evident between 1250 and 1150 BCE, concomitant with a reduction in highly suitable areas. The same trend can be observed in the site-catchment data, which shows an increase of lowly suitable areas between 1250 and 1150 BCE. In both cases, the proportions of suitability values stabilize afterwards and trends towards aridification throughout the Early Iron Age are much smaller than during the Late Bronze to Iron Age transition.

Again, both faunal and botanical remains cannot be adequately related to these modeling results, since only little materials have been published. The botanical assemblage from Tell Afis provides evidence for the cultivation of barley, wheat, and even some lentil and olive (Wachter-Sarkady 1998), whereas preliminary faunal analysis suggests a decline in the percentages of both sheep and goat remains, as well as a potential increase in cattle and pig remains (Minniti 2014).[95]

Considering that during the Iron Age I sites on the Northern Plateau tended to aggregate on higher elevation ranges and on steeper slopes, it might be suggested that the change within the spatial organization of the settlement system during this period was related to a change in agricultural practices, entailing a stronger focus on horticultural crops, especially olives, which can be grown on more difficult terrain than cereals. In addition, the dependence of site locations on the availability of either precipitation or surface water might be indicative of an attempt to arrange agricultural production according to environmental conditions and to seek out areas of higher agricultural potential. From this perspective, the superficially random distribution of Iron Age I sites on the Northern Plateau might be the result of environmental, economic, and social factors, and indicative of an adaptive strategy designed to cope with the effects of long-term aridification and environmental deterioration between ca. 1350 and 1150 BCE.

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[94] The Tell Tweini drill cores show the onset of drier conditions around 1175 BCE. In the climatic modeling data, a similar reduction in rainfall volumes is already indicated around 1250 BCE, lasting until about 1150 BCE, followed by slightly increased precipitation volumes between 1150 and 950 BCE. After 950 BCE, a considerable decrease in precipitation levels is again indicated by the modeling data.

[95] Especially the faunal evidence is, thus, at odds with the results of palaeoenvironmental research and environmental modeling. However, as the data has not been fully published yet, it is not possible to further differentiate between individual phases of the Iron Age, making it impossible to single out the Iron Age I samples.

6.3.3 Incoming Refugees, Outside Dependencies?

Similar to the Northern Plateau, the Lower Orontes Valley witnesses a considerable expansion of settlement activity during the Early Iron Age and the qualitative difference between Late Bronze and Early Iron Age settlement in this sub-region is readily apparent. However, the actual trajectory of this settlement expansion differs from that of the Northern Plateau. Whereas site numbers expand by over 92 % and total occupied area by over 18 %, average site sizes actually decreas by around 32 %. Despite a significant degree of settlement continuity, particularly in the southern Ghab Valley in the vicinity of Tell ʻAcharneh (Fortin and Cooper 2014), a new settlement system developed in the Lower Orontes Valley in the Early Iron Age, characterized by a strong tendency towards spatial clustering.

The archaeological evidence from Tell Qarqur might be tentatively correlated to this process. Iron Age I sherds have been encountered in practically every excavation area, although often times in insecure contexts (Dornemann 2008e, 85), hinting at the importance of Tell Qarqur during this period. More importantly, a large courtyard area associated with several storage silos and bins was uncovered on the southeastern slope of the main mound, although other architectural features were scarce (Dornemann 2008a, 2008b, 2008c, 2008e). These vestiges have been interpreted by the excavators as the remains of a large Iron Age I building, which has been compared to another large building, traces of which were found at the foot of the hill (Dornemann *et al.* 2008, 145). In contrast, the evidence for Early Iron Age occupation at Tell ʻAcharneh consists at the moment almost exclusively of ceramics from both the Upper and Lower Cities (Cooper 2006; Cooper and Fortin 2004; Fortin and Cooper 2013).[96]

The limited indicators for storage activities that have been found at Tell Qarqur are too fragmentary and insufficient to afford a more detailed analysis of socio-economic practices in this part of West-Central Syria during the Early Iron Age. This situation is further exacerbated by a complete lack of faunal or botanical data from these levels. Marked increases in highly suitable areas within site-catchment territories in relation to the final Late Bronze Age might indicate that new sites were established in relation to environmental parameters. This argument might be further supported by a statistically significant dependence of site locations on available water resources, which might indicate that socio-economic organization in the Early Iron Age Lower Orontes was at least in part dependent on environmental conditions during this period, especially with regard to water availability.

Yon (1992, 119) suggested that the inhabitants of the kingdom of Ugarit fled to the inland areas of West-Central Syria, specifically the Northern Plateau, following the destruction of the coastal sites. While it cannot be proven at the moment that these new foundations of small villages in the Lower Orontes Valley and the Northern Plateau were conditioned on the influx of refugees from coastal areas, the simultaneous decrease of settlement density on the Northern Coast and the marked increase of settlement activity further inland is noticeable.

However, if this was the case, then it also would need to be asked, why these people should have fled to this region in the first place, since these areas apparently suffered from environmental stresses. In the Northern Plateau, the trend towards a reduced agricultural suitability, which had already begun in the Late Bronze Age, continued into the Early Iron Age. In contrast to the Late Bronze Age, where the repercussions of climate change were not yet felt by communities on the Northern

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[96] As a result, it is currently not possible to clearly demonstrate occupational continuity between the Late Bronze and the Early Iron Age at Tell ʻAcharneh (Fortin and Cooper 2013, 151), although the ceramic evidence strongly suggests an Iron Age I occupation of some kind at the site.

Plateau, environmental deterioration was now also felt in the immediate vicinity of settlements. It therefore appears that on the Northern Plateau new settlements were established to an increasing degree on only marginally suitable land, at least as far as crop husbandry is concerned. A different trend can be observed in the Lower Orontes Valley, where the proportion of highly suitable land within catchment territories increased relative to the Late Bronze Age. Although the establishment of new settlements during the Iron Age I might also be related to various social factors, for example the proximity to overland trade routes, it is important to note that these newly established settlements existed within a different environmental context than their Late Bronze Age predecessors.

6.3.4 Settlement Contraction as Adaptation?

At the same time that settlement activity on the Northern Plateau and in the Lower Orontes Valley increased, the Middle Orontes Valley experienced a contraction of settlement, observable in a decrease in site numbers (by over 27 %) and total occupied area (by over 13 %), as well as an increase in average site size (by almost 17 %). However, this development did not necessarily entail an increased tendency towards clustering of settlements, as the degree of spatial aggregation actually decreased relative to the preceding Late Bronze Age. The decrease of the total size of site-catchment territories points in the same direction, indicating that agricultural catchments of Iron Age I sites did not overlap to a higher degree than before. Therefore, this process is best understood as the result of the abandonment of a number of small, agricultural villages and the reduction in size of formerly large urban centers.

This development is also mirrored in the excavation data, where a continued urban decline is apparent at Tell Mishrifeh, where only a small village without evidence for public structures existed and a focus was placed on the storage of foodstuffs and small-scale craft production. Similarly, the domestic contexts at Tell Nebi Mend attest to a reduced degree of urbanism, especially when compared to the monumental structures of the Late Bronze Age. The remains of Hama Period F are too fragmentary to allow for a detailed analysis. But evidence for storage activities in the same area that was later turned into the palatial center of the citadel, might be indicative of attempts to organize (and/or centralize?) the storage of agricultural produce. That these developments did not take place without conflict is evident in the destruction layer separating periods F2 and F1 at Hama, although the exact causes for this destruction are far from clear.

Throughout the Early Iron Age, the Middle Orontes Valley experienced some climatic fluctuations, with significant reductions in precipitation volumes occurring at the very beginning and the end of the period, whereas between about 1150 and 950 BCE slight increases in rainfall levels are observable in the MCM data. These climatic fluctuations, however, did not necessarily have an unequivocally good (or bad) effect on agricultural suitability in the Middle Orontes Valley. On the one hand, the proportion of unsuitable land within site-catchment territories decreased notably compared to the Late Bronze Age, but at the same time, the proportions of highly favorable areas decreased as well. This pattern can, thus, be interpreted as a complex environmental process, with some areas of the river valley decreasing in agricultural value, while other regions becoming slightly more amenable to crop cultivation. On the other hand, the development of agricultural suitability within catchment territories might also be interpreted as a deliberate attempt by people to concentrate in areas more suitable for agricultural exploitation. This might be supported by a dependence of site locations on the presence of groundwater resources, both regular and irregular, as well as a general preference of Early Iron Age settlements in the Orontes Valley for low elevations and low slopes, conditions favoring the cultivation of staple crops. In addition, statistical testing also indicates a significant relationship between site locations and the presence of water courses within the vicinity of sites, which is particularly important given that both perennial and intermittent streams, that is, larger streams, played a more important role relative to wadis and other small streams. This can be compared to the results of geoarchaeological research in the vicinity of Tell Mishrifeh, which has identified a reduction in water availability and river competence during the Iron Age I, and has linked site locations in the part of the Middle Orontes Valley to the availability of water sources (Cremaschi 2007; Cremaschi *et al.* 2008; Cremaschi *et al.* 2002; Cremaschi *et al.* 2003).

These findings obtained from environmental modeling and (geo-)statistical analyses can, at least for the moment, not be related to the results of botanical and faunal remains, which would provide more detailed indicators of technological change and economic adaptation. In the case of Tell Mishrifeh, botanical samples have been published only from Areas G and J (Peña-Chocarro and Rottoli 2007; Riehl 2007), both of which were not occupied during the Iron Age I. In the reports on the faunal remains, on the other hand, which are available for both Tell Mishrifeh (Vila and Gourichon 2007) and Tell Nebi Mend (Grigson 2015; Grigson *et al.* 2015), the samples are not clearly differentiated by period and in both cases the Iron Ages I and II are considered together. Therefore, it is impossible to say whether the increase in water-dependent crops, such as grapes and lentils, which has been identified at Tell Mishrifeh (Peña-Chocarro and Rottoli 2007; Riehl 2007), or a decrease in woodland-dwelling species in the faunal assemblage of Tell Nebi Mend (Grigson *et al.* 2015) applies to both the Iron Ages I and II, or just to the Iron Age II.[97]

6.3.5 Urban Decline Despite Favorable Conditions

The environmental and social developments in the Northern Coast (and in inland West-Central Syria) contrast quite strongly with processes observable in other areas of the coastal plains. Although both the Jableh Plain and the Akkar Plain show a decrease in site numbers (by about 25 % and 12 %, respectively), average site size (about 22 % and 13 %, respectively), and total occupied area (about 61 % and 12 %, respectively), both regions remained more intensely settled than the Northern Coast. In contrast, the Central Coast experienced a slight increase in settlement numbers, but due to a lack of additional data, it is impossible to investigate this process in more detail.

Tell Tweini Field A provides clear evidence for settlement continuity in Phases 6G-H and 6E-F during the early 12th and 11th centuries BCE (Bretschneider *et al.* 2014). In the earlier Phase 6G-H, new occupation levels were superimposed on the destruction debris (Phase 7A) of the Late Bronze Age town. Although no coherent architectural remains have been discovered, it is clear that this occupation phase consisted primarily of squatter occupation within the abandoned Late Bronze Age buildings (Bretschneider *et al.* 2014, 328). In the following Phase 6E-F, the architectural evidence consists of a number of newly erected structures containing an assortment of household items, including grinding implements, storage jars, drinking vessels, and loom weights, suggestive of an economic organization on a domestic level (Bretschneider *et al.* 2014, 329-330). Through a combination of stratigraphic evidence, small finds, and radiocarbon samples, the floruit of this reconstruction phase has been dated to a period between 1150 and 950 BCE (Bretschneider *et al.* 2014, 328-329).

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[97] Nonetheless, differences in the Late Bronze and Iron Age proportions of steppe-dwelling and woodland-dwelling species at Tell Mishrifeh and Tell Nebi Mend might indicate that the southern and central regions of the Middle Orontes Valley were subject to slightly different environmental conditions, as suggested recently by Grigson *et al.* (2015, 182).

More fragmentary Early Iron Age remains have been uncovered at Tell Sukas (Phase H2), which is dated by the excavators roughly between 1170 and 850 BCE (Buhl 1983; Lund 1986; Riis 1970). Continuity with the preceding Late Bronze Age levels of Period J is evinced by the continued use of earlier walls and floors (Lund 1986; Riis 1970), although some evidence for new constructions exits as well (Lund 1986, 24). The evidence from Tell Sukas points to a small-scale domestic occupation, but more detailed evidence of the social or economic structure of the local community is lacking.[98]

The Early Iron Age re-occupation of Tell Kazel in the Akkar Plain is characterized by domestic structures in Area II, which contrast markedly with the large residence or palatial structure that occupied this area during the Late Bronze Age (Badre 2003, 2006; Capet 2003; Capet and Gubel 2000). An initial re-occupation of this area occurred during the 12th century BCE (Level 6 Upper), followed by a series of modest domestic structures of Level 5 (Badre 2003, 2006; Capet and Gubel 2000). A reduction in the size of the settlement is evident in the abandonment of Area IV, where the Late Bronze Age temple (Level 5) was covered by a thick accumulation of debris (Level 4), before being re-occupied at a later point in the Early Iron Age (Badre 2003; Badre and Gubel 1999). In contrast to the prosperous town of the Late Bronze Age, equipped with public structures, the Early Iron Age village at Tell Kazel was much impoverished and much smaller in size. Tell ‘Arqa, further inland, did not suffer the same violent destructions as many of the coastal cities (Thalmann 2010, 100). Despite some scattered evidence for a late-13th and early-12th century BCE occupation at the site, Tell ‘Arqa appears to have been largely abandoned until the 9th or 8th century BCE, following the urban decline already begun in the Late Bronze Age (Charaf 2007-2008; Thalmann 1983, 2010).

The transformation of the socio-economic, and probably also socio-political, structures of these regions is not only evident in developments of the settlement system as a whole, but also in the absence of imported ceramics at these sites, indicating a cessation of outside trading contacts. At least on the Jableh Plain, these developments cannot be simply linked to climatic or environmental factors. Granted, the MCM data shows a significant reduction of precipitation levels in this area between about 1150 and 950 BCE, which is also evident in the palaeoenvironmental evidence from Tell Tweini discussed by Kaniewski and colleagues (Kaniewski *et al.* 2010; Kaniewski *et al.* 2012). However, as suitability analysis suggests, these climatic fluctuations did not adversely affect the agricultural potential of the Jableh Plain. Throughout the Early Iron Age, the immediate vicinities of archaeological sites were dominated by extremely fertile land. During the Iron Age I, the Jableh Plain was subject to a process of progressive aridification, but, at least as far as the results of the modeling procedure are concerned, these climatic changes did not significantly affect the agricultural potential in this part of the study area.

These findings might be supported by other types of evidence. In Field A of Tell Tweini (Vandorpe 1999), wheat remains have been recovered in higher numbers than barley, potentially suggesting that the site’s inhabitants did not feel pressured to rely on more drought-resistant crops. Similarly, cattle remains continue to be prominently represented in the faunal assemblage and overall, no evidence for significant diachronic changes in the proportions of domestic species have been identified at Tell Tweini (Linseele *et al.* 2013, 212). However, given that the reports, again, do not clearly

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[98] In this context, however, it should be noted that the settlement history of the Early Iron Age Jableh Plain is still incompletely understood outside of Tell Tweini, since the stratigraphy of Period H Tell Sukas is badly disturbed and rather unclear (cf., Bretschneider and van Lerberghe 2008c; Buhl 1983). The Iron Age remains at both Arab al-Mulk and Tell Daruk are difficult to interpret, given that little stratigraphic control was exercised. In addition, no significant architectural remains were uncovered and only a representative selection of the ceramic finds from the later phases was analyzed, making it impossible to accurately assign specific layers to particular sub-phases of the Iron Age (see, Oldenburg and Rohweder 1981).

differentiate between Iron Age I and Iron Age II contexts (cf., Linseele 2008, 2010; Linseele *et al.* 2013; Vandorpe 1999), a more detailed analysis of agricultural and pastoral practices in the Early Iron Age Jableh Plain has to wait until further data are available.

Statistical testing of site locations in relation to environmental variables also does not reveal a significant pattern, which would indicate that environmental stresses were responsible for the reconfiguration of the settlement system during the Iron Age I. No statistical significant relationship between site locations and the availability of water resources, including precipitation, groundwater, and surface water, could be established. At the moment, no evidence exists that would link changes in site distributions in the Jableh Plain to the geographical, or chronological, distribution of water resources. In this regard, the changes observed in the Iron Age I Jableh Plain are best interpreted as the result of social and political changes, most importantly the dissolution of the kingdom of Ugarit, rather than caused by environmental deterioration. This is further supported by the evidence for violent destruction and immediate re-occupation at several coastal sites, which indicates that settlement locations continued to be regarded as favorable for occupation (see below, **§6.3.7**).

Similar to the Jableh Plain, the Akkar Plain witnessed a long-term decrease in precipitation volumes during the Early Iron Age, albeit along a different geographical and temporal pattern, with rainfall levels dropping significantly between 1250 and 1150 BCE, before increasing again until about 950 BCE. This development of rainfall patterns is mirrored in the suitability analysis, where a slight reduction in agricultural suitability is evident at the beginning of the Early Iron Age, followed by a gradual process of amelioration, which in turn is followed by a reduction in suitability towards the end of the period, between 950 and 850 BCE. Local communities, however, do not appear to have been significantly affected by these climatic fluctuations. Between 1250 and 1150 BCE, a noticeable increase in overall suitability occurred within catchment territories, and the proportions of highly and somewhat suitable land within these territories remained stable. It might be suggested that this development is indicative of an active adaptation by the local inhabitants to changing environmental conditions and an attempt to concentrate in more favorable locations. Unfortunately, the data does not permit statistical analyses to further substantiate this interpretation.

6.3.6 Historical Sources and the Evidence for Socio-Political and Economic Integration

Against this archaeological and environmental background, it is perhaps not too surprising that the few existing historical sources on the Early Iron Age are largely silent about the social, economic, or political structures of West-Central Syria.

In the late 12th/early 11th centuries BCE, the military expeditions of Tiglath-Pileser I brought the Assyrian king into conflict with various groups and rulers of Northern and West-Central Syria. Apart from some rather general statements about his military accomplishments and the tribute extracted by him from his enemies, his inscriptions do not provide much information about the region in question. With the sole exception of the land Amurru (^{kur}*a-mur-ri*), only rulers and kingdoms outside of the confines of West-Central Syria are explicitly named in the reports, for example Carchemish/Hatti (^{kur}*ḫa-at-te*), Byblos (^{kur}*gu-bal*), Sidon (^{kur}*ṣi-du-ni*), and Arvad (^{kur}*ar-ma-da*) (see, Grayson 1991).

On West-Central Syria itself, the reports are conspicuously silent, especially when considering that Tiglath-Pileser I must have traversed this region before reaching the Mediterranean and the coastal cities. It might therefore be asked whether this apparent lack of economic prosperity and political organization is solely a product of the focus of the annalistic texts or actually a reflection of the socio-economic and socio-political realities of the region during this time. The period of Tiglath-Pileser's forays into West-Central Syria, which is dated in archaeological terms to the Iron Age IA/B, stands at the very beginning of a process of political formation and urbanization, which did not fully take hold until slightly later, during the Iron Age IB/C and the Iron Age II (Mazzoni 1995, 2000a, 2000c; Younger 2007). From these periods, the 11th and 10th centuries BCE in absolute chronological terms, come the first local sources for a political history of West-Central Syria, the inscriptions of king Taitas of Palistin, already discussed previously (**§1.3.2**). Apart from these inscriptions, however, historical and archaeological evidence for the development of centralized political entities within Early Iron Age West-Central Syria is lacking.

Therefore, the available data suggest that during the Early Iron Age, West-Central Syria was characterized by a lack of political integration, as well as a general reduction in urban settlement. However, this cannot necessarily be equated with a general trend towards depopulation and the abandonment of sedentary life in favor of agro-pastoral or pastoral lifestyles. Although the excavation data shows a decline in urban culture and a trend towards smaller, more rural sites, survey data clearly indicates an expansion of settlement activities in several parts of the region, especially in the Northern Plateau and the Lower Orontes Valley. That this process was in no way uniform, however, is suggested by the evidence from the coastal areas, where a complex pattern of depopulation (Northern Coast), Early Iron Age restructuring (Jableh Plain), and continued urban decline (Akkar Plain) existed.

As heterogeneous as these social transformations were, so were their relationships with environmental processes. In the coastal areas, which provides evidence for population decline at various scales and according to different patterns, no evidence for significant environmental changes exists. Despite climatic fluctuations, and a general trend towards aridification, the region apparently remained highly suitable for agricultural production, which is not only indicated by modeling results, but also by what little faunal and botanical evidence is available. Conversely, the inland areas of West-Central Syria evince a much stronger relationship between environmental variables and changes in the settlement system, which occurred according to geographically (subregionally) specific contexts. On the Northern Plateau, a proliferation of small- and medium-sized settlements occurred with an expansion of settlement activity into topographically more difficult terrain, potentially indicating shifts within agricultural practices, or rather the development of a new, horticulture- and livestock-centered economic system. Conversely, the Middle Orontes Valley experienced a decrease in settlement activity, which might have happened in response to a decreased availability of sufficient water resources, forcing inhabitants to shift the settlement focus towards areas where water was more readily available. Although the architectural remains alone do not necessarily suggest that Hama developed into an important political center during this period, the evidence of the lion sculptures from the later (Phase E) Building I might indicate such a development (see, Mazzoni 2009; also see below, fn. 8).

6.3.7 Climate Change, Conflict, and Socio-Political Transformation in the Early Iron Age

As argued by Mazzoni (2000c, 31), one of the processes characteristic of the transition from the Late Bronze to the Iron Age is a profound transformation of the political landscape of West-Central Syria and the Levant in general. Indicative of this process are the destruction layers that have been encountered at many sites within the region, especially in the coastal areas.

The violent character of these destructions has been especially emphasized for coastal sites. At Ugarit, the presence of arrow-heads and other weapons within the destruction layers of the early

12th century BCE have been interpreted as evidence for military conflict (e.g., Bell 2005; Caubet 1992; Yon 1992, 2006), although it remains questionable whether these destructions were the result of a single event or occurred in successive stages (Callot 2008, 119).[99] At Ras ibn Hani, both the Southern and the Northern Palace suffered at least a partial violent destruction at the beginning of the 12th century BCE, suggested, for example, by thick destruction layers in the courtyard of the Southern Palace. Yet, both buildings were abandoned in a more-or-less orderly fashion before their final destruction (Badre 1983; Bounni *et al.* 1976, 1978; Bounni *et al.* 1979; Lagarce and Lagarce 1988), implying that the inhabitants had time to prepare their departure. A similar situation has been encountered at Ras al-Bassit (Courbin 1990; Darcque 2004). Evidence for violent destructions was also encountered further down the coast, at Tell Tweini, where the destruction has been dated to the very late 13th century BCE (Bretschneider *et al.* 2014; Bretschneider and van Lerberghe 2008c), at Tell Sukas (Riis 1970), and Tell Iris (al-Maqdissi and Souleiman 2004) in the Jableh Plain, as well as Tell Kazel in the Akkar Plain (Badre 2003; Badre and Gubel 1999; Capet and Gubel 2000; Jung 2007).

At inland sites, the evidence is less clear-cut. The large Residence F at Tell Afis was already abandoned during the mid-13th century BCE (Archi and Venturi 2012, 2013; Baffi and Peyronel 2014; Venturi 2013, 2014, 2015), whereas the smaller residences of Phase Vb ended in a violent destruction sometime in the early 12th century BCE (Venturi 2013, 2014). The Late Bronze Age building at Tell ʻAcharneh was destroyed by fire, clearly attested to by the bright red color of the mudbrick walls and the wall collapse (Fortin and Cooper 2013, 157). At Hama, where the excavators raised the possibility of an early-14th century BCE destruction of an earlier phase of Period G (Fugmann 1958, 133), and at Tell Nebi Mend (Bourke 2012), no evidence for a violent destruction of the Late Bronze Age levels has been encountered. As already discussed above, the palaces of Tell Mishrifeh were already destroyed and abandoned during the mid-14th century BCE, that is, quite some time before the end of the Late Bronze Age.

Given the general environmental favorability of the coastal areas during both the Late Bronze and Early Iron Ages, it is difficult to relate the above-mentioned processes of political, social, and economic transformation during this period to climatic or environmental variables. Judging from the available archaeological and environmental data, interpretations focused on social and political variables appear more appropriate to explain social transformations on the coastal plains during the Early Iron Age. The prominence of Aegean cultural traits that has been noted at many sites during this period is certainly significant in this regard (see, for example, Janeway 2006), but the discussion does not necessarily have to be couched in ethnic terms, as cautioned by Rahmstorf (2005).

In this regard, Bell (2005, 2009) has argued for a correlation between destruction horizons and the intensity of Late Bronze Age trading contacts with Cyprus and the Aegean at these sites, proposing that differential trading contacts with the Aegean might explain the diverging trajectories of destruction and resettlement observable along the Eastern Mediterranean littoral. But while such a hypothesis might explain why certain sites were destroyed while others were not, and why some of these sites experienced a more rapid process of urbanization and re-urbanization, it does not necessarily explain why entire regions, such as the Northern Coast, were apparently not re-occupied at all.

In inland West-Central Syria the situation is more complex. Both the destructions of the palaces at Tell Mishrifeh and Residence F at Tell Afis have been attributed to a general context of

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[99] Note, however that Sommer (2016, 123-124) has recently argued against the destruction of Late Bronze Ugarit through a violent conflagration.

political instability and military conflict during the 14th and 13th centuries BCE (Klengel 1992; Venturi 2011). Conversely, the 12th and 11th centuries BCE appear as a relatively stable period, at least on the Northern Plateau, where Tell Afis illustrates a gradual development, whereas no major disruptions appear to have taken place in the Middle Orontes Valley. It has been noted that the occurrence of Aegean elements in the material culture of Early Iron Age inland West-Central Syria might be related to the expansion of the kingdom of Palistin during this period, although it remains questionable whether this process entailed the influx of foreign people into the area (cf., Fortin and Cooper 2013; Venturi 2011).[100] However, the evidence for environmental change in the Middle Orontes Valley and the Northern Plateau during the Late Bronze and Early Iron Ages might also have contributed to the gradual transformation of the political and economic structure of the region, leading to a complex interplay of social and environmental factors in the transformation of inland West-Central Syria, also entailing a rise in political and military conflict (see, for example, Kirleis and Herles 2007).

6.4 The Iron Age II: Continued Trends and Socio-Political Integration

6.4.1 Renewed Urbanization and Political Integration

During the later Iron Age, the previous trend towards settlement contraction in the Middle Orontes Valley was reversed, with site numbers and total occupied area increasing again (by about 30 % and 15 %, respectively), concomitant with a decrease in average site size (of about 13 %). This establishment of more numerous, yet smaller, settlement in this sub-region went hand in hand with a process of spatial clustering of sites, indicating a process of political or economic integration.

This process occurred within the context of continuously decreasing rainfall levels which, however, did not significantly alter the proportions of agriculturally suitable (or unsuitable) land within the Orontes Valley at large, or within the vicinity of Middle Orontes sites. Both increases of lowly suitable land and decreases of favorable land during this period are minute and presumably did not have a significant effect on agricultural production. This might be attributed to the spatial patterning of the settlement system, which is significantly related to the availability of water and might therefore be the result of a deliberate process of establishing new agricultural sites within sufficiently watered areas (cf., Cremaschi *et al.* 2008; Cremaschi *et al.* 2002; Cremaschi *et al.* 2003).

This process of aggregation and centralization is especially well attested in Period E at Hama, which developed into a densely settled and fortified, and archaeologically well-attested, royal citadel. A suite of monumental buildings, Buildings I-V, attests to this process, consisting of a two-piered gateway (Building I), a royal palace with storage functions (Building II), a secondary palace or potential temple (Building III), and potentially two additional storage facilities (Buildings IV and V) (Dornemann 1997; Fortin 2001b; Fugmann 1958; Matthiae 2008).[101] The architectural

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[100] As noted by Whincop (2009, 56), the excavators of Hama hypothesized that the city was conquered and settled by invading Sea Peoples around 1200 BCE, citing iron tools, metal fibulae, painted Aegean-style ceramics, and cremation burials as evidence for the identity of these invaders (cf., Fugmann 1958, 275). Yet, as Whincop has pointed out, this argument is based on a questionable interpretation of these archeological features as original to the Earl Iron Age levels at Hama (Period F), casting serious doubt on the idea of a Sea Peoples' invasion in the Middle Orontes Valley.

[101] In several instances, interpretations of the functions of these buildings diverge quite substantially. Whereas the gateway function of Building I and the palatial character of Building II are generally not challenged (Fortin 2001b; Fugmann 1958), the interpretation of Building III is much less clear. This has been attributed to its heterogeneous assemblage of small finds, but also its quite fragmentary ground plan, with interpretations ranging from a temple or religious structure (Fugmann 1958; Riis

relief sculpture in the form of carved portal lions encountered in association with Buildings I, II, and III (Fugmann 1958; Orthmann 1971) clearly attests to the important official function of these buildings.[102]

For present purposes, the most important building on the Hama citadel is Building II (**Fig. 6.2**). The preserved lower story of this monumental structure consisted of a large number of small rooms, arranged in two suites in the west and southeast of the building, which were used as storage rooms and magazines. An unusually high number of large storage jars, potentially more than 500 of which many were found *in situ*, attests to the massive capacity for the storage of agricultural products such as grain, wine, and oil (Dornemann 1997, 467; Fortin 2001b, 100). As these jars were in most cases associated with large numbers of shallow bowls, it has been suggested by Venturi (2015, 86) that one of the main functions of Building II was the centralized distribution of provisions within a palace-centered economy, in addition to functioning as a royal armory, as

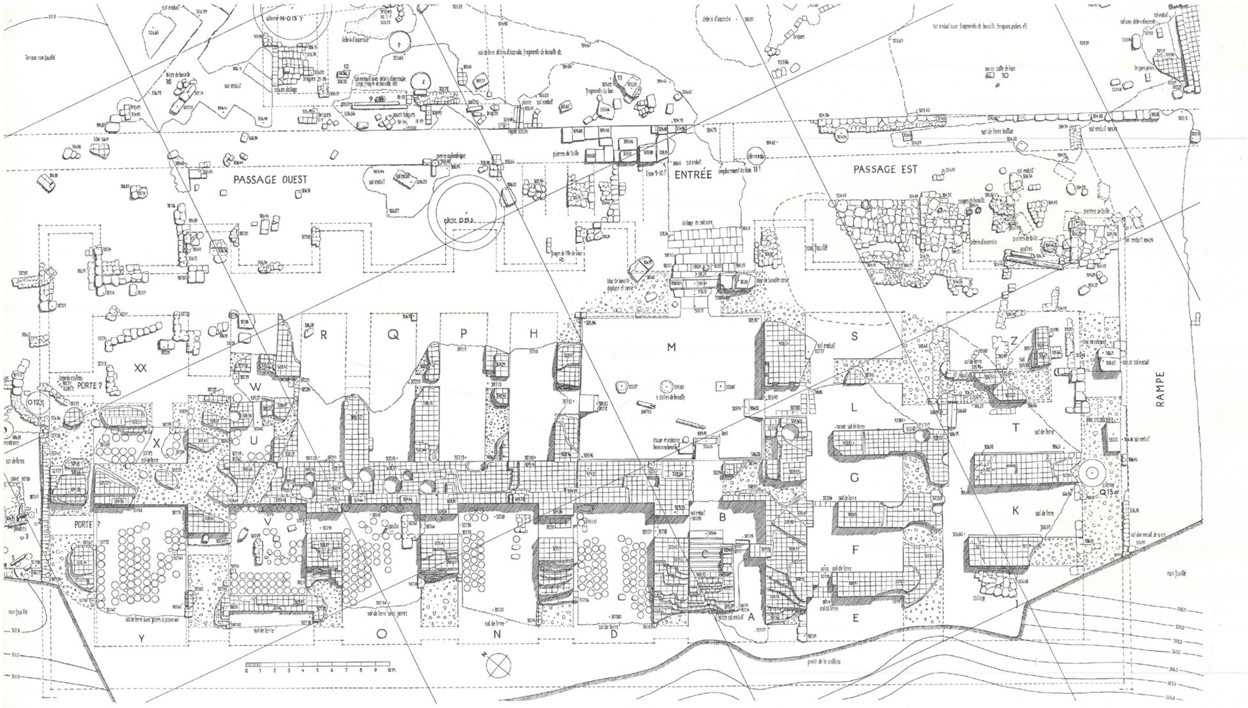

Fig. 6.2: Building II, Hama Period E (Fugmann 1958, fig. 265).

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and Buhl 1990) to a palace (Matthiae 2008). Similarly, Building IV is usually considered a small palatial structure or storage facility, although the excavator's proposed reconstruction is highly questionable (Matthiae 2008, 209). Finally, the function of Building V appears the most enigmatic, and interpretations as a royal harem (Ingholt 1940), an official's residence (Ingholt 1942), a small palace or gatehouse (Fugmann 1958; Mazzoni 2009; Riis and Buhl 1990), or a temple (Ussishkin 1966a) have been offered (cf., Whincop 2009). Considering that an assemblage of more than 550 arrow-heads has been found in Building V, along with numerous fragments of storage ceramics, weaving equipment, and a variety of small craft items (cf., Fortin 2001b; Fugmann 1958), Building V might have served some kind of storage function.

[102] Orthmann (1971) has dated most of the lions and lion fragments found at Hama to his intermediate artistic period (*Späthethitisch I*). However, the portal lions from the Building I gateway belong to two different stylistic groups, with the lions from the outer porch (Hama A/1 and Hama A/2) slightly predating the ones from the inner passage (Hama A/3 and Hama A/4). Conversely, Riis and Buhl (1990, 35) have proposed to arrange the Hama lions into three categories (A-C), of which the first entails the portal lions from the citadel gate. They have proposed to date these lions to the Early Iron Age, Period F1, around 1050-900 BCE, an interpretation which has generally been supported by Mazzoni (2009, 117-118), who has in fact proposed to date these Group A lions to the 12th or 11th centuries BCE. In any case, the sculptural evidence from Hama attests to the existence of an elite center at Hama already before the massive re-building activities of Phase E, although the precise dating of this phase in the early-mid or mid-late Iron Age I is not entirely clear.

evinced by numerous arrow-heads and pieces of scale armor (Fortin 2001b; Fugmann 1958). At the same time, small luxury items and several pieces of painted wall plaster, probably originating from an upper story, indicate that Building II also served as the official royal residence of the kings of Hama (Fugmann 1958; Matthiae 2008).

Much like Hama, several important sites in the Middle Orontes Valley provide evidence for an increased degree of urbanization during the Iron Age II. During the 9th and 8th centuries BCE, Tell Mishrifeh developed into a large settlement, characterized by several craft workshops, centered around textile weaving, in the area of the former Bronze Age royal palace, Areas G, H, and T (Morandi Bonacossi 2006, 2009). A large, representative building in the center of the mound (the 'Aramaean Palace') provides evidence for a public structure engaged in storage activities (al-Maqdissi 2002, 2003a, 2003b; al-Maqdissi and Badawi 2002; al-Maqdissi and Morandi Bonacossi 2005). The building has been compared to Building II at Hama and dated to the 9th and 8th centuries BCE, although its function is not entirely clear (al-Maqdissi 2003a, 2003b; Morandi Bonacossi 2006).[103] During the same period in the 9th and 8th centuries BCE, a large, central storage facility (**Fig. 6.3**) was erected and intensively used for the stockpiling and warehousing of large quantities of agricultural produce and other products, easily observable in the more than 115 storage pits, as well as the remains of a large warehouse and a smaller storage building in Area J (al-Maqdissi and Morandi Bonacossi 2005; Maritan *et al.* 2005; Morandi Bonacossi 2002, 2003, 2006, 2008a, 2008b). The fills of the pits included remains of cereals, grapes, olives, figs, and pulses, whereas larger silos were exclusively reserved for storing olives (Morandi Bonacossi 2008b, 115).

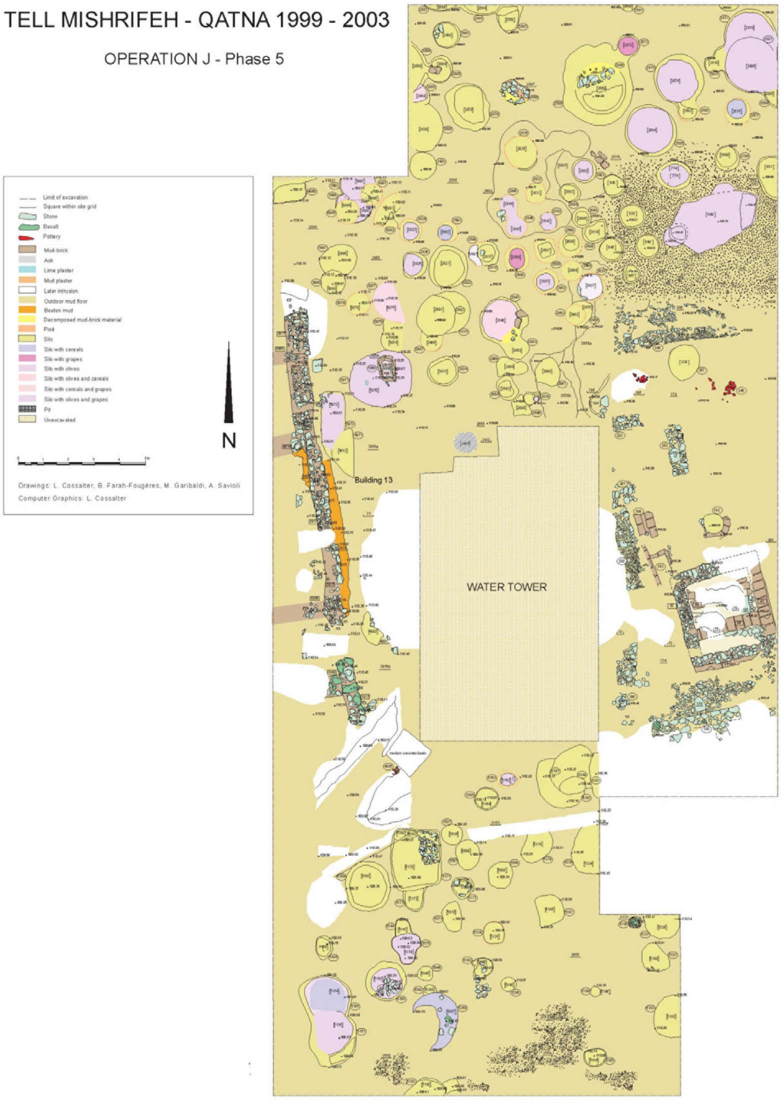

Fig. 6.3: Plan of storage facilities in Area J at Tell Mishrifeh (Morandi Bonacossi 2006, fig. 13).

Similar evidence for storage activities in a public context have been uncovered at Tell Nebi Mend in Trench III, where parts of a large structure (Building B) with a courtyard, sunken pithos jars, and

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[103] In particular, a row of magazine rooms in the south of the building is reminiscent of the storage rooms of Hama Building III and provides evidence for institutional storage activities within a public context. However, an interpretation of this building as a palace, let alone an 'Aramaean' palace (al-Maqdissi 2003b, 8) appears rather conjectural.

kitchen areas indicate the combination of domestic functions and storage activities (Bourke 2012; Parr 1983, 1991; Whincop 2007). At Tell al-Nasriyah, a mere 15 km northwest of Hama, recent excavations have uncovered evidence for several monumental structures (al-Maqdissi *et al.* 2010a, 2011; Parayre 2010), of which at least the one in the Lower City was used for the storage and distribution of agricultural products (al-Maqdissi *et al.* 2011; Parayre 2010).

6.4.2 At the Fringes of State Formation

In the Lower Orontes Valley and on the Northern Plateau, the previous trend towards the establishment of new settlements continued, albeit at a slower pace, and with slightly diverging sub-regional trajectories.

On the Northern Plateau, site numbers increased by only about 7 % and total occupied area increased by around 6 %, whereas average site size remained unchanged, suggesting that most of the newly established settlements of the Iron Age II were rather small in size. As in the preceding Early Iron Age, settlements on the Northern Plateau appear to have been lacking in socio-political or socio-economic integration, which is suggested by the still limited evidence for spatial clustering. This development took place within the context of reduced precipitation levels, which first affected the entire plateau region, before concentrating in its northwestern sector. Yet, these reduced levels of rainfall do not appear to have had a detrimental effect on agricultural suitability of this part of West-Central Syria, as the proportions of suitability values on both a sub-regional and site-dependent scale remain virtually unchanged. The presence of wheat and barley at Tell Afis (Wachter-Sarkady 1998), as well as the occurrence of sheep, goat, cattle, and pig remains at Tell Afis and Tell Tuqan (Minniti 2014) provides evidence for a diversified economy, although the preliminary publication status makes it difficult to adequately evaluate the character of the agro-pastoral system, or its diachronic change.

Yet, although the spatial organization of the settlement system of the Northern Plateau did not change considerably during the Iron Age, archaeological data provide unequivocal evidence for the socio-economic and socio-political transformation of this area. Whereas the occupation of Tell Tuqan and Tell Mardikh remained primarily domestic in character (Baffi 2008, 2011a, 2011b; Baffi and Peyronel 2014; Fiorentino 2014; Matthiae 2006; Mazzoni 1992), and a new agricultural community was established at Tell Mastuma (Iwasaki *et al.* 2009; Wakita *et al.* 2000),[104] Tell Afis eventually developed into a large urban center. In a first construction phase, Temple AII, Courtyard G, and Terrace J were erected on the acropolis, along with a number of buildings in the Lower City. In a second phase, the temple was rebuilt (Temple AI),[105] Annex H was added, and Courtyard

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[104] Several scholars, including Abu Taleb (1973), Astour (1963), Dussaud (1927), Ellinger (1947), Ikeda (1977, 1979), Sader (1987), and Yamada (2000), have proposed an identification of Tell Mastuma with the city of Ashtamaku, which is referred to as a royal city (*āl šarrūti*) in the campaign reports of Shalmaneser III, mainly due to geographical considerations. The excavators of Tell Mastuma, however, have argued against this identification, noting that the archaeological record of this small, agricultural, and unfortified village does not correspond to the description of the city given in the texts and have argued that the location of ancient Ashtamaku should be sought elsewhere (Wakita 2009, 508). Na'aman (2002, 291-292) has also raised concerns with the identification of Tell Mastuma with Ashtamaku on geographical grounds and has instead proposed to locate the city in the Lower Orontes Valley, in the territory of Hamath.

[105] In some earlier publications (e.g., Matthiae 1979a; Mazzoni 1998), Temple AI is referred to as a *Hilani*. The *Hilani*, or *Bīt Ḫilani*, is in itself a complicated and contentious issue and cannot be discussed at length here and the reader is directed to the works of Novák (2004) and Osborne (2011) for detailed, recent discussions on this subject. Generally speaking, modern discourse tends to differentiate between three different concepts: The first refers to a building mentioned in Neo-Assyrian texts, primarily those of Tiglath-Pileser III, Sargon II, Sennacherib, and Ashurbanipal; the second is used to designate an architectural component of Assyrian palaces, also mentioned within Assyrian royal inscriptions; and the third refers to an archaeologically attested type of palatial structure from Northern Syria (Novák 2004; Osborne 2011). Interpretations of the *Hilani*, and its typological, functional, or socio-cultural characteristics have varied considerably over time (e.g., Börker-Klähn 1980; Bossert 1933,

G was transformed into a large refuse pit, concomitant with a gradual development of a dense urban occupation quarter in Area E (Amadasi Guzzo 2014; Cecchini 1998; Mazzoni 2010a, 2010b, 2012b, 2014a, 2014b; Soldi 2009; Venturi 2015). This second construction phase dates rather late in the Iron Age II period, sometime between the late 9th and early 8th centuries BCE, as suggested by a few scattered examples of relief sculpture and inscribed stelae, as well as the finds of the enigmatic Courtyard G (Amadasi Guzzo 2009, 2014; Cecchini 1998, 2014; Mazzoni 2012b, 2014a; Soldi 2009).[106]

Similarly, the Lower Orontes Valley, which experienced declining precipitation levels especially in its south, but also later in the north, does not appear to have witnessed a decline in agricultural potential during this period. Although small areas of marginal land developed in the wake of these climatic changes, the proportion of highly suitable land expanded at the same time, indicative more of a process of geographically heterogeneous environmental changes, rather than large-scale transformation. An indication of the generally not unfavorable conditions is given by the faunal data from Tell Qarqur, which is dominated by sheep and goat, followed by cattle and pig. Other notable taxa include equids, birds, and fish, but also some small quantities of turtle and crab, potentially indicating the exploitation of the seasonal Ghab marshlands by the inhabitants (Arter 2003). Based on the spatial distribution of these faunal remains, Arter (2003, 131) has suggested that a standardized distribution of meat for consumption was practiced at Tell Qarqur during the Iron Age II.

During this period, the trend towards higher settlement numbers, already begun in the Iron Age I, continued in the Lower Orontes Valley without interruption, although on a smaller scale. Site numbers increase by only 20 % and total occupied area by a mere 6 %, whereas average site size drops by around 3 %. Similar to the Early Iron Age, these small, presumably rural settlements formed tight clusters, attesting to a considerable degree of economic or political integration. Evidence for this process is also provided by the archaeological data. Tell Qarqur (Stratum 8) extended beyond the immediate confines of the main tell (Dornemann 2003a), developing into one of the most important settlements of West-Central Syria. The remains of a two-piered gateway on the southern slope of the high mound (Dornemann 1998a, 1998b, 2003a, 2008a; Lundquist 1983) links Tell Qarqur to the general Iron Age socio-political environment centered on the projection of royal authority and the performance of public rituals (e.g., Gilibert 2011; Harmanşah 2005).[107] At the same time, monumental stone foundations on the high tell (Dornemann 1998b, 2003a, 2008a, 2008b, 2008e), domestic structures in various parts of the site (Dornemann *et al.* 2008; Lundquist 1983), and the results of geophysical prospection (Casana *et al.* 2008) indicate that Tell Qarqur was a densely settled, highly urbanized center during this period.

At Tell ‘Acharneh, the remains of a large courtyard structure on the main mound (Cooper 2006; Fortin 2006d; Fortin and Cooper 2013) and both domestic and public structures in the Lower Town

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1961; Frankfort 1952; Fritz 1983; Margueron 1979; Ussishkin 1966b; Wachtsmuth 1958; Weidhaas 1939), but this particular type of building has only recently been explicitly linked to Aramaean cultural influences (Sader 2010, 293-294), although this interpretation is highly problematic and tentative at best. At Tell Afis, the initial identification of a *Hilani* has been subsequently revised in accordance with more recent excavation results. To date, no palatial structure, or administrative building for that matter, has been uncovered at Iron Age Tell Afis.

[106] A small, broken fragment of an Aramaic inscription was found during the excavation of the Area A temple. Based on the identification of the name of Haza’el of Damascus, already known from the Zakkur Inscription, and paleographic similarities with the Tel Dan Stele (KAI 310), the Haza’el ivory plaque (KAI 232) and horse blinkers (KAI 311), and the Melqart Stele (KAI 201), Amadasi Guzzo (2009, 2014) has suggested a date in the late 9th or early 8th centuries BCE.

[107] Three building phases of the Area A gateway were identified during excavation. These have been dated by the excavators to the 10th to 8th centuries BCE, which, technically, would place the earliest construction phase of the gate already in the final Early Iron Age (Dornemann 1998b, 2003a, 2008b). However, only the latest phases of the building are sufficiently understood to warrant a detailed analysis.

(Cooper 2006; Cooper and Fortin 2004; Fortin 2006d; Fortin and Cooper 2013) attest to the development of an urban settlement at the site during the Iron Age. In the area between the two mounds (Area PN), evidence for a multi-layered defensive glacis, possibly blocking a hypothesized city gate in anticipation of an impending attack (Cooper 2006; Fortin 2006d; Fortin and Cooper 2013), might provide evidence for military conflict during this period. Not much historical documentation exists on Tell ‘Acharneh during this period. Local sources, particularly the QAL’AT AL-MUDIQ stele (Hawkins 2000) to the north of the site, illustrate that this part of the Orontes Valley belonged to the kingdom of Hamath during the mid-9th century BCE. Neo-Assyrian campaign reports only refer to this area in passing and apart from these sources, no records on the social or political history exist (Dion 2006). Some scholars have tentatively identified Tell ‘Acharneh as one of the cities represented on the Balawat Gates, but this identification is highly contentious (cf., Fortin 2006b; Fortin and Cooper 2013). [108]

Despite some obvious differences between the two sub-regions, the Lower Orontes Valley and the Northern Plateau exhibit a number of similarities. Most prominent of these is the continuous expansion of settlement in these regions, which is especially marked in the Early Iron Age, whereas the Iron Age II only witnesses the articulation and solidification of previously established patterns and processes. Another similarity is the development of highly urbanized political and economic centers, such as Tell Afis on the Northern Plateau and Tell Qarqur and Tell ‘Acharneh in the Lower Orontes Valley. Unlike the Middle Orontes Valley, where tentative evidence exists at Hama for the establishment of an urban center during the preceding Early Iron Age, the highly urbanized settlement at Tell Afis appears to have developed gradually from more modest, domestic contexts.

6.4.3 Stagnation of Settlement?

The general drying trend throughout the later Iron Age is also perceptible on the Northern and Central Coasts of West-Central Syria. This is especially true for the Northern Coast, where between 950 and 750 BCE precipitation levels dropped for two consecutive centuries. On the Central Coast, on the other hand, small fluctuations are indicated by the modeling data, with a significant drop in precipitation volumes at the beginning of the period, followed by a slight amelioration towards the end of the Iron Age II. On the Northern Coast, this resulted in a small reduction in the overall agricultural suitability in this area which, however, does not appear to have affected the existing settlements. On the Central Coast, a slight reduction in agricultural suitability is apparent both on a sub-regional and a local scale, although reductions in highly suitable land and increases in moderately suitable areas are minor in scale.

As far as the available archaeological data is concerned, no changes appear to have occurred to the settlement systems of these two coastal areas during the Iron Age II. At Ras al-Bassit, two

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[108] Additional, yet highly insecure, data on the urbanization of the Lower Orontes Valley during the Iron Age II might be identified at Rasm et-Tanjara. After the accidental discovery of a large hoard of luxury items (presumably in 1960), several steatite vessels found their way into the antiquities market (Athanassiou 1977; Mazzoni 2001a, 2005a; Stucky 1971; Wicke 2008). Shortly thereafter, brief salvage excavations were carried out in 1961, reportedly uncovering the remains of a heavily burned ‘Aramaean’ stratum overlaying a Late Bronze and Early Iron Age cemetery (Athanassiou 1977, 27). Although the provenience of the objects commonly associated with Rasm et-Tanjara cannot be confirmed with certainty (Mazzoni 2001a, 2005a; Wicke 2008), the later discovery of a pyxis at this site (Shaath 1986), as well as at Tell Afis and Tell Deinit (Mazzoni 2001a, 2005a; Shaath 1986), indicates that such luxury items, dated primarily to the 10th and 9th centuries BCE, were in use at Rasm et-Tanjara during this period. A potentially important Iron Age occupation of the site is further corroborated by several fragments of Syrian-style ivory carving (Athanassiou 1977, 27-28), which might indicate a 9th century BCE occupation (cf., Mazzoni 2009). In addition to these items, Athanassiou (1977, 17) also alludes to an unconfirmed report of a lion orthostat found at Rasm et-Tanjara, although no further information is provided. Although the evidence is very fragmentary and insecure, the discovery of luxury items at Rasm et-Tanjara might hint at the elevated position of this site within the regional settlement system.

successive building phases attest to the development of the settlement from limited architectural remains and storage silos to more substantial buildings, concomitant with a gradual expansion of the settlement beyond the immediate confines of the tell proper (Courbin 1990). Scattered imported Greek ceramics indicate a continuous occupation of Ras al-Bassit between the Iron Age I and II (Courbin 1982; Darcque 2004), but the fragmentary state of the publication does not allow to reconstruct the character of the settlement in more detail. The Iron Age II levels at Ras ibn Hani are even more fragmentarily preserved, but both local and imported ceramics attest to an occupation phase sometime in the 9th and 8th centuries BCE (Bounni *et al.* 1976).

6.4.4 Urban Regeneration

Whereas settlement activity on the Northern and Central Coast appears to have stagnated during the Iron Age II, the Jableh Plain witnessed a renewed increase in settlement density during the same period. Overall site numbers rebounded to their late 2nd millennium BCE levels, with average site sizes increasing even beyond those of the Late Bronze Age. Total occupied area, however, did not reach its former expanse. Although site numbers are insufficient to properly conduct geostatistical analyses of the spatial patterning of archaeological sites in the Jableh Plain, the increase in agricultural site-catchment territories beyond their Late Bronze Age levels might be taken as an indication that sites were placed at larger intervals during the Iron Age II, resulting in less overlap between site territories. The settlement data from the Jableh Plain, thus, points to a development of larger, more dispersed settlements during this period.

During the Iron Age II, Tell Tweini (Phase 6A-D) developed a dense urban agglomeration covering the entire tell. Excavation and geophysical survey have established the existence of domestic buildings, streets, town squares, monumental buildings, and workshop areas during this phase (Bretschneider and Hameeuw 2008; Bretschneider and van Lerberghe 2008c). At Tell Sukas, the continued use of Early Iron Age structures and the erection of new ones suggests a resurgence in settlement activity, without fundamentally altering the domestic character of the settlement (Buhl 1983; Lund 1986), and the occupation at Tell Siano developed from a domestic context in the 9th century BCE to a potentially defensive function in the 8th century BCE (Bounni and al-Maqdissi 1992, 1993, 1998).

These processes took place within a highly favorable environment. Despite the general region-wide aridification trend, the Jableh Plain experienced slightly moister conditions around the Iron Age I-II transition, as well as later during the Iron Age, which is indicated by both palaeoclimatic proxy data and environmental modeling results. Consequently, agricultural suitability within the Jableh Plain as a whole did not change between the Early Iron Age and the Iron Age, both on a sub-regional and a site-dependent scale. As before, settlements in the Jableh Plain had ample access to favorable agricultural land.

While dramatic climatic and environmental changes, thus, appear as an unlikely cause for the social transformations observable during the Iron Age in the Jableh Plain, it might be asked whether the generally favorable agricultural and environmental conditions played a role in the regeneration of urban life in this area. The botanical remains indicate a predominance of wheat over barley, as well as the widespread cultivation of olives (Vandorpe 1999), whereas faunal evidence provides little evidence for diachronic changes between the Late Bronze and the Iron Age in general (Linseele *et al.* 2013), as already mentioned before.[109]

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[109] In both instances, it is again important to keep in mind that a lack of differentiation between sub-phases within the Iron Age

6.4.5 Climate Change and Continuous Ruralization

The Akkar Plain, however, appears to have been much more affected by climatic changes during this period. Especially around the transition from the Iron Age I to the Iron Age II, but also to a lesser degree during the Iron Age II proper, the Akkar Plain experienced two centuries of more-or-less pronounced drops in rainfall levels. These changes resulted in a decreasing agricultural suitability, observable in higher proportions of moderately suitable land, both within the sub-region in general as well as within the immediate surroundings of settlements.

Given the continued prominence of good arable land within site-catchment territories, it remains questionable whether these climatic changes actually had a significant effect on the agricultural economy of the Akkar Plain. Yet, as the distribution of suitability scores within these agricultural territories also suggests, areas less suitable for wheat crop husbandry were more prominent within these territories than in the preceding Early Iron Age. This can be mainly attributed to the establishment of new settlements in the eastern Homs Gap, which are situated on the fringes of the coastal mountain range. Thus, although the data might at first sight indicate a reduction in the agricultural favorability of this area, it might also be possible that these newly established settlements were more heavily reliant on livestock herding or horticulture, rather than cereal cultivation.

The transformation of the socio-economic structure of the Akkar Plain is evident in the archaeological data. The site of the former temple at Tell Kazel (Area IV) was abandoned (Badre and Gubel 1999), whereas the available evidence from other parts of the site indicates the development of a small, rural village of much reduced size when compared to the Late Bronze and Early Iron Ages (Capet and Gubel 2000, 437). During the same period, a settlement was initially re-established at Tell ʻArqa (Level 10), which successively decreased in size and was finally abandoned and used as a cemetery (Thalmann 1978a, 1983).

6.4.6 Socio-Political Integration and the Formation of the Kingdom of Hamath

Trends and development in the settlement system of West-Central Syria, especially those pointing towards an increasing degree of integration and aggregation in the inland regions of West-Central Syria, can be linked to developments in the socio-economic and socio-political organization of the region. It might be suggested that changes and transformations observed in West-Central Syria between the Iron Age I and the Iron Age II provide a glimpse of the processes that led to the establishment of the kingdom of Hamath (and Lu'ash) during this time.

Between the 12th and 10th centuries BCE, both the Lower Orontes Valley and the Northern Plateau experienced a marked expansion of settlement activity relative to the Late Bronze Age. In both areas, this process was accompanied by a reduction in the average size of settlements. On the Northern Plateau, this led to the spread of small, rural settlements across the landscapes, potentially as the result of a process of economic reconfiguration and adaptation, as well as the apparent dissolution of political or economic integration. In the Lower Orontes Valley, settlements were apparently more urban in character, given that site sizes remained comparatively high and considering the potential (yet tentative) evidence for urban occupation at Tell Qarqur and Tell ʻAcharneh during this period. The differences between the two regions might be attributed to the integration of the Lower Orontes Valley into the fledgling kingdom of Palistin (Fortin and Cooper 2013; Hawkins 2011), but might also be attributed to environmental factors, the Northern Plateau being subject to climatic and environmental changes.

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samples makes it difficult to properly assess diachronic change in the proportions of different taxa.

That this situation had not markedly changed in the early 9th century BCE can be gleaned from the inscriptions of Ashurnasirpal II, who reports extracting only straw and barley from the region of Lu’ash, or Luhutu (^{kur}*lu-ḫu-ti*), which is located in the Northern Plateau (Dion 2006; Grayson 1991). At the same time, Ashurnasirpal’s annexation of the city of Aribua (^{uru}*ua-ri-bu-a*), which then belonged to the kingdom of Pattina in the ‘Amuq Valley (Dion 2006; Liverani 1992), might indicate that during that time a strong, independent kingdom had not yet developed in inland West-Central Syria.

Shortly thereafter, by the time of the reign of Ashurnasirpal’s immediate successor, Shalmaneser III, the political situation had changed considerably. The establishment of the kingdom of Hamath in the Orontes Valley and the Northern Plateau is not only attested by the local inscriptions of king Urhilina (Rastan, Qal’at al-Mudiq, Hines, Hama 4-5, and Hama 8-9) and king Uratamis (Hama 1-3 and Hama 6-7), but also by the campaign reports of Shalmaneser III, especially the account of his sixth year campaign inscribed on the Kurkh Monolith (Grayson 1996; Yamada 2000). In this inscription, he recounts the capture and destruction of several cities belonging to the kingdom of Hamath, probably located on the Northern Plateau or in the Lower Orontes Valley, including ‘his royal city’ (*āl šarrūtīšu*) Qarqar, modern Tell Qarqur (Grayson 1996, 23; cf., Ikeda 1979; Yamada 2000). The booty list obtained from these encounters consists of captives, military equipment, and palace property, but does not include the large amounts of people, animals, and goods extracted from other polities, such as Pattina/Unqi (Yamada 2000).[110]

During this period, by the mid-9th century BCE, the coastal areas of West-Central Syria appear to have been political independent. This is implied by the account of the battle of Qarqar (A.0.102.2), which lists the kingdoms of Ushnatu (^{kur}*ú-sa-na-ta-a-a*) and Sianu (^{kur}*ši-a-na-a-a*) among the coalition opposing the Assyrian expansion (Grayson 1996, 23), but can also be gathered from one of Shalmaneser III’s later annals (A.0.102.6), where “twelve kings on the shore of the sea” (Grayson 1996, 36) are listed alongside the kings of Damascus and Hamath in his campaign reports. In the mid-late 8th century BCE, on the other hand, these regions appear to have belonged to the kingdom of Hamath, as part of the “nineteen districts of the city Hamath” (Tadmor and Yamada 2011, 43) annexed by Tiglath-Pileser III in 738 BCE (Bounni and al-Maqdissi 1992; Dion 2006).

Although the exact processes through which the kingdom of Hamath was established and expanded over the course of the Iron Age are still not entirely known, it might be suggested that both environmental and social processes played a role. In inland Syria, both the Middle Orontes Valley and the Northern Plateau were effected by climatic and environmental changes. But whereas settlement on the plateau developed a strongly rural character without apparent social, political, or economic integration, the settlement system of the Middle Orontes Valley retained its aggregated character with an apparent trend towards larger settlements. It might thus not be surprising that the earliest sculptural evidence from Hama dates roughly to this period (see, Mazzoni 2009). While the coastal areas experienced a more-or-less pronounced decline in settlement intensity and population levels, and the Lower Orontes Valley potentially came under the influence of an Early Iron Age kingdom centered in the Amuq Valley, the Middle Orontes Valley became the fledgling center of a new kingdom. These diverging trajectories might explain why Hama and the Middle

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[110] These rather meager lists of booty and tribute extracted from the different territories and cities of the kingdom of Hamath by Assyrian kings are rather striking, if seen in connection with the evidence for the production of luxury items in the region during the early 1st millennium BCE. Two categories of objects are especially important in this regard, small steatite pyxides and so-called hand-lion bowls, closely related to Syro-Hittite stone sculpture and produced primarily in the 10th and 9th centuries BCE (Mazzoni 2001a, 2005a; Shaath 1986; Stucky 1971; Wicke 2008; Winter 1983), as well as carved ivories, many of which were found at Hama, but which were also brought to the Assyrian heartland as booty, and which were primarily produced in the 9th century BCE (Mazzoni 2009).

Orontes Valley region developed into the core area of the kingdom of Hamath early in the Iron Age II, whereas settlement on the Northern Plateau was still characterized by a gradual, albeit slow, urbanization process. Only the political changes of the late 9th and 8th centuries, increased Assyrian intervention and the rise of king Zakkur, resulted in a large-scale urbanization process. This process was accompanied by intensive agricultural exploitation and taxation, leading to the accumulation of wealth in the new centers on the plateau (Venturi 2015, 93), culminating in the establishment of the 'unified' kingdom of Hamath and Lu'ash in the final part of the Iron Age II.

CHAPTER 7
CONCLUSION

> “Climatic variation has produced variation in both the quantitative and qualitative character of the economic base of cultures, nations, and societies. The new recognition is not a revival of environmental determinism; it implies neither that all environmental changes have a climatic cause, nor that all cultural changes have an environmental cause, and it does not rest on an assumption that the links between climatic and human history are simple and straightforward.” (Bryson and Padoch 1980, 583)

7.1 SYRIA NOW AND THEN: A MODERN PERSPECTIVE

Between 1900 and 2005, Syria experienced six significant drought episodes (Gleick 2014, 332). Over the course of the past 50 years or so, the country experienced a total of 25 years of drought, with drought events lasting for several years on average, a trend that has also been observed in other regions of the Eastern Mediterranean and beyond (de Châtel 2007, 2014). The consequences of these drought events were catastrophic: The 1961 drought resulted in significant losses of livestock in Syria, affecting around 80 % of the camel and 50 % of the sheeop populations. The severe drought of 1998-2002 eliminated the livestock holdings of some 300,000 people, resulting in food shortages and an increased reliance on government subsidies for food purchases (de Châtel 2014, 523). Then, beginning in 2007-2008, one of the worst multi-year drought episodes on record, characterized by extremely low precipitation volumes, affected Syria and the entire Fertile Crescent (de Châtel 2014; Gleick 2014; Kelley *et al.* 2015; Trigo *et al.* 2010). Again, the consequences were momentous: In the winter of 2007-2008, precipitation levels dropped by two thirds compared to the long-term average, with average crop yields diminishing by 32 % in irrigated areas and up to 79 % in rain-fed areas (de Châtel 2014, 524), with wheat and barley yields dropping by 47 % and 67 %, respectively, reducing a harvest of formerly 4.7 million tons per year to a mere 2.1 million tons (de Châtel 2014; Gleick 2014). Between 2007 and 2008, food prices nearly doubled, whereas the proportion of the agricultural sector in the gross domestic product of Syria dropped from 25 % in 2003 to around 17 % in 2008. By 2010, prices for animal fodder had risen by 75 %, obliterating most livestock herds (Kelley *et al.* 2015, 3241-3242). By 2011, the United Nations estimated that around two to three million people were affected by the drought, with around one million people under imminent threat of food insecurity and malnutrition (Gleick 2014, 334). As a result of food shortages, nutrition-related diseases among children became much more common and school enrollment rates dropped by 80 % (Kelley *et al.* 2015, 3242). In March 2011, the first protests erupted in the southern Syrian city of Dara’a and by current estimates, the resulting conflict has caused the death of around a quarter million people and has resulted in over five million refugees and millions of internally displaced people (IDPs). The central government has lost control over large parts of the country and a variety of civil groups and armed factions have sprung up across the country and assumed control over parts of the country and its inhabitants, either at gunpoint or peacefully through communal organization.

But what at first sight looks like a modern textbook case of sudden, climate-induced social strife and state collapse is, in fact, a much more complex story of socio-natural interactions and how social, political, and environmental processes are intimately intertwined. Many scholars have commented on the complex relationships between social, economic, technological, political, ideological, religious, and even environmental factors that played a role in the gradual erosion of state authority in Syria recent years (de Châtel 2007, 2014; de Châtel and Raba‘a 2014; Gleick 2014; Kelley *et al.* 2015; Trigo *et al.* 2010).

The causes of the current Syrian conflict have to be sought in a combination of population dynamics, socio-political systemic inadequacies, and natural developments specific to Syria, since other countries of the region were not affected to the same degree by the recent drought cycle in the Middle East. In fact, systemic failures in the political, social, and economic spheres have been identified as major contributors to the current crisis. Long-term governmental policies to increase agricultural production, among them the preference of certain cash crops (like cotton), a lack of oversight over water resources, and a variety of government subsidies for the agricultural sector, over the past few decades resulted in an increased vulnerability of the agricultural system to outside stresses (de Châtel 2007, 2014; Kelley *et al.* 2015; Serra 2015). At the same time, a dramatic increase in population levels, coupled with an influx of over a million Iraqi refugees, unemployment, and social inequality became rampant (Kelley *et al.* 2015). After years and decades of agricultural mismanagement, over-intensification, and livestock overgrazing (Serra 2015), and two severe drought cycles in close succession (Trigo *et al.* 2010), the agricultural system finally became unable to cope with these stresses, particularly in the country’s poorer, but agriculturally important, northeastern provinces (cf., de Châtel 2014; Gleick 2014; Kelley *et al.* 2015). The result was a large-scale migration of people from rural areas to urban agglomerations (de Châtel 2014; Kelley *et al.* 2015), but also to rural areas in the southwest, where climatic conditions improved quickly after the initial deterioration of 2006-2007 (de Châtel 2014).

The case of the current Syrian crisis highlights the important role played by population dynamics in the development of socio-political strife, a topic hotly debated in contemporary conflict studies (Gleick 2014; Goldstone 2002). But it also highlights the need to consider political, social, economic, and environmental factors in an integrated discussion of social transformation and conflict, as called for by a variety of scholars (Adger *et al.* 2013; Cane *et al.* 2014; Raleigh *et al.* 2014; Solow 2013). These factors form a complex and interrelated web of mutual influences, in which environmental factors play a role, albeit not necessarily the most important one. While rising levels of social unrest and political conflict might be related to climatic and environmental phenomena (e.g., Burke *et al.* 2009; Hsiang *et al.* 2013; Hsiang *et al.* 2011), in the case of modern Syria both social and environmental variables play an important role as well. Indeed, it has been argued that the impacts of the most recent drought would not have been as severe, if adequate social, economic, ecological, and political coping mechanisms had been in place (de Châtel 2014; Kelley *et al.* 2015).

Besides being a good example of how interrelated socio-natural factors influence social and political transformations, contemporary Syria and other modern conflicts have the potential to inform archaeological socio-natural systems research and outline future research strategies. In the case of Syria, it has been pointed out that the effects of the most recent drought were not just determined by its severity, but also by its prolonged duration, as well as it being preceded by other significant drought events in the late 1990s and before (Kelley *et al.* 2015; Trigo *et al.* 2010). This calls attention to the fact that when studying the effects of climatic change, it is necessary not only to consider short-lived, sudden changes. History and context matter and these ‘freak events’ must be examined on a background of long-term change. Similarly, it is necessary to keep in mind that the effects of social and environmental transformations can be chronologically and spatially discontinuous and that transformations in one region might influence another region in a particular way, as suggested by the short discussion on population dynamics and migration presented above. Likewise, the example of modern Syria cautions against the simple equation of climatic change with environmental change and social breakdown. As Serra (2015) has argued, ecological systems, in his particular example the rangelands and pastures of Syria, possess a variety of natural coping mechanisms that would have allowed these systems to adjust to long-term changes in both global and regional climates. The large-scale deterioration of the landscape was only possible through the combination of the adverse effects of environmental deterioration and maladaptive social practices that resulted in the overexploitation of natural resources.

7.2 Some Answers...

As this study has shown, it is possible to talk about the Late Bronze/Iron Age transition in West-Central Syria without having to rely on a number of broad, ill-defined concepts that ultimately obscure and hamper a detailed analysis of social, economic, political, and environmental processes. This study has proposed that Socio-Natural Systems (SNS) thinking, borrowed from ecology, constitutes an adequate theoretical framework in which such an analysis can be carried out. Neither theoretically nor methodologically unified, SNS approaches do provide a framework in which a variety of questions can be pursued in a variety of contexts and relying on a variety of data. In an effort to analyze and evaluate the effects of climate change on socio-political and socio-economic organization in West-Central Syria during the late 2nd and early 1st millennia BCE, the analysis presented here has concentrated on an investigation of the impacts of environmental change on agricultural systems and their effects on the overall social and political organization. In doing so, this study has achieved four main results:

7.2.1 Changing Climates - Changing Environments?

First, it has become clear that it is important to clearly differentiate between climate change as a natural phenomenon, observable in palaeoenvironmental proxy data and climatic simulations, and the impact these changes actually have on economic systems and social structures. In other words, in talking about climate change, it is not enough to only identify the onset of more-or-less significantly altered climatic regimes, but it is also necessary to develop an analytical framework with which the impacts of these changes can be identified and measured. In this particular context, modeled climate data has first been used to simulate climatic conditions that compare well with what has been gathered from palaeoenvironmental data. In a second step, a predictive GIS model has been developed as a way to quantify the effects of these climatic changes on agricultural production, for which wheat crop cultivation has been used as a case study, or base line.

In comparing the climatic data with the results of the environmental model, it has become apparent that climatic changes, such as diminishing rainfall levels, do not necessarily entail the deterioration of the environment and a decline in agricultural production. Especially the Northern Coast and the Jableh Pain, as defined here, constitute good examples of this issue, as both sub-regions do not appear to have been influenced significantly by declining levels of precipitation during the late 2nd and early 1st millennia BCE. In other regions of West-Central Syria, however, climatic changes had a much more severe impact on local environments, as suggested by the data from the Northern Plateau.

As the brief example of modern Syria has shown, climate change should not automatically be equated with environmental transformation or degradation, and in turn, environmental change should not be assumed to automatically lead to social change. The consideration of both natural and social factors is an important aspects of SNS analysis and neither aspects can, or should be, considered in isolation.

7.2.2 Environment First - But not Always

Second, through a detailed analysis of climatic patterns and their effects on the environment, subjecting the data to statistical testing, and combining the results of these processes with the available archaeological data, it is possible to point out instances in which the environmental data would support an identification of climatic influence on social change. This is especially apparent in the Northern Plateau, which not only provides the most cogent evidence for climatic and environmental degradation, but also furnishes potential evidence for socio-economic adaptation, such as changing patterns of landscape exploitation between the Late Bronze and the Early Iron Age.

A detailed, and multi-faceted, analysis of environmental processes should thus, as called for by Scholz (2011), constitute the starting point of every SNS analysis. Neither does this constitute an exercise in environmental determinism, nor does it mean that every instance of social change should be seen as related to environmental factors. But a detailed analysis of environmental processes is necessary, if the effects of climatic and environmental change on social systems are to be shown. In this regard, the detailed analysis of environmental factors within an SNS framework can also point out instances where such a relationship between social and natural variables cannot be shown. In the context of the present study, this has become particularly apparent on the coastal plains, where social, political, and economic changes are quite pronounced, although environmental changes are rather minute.

7.2.3 Location, Location, Location...

Third, in discussing and analyzing the spatial and chronological patterns within the environmental and archaeological data, this study has shown the importance of tacking between different scales of analysis when conducting socio-natural system research. Rather than considering only regional contexts, and relying on data on a regional scale, it is necessary to also consider more localized, small-scale contexts when attempting to investigate the relationships between humans and their environment, which is especially important in such a topographically variegated study area as West-Central Syria. Neither can it simply be assumed that climatic and environmental changes affect all parts of a region equally, nor can it be assumed that environmental change triggers simultaneous and uniform responses by the people affected (Riehl 2012, 119). Instead, a detailed analysis of the chronological and spatial dimensions of environmental change and social response is necessary.

In the context of West-Central Syria in the Late Bronze and Iron Ages, it has been shown that various areas of the study region experienced different patterns of climatic change at different times. Even more importantly, different parts of the region appear to have responded to these changes differently. Whereas the coastal plains appear to have been little, if at all, influenced in their agricultural suitability over time, the inland regions of West-Central Syria, especially the Northern Plateau, experienced considerable shifts in agricultural suitability. Similarly, the trajectories of population development differed significantly between various areas of West-Central Syria. Whereas the Northern Coast experienced a strong decline in population levels (it is tempting to use the term 'collapse' here...) at the end of the Late Bronze Age, the Akkar Plain shows a more gradual pattern of population decline already starting in the Late Bronze Age and continuing into the Iron Age. Further inland, on the other hand, the Lower Orontes Valley and the Northern Plateau experienced a considerable expansion in settlement activity during this time, which might ultimately be related to developments on the coast.

The use of different scales of analysis is also important when considering social processes. As outlined in Chapter 3, it needs to be acknowledged that global, regional, and local processes are linked to each other in reciprocal relationships. Small-scale changes on a local level might influence transformations on a larger level, and vice versa. Similarly, developments in one particular geographic area might have repercussions on another. The relationships between the Northern Coast and the Northern Plateau might be considered illustrative of this issue, as the former region might have been dependent on agricultural products of the latter during the Late Bronze Age, whereas the socio-economic transformations affecting the Northern Plateau during the Early Iron Age might have been conditioned on population dynamics on the Northern Coast.

7.2.4 Qualitative and Quantitative Differences

Fourth, by conducting a careful statistical analyses of the spatial distribution of archaeological sites and their respective attributes, this strudy has suggested that settlement expansions and contractions during the Late Bronze and Iron Ages did not follow a linear trajectory, but instead were subject to spatially and chronologically specific trends.

In this regard, the qualitatrive difference between settlement patterns of the Late Bronze and the Iron Ages are particularly important. On the one hand, this observation suggests that significant socio-economic and socio-political changes occurred between these two periods, at least from the point of view of spatial organization. On the other hand, quantitative differences between the Early and the Late Iron Age indicate an evolutionary, rather than revolutionary, transformation of social organization, with preexisting patterns being elaborated on and expanded.

It is important to note that these observations lend some support to long-held notions of a fundamental difference between Late Bronze and Iron Age society. Yet, this observation only pertrains to the spatial distribution of Late Bronze and Iron Age settlements, their respective agricultural catchment areas, and their relationships with the environment, and due caution should be used when attempting to relate these findings to broader issues of ethnic, cultural, or political organization.

7.3 ... AND MANY OPEN QUESTIONS

These results notwithstanding, there remain many issues and questions this study has been unable to address. In fact, due to the scale of this project's study region and the mass of data available, but also due to the limitations of the evidence, it has only been possible to present here a preliminary analysis of socio-natural interactions and their role in shaping the development of Late Bronze and Iron Age society.

7.3.1 Technology and Agricultural Practices

One of the most important issues concerns the nature of agricultural and other economic practices during this period. Liverani (2014, 391) has argued that new agricultural technologies were developed in the Levant during the Iron Age, including terracing and irrigation techniques. Similarly, he has argued that the Iron Age saw the development of specialized crop cultivation, especially with regard to vines and olives (Liverani 2014, 329). While these developments might be to a degree perceptible in the textual record, most prominently the Assyrian campaign reports and their extensive lists of booty and tribute, such transformations are as of yet difficult to establish in the archaeological record.

As discussed before (**§5.3.6**), archaeological evidence for hydraulic features, such as wells, cisterns, or canals, is almost entirely lacking from West-Central Syria. It might be possible to associate changes in the settlement system of West-Central Syria, in particular the expansion of sites into higher, steeper terrain on the Northern Plateau, with these changes, especially since agricultural systems in arid climates are often characterized by an increased degree of diversification as an adaptive strategy (cf., Araus *et al.* 2007, 143; Herhahn and Hill 1998, 469). When talking about Iron Age West-Central Syria, however, such a connection between environmental factors and socio-economic strategies is at the moment little more than conjectural.

Moreover, this raises questions as to the feasibility of such an expansion within the context of climatic change, as the expansion of olive cultivation into marginal zones is known to be prone to drought stress and dependent on extensive use of groundwater resources (see, van der Zanden 2011, 2). In this context, it might be asked whether a massive expansion especially of olive cultivation, which is clearly shown at Tell Mishrifeh, within an insecure environmental context might have eventually resulted in the overexploitation of the environment, leading to the eventual abandonment of Tell Mishrifeh later in the Iron Age due to adverse environmental conditions (cf., Morandi Bonacossi 2006). In other words, is it possible that some of the agricultural and economic strategies of the inhabitants of West-Central Syria proved unsustainable in the context of long-term environmental change and progressive agricultural intensification? Likewise, could the increased demand for wool, observable in the increased quantities of textile weaving equipment (e.g., Cecchini 2000a, 2011; Rahmstorf 2005, 2011) and sheep faunal remains within Iron Age contexts, have resulted in an overexploitation of available pastures, contributing to long-term land degradation (cf., Serra 2015)? And how does this expansion of livestock herd sizes relate to the potential risk of farmers having to liquidate their livestock in times of large-scale drought events, as has happened in modern Syria (cf., de Châtel 2014)?

7.3.2 Causes for Diverging Trajectories

In addition, it needs to be investigated how regions of seemingly similar, and apparently favorable, environmental conditions developed on very different trajectories. This is especially pertinent with regard to the coastal plains. From the perspective of environmental modeling, all coastal areas appear to have suffered only minimally from climatic change over time. Yet, far from becoming the centers of a major population development during the Iron Age, settlement intensity on the coast remained rather limited during this period. This is especially true for the Northern Coast which, at least according to the available archaeological data, was essentially depopulated after the end of the Late Bronze Age. This stands in stark contrast to the environmental development of this region, which evinces a continuously high degree of agricultural suitability. Why, then, was this region not resettled in the course of the Iron Age? Given that the available data does not indicate an environmental cause for this phenomenon, it is expected that the underlying causes for this development should be sought in the social or political sphere. As previously noted, Bell (2005, 2009) has argued that Aegean trading contacts (or a lack thereof) during the Late Bronze Age might explain why different regions of the Levantine littoral developed differentially during the Iron Age. But is this explanation sufficient to explain why apparently favorable regions were not intensely settled anymore?

The Northern Coast constitutes an especially complex and intriguing example of how different social, political, or environmental factors might have contributed to specific historical developments. As already discussed before, the modeling data presented here does, to some degree, defy the notion of envrionmental degradation in this area of West-Central Syria. The continuously high degree of agricultural favorability indicates that this particular area‘s environment was not strongly affected by climatic changes and, at least in theory, was capable of supporting a significant population.

Yet, this is not mirrored in the overall development of the area‘s settlement system, which was all but vanquished at some point in the ealry 12th century BCE, never to recover again during the Iron Age. What, then, was the cause of these profound transformations? The analogy of modern Syria might provide some answers. Much like Syria today, the environment of ancient Ugarit was affected by long-term climatic shifts, observable primarily in diminishing levels of precipitation. In both instances, however, these climatic changes alone do not appear to have been sufficient for causing a profound deterioration of environmental conditions or the wholesale breakdown of the ecological system. At ancient Ugarit, agricultural suitability did not diminish significantly. In modern Syria, as argued by Serra (2015), natural and agricultural environments, if left alone, would have likely been able to withstand the climatic schocks of the 20th century CE on their own accord. Detrimental social and economic practices were necessary to tip the scales towards widespread degradation of agricultural and pastoral land - a true interaction of social and environmental variables within a complex system.

Could the developments between the Late Bronze and the Iron Age on the Northern Coast be explained in a similar way? As outlined in Chapter 6, the overreliance of the inhabitants of the kingdom of Ugarit on foreign trade to satisfy their basic needs of sustenance (Sommer 2016), might have resulted first in diminished quantities of available produce and higher food prices, ultimately leading to food scarcity and famine. As inland areas experienced crop failures and a decline of livestock herds, living conditions on the coast, which relied heavily on these products, would have been severely affected as well, perhaps even resulting in social unrest. Potentially confronted with hostile groups from other areas of the Mediterranean, many people might have decided to move to other areas, for example the Orontes Valley, in search for a better future.

Although such a reconstruction is little more than hypothetical at the moment, it is hard not to imagine how gradual environmental changes, especially outside of the borders of the kingdom of Ugarit proper, might have affected the kingdom‘s population in the long run. This proposed reconstruction echoes the modern situation in several ways, due to the common themes of environmental stress, socio-economic maladaption, conflict, and migration. As an illustrative example of how both social and natural factors can combine in unexpected ways and exert a strong, adverse influence on people‘s lives, the example of modern Syria might chart the way for future research into the development of the Norther Coast and other areas of the Levant during the Late Bronze and Iron Ages. How severe were climatic fluctuation? How significant was their effect on the local environment? How did economic practices influence the environment and its natural resilience? Is it possible to identify attempts to cope with such environmental stresses? Were areas actually as severely depopulated as the current archaeological record would have us believe?

7.4 DATA LIMITATIONS AND FUTURE DIRECTIONS

To achieve these goals and to answer the outstanding questions, the theoretical and methodological approaches used in this project need to be refined and further developed in the future. For Late Bronze and Iron Age West-Central Syria, data limitations still impose several restrictions on the scope and detail of the analysis of socio-natural interactions.

7.4.1 Chronological Precision

One of the most obvious limitations is the archaeological record. Both survey and excavation projects have been conducted with widely diverging research goals and analysis strategies, resulting in an archaeological record that cannot always be synchronized easily. Many of the survey projects lack detailed data on the periodization of the recorded sites, either because the results have not yet been fully published, or because no distinction between sub-phases of individual periods has been made. In many cases, sites can only be very generally assigned to one of the three major periods (Late Bronze Age, Iron Age I, Iron Age II). This makes a correlation of settlement data and environmental data difficult, especially since GIS analysis of the MCM data has the potential to model climatic and environmental processes on a century scale. This leads to the paradox situation of the environmental data being available at a higher resolution than the archaeological evidence.

As far as archaeological excavations are concerned, it has become apparent that important information for reconstructing economic and socio-natural processes are often missing from the record. For example, the excavations at Tell Afis, Tell Mishrifeh, and also Tell Mastuma have furnished a wealth of information with which economic practices, especially the storage of agricultural produce, can be reconstructed with considerable detail. Similar data, however, are missing from many other sites, especially in the coastal region. In order to be able to reconstruct agricultural and related economic practices across the entire study area, much more focus and detail on such socio-economic aspects is needed in the future.

7.4.2 Botanical and Faunal Data

Similarly, faunal and botanical remains, some of the best indicators of environmental change and changing economic practices, have not been recovered at all sites. And even where they have been systematically collected, these remains have often been published only in preliminary fashion and sometimes no differentiation between individual sub-phases is being made, especially when Iron Age levels are concerned. Due to this lack, for many parts of West-Central Syria, the results of the climatic modeling and the suitability analyses constitute the only ways in which climatic and environmental processes can be studied at all. This is especially apparent on the Northern Coast and in the Akkar Plain, where almost no data is available, but also applies to such areas as the Lower Orontes Valley or the Northern Plateau, where faunal and botanical reports lack important detail.

Therefore, the collection and analysis of archaeobotanical and zooarchaeological remains should be one focus of future research, as these types of data have a high potential of illuminating the response of agricultural communities to environmental change. In other words, botanical and faunal remains are one of the most important indicators of adaptive strategies designed to cope with changing climatic and environmental, but also social, conditions.

The value of increased detail in the botanical and faunal data is illustrated by a study from the ancient city of Ashkelon on the Southern Levantine coast (Weiss and Kislev 2004). As the authors show, detailed botanical analyses can be used to delineate potential locations and compositions of agricultural fields and illuminate patterns of trade and land exploitation. Furthermore, attention to various characteristics of the plant remains, such as the specific stage of plant development, can provide valuable insights into harvesting techniques, which can be correlated with social and political developments, such as the stockpiling of foodstuffs in anticipation of military conflict (Weiss and Kislev 2004, 6).

7.4.3 Environmental Modeling

This leads to the last aspect that needs to be addressed: Environmental modeling. As Verhagen (2007, 80) has argued, in order for a predictive model to be fully effective, modeling parameters need to be independent of each other. In the context of the agricultural suitability model developed here, this has not yet been fully realized. While most of the modeling parameters – slope, soil type, hydrogeology, and precipitation – are derived from different datasets and are therefore independent of each other, one of the most important parameters – water deficit – is still essentially a function of the precipitation and temperature data generated through the MCM. One way to make this parameter independent would be to rely on the results of archaeobotanical analyses, particularly the results of isotope analyses of plant remains. As discussed recently by several authors (Bogaard *et al.* 2016; Ferrio *et al.* 2003; Vaiglova *et al.* 2014; Wallace *et al.* 2013; Wallace *et al.* 2015), isotope values, especially the $\Delta^{13}C$ values, can be used to infer the water status of crop plants, as higher $\Delta^{13}C$ values are associated with a greater water input, either through natural processes or through artificial irrigation (Wallace *et al.* 2013, 394). In this context, Wallace *et al.* (2013; 2015) have suggested that a $\Delta^{13}C$ value of less than 16 ‰ are indicative of water stress in wheat crops, whereas values of 16-17 ‰ and over 17 ‰ are indicative of moderate and high crop water levels, respectively, a position also adopted by Boogard *et al.* (2016). These absolute threshold values could easily be integrated into the GIS model and provide a much more robust and accurate way to measure the degree of water stress and its effect on agricultural suitability. However, as the review of palaeoenvironmental and archaeobotanical data in Chapter 4 has made clear, the scarcity of plant isotope samples from Late Bronze and Iron Age contexts in West-Central Syria currently precludes the adoption of such an approach to modeling water stress and more research in this direction is necessary before these data can be fully integrated into a predictive model.

7.5 CONCLUDING REMARKS

The application of a Socio-Natural Systems perspective has the potential to change the way archaeology looks at societal change, eschewing traditional models of collapse and decline and replacing them with a more nuanced (and more neutral) idea of change and transformation. Due to the flexibility of Socio-Natural Systems approaches, these investigations can take many different forms and accommodate many different research projects. The study presented in the context of this dissertation only provides a glimpse of how SNS thinking can be applied to the study of such a transformative period, and only constitutes the first attempt of applying these principles to the Late Bronze/Iron Age transitions in West-Central Syria. The theoretical perspectives and methodological approaches outlined in the previous chapters can easily be applied to a variety of contexts, but should not be seen as the best, or even the only, way to investigate the manifold interconnections and interdependencies between societies and their environments. Much more research is needed and both theoretical perspectives and methodological techniques need to be refined in the future.

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APPENDIX 1
LIST OF ARCHAEOLOGICAL SITES

ID	Name	UTM East (36N)	UTM North (36N)	Site Size (ha)	Occupation Periods	Source	Analysis Region	Placement Certainty
AS1	Tell Mardikh	843267.1	3968207.3	1.8	LB, IA II	Sauer nd.; Matthiae 2006; Baffi and Peyronel 2014	Northern Plateau	high
AS2	Tell Mastuma	827801.1	3976489.2	4.0	IA II	Sauer nd.; Iwasaki et al. 2009; Mazzoni 2014	Northern Plateau	high
AS3	Qarqur	801195.8	3960455.8	12.0	LB, IA	Sauer nd.	Lower Orontes	high
AS4	Ras Shamra	752341.5	3943390.1	36.0	LB	Sauer nd.	Northern Coast	high
AS5	Ras ibn Hani	748811.6	3941391.6	3.5	LB, IA	Sauer nd.	Northern Coast	high
AS6	Jable	765425	3916792	N/A	LB?, IA?	Sauer nd.	Jableh Plain	high
AS7	Tell Sukas	765696.9	3910931.3	0.8	LB, IA	Sauer nd.; Riis et al. 2004	Jableh Plain	high
AS8	Burj el-Hammam	769277	3902201.7	N/A	IA	Sauer nd.	Jableh Plain	low
AS9	Tell Bsireh	763497.2	3875543.2	N/A	LB, IA	Sauer nd.	Central Coast	low
AS10	Amrit	765937	3859034	N/A	LB, IA	Sauer nd.	Central Coast	high
AS11	Tell Jamus	787299.2	3838761.6	5.5	LB, IA	Sauer nd.	Akkar Plain	low
AS12	Tell Qeddah	846955.3	3857058.9	5.4	LB, IA	Sauer nd.; Turri 2015	Middle Orontes	high
AS13	Tell Mishrifeh	853567.7	3861564.2	110; 70	LB, IA	Sauer nd.; al-Maqdissi and Morandi Bonacossi 2009	Middle Orontes	high
AS14	Tell Ayyu	840754.4	3882141.7	12.0	LB, IA	Sauer nd.; DAI Survey	Middle Orontes	high
AS15	Tell Darko	841687.5	3886530.6	9.5	LB	Sauer nd.	Middle Orontes	high
AS16	Hama	841675.2	3894574.2	12.0	LB, IA	Sauer nd.	Middle Orontes	high
AS17	Tell Abbadeh	843420.7	3906394.2	4.5	LB, IA	Sauer nd.	Middle Orontes	medium
AS18	Tell Massin	836915.5	3915062.3	0.8	LB	Sauer nd.	Middle Orontes	low
AS19	Tell Bezzam	840790.3	3916740.7	2.7	LB, IA	Sauer nd.	Middle Orontes	medium
AS20	Tell Murek	835215.3	3920606.2	3.5	LB	Sauer nd.	Middle Orontes	high
AS21	Tell Halabi	834755	3920942.3	1.6	LB, IA	Sauer nd.	Middle Orontes	high
AS22	Tell As	825891.1	3926845	7.5	LB?, IA	Sauer nd.; Turri 2015	Lower Orontes	high
AS23	Khan Sheikhun	830998.9	3928324.4	3.3	LB, IA	Sauer nd.	Lower Orontes	medium
AS24	Tell Ar	833833.7	3933074.9	1.8	LB, IA	Sauer nd.	Lower Orontes	high

ID	Name	UTM East (36N)	UTM North (36N)	Site Size (ha)	Occupation Periods	Source	Analysis Region	Placement Certainty
AS25	Tell Hish	830447.7	3939324.3	7.8	LB, IA	Sauer nd.	Lower Orontes	high
AS26	Tell Banusreh	832973.9	3947691.2	4.6	LB, IA	Sauer nd.	Northern Plateau	medium
AS27	Tell Maar Shurin	837047.4	3952516.4	N/A	LB, IA	Sauer nd.; De Maigret 1978; CRANE	Northern Plateau	high
AS28	Kefr Battikh (Kafar Batyha)	836455.9	3966264.2	1.0	IA	Sauer nd.; Iwasaki et al. 2009	Northern Plateau	high
AS29	Dadikh (Tell el-Dadih)	837658.8	3968528	1.4	LB, IA	Sauer nd.; Iwasaki et al. 2009	Northern Plateau	high
AS30	Tell Afis	842882.1	3979987.6	28.5; 32	LB, IA	Sauer nd.; Baffi and Peyronel 2014	Northern Plateau	high
AS31	Tell Sheikh Mansur	848992.5	3975948.6	3.0	LB, IA	Sauer nd.; De Maigret 1978; CRANE	Northern Plateau	high
AS32	Tell Nabariz	850900.6	3982200	0.8	LB	Sauer nd.	Northern Plateau	low
AS33	Tell Bisseh	841112.4	3862229.3	4.0	LB, IA	Sauer nd.	Middle Orontes	high
AS34	Tellet el-Farhaniyyeh	839617.4	3863758.5	N/A	IA	Sauer nd.	Middle Orontes	low
AS35	Tell Nqireh/ Naqar	837244.5	3841833.89	5.0	LB, IA	Sauer nd.; Turri 2015	Middle Orontes	medium
AS36	Tell Nebi Mend	822963.4	3829636.9	10.0	LB, IA	Sauer nd.; Turri 2015	Middle Orontes	high
AS37	Tell Acharneh	808863.7	3910255.2	70.0	LB, IA	Fortin 2006	Lower Orontes	high
AS38	Tell ‘Arqa	779562.7	3825199.9	7.0	LB, IA	Thalmann 2006	Akkar Plain	high
AS39	Tell Tuqan	857560.3	3972013.7	4.3	IA I; IA II	Baffi 2006; Mazzoni 2014	Northern Plateau	high
AS40	Hatab (E)	834216.4	3901001.6	N/A	IA	DAI Survey	Middle Orontes	high
AS41	Hatab (NE)	834284.5	3902543.8	N/A	IA	DAI Survey	Middle Orontes	high
AS42	Tell Afyun	834522.9	3885029	5.0	LB, IA	DAI Survey	Middle Orontes	high
AS43	Tell Siskun	836542.7	3882440.5	3.0	LB	DAI Survey	Middle Orontes	high
AS44	Tafsilun (W)	828649.4	3911739.5	7.0	LB, IA	DAI Survey	Middle Orontes	high
AS45	Tafsilun (E)	828755	3911767	0.8	LB, IA	DAI Survey	Middle Orontes	high
AS46	Tell Wa‘ara	830087.6	3912227.7	N/A	LB	DAI Survey	Middle Orontes	high
AS47	Tell Nasriya (ramparts)	833191.8	3905191.9	N/A	LB, IA	DAI Survey	Middle Orontes	high
AS48	Tell Nasriya	832719.3	3904816.4	70.0	IA	DAI Survey	Middle Orontes	high

ID	Name	UTM East (36N)	UTM North (36N)	Site Size (ha)	Occupation Periods	Source	Analysis Region	Placement Certainty
AS49	Tell al-Dafa‘i	839564.7	3899277.5	3.0	LB, IA	DAI Survey	Middle Orontes	high
AS50	Tell Masruqa	839845.9	3896599.2	N/A	LB	DAI Survey	Middle Orontes	high
AS51	Tell al-Gafa	828576	3878527	5.0	LB, IA	DAI Survey	Middle Orontes	high
AS52	Tell Masruh	834409.8	3880513.3	6.0	LB, IA	DAI Survey	Middle Orontes	high
AS53	Gammaqliye (W)	851619.4	3876438.8	N/A	LB, IA	DAI Survey	Middle Orontes	high
AS54	Tell Buraq	846119.5	3883011.3	1.1	IA	DAI Survey	Middle Orontes	high
AS55	Tell Ahmar	826406.3	3897434.5	2.0	LB, IA	DAI Survey	Middle Orontes	high
AS56	Tell Sikkin Sarute	826466.6	3896784.5	4.0	LB, IA	DAI Survey	Middle Orontes	high
AS57	Tell Arzah	837129.4	3898825.5	20.0	LB, IA	DAI Survey	Middle Orontes	high
AS58	Tell Rabun/ Tell Gaber	848590.1	3890104.6	3.0	LB, IA	DAI Survey	Middle Orontes	high
AS59	Tell Ain Jubb ad-Dam	844353.9	3879758.2	0.4	LB, IA	DAI Survey	Middle Orontes	high
AS60	Tell Hanifa	853603.4	3883715.7	1.9	IA	DAI Survey	Middle Orontes	high
AS61	Tell al-Ghazalet	854395.9	3881331.4	3.5	LB, IA	DAI Survey	Middle Orontes	high
AS62	Tell as-Sus	853082	3877582.8	12.0	LB, IA	DAI Survey	Middle Orontes	high
AS63	Tell Wawiyat	850869.7	3876782.8	3.0	LB, IA	DAI Survey	Middle Orontes	high
AS64	Tell al-Naoura	845237.9	3874163.8	4.0	LB, IA	DAI Survey	Middle Orontes	high
AS65	Tell al-Karzalie	845296.4	3877862.3	0.5	IA	DAI Survey	Middle Orontes	high
AS66	Gammaqliye	840754.7	3882146.7	3.3	LB	DAI Survey	Middle Orontes	high
AS67	Tell Gargara	824953.3	3894419.3	4.0	IA	DAI Survey	Middle Orontes	high
AS68	Site 71	833753.1	3904748.6	N/A	LB	DAI Survey	Middle Orontes	high
AS69	Tell es-Shir	829826.9	3901151.3	4.2	IA	DAI Survey	Middle Orontes	high
AS70	Zor Abu Dardah (E)	850079.5	3876130.6	N/A	IA	DAI Survey	Middle Orontes	high
AS71	Tell Fadlalah	843507.5	3871004.4	4.0	LB, IA	DAI Survey	Middle Orontes	high
AS72	Tell Krah	844732.5	3871310.7	4.0	LB, IA	DAI Survey	Middle Orontes	high

ID	Name	UTM East (36N)	UTM North (36N)	Site Size (ha)	Occupation Periods	Source	Analysis Region	Placement Certainty
AS73	Tell Tweini	766812.4	3918219	12.0	LB?, IA	Vansteenhuyse 2010; Bretschneider et al. 2014	Jableh Plain	high
AS74	Ras el-Bassit	756311.8	3970587	0.3	LB, IA	Corbin 1982, 1983, 1986, 1990, 1993	Northern Coast	high
AS75	Tell Kazel	773495.7	3844728.6	11.0	LB, IA	Badre 2006	Akkar Plain	high
AS76	Tell Kourin	822599.4	3974970.6	6.7	IA	Iwasaki et al. 2009	Northern Plateau	high
AS77	Tell Kafar Najid	823478.1	3970384.7	3.0	LB, IA	Iwasaki et al. 2009	Northern Plateau	high
AS78	Tell Borjhab	819333.1	3977082.8	1.3	IA	Iwasaki et al. 2009	Northern Plateau	high
AS79	Tell Roman	824519.1	3979640.8	8.9	IA	Iwasaki et al. 2009	Northern Plateau	high
AS80	Tell Babi	821272.7	3981634.8	3.4	IA	Iwasaki et al. 2009	Northern Plateau	medium
AS81	Tell Ariha	825659.6	3968831.1	1.3	IA	Iwasaki et al. 2009	Northern Plateau	high
AS82	Tell Nahali	825045.8	3964330.8	1.9	IA	Iwasaki et al. 2009	Northern Plateau	high
AS83	Tell Ourem el-Jouz	822193.8	3966353.2	2.7	IA	Iwasaki et al. 2009	Northern Plateau	medium
AS84	Tell Jarnaz	829875.1	3986343.9	0.4	IA	Iwasaki et al. 2009	Northern Plateau	high
AS85	Tell Bet Sofan	832880.7	3989555.6	4.3	IA	Iwasaki et al. 2009	Northern Plateau	high
AS86	Tell Tar	831502.7	3981460.8	1.8	IA	Iwasaki et al. 2009	Northern Plateau	high
AS87	Tell Deinit	831628.8	3978450.3	1.6	IA II	Iwasaki et al. 2009, Shaath 2012; Mazzoni 2014	Northern Plateau	high
AS88	Tell el-Shela	831263.4	3975801.8	0.8	IA	Iwasaki et al. 2009	Northern Plateau	high
AS89	Tell Msaibin	829311.5	3972699.9	0.7	IA	Iwasaki et al. 2009	Northern Plateau	high
AS90	Tell el-Neirab	836068.8	3975977.2	1.6	IA	Iwasaki et al. 2009	Northern Plateau	high
AS91	Tell el-Safin (W)	832322	3974511.5	1.2	IA	Iwasaki et al. 2009	Northern Plateau	high
AS92	Tell el-Safin (E)	834604	3973762.9	0.9	IA	Iwasaki et al. 2009	Northern Plateau	medium
AS93	Tell el-Bahra	833082.7	3969479.4	0.7	IA	Iwasaki et al. 2009	Northern Plateau	high
AS94	Tell el-Jabani	820546.1	3980479.4	1.0	IA	Iwasaki et al. 2009	Northern Plateau	high
AS95	Qalaat Mudiq	807851.6	3923792.7	7.0	LB?, IA	Turri 2015	Lower Orontes	medium
AS96	Saida	796516	3775554.9	N/A	LB?	Turri 2015	Upper Orontes	high

ID	Name	UTM East (36N)	UTM North (36N)	Site Size (ha)	Occupation Periods	Source	Analysis Region	Placement Certainty
AS97	Tell Maqna	796518.8	3775466.3	4.0	LB, IA I, IA II	Turri 2015	Upper Orontes	high
AS98	Tell Ard et-Tlaili	789792.3	3774846.2	0.9	LB?	Turri 2015	Upper Orontes	high
AS99	Tell en-Naba	801738.1	3782535.7	0.9	LB, IA I	Turri 2015	Upper Orontes	high
AS100	Tell Ayn Ahla	802107.7	3782440.7	4.0	LB, IA I, IA II	Turri 2015	Upper Orontes	high
AS101	Tell Ayn Shat	797805.6	3782403.4	3.2	LBA, IA I, IA II	Turri 2015	Upper Orontes	high
AS102	Tell el-Mathani	801697.6	3782849.6	3.1	LB, IA	Turri 2015	Upper Orontes	high
AS103	Tell el-Hosn	802176.5	3783175.9	0.9	LB, IA II	Turri 2015	Upper Orontes	high
AS104	Tell el-Uyun	801675.4	3784114.9	0.8	LB, IA I, IA II	Turri 2015	Upper Orontes	high
AS105	Tell Labwe el-Yamin	808593.6	3789104.6	7.5	LB?, IA I?, IA II	Turri 2015	Upper Orontes	high
AS106	Tell Qasr Labwe	808201.9	3789224.9	6.1	LB, IA I, IA II	Turri 2015	Upper Orontes	high
AS107	Labwe esh-Shemal	808929.5	3789271.1	1.2	LB, IA?	Turri 2015	Upper Orontes	high
AS108	Haql el-Bayda/Tlinta	806464.3	3791567.1	0.2	LB, IA I, IA II	Turri 2015	Upper Orontes	high
AS109	Tell Sugha	807207.8	3792246.8	0.1	LB, IA I	Turri 2015	Upper Orontes	high
AS110	Tell Haql el-Jami	808252.3	3794991.2	0.2	LB, IA I, IA II	Turri 2015	Upper Orontes	high
AS111	Marah el-Wazza	808996.2	3798436.8	1.2	LB, IA	Turri 2015	Upper Orontes	high
AS112	Hermel	811483.5	3811204.5	4.0	LB, IA I, IA II	Turri 2015	Upper Orontes	high
AS113	Khirbet Busaybis	815675.8	3812756.5	0.7	LB, IA I, IA II	Turri 2015	Upper Orontes	high
AS114	SHR 286	823688.3	3830640.6	1.0	IA	Turri 2015	Middle Orontes	high
AS115	Tell Masaud	829876.2	3831603.5	1.0	IA II	Turri 2015	Middle Orontes	high
AS116	Safinat Nuh	825088.7	3831890.3	18.3	LB, IA	Turri 2015	Middle Orontes	high
AS117	SHR 254	835437.9	3832581.3	8.0	LB?	Turri 2015	Middle Orontes	high
AS118	Tell Natanin	840198.4	3833588.6	8.0	LB, IA	Turri 2015	Middle Orontes	high
AS119	Tell es-Sur	824420.4	3833610.4	2.0	LB, IA	Turri 2015	Middle Orontes	high
AS120	Tell el-Kabir	823535.8	3834212.7	2.0	LB, IA	Turri 2015	Middle Orontes	high
AS121	Tell es-Safir	823535.8	3834212.7	2.0	LB, IA	Turri 2015	Middle Orontes	high

ID	Name	UTM East (36N)	UTM North (36N)	Site Size (ha)	Occupation Periods	Source	Analysis Region	Placement Certainty
AS122	Tell el-Hassan	833473.4	3836088.1	2.0	LB, IA	Turri 2015	Middle Orontes	high
AS123	Tell Aqarib	836399.3	3836216.5	0.7	LB, IA	Turri 2015	Middle Orontes	high
AS124	Tell Ahmar	838015.1	3836497.7	1.5	LB, IA	Turri 2015	Middle Orontes	high
AS125	Tell et-Tin/ Tell al-Bahar	823793.5	3836032.6	6.0	LB, IA	Turri 2015	Middle Orontes	high
AS126	Tell al-Wawiya	826689.4	3837001.2	1.0	LB, IA I, IA II	Turri 2015	Middle Orontes	high
AS127	Tell ez-Zamr	828872.5	3838111.9	N/A	LB, IA	Turri 2015	Middle Orontes	high
AS128	Tell Qattina	831513.4	3840784.2	2.0	IA	Turri 2015	Middle Orontes	high
AS129	Tell Hdeidet el-Asi	832580.5	3844289.4	0.6	LB, IA II	Turri 2015	Middle Orontes	high
AS130	Tell Ali Idriss	835403.3	3845914.1	5.0	LB, IA II	Turri 2015	Middle Orontes	high
AS131	Tell Baba Amru	837046.2	3846162.9	1.0	LB, IA	Turri 2015	Middle Orontes	high
AS132	Homs	839392.5	3848482.8	7.6	LB, IA I	Turri 2015	Middle Orontes	high
AS133	Marj esh-Shershar	818433.5	3849466.5	1.5	LB, IA II?	Turri 2015	Middle Orontes	high
AS134	Wadi el-Qweyq	828496.5	3851220.5	N/A	LB	Turri 2015	Middle Orontes	high
AS135	Mazar Mual-lem Ali	813395.9	3850893.2	1.1	LB, IA II	Turri 2015	Middle Orontes	high
AS136	Qalat Qdah	816108.9	3854385.6	N/A	LB	Turri 2015	Middle Orontes	high
AS137	Dar el-Kabir	837230.4	3855392.9	2.6	LB, IA	Turri 2015	Middle Orontes	high
AS138	Tell el-Blan	853450.3	3852068.7	N/A	LB, IA	Turri 2015	Middle Orontes	high
AS139	GeoSu9	852734.3	3853752.8	N/A	LB, IA	Turri 2015	Middle Orontes	high
AS140	Tell Berze	858846.4	3855312.2	2.4	LB, IA II	Turri 2015	Middle Orontes	high
AS141	Tell Tahune/ Tell el-Feraumiye	862253.2	3858439.5	5.5	LB, IA	Turri 2015	Middle Orontes	high
AS142	Tell el-Wasma	861570.9	3859020.7	1.5	LB, IA	Turri 2015	Middle Orontes	high
AS143	Tell Jandar	859931.9	3861535	3.9	LB	Turri 2015	Middle Orontes	high
AS144	Tell el-Basha	847433.4	3861730.4	1.5	LB, IA	Turri 2015	Middle Orontes	high
AS145	Tell Mijweiz	848373.6	3864233.4	3.8	LB, IA II	Turri 2015	Middle Orontes	high

ID	Name	UTM East (36N)	UTM North (36N)	Site Size (ha)	Occupation Periods	Source	Analysis Region	Placement Certainty
AS146	Tell Abu Qubeis	861530.4	3865154.9	N/A	LB, IA	Turri 2015	Middle Orontes	high
AS147	Tell Dhahabiye	850147.2	3868157.7	1.8	LB, IA II	Turri 2015	Middle Orontes	high
AS148	Tell Hajbah	859649	3867384.1	3.8	LB, IA II	Turri 2015	Middle Orontes	high
AS149	GeoSu19	854597.9	3872164.1	N/A	LB, IA	Turri 2015	Middle Orontes	high
AS150	Khirbet Tahounet el-Majma	854731.3	3872736.1	N/A	LB, IA II	Turri 2015	Middle Orontes	high
AS151	GeoSu30/ Rahm el-Kharj	854634.2	3872409.9	N/A	LB	Turri 2015	Middle Orontes	high
AS152	GeoSu28	852168.5	3875815.7	N/A	LB, IA	Turri 2015	Middle Orontes	high
AS153	GeoSu27	853548.7	3876558.2	2.5	LB, IA	Turri 2015	Middle Orontes	high
AS154	Tell er-Rayan	853232.8	3841234.9	N/A	LB, IA II	Turri 2015	Middle Orontes	high
AS155	Tell Aifir Tahtani	861604.6	3842226.7	0.3	LB	Turri 2015	Middle Orontes	high
AS156	Tell Zubeida	850074.1	3841793.2	1.2	LB, IA II	Turri 2015	Middle Orontes	high
AS157	Tell Qalayaa	854122.4	3849149.2	4.0	LB, IA II	Turri 2015	Middle Orontes	high
AS158	Tell Bissi	841257.6	3860933.1	N/A	LB, IA	Turri 2015	Middle Orontes	high
AS159	Zafraneya	844415.4	3866086.6	2.7	LB, IA II	Turri 2015	Middle Orontes	high
AS160	Tell es-Sur	880838.8	3860512.5	15.0	LB, IA II	Turri 2015	Middle Orontes	high
AS161	Tell Moukharam Tahtani	870115.4	3863808.5	1.6	LB, IA II	Turri 2015	Middle Orontes	high
AS162	Tell Khaznah (S)	865544.9	3867182.1	N/A	LB, IA II	Turri 2015	Middle Orontes	high
AS163	Tell Hassan Bacha	871589.5	3870383.1	1.2	LB, IA II	Turri 2015	Middle Orontes	high
AS164	Tell Hana	867585.6	3877469.4	9.0	LB, IA II	Turri 2015	Middle Orontes	high
AS165	Tell Arbid	868885.3	3873163.9	6.2	LB, IA II	Turri 2015	Middle Orontes	high
AS166	Tell Ghazali/ Salamiya	869969.3	3880511.9	6.0	LB	Turri 2015	Middle Orontes	high
AS167	Tell Mraj	844047.1	3872816	1.0	LB?, IA	Turri 2015	Middle Orontes	high
AS168	Masiyaf	804643.9	3885356.9	N/A	LB	Turri 2015	Middle Orontes	high
AS169	Tell Jamali	828961.1	3911473.8	7.0	LB, IA	Turri 2015	Middle Orontes	high

ID	Name	UTM East (36N)	UTM North (36N)	Site Size (ha)	Occupation Periods	Source	Analysis Region	Placement Certainty
AS170	Tell Dades	810773	3901584.5	12.0	LB?, IA	Turri 2015	Lower Orontes	high
AS171	Tell Sikkine Qade	815741.8	3905256.6	10.0	LB?, IA	Turri 2015	Lower Orontes	high
AS172	Tell Salhab	807650.9	3907043.5	4.0	LB	Turri 2015	Lower Orontes	high
AS173	Tell Ayun	820325.6	3908629.2	9.4	LB, IA	Turri 2015	Lower Orontes	high
AS174	Tell Malah	820223.5	3912781.2	6.3	LB, IA	Turri 2015	Lower Orontes	high
AS175	Khirbet Jessa	809432.3	3914603.5	N/A	LB, IA	Turri 2015	Lower Orontes	high
AS176	Tell Salba	813245.9	3915690.9	12.3	LB?	Turri 2015	Lower Orontes	high
AS177	Tell Sqalbiye	808265.9	3919140.7	15.0	LB, IA	Turri 2015	Lower Orontes	high
AS178	Tell Hamamiyate	821351.8	3920966.1	12.5	LB?, IA	Turri 2015	Lower Orontes	high
AS179	Tell Larji	823316.9	3930815	15.0	LB?, IA	Turri 2015	Lower Orontes	high
AS180	Tell esh-Sheikh Sultan	811698.4	3931391.7	2.3	LB	Turri 2015	Lower Orontes	high
AS181	Tell Faraji	847824.9	3938181.2	2.2	LB	Turri 2015	Middle Orontes	high
AS182	Tell Amqiye/ Aamqiye (S)	806797.1	3942729.4	6.1	LB?, IA, IA II	Turri 2015; Graff 2006	Lower Orontes	high
AS183	Rasm et-Tanjara	804159.4	3943275.1	13.0	LB, IA	Turri 2015	Lower Orontes	high
AS184	Tell el-Kerkh	813060.6	3969539.2	16.0	LB, IA	Turri 2015; Sauer nd.	Lower Orontes	high
AS185	Tell Hassane	814086	3970986.8	5.6	LB, IA	Turri 2015; Sauer nd.	Lower Orontes	high
AS186	Tell Dawud	814167.9	3973767.6	10.5	LB, IA	Turri 2015; Sauer nd.	Lower Orontes	high
AS187	Tell Nahri	816316.3	3977678	N/A	LB	Turri 2015	Northern Plateau	high
AS188	Tell Arri	817334.8	3980526.1	2.0	LB	Turri 2015	Northern Plateau	high
AS189	Tell Ezou	818843.8	3848594.4	N/A	LB	Haidar-Boustani et al. 2007	Middle Orontes	medium
AS190	Tell Frach	807648.4	3842459.6	0.8	IA	Haidar-Boustani et al. 2008	Akkar Plain	medium
AS191	Khirbat Samouni	810790.1	3837560.8	1.4	IA II	Haidar-Boustani et al. 2009	Akkar Plain	medium
AS192	Mazar Sheik Abed Rahman	812817.3	3851731.5	1.1	IA II	Haidar-Boustani et al. 2010	Middle Orontes	medium
AS193	Tell Barsuna	752118.1	3946467.4	N/A	LB	Lehmann 2002; CRANE	Northern Coast	high
AS194	Minat al-Bayda	750743.8	3943820.7	N/A	LB	Lehmann 2002; CRANE	Northern Coast	high

ID	Name	UTM East (36N)	UTM North (36N)	Site Size (ha)	Occupation Periods	Source	Analysis Region	Placement Certainty
AS195	Qalat Siryani	765423.9	3943049.6	0.9	LB	Lehmann 2002; CRANE	Northern Coast	high
AS196	Tell Jamqa	763987.6	3861904.2	N/A	LB?, IA	Lehmann 2002; CRANE	Central Coast	high
AS197	Tartous	763472.2	3863673	N/A	LB, IA	Lehmann 2002; CRANE	Central Coast	high
AS198	Qarnun	762622	3865778.7	N/A	IA?	Lehmann 2002; CRANE	Central Coast	high
AS199	Tell al-Daruk	763358.6	3869297.7	0.4	LB, IA	Lehmann 2002; CRANE	Jableh Plain	high
AS200	Qalat ar-Rus	764870.9	3923305.9	9.0	LB, IA II	Lehmann 2002; al-Maqdissi 2004	Jableh Plain	high
AS201	Tabbat al-Hammam	768800.1	3847173.3	0.9	LB, IA	Braidwood 1940; Lehmann 2002; CRANE	Akkar Plain	high
AS202	Tell Simiriyan/Tell Abu Ali	772636.9	3849329.6	2.8	LB, IA	Braidwood 1940; Lehmann 2002; CRANE	Akkar Plain	high
AS203	Arab al-Mulk	766142.1	3906371.5	N/A	LB, IA	Lehmann 2002; CRANE	Jableh Plain	high
AS204	Tell Siano	772800.4	3917696.1	10.0	LB, IA I	Lehmann 2002; al-Maqdissi 2004	Jableh Plain	high
AS205	al-Qadbun	797227.4	3888113.6	0.3	IA	Lehmann 2002; CRANE	Central Coast	high
AS206	Tell Bira	779644.4	3835975.5	1.5	LB?	Lehmann 2002; CRANE	Akkar Plain	high
AS207	Manjaz	797599.3	3835229.9	3.9	LB	Lehmann 2002; CRANE	Akkar Plain	high
AS208	Sheikh Zanad	774087.9	3833079	0.8	IA	Lehmann 2002; CRANE	Akkar Plain	high
AS209	Ard Artusi	772160.3	3823217.3	N/A	LB	Lehmann 2002; CRANE	Akkar Plain	high
AS210	Kafr Ruma	829312.9	3948835.9	N/A	IA?	Lehmann 2002; CRANE	Northern Plateau	high
AS211	Tell Mennis	839195.4	3951980.1	2.9	LB, IA	De Maigret 1978; Mantellini et al. 2013; CRANE	Northern Plateau	high
AS212	Tell Ras el-‘Ain	859191.1	3969865.4	N/A	LB	De Maigret 1978; Mantellini et al. 2013; CRANE	Northern Plateau	high
AS213	Tell Damm	853205.8	3943766.5	2.0	LB, IA	De Maigret 1978; Mantellini et al. 2013; CRANE	Northern Plateau	high
AS214	Tell Sheikh Fares	862248.6	3965759.1	2.5	LB, IA	De Maigret 1978; Mantellini et al. 2013; CRANE	Northern Plateau	high
AS215	Tell Tawil	861859.2	3978480.4	3.0	LB	De Maigret 1978; Mantellini et al. 2013; CRANE	Northern Plateau	high

ID	Name	UTM East (36N)	UTM North (36N)	Site Size (ha)	Occu-pation Periods	Source	Analysis Region	Placement Certainty
AS216	Tell Hader	864547.5	3990161.8	7.0	LB	De Maigret 1978; Mantellini et al. 2013; CRANE	Northern Plateau	high
AS217	Tell Ghadfah	842794.3	3954306.3	N/A	IA	De Maigret 1978; Mantellini et al. 2013; CRANE	Northern Plateau	high
AS218	Tell Surman	848462.9	3947842.9	6.4	IA	De Maigret 1978; Mantellini et al. 2013; CRANE	Northern Plateau	high
AS219	Tell Farwan	851742.8	3955020.1	1.0	IA	De Maigret 1978; Mantellini et al. 2013; CRANE	Northern Plateau	high
AS220	Tell Qatrah	851425.5	3953101.6	0.8	IA	De Maigret 1978; Mantellini et al. 2013; CRANE	Northern Plateau	high
AS221	Tell Sha‘rah	853894.7	3951556	N/A	IA	De Maigret 1978; Mantellini et al. 2013; CRANE	Northern Plateau	high
AS222	Tell ‘Aiaz/ A‘jaz	855680.6	3949285.2	4.0	IA	De Maigret 1978; Mantellini et al. 2013; CRANE	Northern Plateau	high
AS223	Tell Talafeh	856924.6	3979125.5	N/A	IA	De Maigret 1978; Mantellini et al. 2013; CRANE	Northern Plateau	high
AS224	Tell ‘Augiah	867047.4	3953681.1	1.8	IA	De Maigret 1978; Mantellini et al. 2013; CRANE	Northern Plateau	medium
AS225	Tell Sheikh Barakah	860176.3	3942315.6	4.5	IA	De Maigret 1978; Mantellini et al. 2013; CRANE	Northern Plateau	high
AS226	Tell Nuwaz	838735.7	4004459.2	1.6	LB, IA	Mazzoni 2005	Northern Plateau	high
AS227	Tell Serji	851373.8	3994353.5	0.7	LB, IA	Mazzoni 2005	Northern Plateau	medium
AS228	Tell Shillak	841783.5	3992905.5	N/A	LB, IA	Mazzoni 2005	Northern Plateau	high
AS229	Tell Zerdene	838491.4	3995460.5	N/A	LB, IA	Mazzoni 2005	Northern Plateau	medium
AS230	Tell Sandal	837522.4	3997697.4	N/A	LB, IA	Mazzoni 2005	Northern Plateau	high
AS231	Tell Walad Khalil	833419.9	3992799.3	1.0	LB, IA	Mazzoni 2005	Northern Plateau	high
AS232	Tell Selih Zohour	805129.3	3961425.1	2.2	IA	Graff 2006	Lower Orontes	high
AS233	Tell Eneb	810610.7	3959651	2.6	IA II	Graff 2006	Lower Orontes	high
AS234	Ain el Lidjj	809619.7	3954782.9	N/A	IA	Graff 2006	Lower Orontes	high
AS235	Tell Qastoun Kebir	806570.6	3954453.9	14.7	IA	Graff 2006	Lower Orontes	high
AS236	Tell Qastoun Sehrir	806340.8	3954326.6	4.1	IA	Graff 2006	Lower Orontes	high

ID	Name	UTM East (36N)	UTM North (36N)	Site Size (ha)	Occupation Periods	Source	Analysis Region	Placement Certainty
AS237	Tell Wasit	802620.3	3950966.7	3.3	IA I, IA II	Graff 2006	Lower Orontes	high
AS238	Tell Rasm Kebir	804933.1	3949680.9	3.0	IA	Graff 2006	Lower Orontes	high
AS239	Tell Meleh 1	804749.9	3950660	N/A	IA II	Graff 2006	Lower Orontes	high
AS240	Tell Meleh 2	804734.1	3950542.7	3.5	IA	Graff 2006	Lower Orontes	high
AS241	Tel Rasm Kumeiti	803381.6	3951860.2	1.4	IA	Graff 2006	Lower Orontes	high
AS242	Tell Makbara	803190.9	3952192.3	0.5	IA	Graff 2006	Lower Orontes	high
AS243	Tell Hamaymat	808782.5	3952149.5	N/A	IA	Graff 2006	Lower Orontes	high
AS244	Tell Jabani	810143	3949079.2	N/A	IA	Graff 2006	Lower Orontes	high
AS245	Tell Rasm Shakra	805566.1	3948704.2	1.9	LB?, IA	Graff 2006	Lower Orontes	high
AS246	Tell Bahira/ Tell Hizareen 1	805329.1	3948367	0.2	IA	Graff 2006	Lower Orontes	high
AS247	Tell Massus	801210.8	3939996	0.2	IA	Graff 2006	Lower Orontes	high
AS248	Tell Qleidin	806623.2	3946266	2.5	IA	Graff 2006	Lower Orontes	high
AS249	Tell Mabtuhah (S)	805155.5	3947141.6	4.8	IA	Graff 2006	Lower Orontes	high
AS250	Tell Mabtuhah (N)	805088.5	3947252.8	6.9	IA I, IA II	Graff 2006	Lower Orontes	high
AS251	Tell Chleil 1	801037.2	3948532.6	3.2	IA	Graff 2006	Lower Orontes	high
AS252	Tell Rasm Chanzuri	805173.2	3943585.5	1.9	IA	Graff 2006	Lower Orontes	high
AS253	Rasm Badzuri 1	804749.6	3942315.7	3.2	IA II	Graff 2006	Lower Orontes	high
AS254	Rasm Badzuri 3	804653.9	3942273.8	N/A	IA	Graff 2006	Lower Orontes	high
AS255	Rasm Badzuri 2	804925.8	3942155.1	0.9	IA I, IA II	Graff 2006	Lower Orontes	high
AS256	Aamqiye (N)	806804	3942961.3	3.8	IA	Graff 2006	Lower Orontes	high
AS257	Tell Bahasa	796985.3	3952989.3	0.9	LB, IA	Graff 2006	Lower Orontes	high
AS258	Tell Ziyara	802333.3	3953955	0.7	IA II	Graff 2006	Lower Orontes	high
AS259	Tell Khirbet Um Amoud	806714.4	3964000.1	N/A	IA II	Graff 2006	Lower Orontes	high
AS260	Tell Arnaba	813186.4	3956122.9	3.8	IA I, IA II	Graff 2006	Lower Orontes	high

ID	Name	UTM East (36N)	UTM North (36N)	Site Size (ha)	Occupation Periods	Source	Analysis Region	Placement Certainty
AS261	Qala‘at Merza	795457.9	3950925.6	N/A	IA	Graff 2006	Lower Orontes	high
AS262	Rams Camp Alman	797813.2	3956949.7	1.6	IA	Graff 2006	Lower Orontes	high
AS263	Tell Camp Alman	796851.9	3957132.3	3.1	IA	Graff 2006	Lower Orontes	high
AS264	Dahar al-Sheer	797188.3	3959722.6	N/A	IA	Graff 2006	Lower Orontes	high
AS265	Jib el-Teen	803027.2	3965678.3	2.5	IA I, IA II	Graff 2006	Lower Orontes	high
AS266	Sheikh Said	799835.2	3963842.7	N/A	IA II	Graff 2006	Lower Orontes	high
AS267	Tell et-Tell	800709.4	3968886.7	17.5	IA II	Graff 2006	Lower Orontes	high
AS268	Daharat Jura Hamami	798487.4	3966207.6	N/A	IA II	Graff 2006	Lower Orontes	high
AS269	Melih 4	804448.8	3950060.2	N/A	IA	Graff 2006	Lower Orontes	high
AS270	Tell Zahrat	799452.2	3963355.2	4.4	IA II	Graff 2006	Lower Orontes	high
AS271	Site 95	800207.1	3965966.3	N/A	IA II	Graff 2006	Lower Orontes	high
AS272	Tell Iris	771379.5	3915910.3	2.0	LB	al-Maqdissi and Souleiman 2004	Jableh Plain	medium

APPENDIX 2
FAO CLIMATE STATION DATA

Station Identifiers						Station Data												
Map ID	Station ID	Station Name	Long	Lat	Elevation (m)		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CS1	LB46BD00	Abde	36	34.52	15	Max Temp (°C)	16.8	17.6	19.4	22	24.8	27.6	28.7	29.6	28.8	26.6	23.7	18.7
						Min Temp (°C)	9.1	9.5	11	13.2	16.2	19.6	21.6	22.4	21.6	18.2	14.2	10.2
						Mean Temp (°C)	13	13.5	15.2	17.6	20.4	23.6	25.2	26	25.2	22.4	19	14.4
						Precipitation (mm)	185	130	114	55	15	1	0	1	9	84	100	219
						Evaporation (mm)	12.7	12.8	14.3	16.5	20.1	25.3	27.9	29.2	26.3	21.9	17.8	13.3
CS2	SY56MMRN	Ammourine	36.35	35.3	175	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)	6.6	8.8	12.6	16.8	21.2	26.3	28.4	27.8	24	19.5	13.3	9.1
						Precipitation (mm)	111	96	66	32	19	2	0	0	8	23	27	104
						Evaporation (mm)												
CS3	SY56NNZH	Annazah	36.05	35.17	620	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	25	221	174	101	54	7	2	1	18	71	138	275
						Evaporation (mm)												
CS4	SY56RH00	Ariha	36.6	35.8	750	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	97	101	67	36	18	7	0	0	8	22	40	112
						Evaporation (mm)												
CS5	SY66RMNZ	Armanaz	36.08	36.48	250	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	117	121	79	56	19	11	0	0	13	26	43	126
						Evaporation (mm)												

Station Identifiers						Station Data												
Map ID	Station ID	Station Name	Long	Lat	Elevation (m)		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CS6	SY58BLNH	Bailaneh	35.92	38.72	268	Max Temp (°C)	11.2	14	18.8	24.4	30.4	5.2	38	37.7	34.6	28	20	12.7
						Min Temp (°C)	0.8	2.1	5.5	9.5	14.3	18.2	20.6	20.4	16.8	11	5.2	1.7
						Mean Temp (°C)	6	8.1	12.1	16.9	22.3	26.7	29.3	29.1	25.7	19.8	12.6	7.2
						Precipitation (mm)	33	22	40	26	25	0	0	0	1	13	16	33
						Evaporation (mm)	30.5	43.3	81.6	124.7	182.7	251.6	287.2	249.3	175.5	104.4	53.1	29.8
CS7	SY55BNS0	Banias	35.93	35.17	30	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	146	164	124	38	27	0	0	0	6	41	88	207
						Evaporation (mm)												
CS8	SY57BRDH	Bardah	37.17	35.92	300	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	47	46	35	40	15	1	0	0	3	15	22	52
						Evaporation (mm)												
CS9	SY55BK00	Bouka	35.8	35.53	50	Max Temp (°C)	15	16	18.3	21.9	25.2	28.3	29.9	31.4	30.3	27.5	22.7	16.6
						Min Temp (°C)	7.1	7.7	9.7	12.5	15.4	19.4	22.2	22.5	20.5	17.2	13	9.1
						Mean Temp (°C)	11.1	11.9	14	17.2	20.3	23.9	26.1	26.9	25.4	22.3	17.9	12.9
						Precipitation (mm)	177	132	90	51	32	7	2	5	16	62	94	209
						Evaporation (mm)	9.4	9.9	11.3	14.1	17.4	21.3	25	25.9	22.7	18	13.3	10.6
CS10	SY46BRJ0	Breij	36.75	34.23	1120	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	34	23	16	19	19	0	0	0	2	23	22	25
						Evaporation (mm)												

Station Identifiers						Station Data												
Map ID	Station ID	Station Name	Long	Lat	Elevation (m)		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CS11	SY56DRKS	Darkush	36.38	35.97	225	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	129	115	81	47	12	1	0	0	11	25	53	131
						Evaporation (mm)												
CS12	SY46DRKS	Dreikeesh	36.13	34.88	650	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	230	189	166	114	26	1	0	4	27	54	120	270
						Evaporation (mm)												
CS13	SY56DLB0	Edleb (Idlib)	36.62	35.93	451	Max Temp (°C)	10	12.2	16.8	21.9	27.2	31	32.6	33.6	31.1	26.2	18.9	12.1
						Min Temp (°C)	2.9	3.6	6.7	10.7	14.5	19	21	21.5	19.2	14.8	8.7	4.5
						Mean Temp (°C)	6.5	7.9	11.3	16.3	20.9	25	26.8	27.5	25.1	20.5	13.8	8.3
						Precipitation (mm)	100	92	59	43	16	4	0	1	5	23	39	97
						Evaporation (mm)	7.7	7.9	8.7	10.9	12.8	14.9	18.9	18.4	16.2	13	9.9	8.6
CS14	SY56ND00	Ein-Eido	36.03	35.67	500	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	199	188	157	92	36	12	24	4	35	64	108	259
						Evaporation (mm)												
CS15	SY56NLKR	Ein el-Kroum	36.25	35.3	550	Max Temp (°C)	11.1	13	17.4	22.7	26.2	31.3	32.7	33.1	32	26.7	19.7	12.7
						Min Temp (°C)	4.3	5	8	10.8	14.9	19.2	23.3	22.6	18.8	14.1	8.9	5
						Mean Temp (°C)	7.7	9	12.7	16.6	20.5	25.5	28	27.9	25.4	20.4	14.3	8.9
						Precipitation (mm)	284	253	233	145	48	11	1	8	20	67	122	316
						Evaporation (mm)	8.4	8.4	9.5	11	12.3	13.4	15.1	16.2	15.2	14.9	11.9	9.1

Station Identifiers						Station Data												
Map ID	Station ID	Station Name	Long	Lat	Elevation (m)		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CS16	SY56LHD0	el-Jeed	36.32	35.55	165	Max Temp (°C)	11.1	13.1	17.8	23.1	28.5	32.7	34.4	34.5	32.8	27.2	20	12.7
						Min Temp (°C)	3	4	6.7	8.8	12.5	16.5	19.7	18.6	14.6	11	6.3	3.6
						Mean Temp (°C)	7.1	8.5	12.3	15.9	20.5	24.6	27.1	26.5	23.7	19.1	13.1	8.1
						Precipitation (mm)	149	99	124	66	56	19	0	1	19	40	61	178
						Evaporation (mm)	8.3	8.7	10.7	11.9	14	15.2	15.8	17.3	16.4	14.6	11.6	9
CS17	SY68LKHF	el-Khafseh	36.2	38.07	337	Max Temp (°C)	11.4	13.2	18.1	23.7	30.1	35.3	38	37.9	33.9	27.5	20.5	13.2
						Min Temp (°C)	2	2.4	5.1	8.8	13.6	18.1	20.4	20.4	16.2	11	6.2	3.1
						Mean Temp (°C)	6.7	7.8	11.6	16.3	21.9	26.7	29.2	29.1	25.1	19.3	13.3	8.1
						Precipitation (mm)	56	27	27	26	13	1	0	0	1	17	22	41
						Evaporation (mm)	33	43.7	82.2	122.5	190	265.3	306.1	282.1	196	113.2	60.4	34.5
CS18	SY56LRG0	el-Rouge	36.42	35.9	220	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)	6.4	8.7	12.8	17	22.4	25.8	28	28.6	25.6	21.4	14.2	9.5
						Precipitation (mm)	116	112	75	50	15	9	0	0	3	38	48	117
						Evaporation (mm)												
CS19	SY55LSN0	el-Sin	35.95	35.23	40	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	163	133	127	60	28	6	3	0	12	45	100	191
						Evaporation (mm)												
CS20	SY47FRKL	Friklos	37.08	34.6	673	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	38	32	25	21	16	0	0	0	0	18	21	36
						Evaporation (mm)												

Station Identifiers						Station Data												
Map ID	Station ID	Station Name	Long	Lat	Elevation (m)		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CS21	LB46HLB0	Halbe	36.05	34.52	160	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	180	133	93	53	14	1	1	1	6	27	103	131
						Evaporation (mm)												
CS22	SY56HM00	Hama	36.72	35.13	309	Max Temp (°C)	12	14.3	18	23.6	29.5	34.5	36.5	37.1	33.6	28.3	20.6	13.6
						Min Temp (°C)	3.5	4.1	6.3	9.8	13.9	18.3	20.4	20.6	17.7	13.2	7.9	5
						Mean Temp (°C)	7.3	8.7	11.8	16.3	21.6	26.3	28.3	28.5	25.2	20.3	13.7	8.8
						Precipitation (mm)	66	56	42	23	14	7	0	0	0	16	38	46
						Evaporation (mm)	8.5	7.8	8.1	10.5	10.8	12.7	13.8	14.9	13.4	11.5	10.6	8.8
CS23	SY46HS00	Hassia	36.75	34.37	625	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)	5.1	6.9	11	14.9	19.2	21.8	23.3	23.2	21	18.3	12.9	8.4
						Precipitation (mm)	28	31	16	12	21	1	0	0	4	16	16	25
						Evaporation (mm)												
CS24	SY56HWRT	Hawret Amoureen	36.37	35.32	175	Max Temp (°C)	12.1	14.5	18.3	23.5	29.3	33.7	35.2	35.6	32.9	28.3	21.3	13.3
						Min Temp (°C)	4	4.5	6.6	9.3	12.5	16.9	19.3	18.9	15.4	11.1	6.8	4.8
						Mean Temp (°C)	8.1	9.5	12.5	16.4	20.9	25.3	27.3	27.2	24.1	19.7	14.1	9.1
						Precipitation (mm)	115	86	68	37	16	1	0	0	6	19	37	117
						Evaporation (mm)	8.9	9	9.9	11.4	12.6	13.5	14.1	16.3	15.3	13.3	10.9	9.5
CS25	LB46HRML	Hermel	36.87	34.37	750	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	55	43	36	27	13	1	1	1	1	8	22	44
						Evaporation (mm)												

Station Identifiers						Station Data												
Map ID	Station ID	Station Name	Long	Lat	Elevation (m)		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CS26	SY46HMS0	Homs	36.72	34.75	485	Max Temp (°C)	11.3	13.1	17.1	21.7	26.9	30.7	32	32.8	31.3	26.8	19.6	12.6
						Min Temp (°C)	2.3	4.4	5.6	9.2	12.7	17.1	19.1	19.6	16.9	11.9	7.1	3.7
						Mean Temp (°C)	6.8	8.7	11.3	15.5	19.8	23.9	25.5	26.2	24.1	19.3	13.3	8.1
						Precipitation (mm)	105	88	64	45	17	1	0	0	4	15	46	95
						Evaporation (mm)	8.2	8.4	9.6	11.8	13.6	15.7	19.7	20.7	18.3	13.7	10.5	8.7
CS27	SY67JBBL	Jabboul	36.07	37.48	330	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	62	51	27	38	22	3	0	0	1	17	17	55
						Evaporation (mm)												
CS28	SY56JSRL	Jisr el-Shoggour	36.32	35.82	200	Max Temp (°C)	12.3	14.4	18.6	23.2	28.3	31.7	33.1	34	32	27.9	20.8	13.5
						Min Temp (°C)	4.6	4.7	7.8	10.2	14.3	19.4	23.2	22.7	18.5	12.5	7.5	5.1
						Mean Temp (°C)	8.5	9.6	13.2	16.7	21.3	25.6	28.1	28.3	25.3	20.2	14.1	9.3
						Precipitation (mm)	148	125	87	47	18	8	0	1	11	35	55	147
						Evaporation (mm)	8.9	9.2	10.3	12.5	13.9	15.8	18.2	18.5	16.8	15.4	12.4	9.7
CS29	SY56JRN0	Jooreen	36.25	35.6	500	Max Temp (°C)	11.6	13.6	17.6	22.6	28.5	32.9	34.7	34.7	33	26.5	20.1	12.8
						Min Temp (°C)	4	4.6	6.8	8.5	12.9	18.4	22.5	21.5	16.2	11.4	7.1	5
						Mean Temp (°C)	7.8	9.1	12.2	15.5	20.7	25.7	28.6	28.2	24.6	18.9	13.6	8.9
						Precipitation (mm)	222	166	141	86	35	22	0	6	30	52	76	208
						Evaporation (mm)	8.6	9	10.2	11.6	13.7	13.2	13.7	15.7	15.5	14	11.8	9.8
CS30	SY55KRTT	Karatat	35.85	35.82	50	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	157	142	110	55	35	6	2	6	25	73	118	229
						Evaporation (mm)												

Station Identifiers						Station Data												
Map ID	Station ID	Station Name	Long	Lat	Elevation (m)		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CS31	SY55KSSB	Kassab	35.97	35.92	730	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	272	265	216	109	51	21	11	13	38	92	134	355
						Evaporation (mm)												
CS32	SY56KHNS	Khan Sheikuun	36.62	35.43	400	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	78	60	47	30	17	2	0	0	6	19	28	79
						Evaporation (mm)												
CS33	SY57KHNS	Khanasser	37.48	35.77	350	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)	6.1	8.5	12.3	16.5	22.7	27	29	29.8	25.4	21	13.7	8.1
						Precipitation (mm)	41	41	32	35	12	2	0	0	2	8	18	40
						Evaporation (mm)												
CS34	SY46KHRB	Khirb el-Teen	36.53	34.68	600	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	143	111	67	56	15	1	0	0	2	23	49	145
						Evaporation (mm)												
CS35	SY55LTTK	Lattakia	35.77	35.53	7	Max Temp (°C)	15.6	16.6	18.9	21.8	24.9	27.7	29.6	30.5	29.4	27	22.5	17.4
						Min Temp (°C)	8.7	9.2	11.5	14.1	17.6	21.1	23.8	24.2	22.3	18.7	14.2	10.1
						Mean Temp (°C)	10.7	11.9	14.3	17.3	20.2	23.6	26.2	26.8	25.2	21.9	17.2	12.9
						Precipitation (mm)	158	121	91	43	24	6	3	3	13	71	95	162
						Evaporation (mm)	8.9	9.2	11.1	13.6	17.6	22.2	25.5	26	22.2	17.1	11.6	9.9

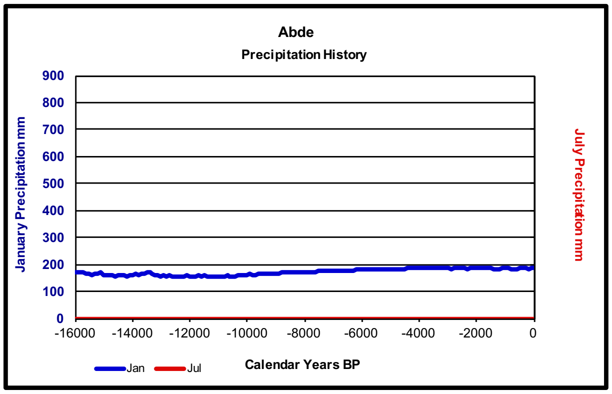
Station Identifiers						Station Data												
Map ID	Station ID	Station Name	Long	Lat	Elevation (m)		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CS36	SY56MRTL	Maret el-Numan	36.65	35.63	496	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)	4.5	6.5	10.4	15	21	25.5	28.4	28.5	24.1	18.8	11.7	7.3
						Precipitation (mm)	85	70	55	30	19	7	0	0	3	19	33	81
						Evaporation (mm)												
CS37	SY46MSHT	Mashtal Hilu	36.25	34.87	200	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	200	187	175	96	29	0	0	3	19	58	115	243
						Evaporation (mm)												
CS38	SY56MSSF	Massiaf	36.33	35.05	530	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	269	229	210	96	42	7	0	1	4	45	110	261
						Evaporation (mm)												
CS39	SY55MNLB	Mina el-Beida	35.75	35.55	8	Max Temp (°C)	15.4	16.6	18.5	21.5	24.5	27.8	29.7	30.9	29.5	26.8	22.4	17.5
						Min Temp (°C)	8.4	8.8	10.2	12.6	15.4	19.1	21.7	22.7	20.4	17	13.3	10.5
						Mean Temp (°C)	11.8	12.6	14.7	17.1	20.3	23.9	26.2	27	25	21.8	17.8	13.9
						Precipitation (mm)	160	111	85	29	30	9	1	6	31	67	99	231
						Evaporation (mm)	9.2	9.7	11.5	13.8	17.6	21.3	24.8	26	21.8	17.2	12.6	10.6
CS40	SY46NBK0	Nabk	36.72	34.03	1333	Max Temp (°C)	7.9	9.5	13.2	17.8	22.8	27.9	30.3	30.6	26.4	21.5	15	10.6
						Min Temp (°C)	-1.1	-0.6	1.2	4.5	8.2	12	13.8	14.3	11.1	8	4.2	1
						Mean Temp (°C)	3	4.2	7.1	11.3	15.5	20.2	22.2	22.2	18.4	14.3	9.1	5.3
						Precipitation (mm)	26	21	13	16	11	1	0	0	2	12	18	24
						Evaporation (mm)	5.8	5.7	6	7	8.4	9.5	10.4	10.7	10.4	9.1	7.4	6.6

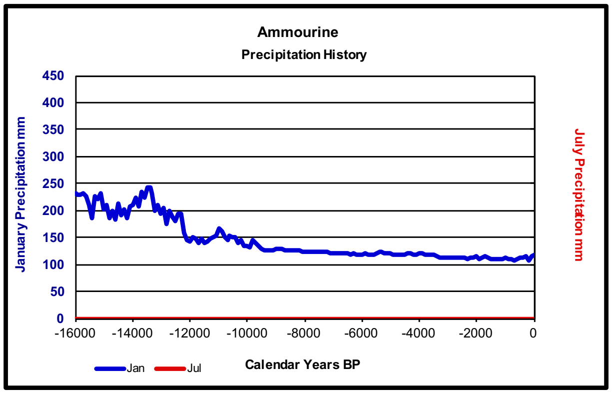
Station Identifiers						Station Data												
Map ID	Station ID	Station Name	Long	Lat	Elevation (m)		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CS41	SY48PLMY	Palmyra	34.55	38.3	404	Max Temp (°C)	11.9	14.7	19.1	24.9	30.5	35.2	37.9	37.6	34.4	28	19.9	13.6
						Min Temp (°C)	2.1	3.8	6.8	11.4	15.8	19.3	21.3	21.2	19	13.8	7.5	3.5
						Mean Temp (°C)	6.7	9	12.8	17.9	23.1	27.3	29.4	29	26.2	20.5	13.2	8.2
						Precipitation (mm)	20.6	19.9	21.1	20.8	6.9	0.2	0	0	0.1	10.8	14.2	21.1
						Evaporation (mm)	44.6	64.1	117.1	176.5	253.6	326.1	382.8	350.6	254.6	160.1	78.3	46.6
CS42	SY46QTTN	Qattineh	35.63	34.67	500	Max Temp (°C)	10.7	12.4	15.7	20.2	24.6	27.4	28.1	29.3	28.4	25.4	19.4	12.8
						Min Temp (°C)	3.1	3.5	5.9	9.4	13	17.3	19.9	20.2	17.1	12.8	7.7	4.3
						Mean Temp (°C)	6.9	8.1	10.9	14.8	18.9	22.3	23.6	24.2	22.5	19.1	13.4	8.3
						Precipitation (mm)	102	60	46	24	13	0	0	0	2	16	26	94
						Evaporation (mm)	8.2	8.4	9.7	12.1	14.8	18	20.9	22	19	14.3	10	8.8
CS43	LB46QLTR	Qlaiaat Aeroport	36	34.58	6	Max Temp (°C)	15.7	17.2	18.5	21.5	23.6	26.9	29.3	30.4	29.7	27.6	22.3	17.4
						Min Temp (°C)	6.7	8.9	9.9	12.4	14.8	18.6	21.1	22	20.6	17.3	12.8	9.6
						Mean Temp (°C)	11.5	13.2	14.4	17.4	20	23.8	26.3	27.1	25.7	22.5	17.5	13.3
						Precipitation (mm)	208	124	110	48	18	1	1	1	13	25	110	157
						Evaporation (mm)	10	11.2	12	14.7	18.5	23	26.3	26.2	23.1	18.3	14.2	11.3
CS44	SY46SDD0	Sadad	36.92	34.3	800	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	37	24	20	11	8	0	0	0	3	22	21	31
						Evaporation (mm)												
CS45	SY46SFT0	Safita	36.13	34.82	359	Max Temp (°C)	13.3	14.2	16.8	20.7	24.6	28.1	29.1	30.1	28.9	26.2	21.2	15.4
						Min Temp (°C)	6.1	7.5	9.6	12.8	15.9	19	20.9	21.6	20.1	17.5	14.2	9.5
						Mean Temp (°C)	9.7	10.7	13	16.4	20	23.3	24.6	25.3	24	21.4	17.3	12.2
						Precipitation (mm)	215	217	159	108	22	0	2	5	40	76	135	240
						Evaporation (mm)	8.5	8.9	10.2	12.3	15.4	18.9	22.6	23.5	20	15.5	11.1	9.7

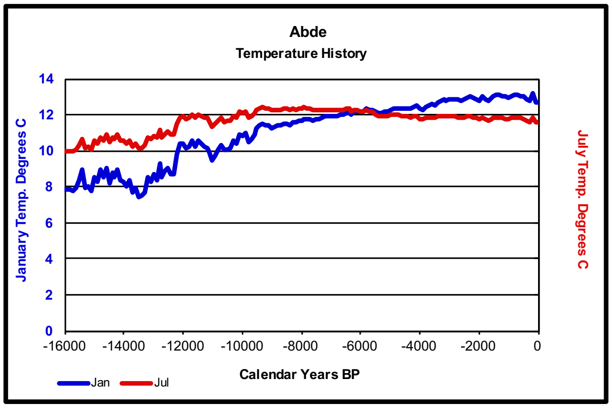
Station Identifiers						Station Data												
Map ID	Station ID	Station Name	Long	Lat	Elevation (m)		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CS46	SY57SLMY	Salamiyeh	37.03	35	480	Max Temp (°C)	11.4	13.3	17.4	22.4	28.6	33.5	35.1	35.6	32.6	27.3	19.3	12.7
						Min Temp (°C)	1.2	2.2	4.4	7	11.4	15.2	17.6	17.6	14.5	10.4	5.1	2.6
						Mean Temp (°C)	6.3	7.7	10.9	14.7	19.9	24.3	26.3	26.6	23.5	18.9	12.2	7.7
						Precipitation (mm)	63	52	42	35	15	2	0	0	2	10	30	58
						Evaporation (mm)	8	8.2	9.1	10.4	12.3	13.7	16.8	17.7	15.3	12.4	9.7	8.6
CS47	SY67SFRH	Sfeerah	36.7	37.35	40	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)												
						Evaporation (mm)	61	48	32	37	18	2	0	0	0	14	12	65
CS48	SY45SHKR	Shoukran	35.93	34.73	500	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	218	217	192	96	44	14	11	12	34	75	120	269
						Evaporation (mm)												
CS49	LB465SRDD	Sir ed-Denniye	36.02	34.37	915	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	264	196	178	68	24	1	1	1	8	43	116	201
						Evaporation (mm)												
CS50	SY56SLNF	Slenfeh	36.18	35.6	1100	Max Temp (°C)	6.5	7.3	10.6	15	19.3	22.5	24	25.2	23.2	19.6	14.7	9.4
						Min Temp (°C)	1.6	1.5	4	7.4	10.9	14.2	16	16.9	14.7	12	8.2	2.8
						Mean Temp (°C)	4.1	4.4	7.3	11.2	15.1	18.3	20	21.1	18.9	15.8	11.5	6.1
						Precipitation (mm)	220	207	231	128	56	27	8	7	34	67	105	273
						Evaporation (mm)	6.7	6.6	7.7	9	11	13.2	15.7	16.3	14.2	10.9	8.7	7.2

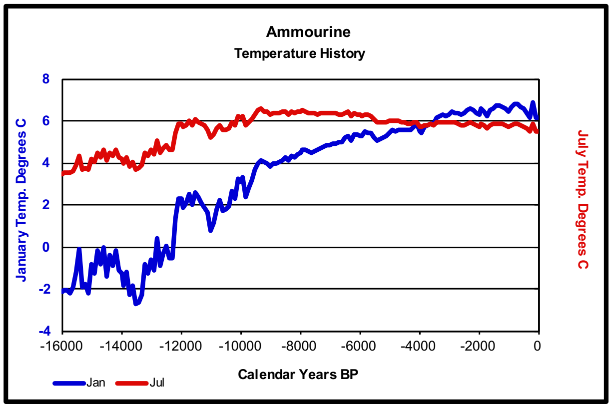
Station Identifiers						Station Data												
Map ID	Station ID	Station Name	Long	Lat	Elevation (m)		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
CS51	SY45TRTS	Tartous	35.88	34.88	5	Max Temp (°C)	15.9	16.4	18.7	22	25.3	27.8	29.4	30.1	29.2	26.8	23.1	18
						Min Temp (°C)	8.7	8.8	10.4	12.8	15.8	19.2	21.8	22.4	20.4	20	13.9	10.3
						Mean Temp (°C)	12.3	12.6	14.5	17.4	20.5	23.5	25.2	26.3	24.8	23.4	18.5	14.1
						Precipitation (mm)	183	135	122	66	19	1	0	1	15	56	102	185
						Evaporation (mm)	9.7	9.8	11.4	13.5	16.6	20.6	24	25.3	21.9	19	12.8	10.9
CS52	LB45TRPL	Tripolis	35.8	34.45	6	Max Temp (°C)	16.5	16.9	18.6	21.1	24.6	27.1	29.3	30.2	29.5	27.1	23.8	18.9
						Min Temp (°C)	9.5	9.8	11.1	13.7	17.1	19.8	22.1	23	21.5	18.8	15.4	10.9
						Mean Temp (°C)	12.8	13.3	14.9	17.5	21.3	24	26.2	27.1	25.7	22.8	19	14.6
						Precipitation (mm)	169	122	108	48	15	3	1	1	7	66	112	167
						Evaporation (mm)	10.5	10.6	12.4	15	18.8	23.2	25.9	25.7	23.2	19.7	13.9	11.3
CS53	SY55WDKN	Wadi Kandil	35.85	35.72	150	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)	168	168	116	49	39	8	2	10	39	64	100	253
						Evaporation (mm)												
CS54	SY36YBRD	Yabrud	33.95	36.63	1430	Max Temp (°C)												
						Min Temp (°C)												
						Mean Temp (°C)												
						Precipitation (mm)												
						Evaporation (mm)	29	24	20	14	12	0	0	0	2	17	21	31

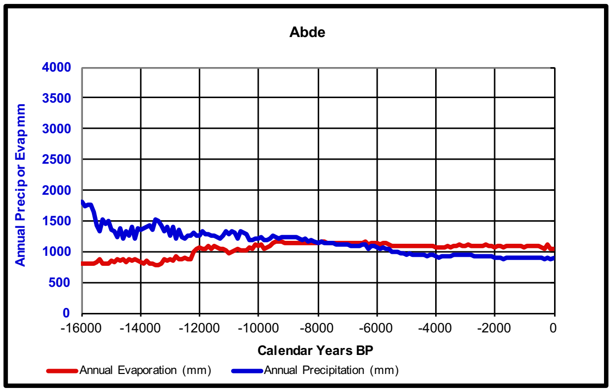
APPENDIX 3
MACROPHYSICAL CLIMATE MODELING OUTPUT DATA

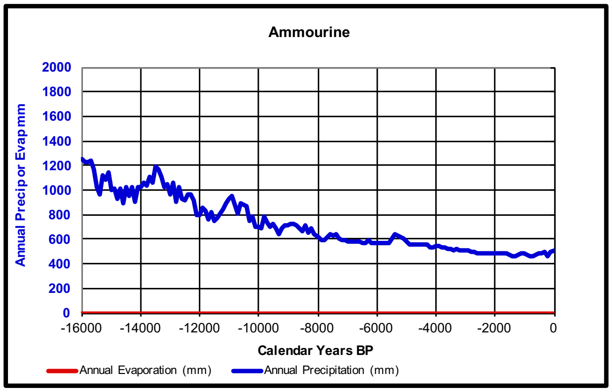

Abde
Precipitation History
January Precipitation mm
July Precipitation mm
900
800
700
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

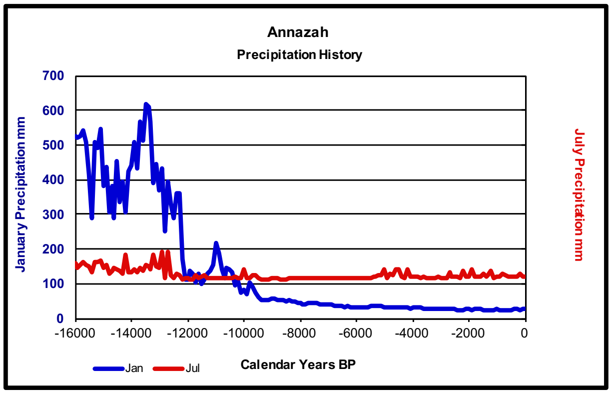

Ammourine
Precipitation History
January Precipitation mm
July Precipitation mm
450
400
350
300
250
200
150
100
50
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

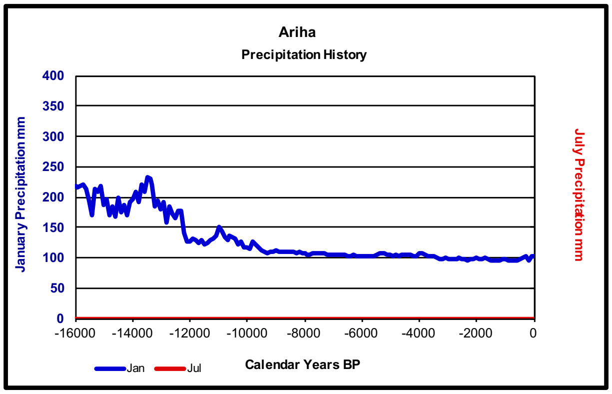

Abde
Temperature History
January Temp. Degrees C
July Temp. Degrees C
14
12
10
8
6
4
2
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

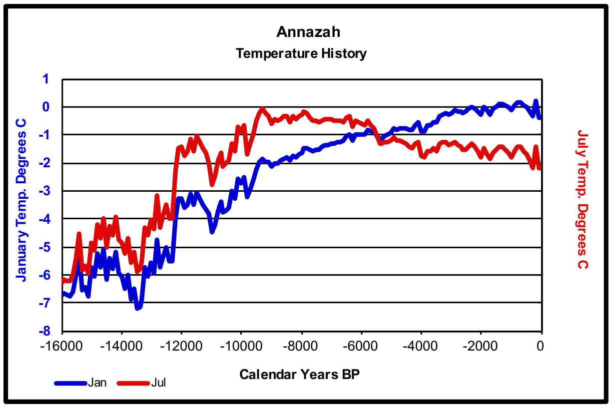

Ammourine
Temperature History
January Temp. Degrees C
July Temp. Degrees C
8
6
4
2
0
-2
-4
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

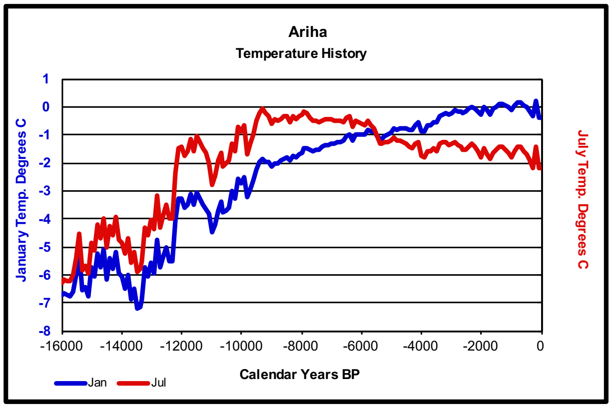

Abde
Annual Precip or Evap mm
4000
3500
3000
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

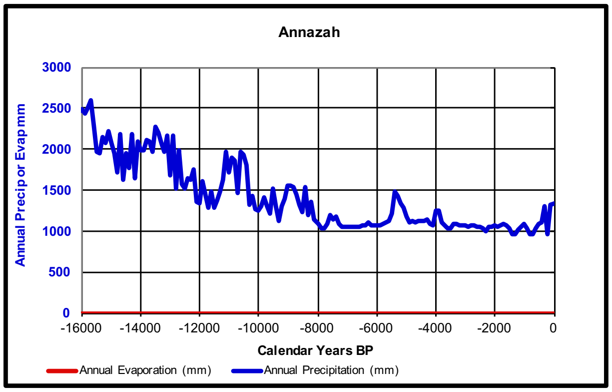

Ammourine
Annual Precip or Evap mm
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

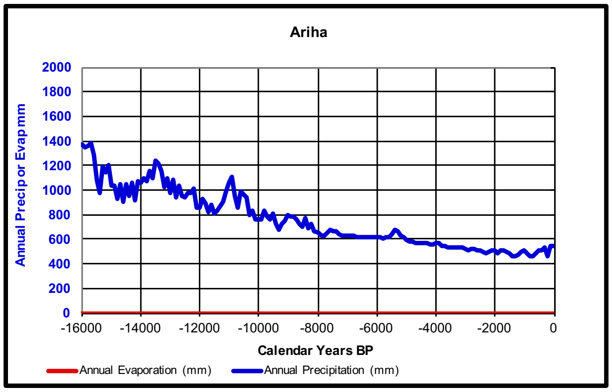

Annazah
Precipitation History
January Precipitation mm
July Precipitation mm
0
100
200
300
400
500
600
700
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

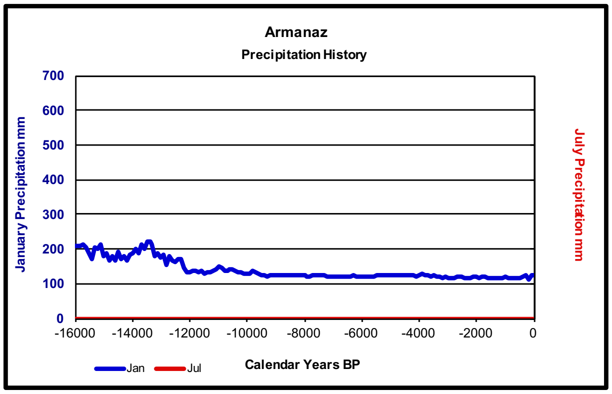

Ariha
Precipitation History
January Precipitation mm
July Precipitation mm
0
50
100
150
200
250
300
350
400
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

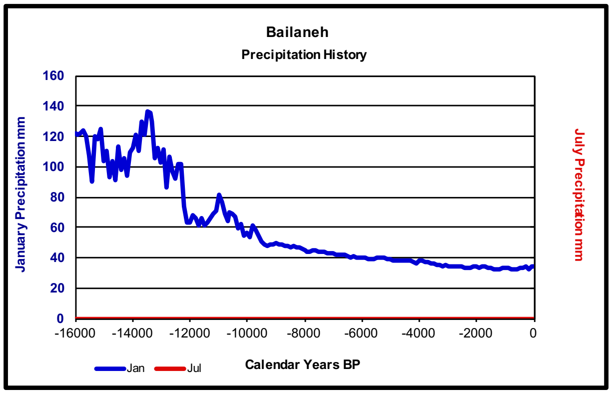

Annazah
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

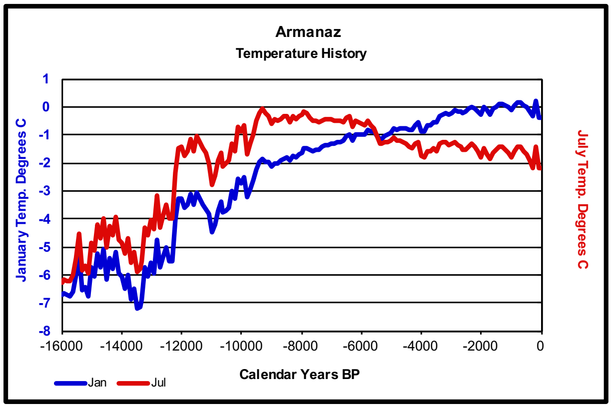

Ariha
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

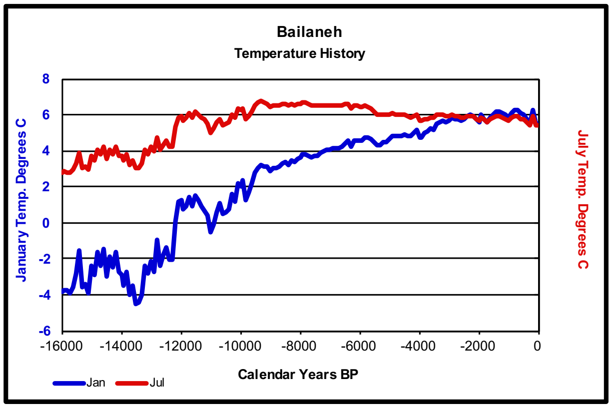

Annazah
Annual Precip or Evap mm
0
500
1000
1500
2000
2500
3000
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

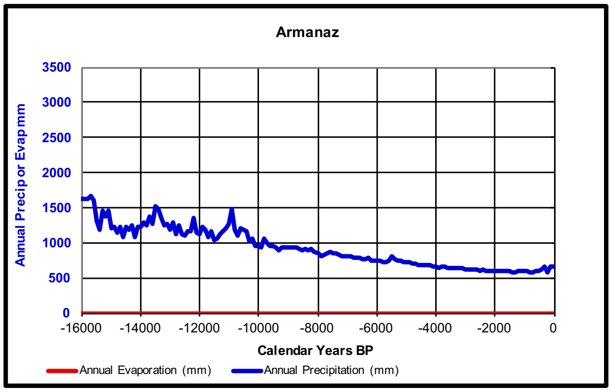

Ariha
Annual Precip or Evap mm
0
200
400
600
800
1000
1200
1400
1600
1800
2000
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

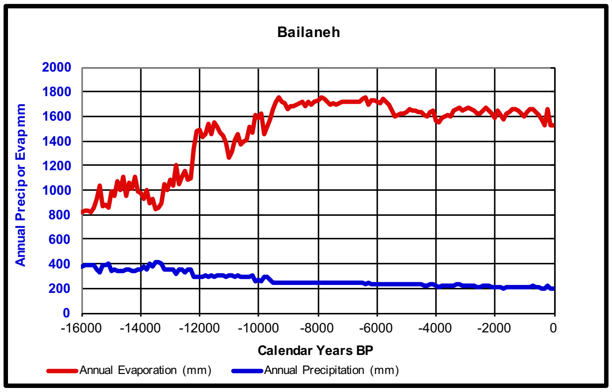

Armanaz
Precipitation History
January Precipitation mm
July Precipitation mm
700
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

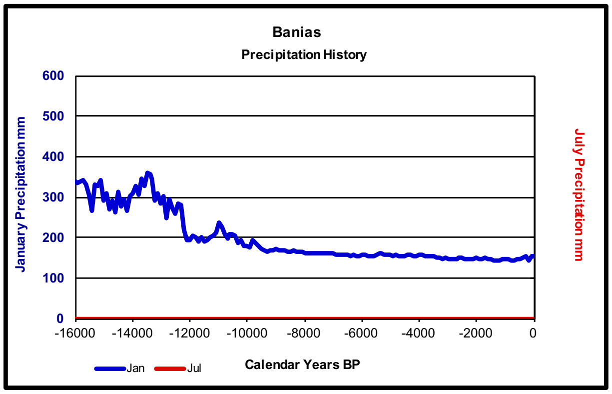

Bailaneh
Precipitation History
January Precipitation mm
July Precipitation mm
160
140
120
100
80
60
40
20
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

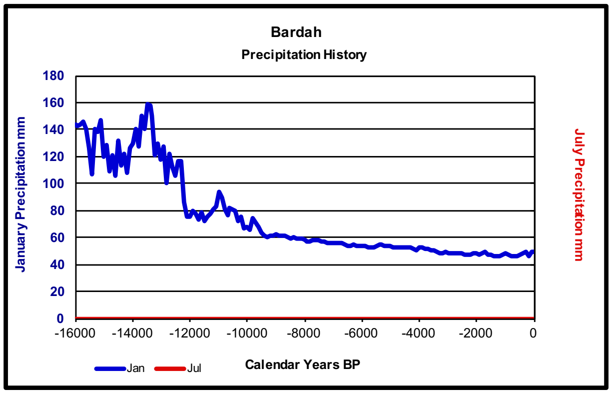

Armanaz
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

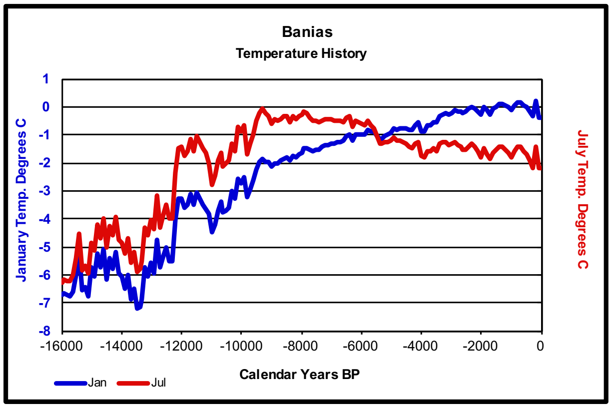

Bailaneh
Temperature History
January Temp. Degrees C
July Temp. Degrees C
8
6
4
2
0
-2
-4
-6
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

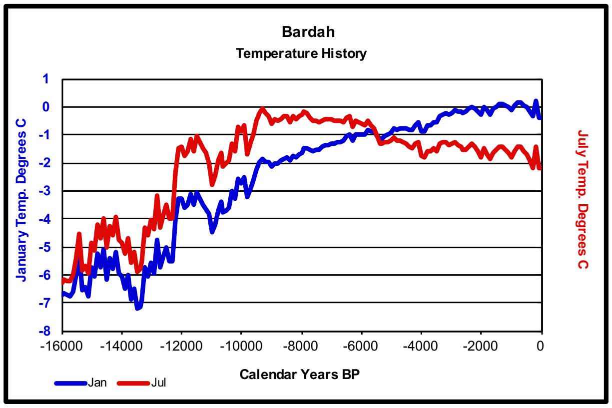

Armanaz
Annual Precip or Evap mm
3500
3000
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

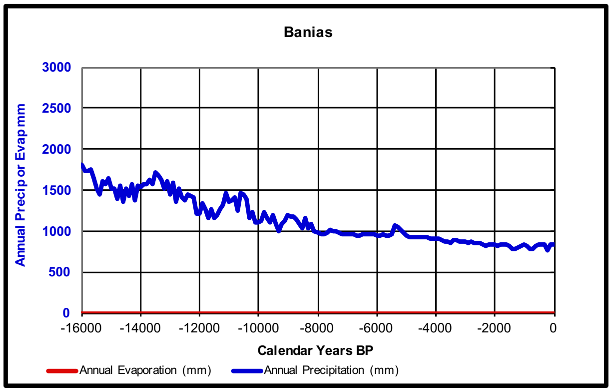

Bailaneh
Annual Precip or Evap mm
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

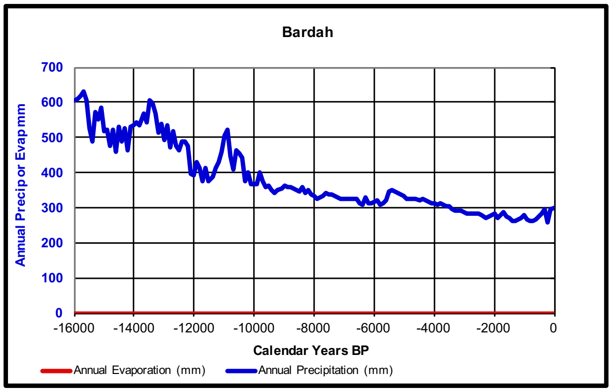

Banias
Precipitation History
January Precipitation mm
July Precipitation mm
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

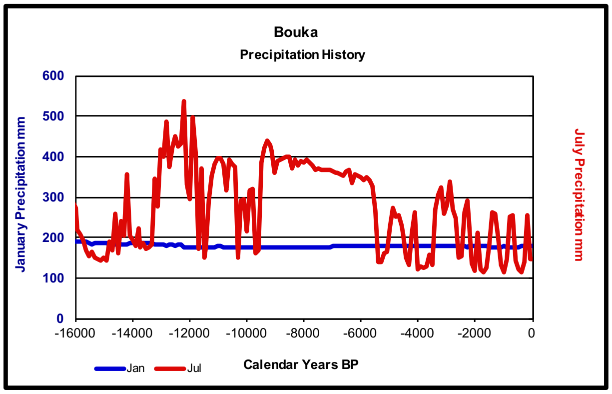

Bardah
Precipitation History
January Precipitation mm
July Precipitation mm
180
160
140
120
100
80
60
40
20
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

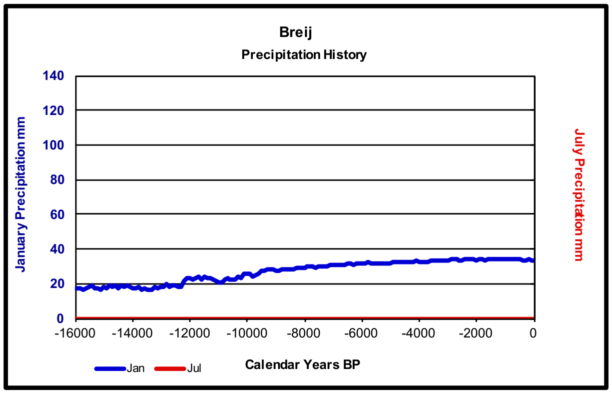

Banias
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

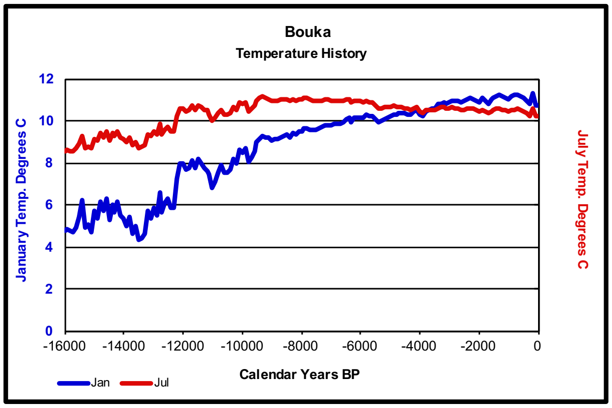

Bardah
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

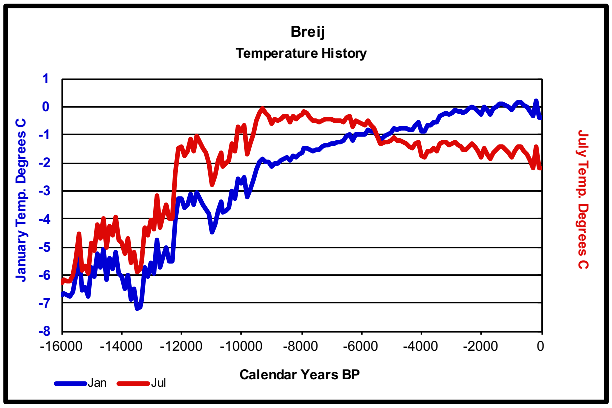

Banias
Annual Precip or Evap mm
3000
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

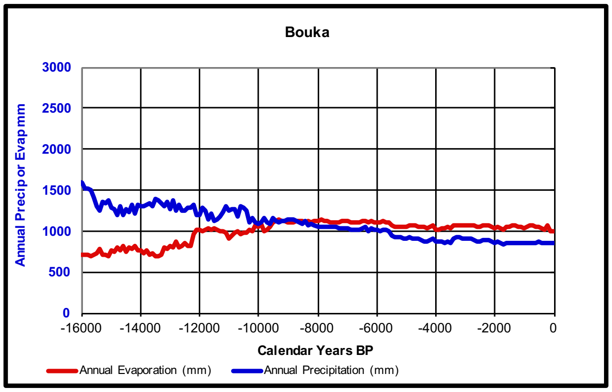

Bardah
Annual Precip or Evap mm
700
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

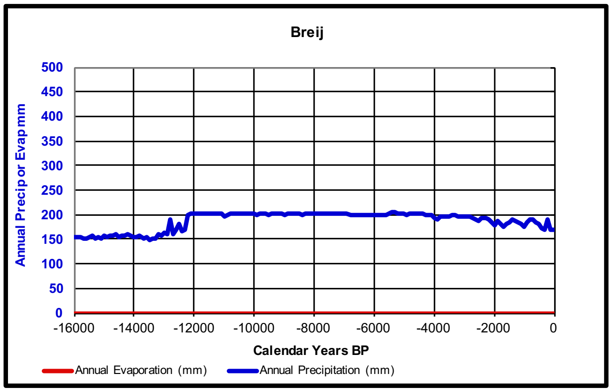

Bouka
Precipitation History
January Precipitation mm
July Precipitation mm
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

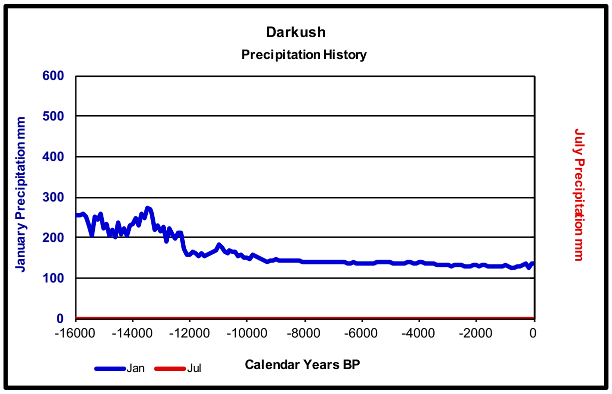

Breij
Precipitation History
January Precipitation mm
July Precipitation mm
140
120
100
80
60
40
20
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

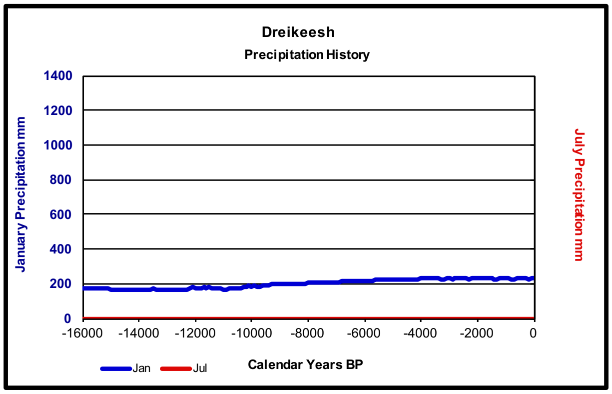

Bouka
Temperature History
January Temp. Degrees C
July Temp. Degrees C
12
10
8
6
4
2
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

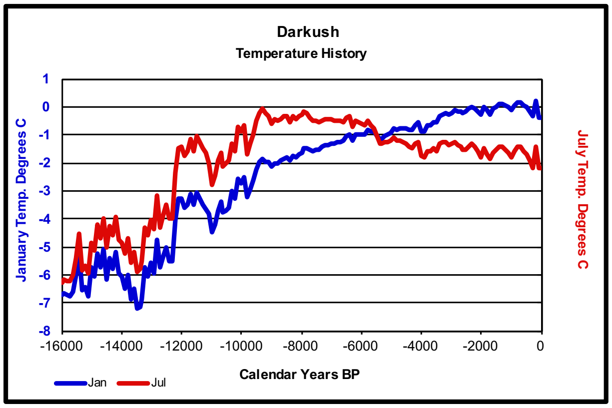

Breij
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

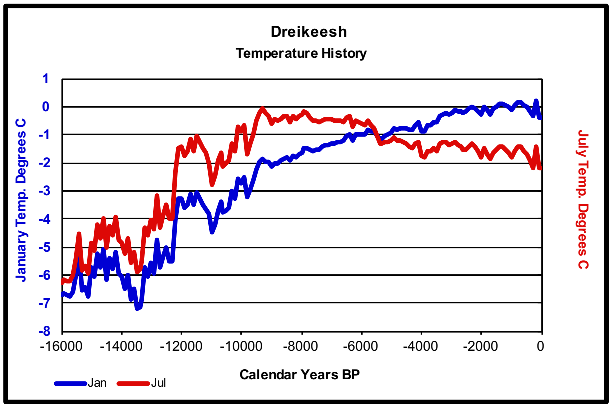

Bouka
Annual Precip or Evap mm
3000
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

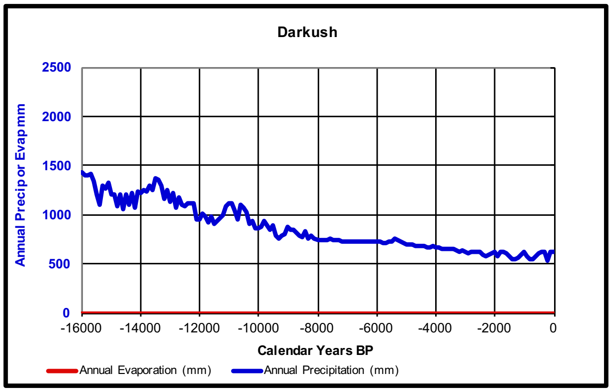

Breij
Annual Precip or Evap mm
500
450
400
350
300
250
200
150
100
50
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

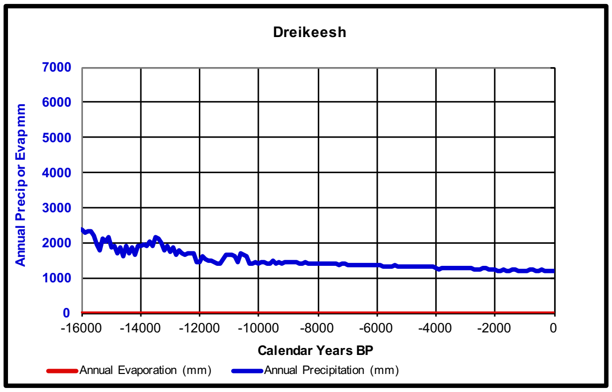

Darkush
Precipitation History
January Precipitation mm
July Precipitation mm
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

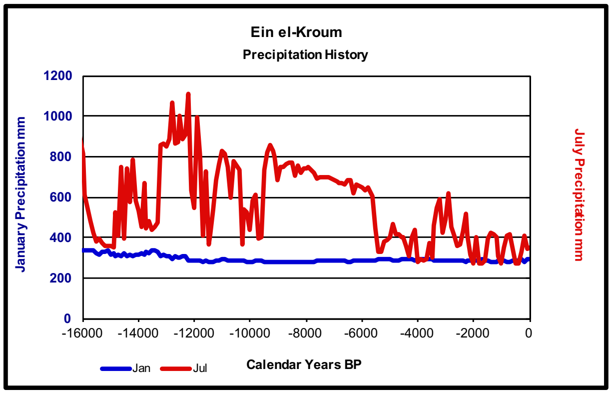

Dreikeesh
Precipitation History
January Precipitation mm
July Precipitation mm
1400
1200
1000
800
600
400
200
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

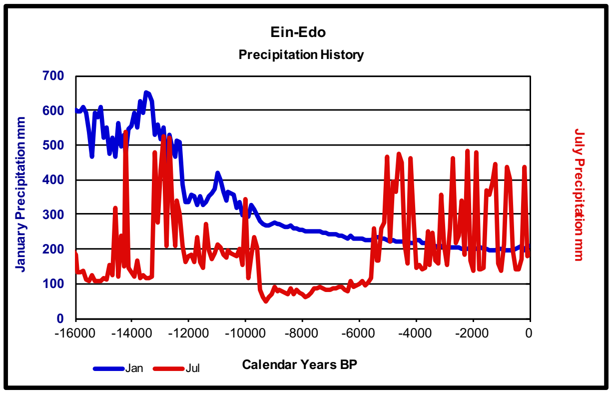

Darkush
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

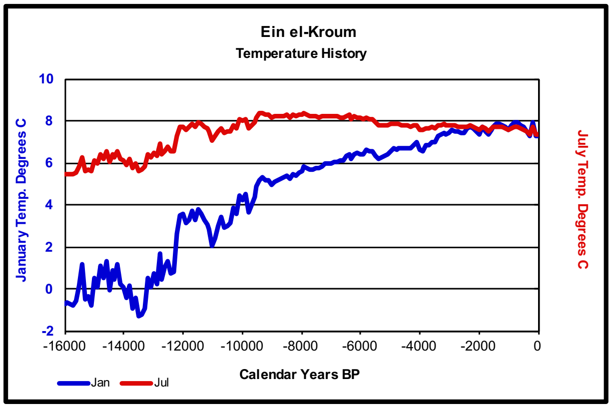

Dreikeesh
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

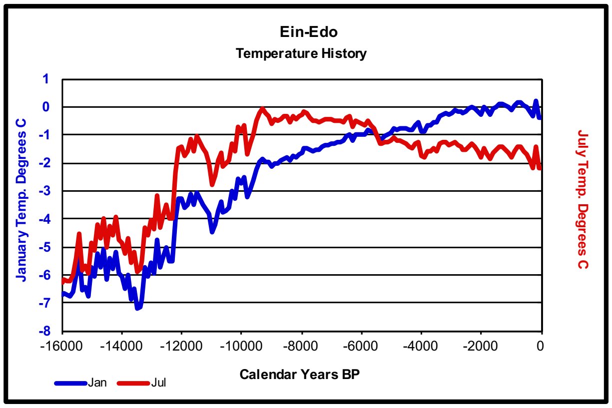

Darkush
Annual Precip or Evap mm
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

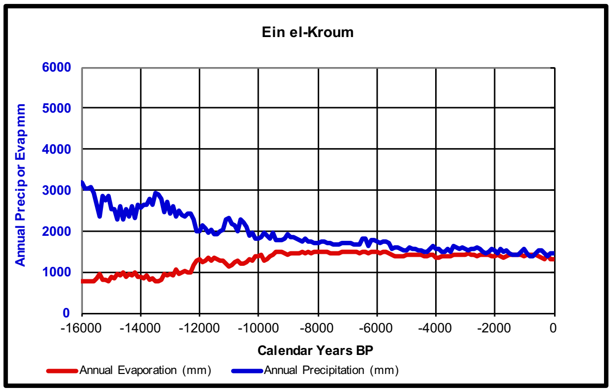

Dreikeesh
Annual Precip or Evap mm
7000
6000
5000
4000
3000
2000
1000
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

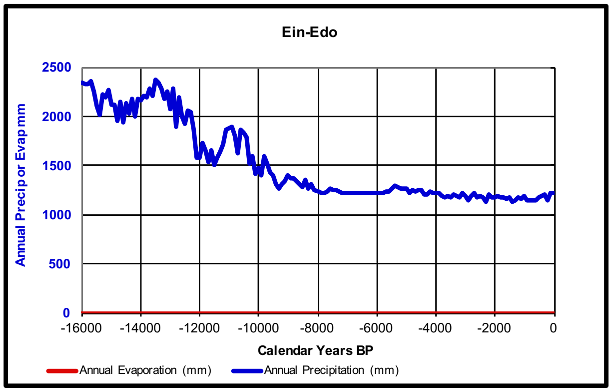

Ein el-Kroum
Precipitation History
January Precipitation mm
July Precipitation mm
1200
1000
800
600
400
200
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

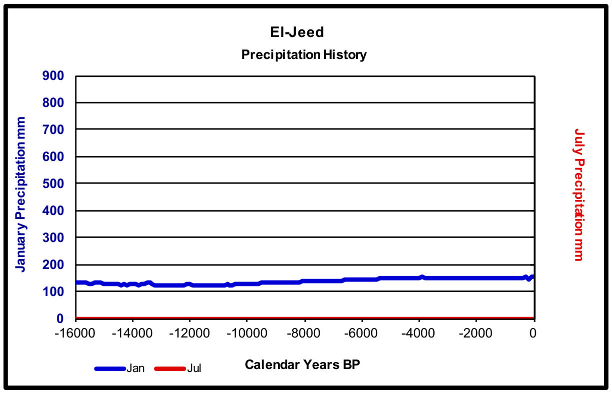

Ein-Edo
Precipitation History
January Precipitation mm
July Precipitation mm
700
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

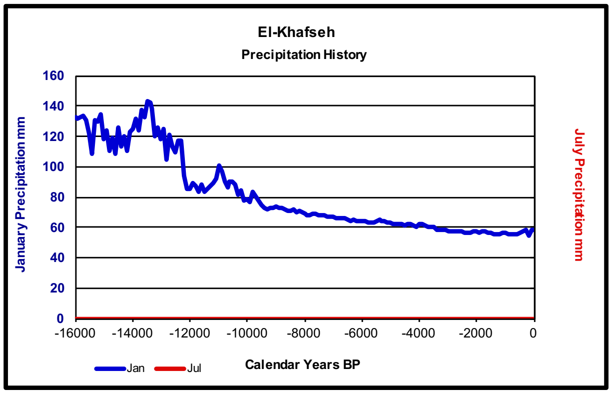

Ein el-Kroum
Temperature History
January Temp. Degrees C
July Temp. Degrees C
10
8
6
4
2
0
-2
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

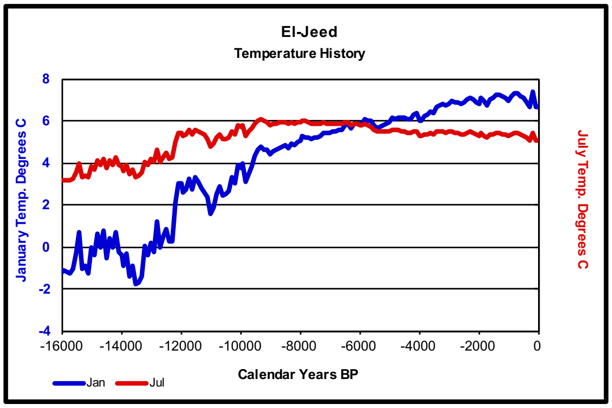

Ein-Edo
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

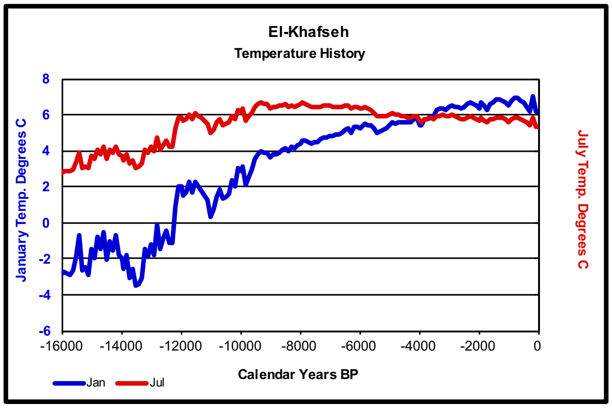

Ein el-Kroum
Annual Precip or Evap mm
6000
5000
4000
3000
2000
1000
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

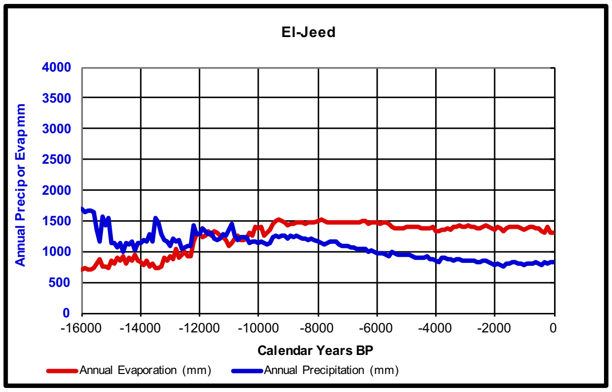

Ein-Edo
Annual Precip or Evap mm
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

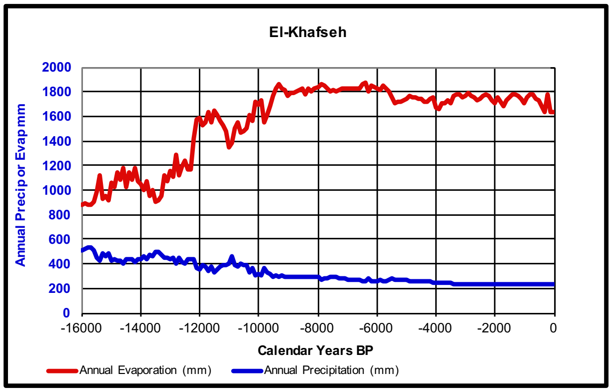

El-Jeed
Precipitation History
January Precipitation mm
July Precipitation mm
900
800
700
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

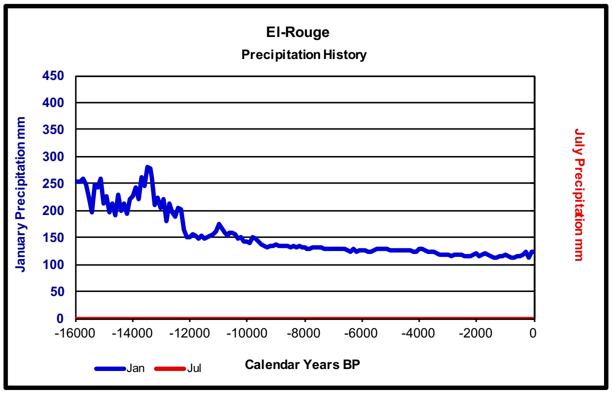

El-Khafseh
Precipitation History
January Precipitation mm
July Precipitation mm
160
140
120
100
80
60
40
20
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

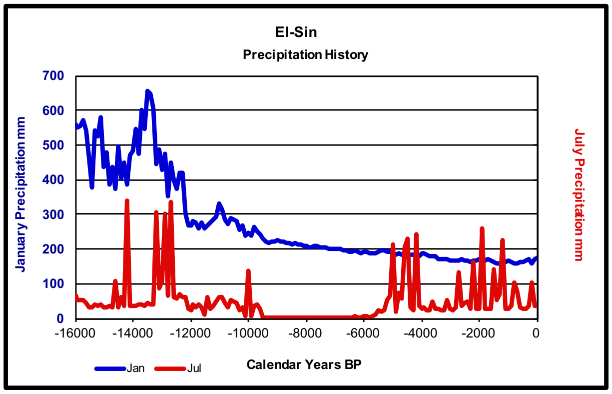

El-Jeed
Temperature History
January Temp. Degrees C
July Temp. Degrees C
8
6
4
2
0
-2
-4
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

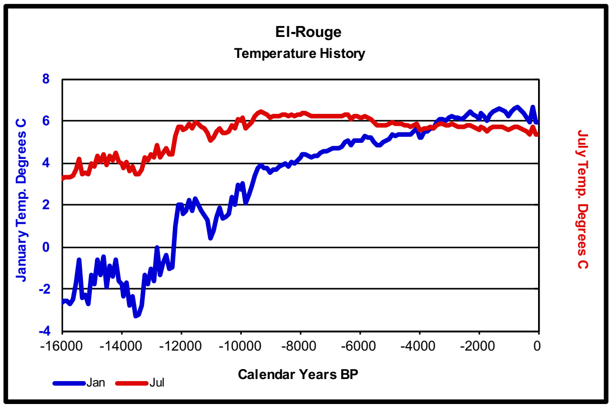

El-Khafseh
Temperature History
January Temp. Degrees C
July Temp. Degrees C
8
6
4
2
0
-2
-4
-6
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

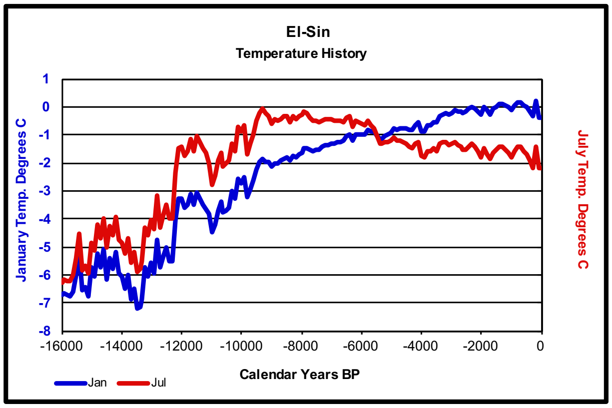

El-Jeed
Annual Precip or Evap mm
4000
3500
3000
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

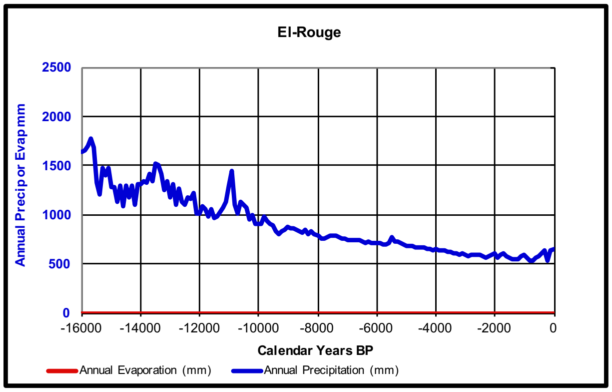

El-Khafseh
Annual Precip or Evap mm
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

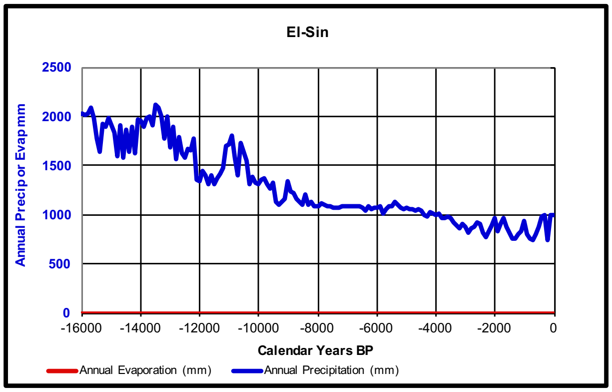

El-Rouge
Precipitation History
January Precipitation mm
July Precipitation mm
450
400
350
300
250
200
150
100
50
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

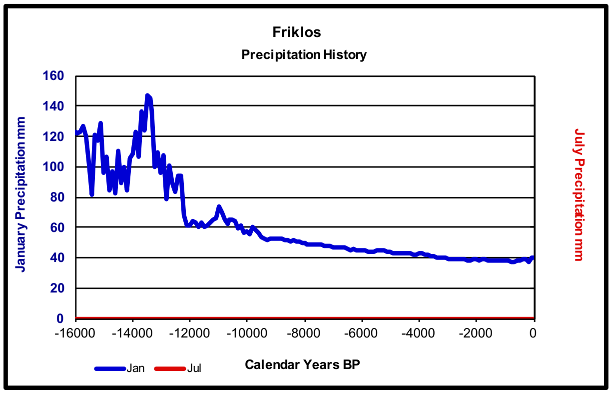

El-Sin
Precipitation History
January Precipitation mm
July Precipitation mm
700
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

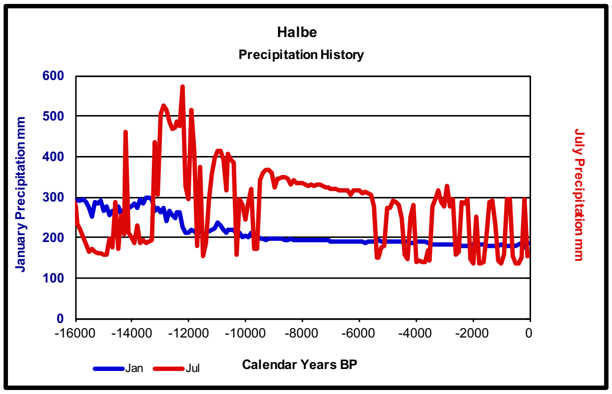

El-Rouge
Temperature History
January Temp. Degrees C
July Temp. Degrees C
8
6
4
2
0
-2
-4
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

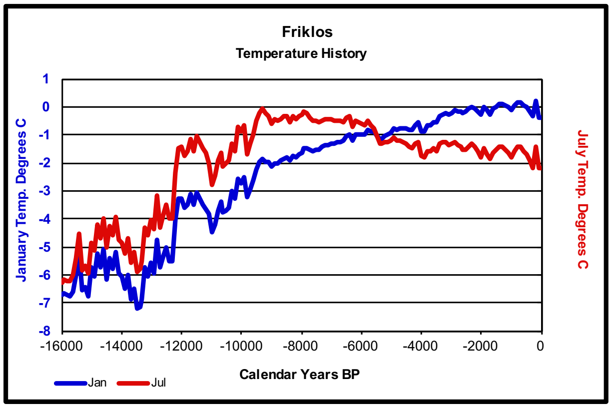

El-Sin
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

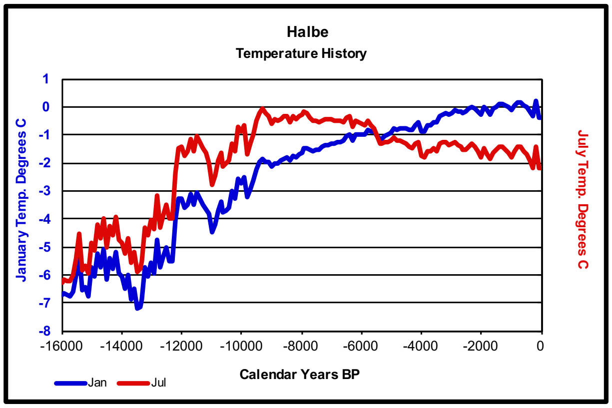

El-Rouge
Annual Precip or Evap mm
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

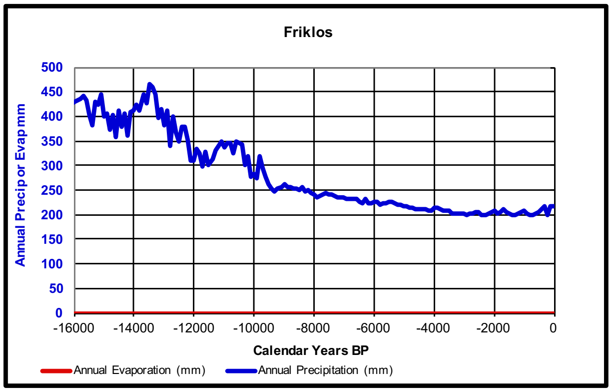

El-Sin
Annual Precip or Evap mm
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

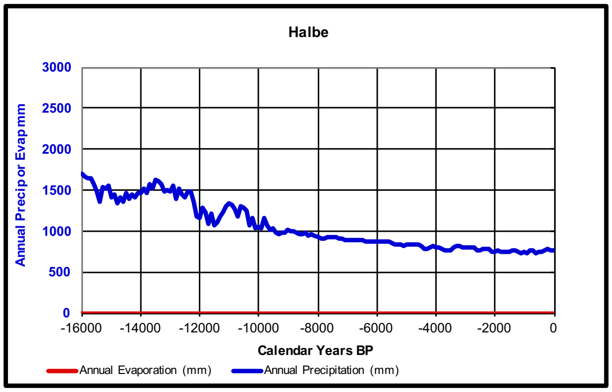

Friklos
Precipitation History
January Precipitation mm
July Precipitation mm
160
140
120
100
80
60
40
20
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

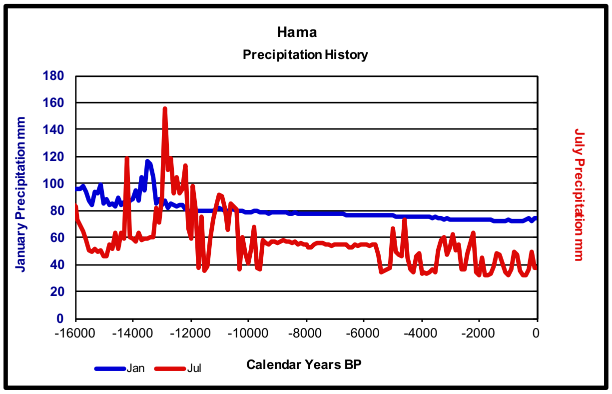

Halbe
Precipitation History
January Precipitation mm
July Precipitation mm
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

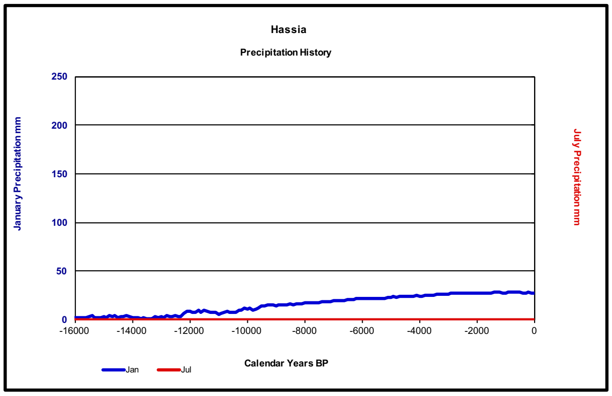

Friklos
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

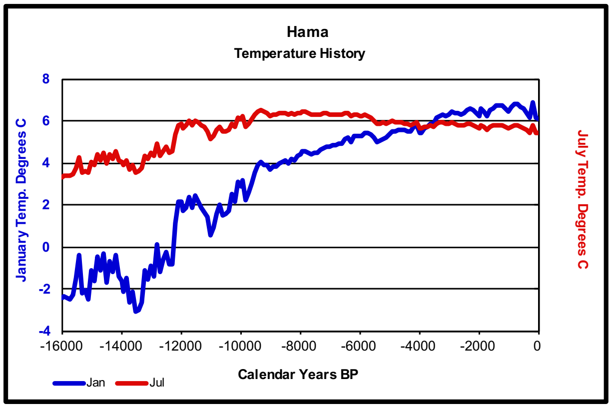

Halbe
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

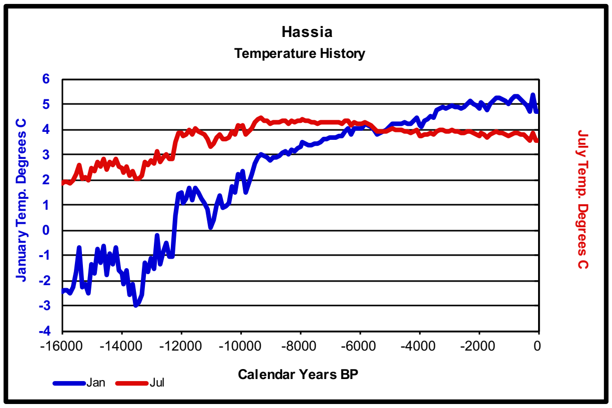

Friklos
Annual Precip or Evap mm
500
450
400
350
300
250
200
150
100
50
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

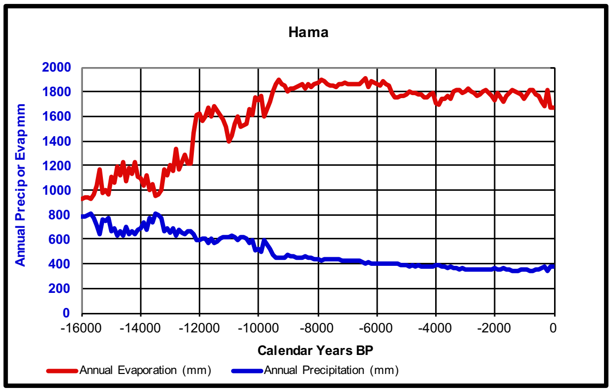

Halbe
Annual Precip or Evap mm
3000
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

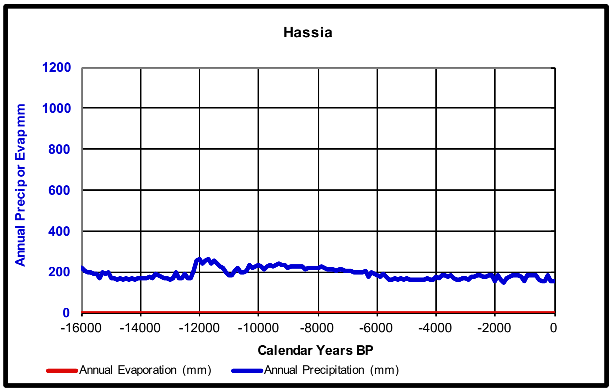

Hama
Precipitation History
January Precipitation mm
July Precipitation mm
180
160
140
120
100
80
60
40
20
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

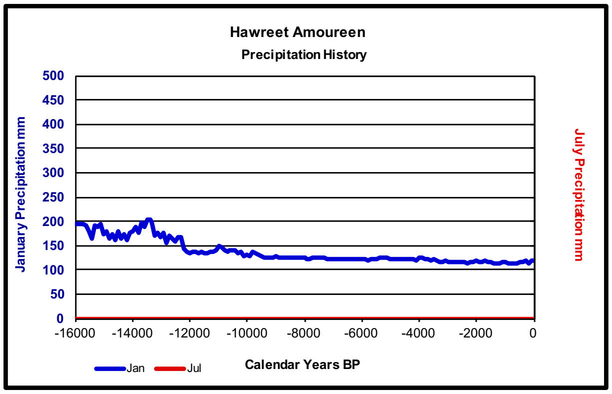

Hassia
Precipitation History
January Precipitation mm
July Precipitation mm
250
200
150
100
50
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

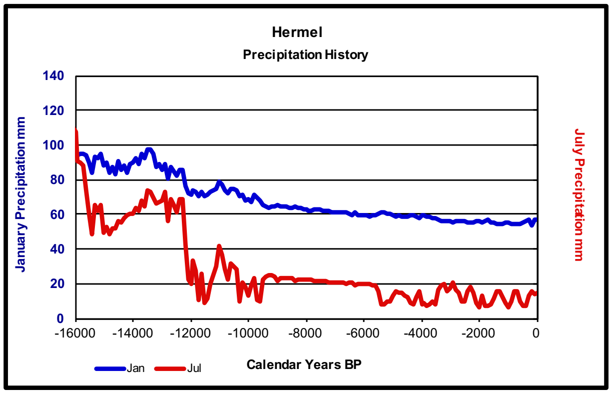

Hama
Temperature History
January Temp. Degrees C
July Temp. Degrees C
8
6
4
2
0
-2
-4
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

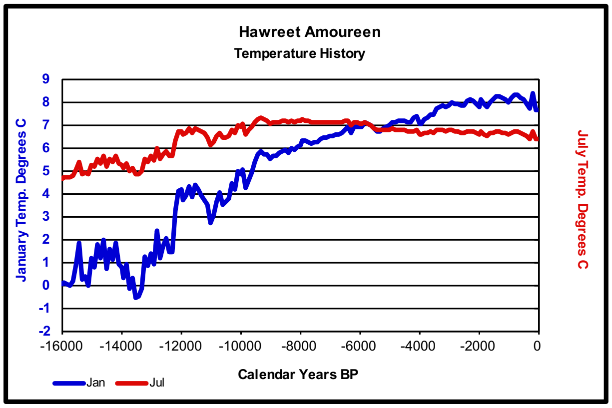

Hassia
Temperature History
January Temp. Degrees C
July Temp. Degrees C
6
5
4
3
2
1
0
-1
-2
-3
-4
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

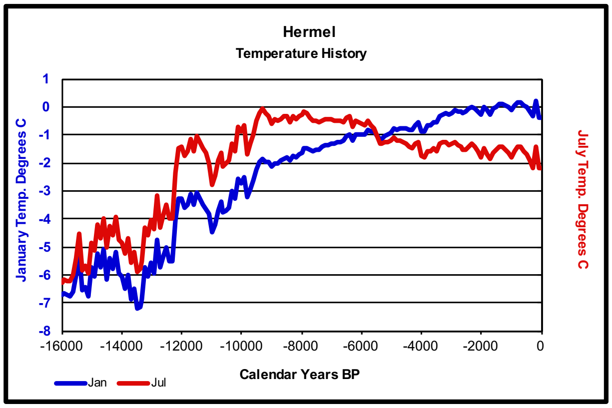

Hama
Annual Precip or Evap mm
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

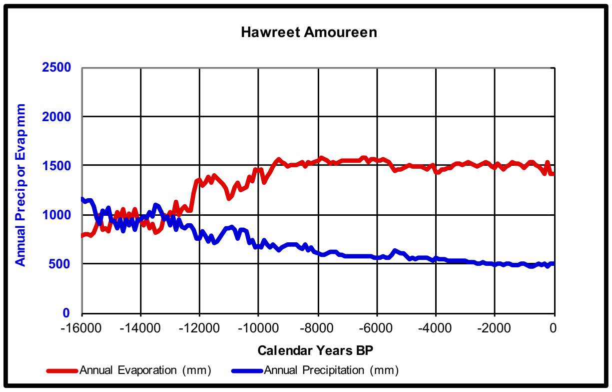

Hassia
Annual Precip or Evap mm
1200
1000
800
600
400
200
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

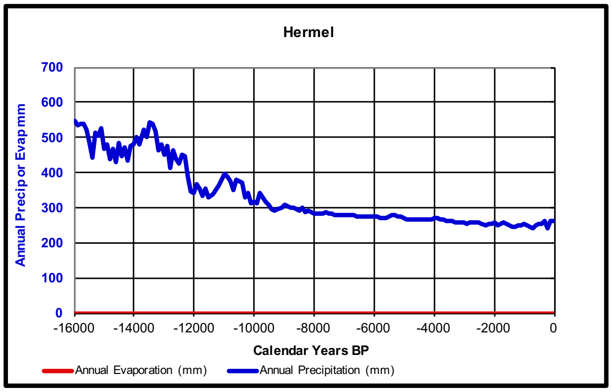

Hawreet Amoureen
Precipitation History
January Precipitation mm
500
450
400
350
300
250
200
150
100
50
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
July Precipitation mm
Jan
Jul
Calendar Years BP

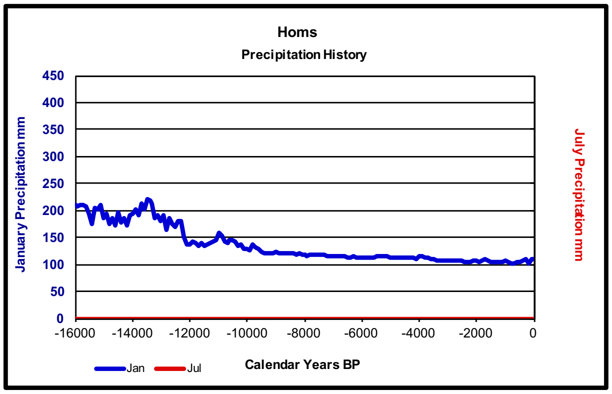

Hermel
Precipitation History
January Precipitation mm
140
120
100
80
60
40
20
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
July Precipitation mm
Jan
Jul
Calendar Years BP

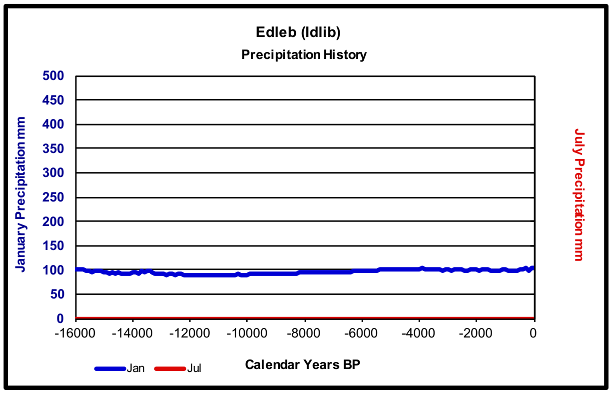

Hawreet Amoureen
Temperature History
January Temp. Degrees C
9
8
7
6
5
4
3
2
1
0
-1
-2
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
July Temp. Degrees C
Jan
Jul
Calendar Years BP

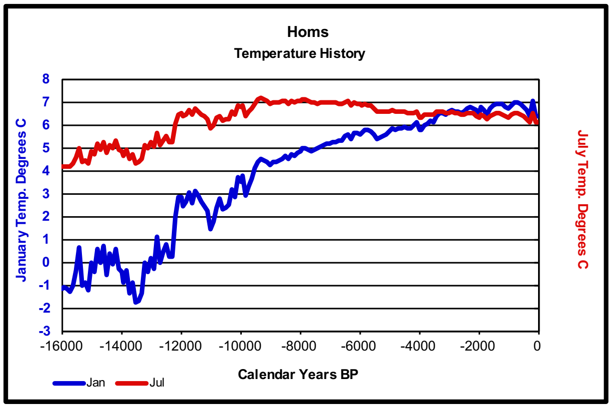

Hermel
Temperature History
January Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
July Temp. Degrees C
Jan
Jul
Calendar Years BP

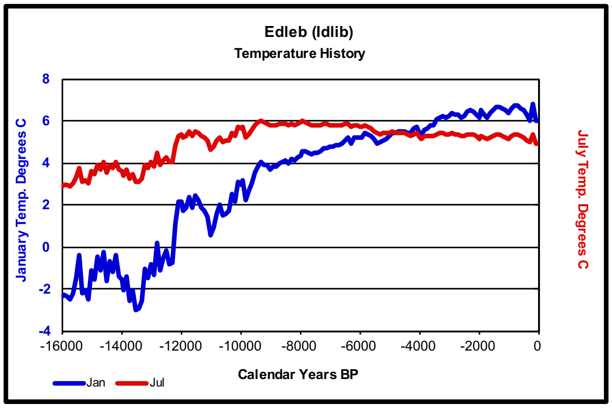

Hawreet Amoureen
Annual Precip or Evap mm
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

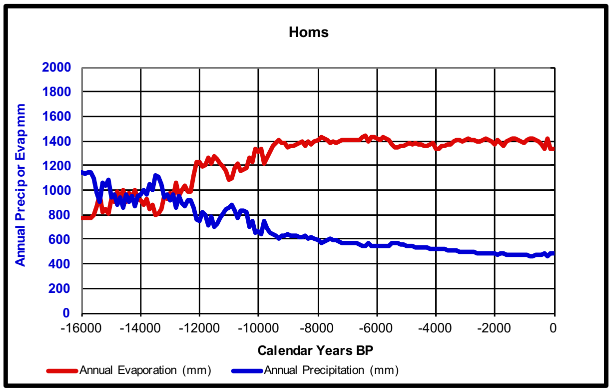

Hermel
Annual Precip or Evap mm
700
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

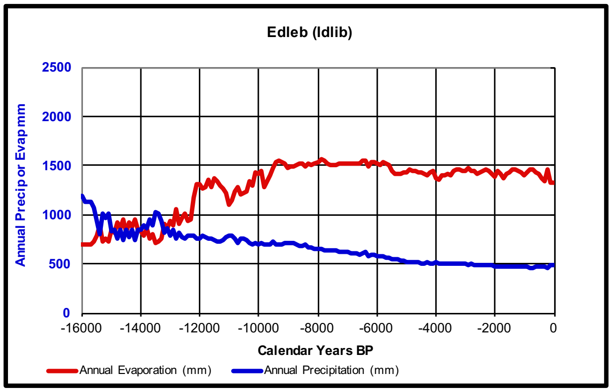

Homs
Precipitation History
January Precipitation mm
July Precipitation mm
450
400
350
300
250
200
150
100
50
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

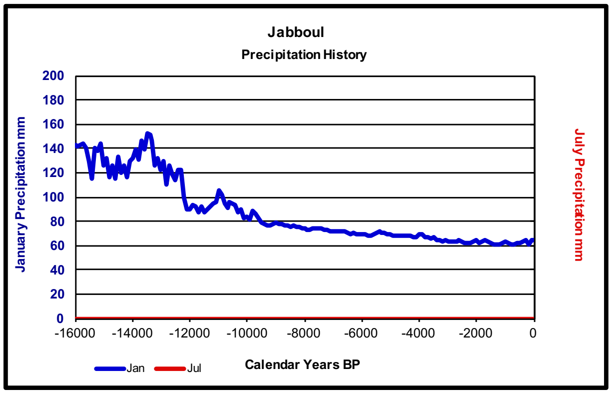

Edleb (Idlib)
Precipitation History
January Precipitation mm
July Precipitation mm
500
450
400
350
300
250
200
150
100
50
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

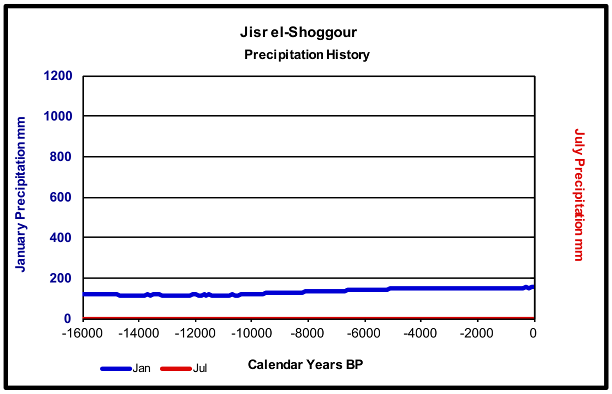

Homs
Temperature History
January Temp. Degrees C
July Temp. Degrees C
8
7
6
5
4
3
2
1
0
-1
-2
-3
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

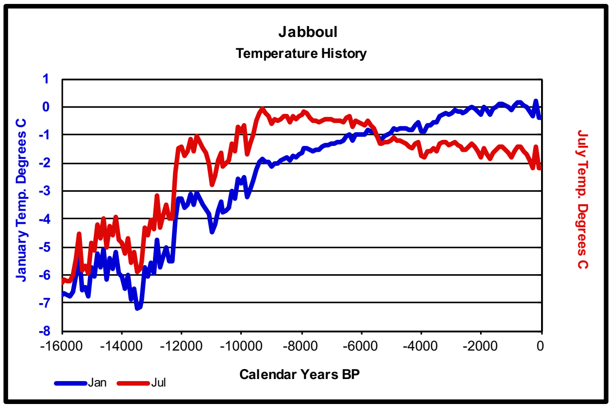

Edleb (Idlib)
Temperature History
January Temp. Degrees C
July Temp. Degrees C
8
6
4
2
0
-2
-4
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

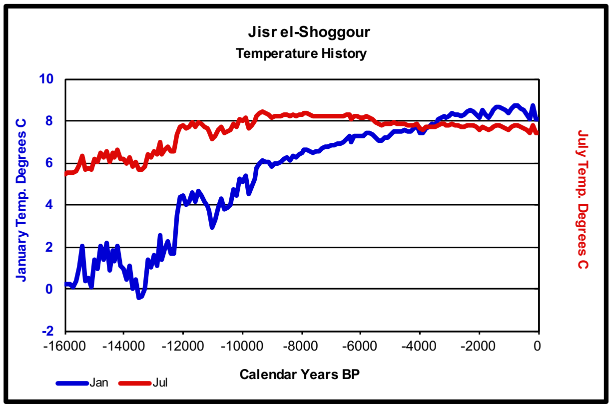

Homs
Annual Precip or Evap mm
2000
1800
1600
1400
1200
1000
800
600
400
200
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

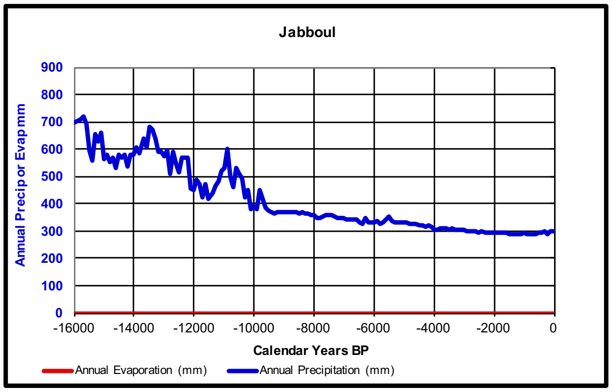

Edleb (Idlib)
Annual Precip or Evap mm
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

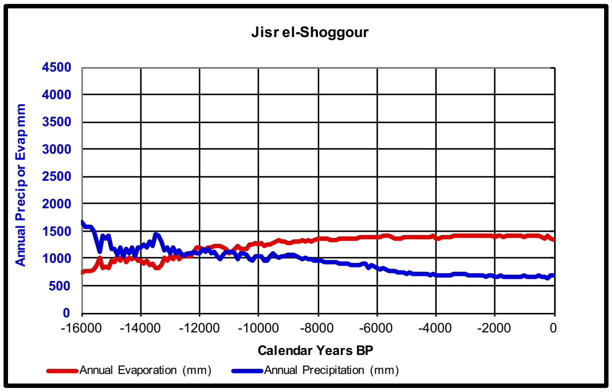

Jabboul
Precipitation History
January Precipitation mm
July Precipitation mm
200
180
160
140
120
100
80
60
40
20
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

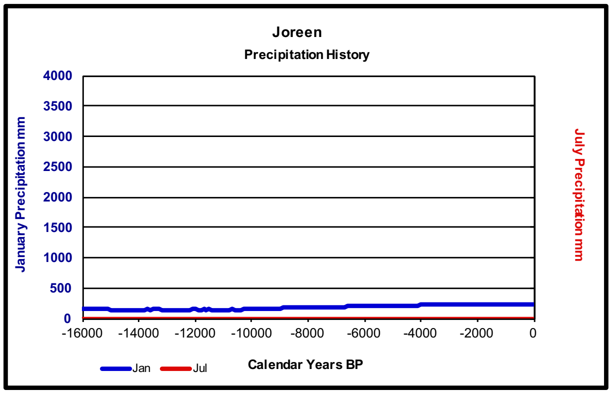

Jisr el-Shoggour
Precipitation History
January Precipitation mm
July Precipitation mm
1200
1000
800
600
400
200
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

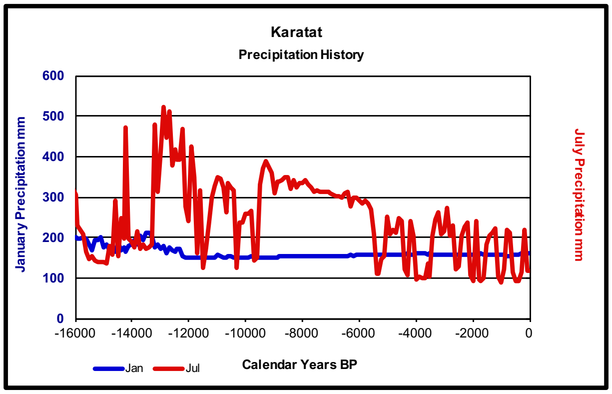

Jabboul
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

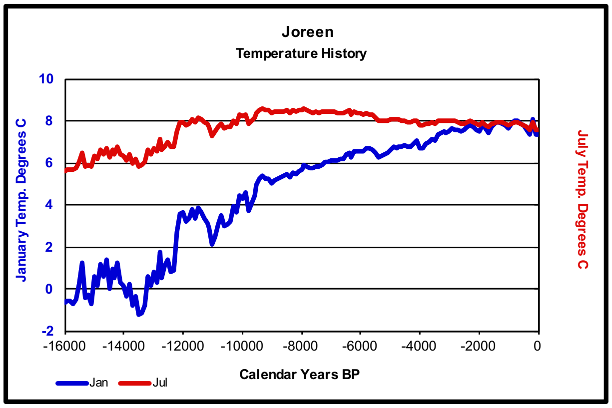

Jisr el-Shoggour
Temperature History
January Temp. Degrees C
July Temp. Degrees C
10
8
6
4
2
0
-2
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

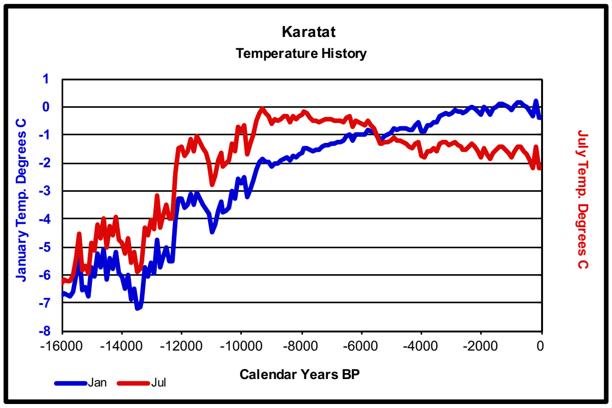

Jabboul
Annual Precip or Evap mm
900
800
700
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

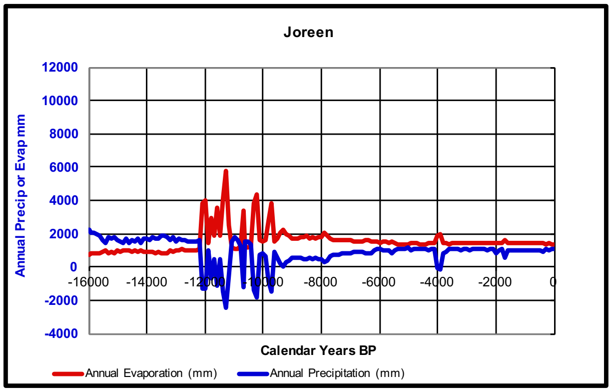

Jisr el-Shoggour
Annual Precip or Evap mm
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

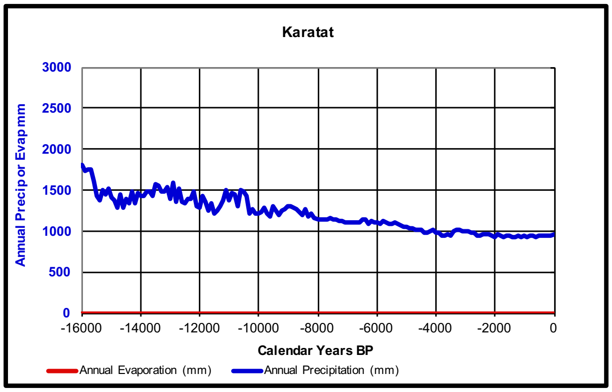

Joreen
Precipitation History
January Precipitation mm
July Precipitation mm
4000
3500
3000
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

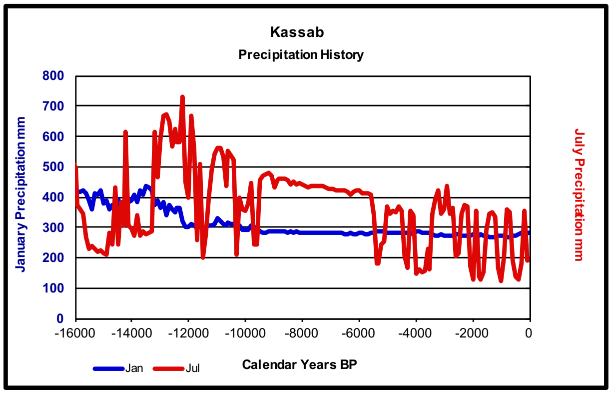

Karatat
Precipitation History
January Precipitation mm
July Precipitation mm
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

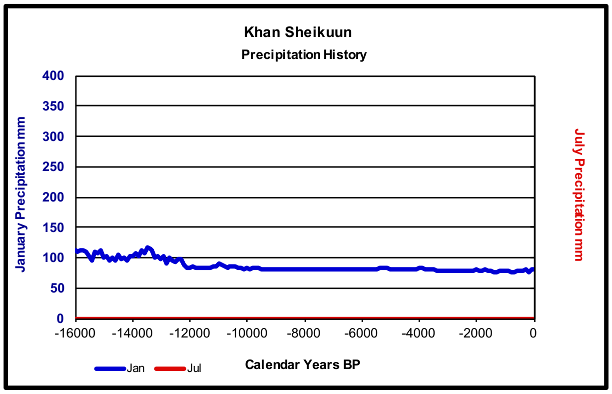

Joreen
Temperature History
January Temp. Degrees C
July Temp. Degrees C
10
8
6
4
2
0
-2
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

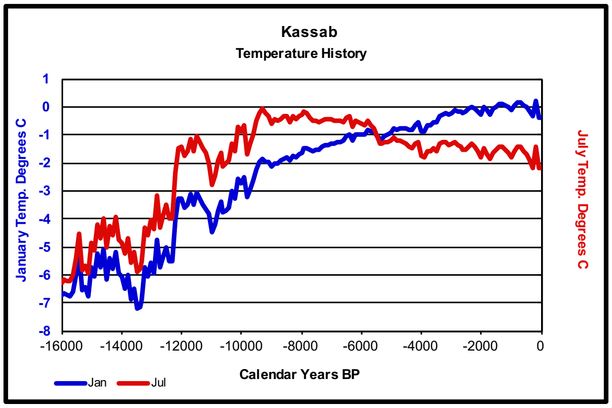

Karatat
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

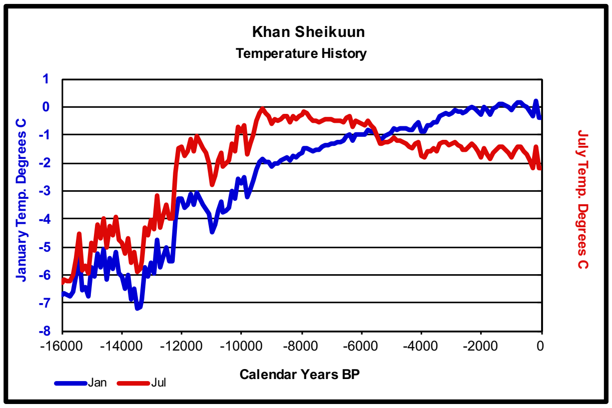

Joreen
Annual Precip or Evap mm
12000
10000
8000
6000
4000
2000
0
-2000
-4000
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

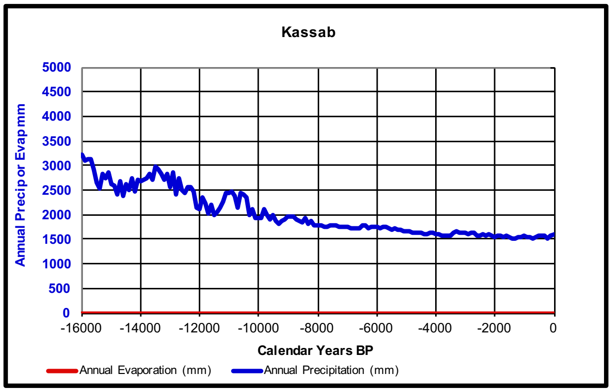

Karatat
Annual Precip or Evap mm
3000
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

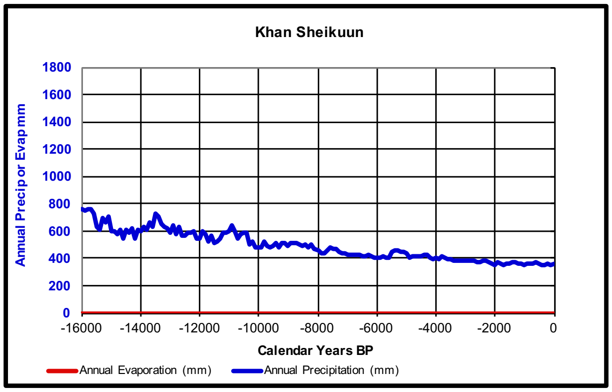

Kassab
Precipitation History
January Precipitation mm
July Precipitation mm
800
700
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

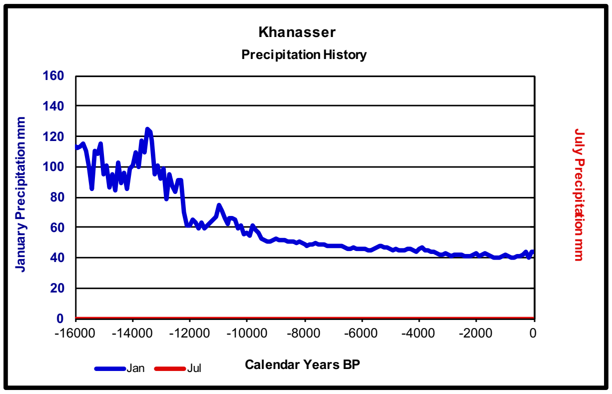

Khan Sheikuun
Precipitation History
January Precipitation mm
July Precipitation mm
400
350
300
250
200
150
100
50
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

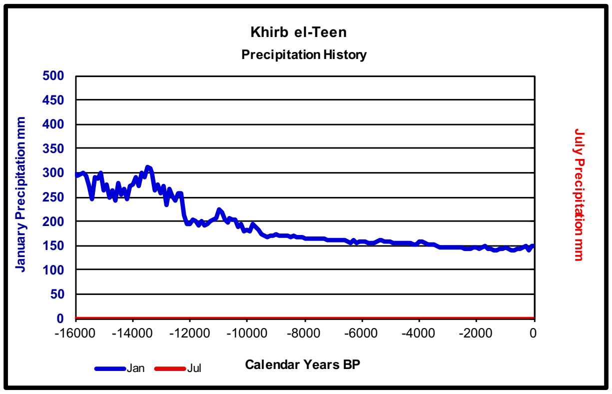

Kassab
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

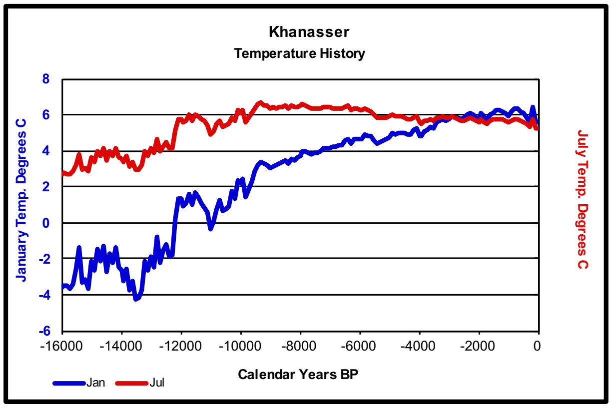

Khan Sheikuun
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

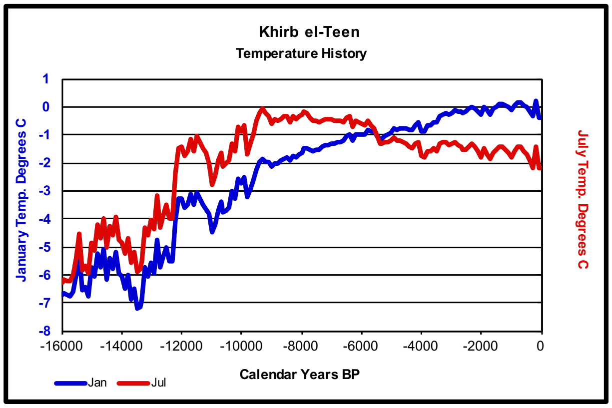

Kassab
Annual Precip or Evap mm
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

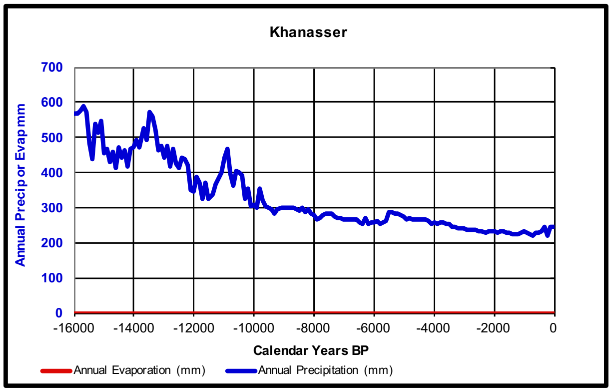

Khan Sheikuun
Annual Precip or Evap mm
1800
1600
1400
1200
1000
800
600
400
200
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

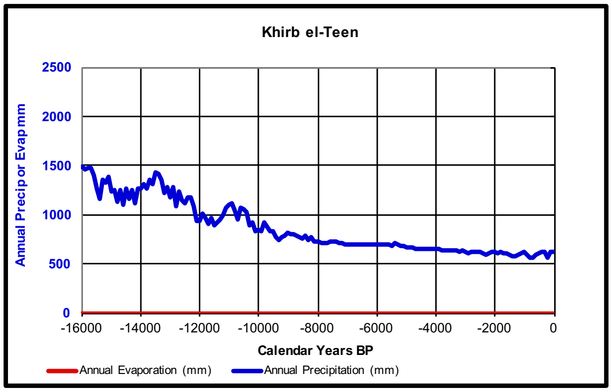

Khanasser
Precipitation History
January Precipitation mm
July Precipitation mm
160
140
120
100
80
60
40
20
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

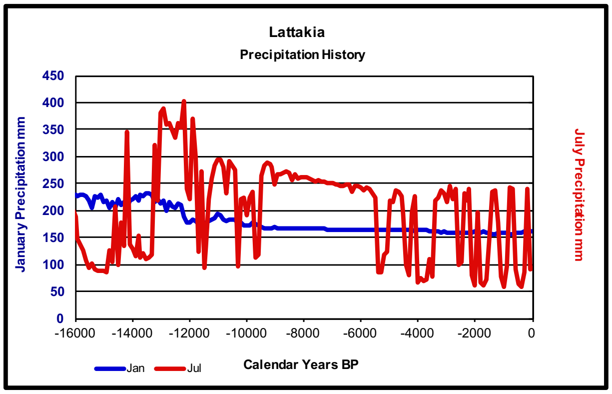

Khirb el-Teen
Precipitation History
January Precipitation mm
July Precipitation mm
500
450
400
350
300
250
200
150
100
50
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

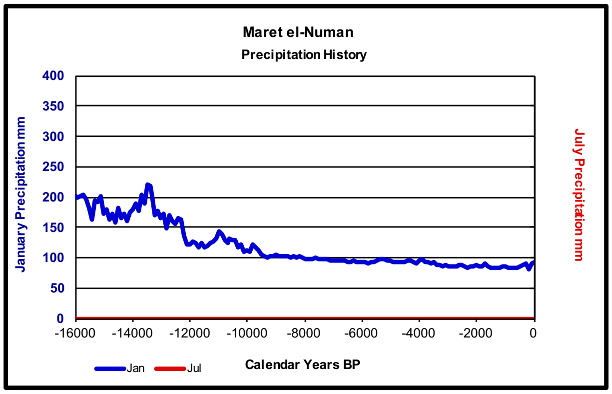

Khanasser
Temperature History
January Temp. Degrees C
July Temp. Degrees C
8
6
4
2
0
-2
-4
-6
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

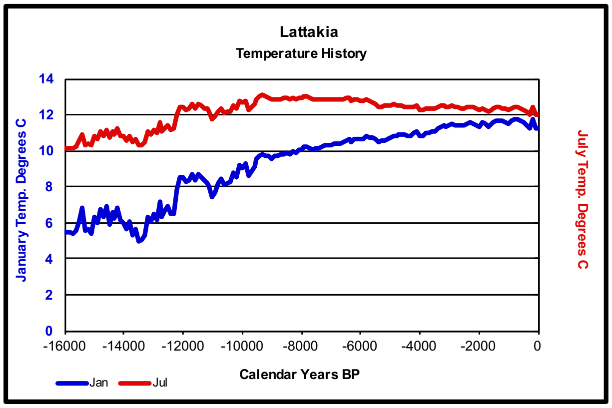

Khirb el-Teen
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

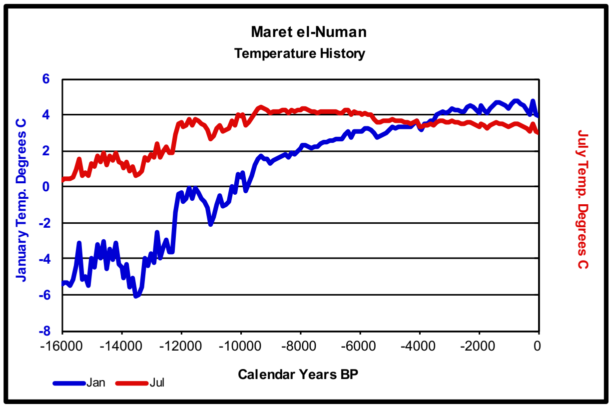

Khanasser
Annual Precip or Evap mm
700
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

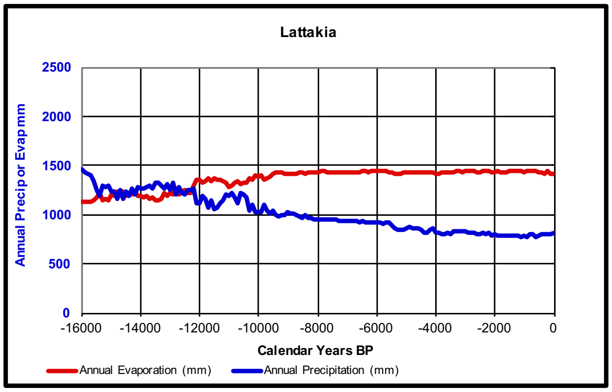

Khirb el-Teen
Annual Precip or Evap mm
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

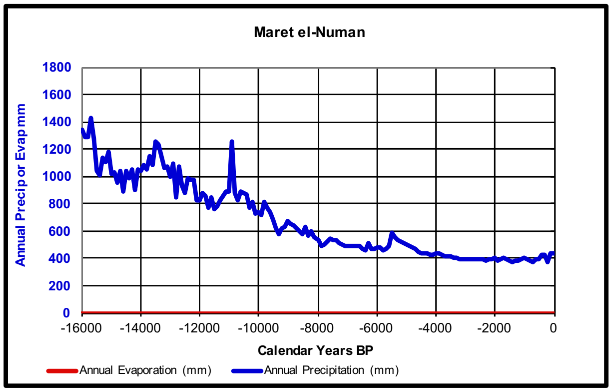

Lattakia
Precipitation History
January Precipitation mm
July Precipitation mm
450
400
350
300
250
200
150
100
50
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

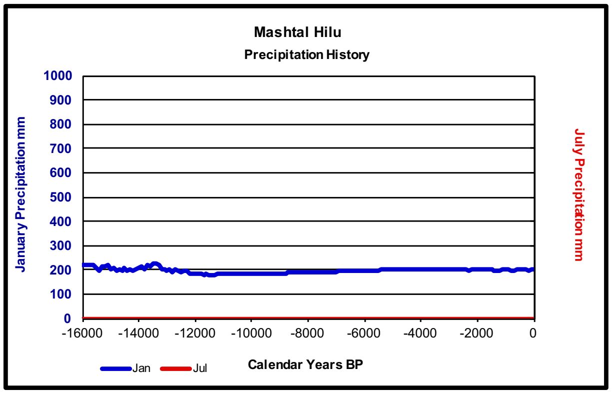

Maret el-Numan
Precipitation History
January Precipitation mm
July Precipitation mm
400
350
300
250
200
150
100
50
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

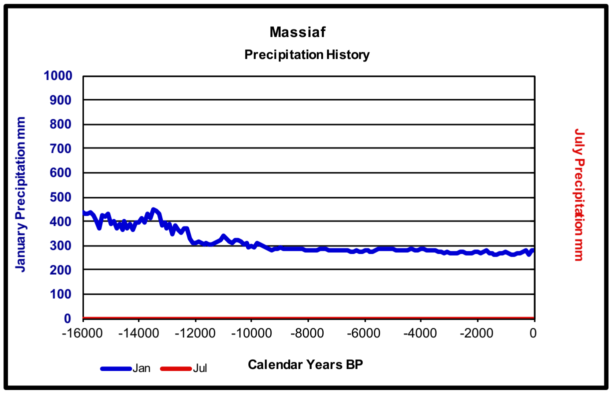

Lattakia
Temperature History
January Temp. Degrees C
July Temp. Degrees C
14
12
10
8
6
4
2
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

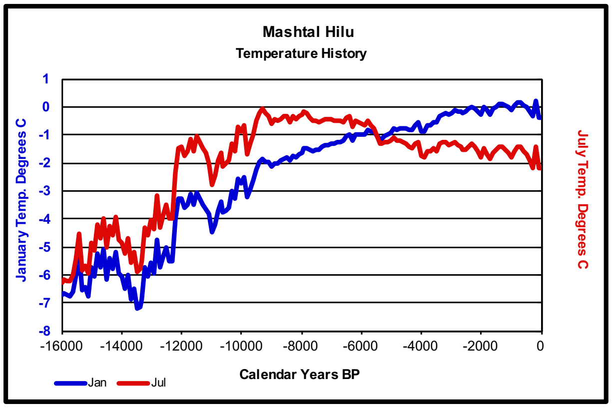

Maret el-Numan
Temperature History
January Temp. Degrees C
July Temp. Degrees C
6
4
2
0
-2
-4
-6
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

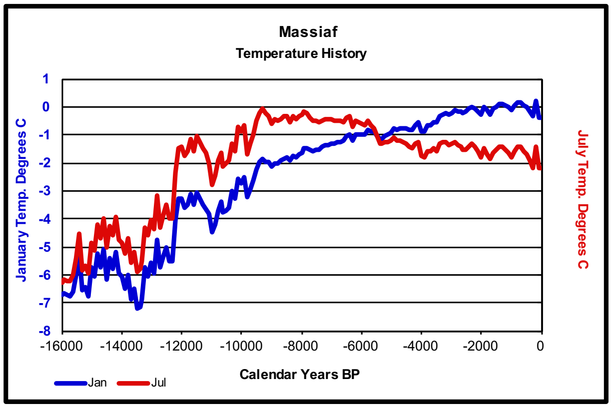

Lattakia
Annual Precip or Evap mm
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

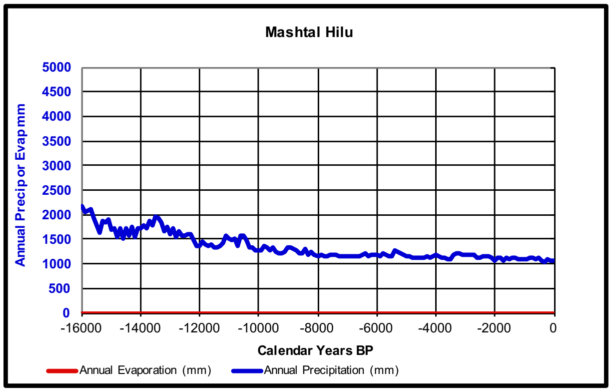

Maret el-Numan
Annual Precip or Evap mm
1800
1600
1400
1200
1000
800
600
400
200
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

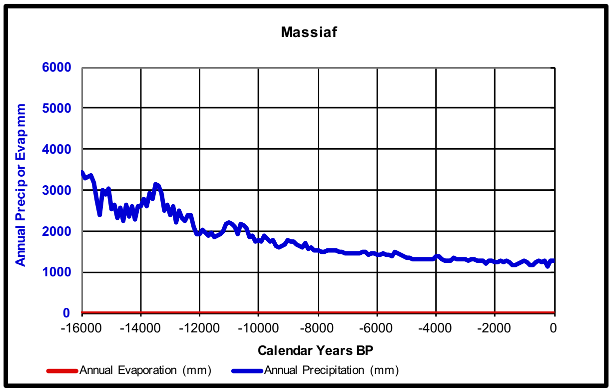

Mashtal Hilu
Precipitation History
January Precipitation mm
July Precipitation mm
1000
900
800
700
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

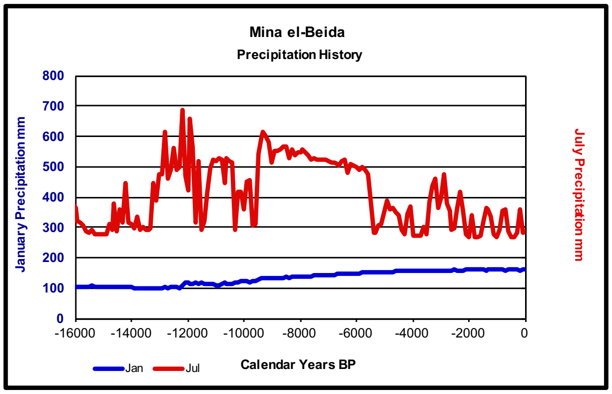

Massiaf
Precipitation History
January Precipitation mm
July Precipitation mm
1000
900
800
700
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

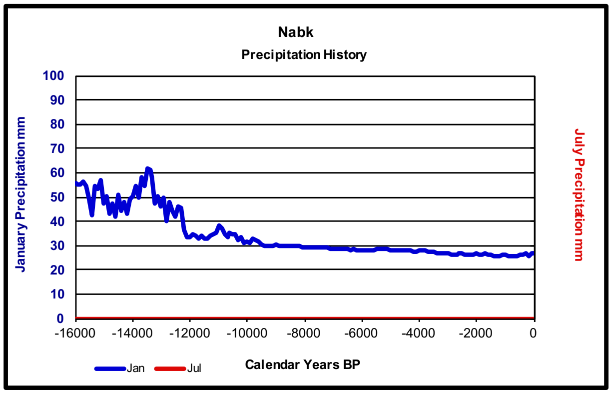

Mashtal Hilu
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

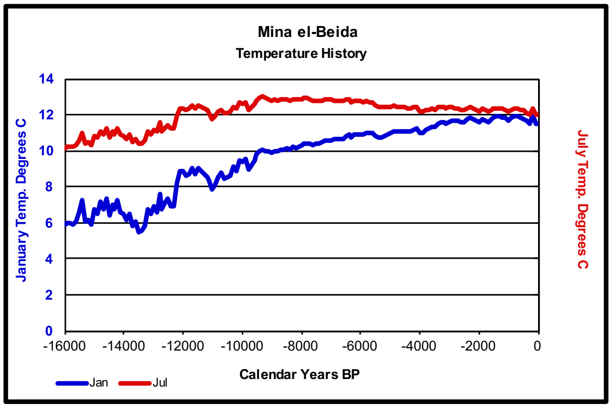

Massiaf
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

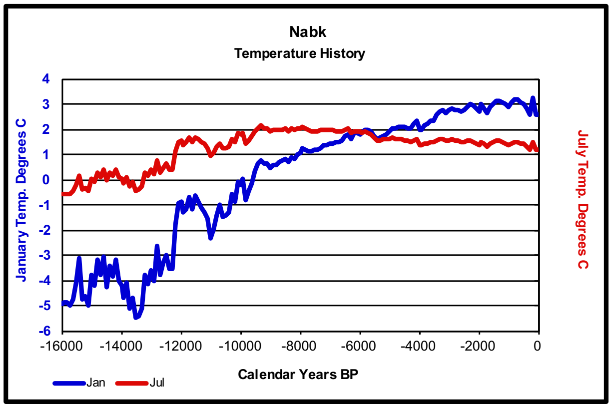

Mashtal Hilu
Annual Precip or Evap mm
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

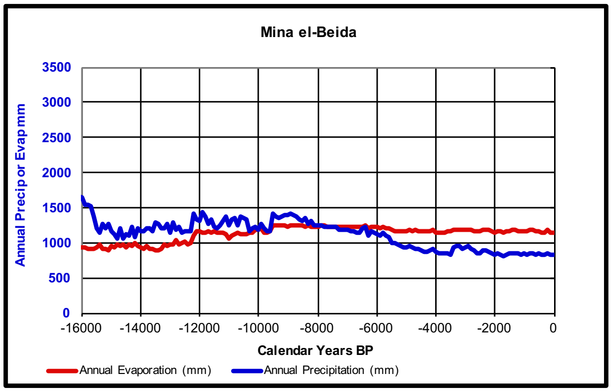

Massiaf
Annual Precip or Evap mm
6000
5000
4000
3000
2000
1000
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

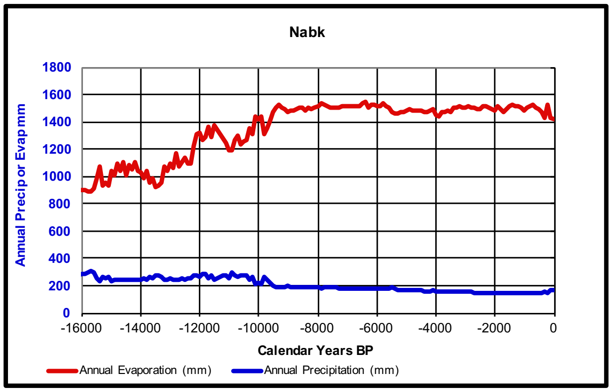

Mina el-Beida
Precipitation History
January Precipitation mm
July Precipitation mm
800
700
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

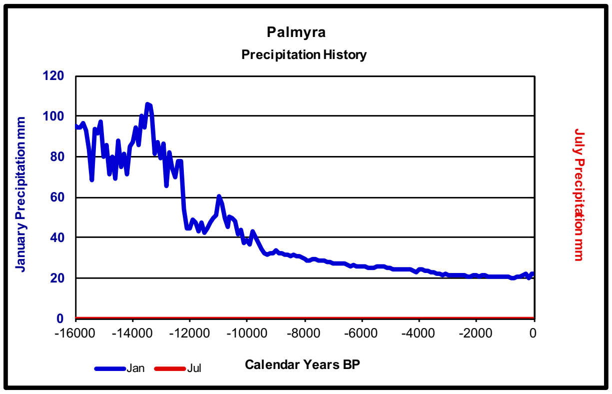

Nabk
Precipitation History
January Precipitation mm
July Precipitation mm
100
90
80
70
60
50
40
30
20
10
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

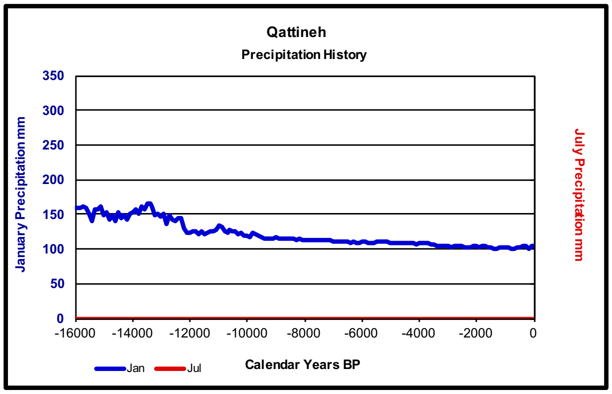

Mina el-Beida
Temperature History
January Temp. Degrees C
July Temp. Degrees C
14
12
10
8
6
4
2
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

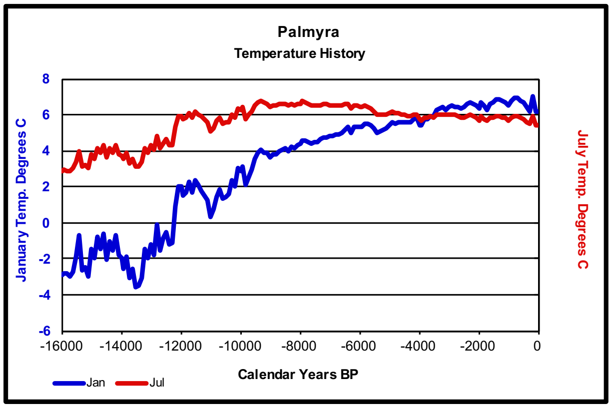

Nabk
Temperature History
January Temp. Degrees C
July Temp. Degrees C
4
3
2
1
0
-1
-2
-3
-4
-5
-6
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

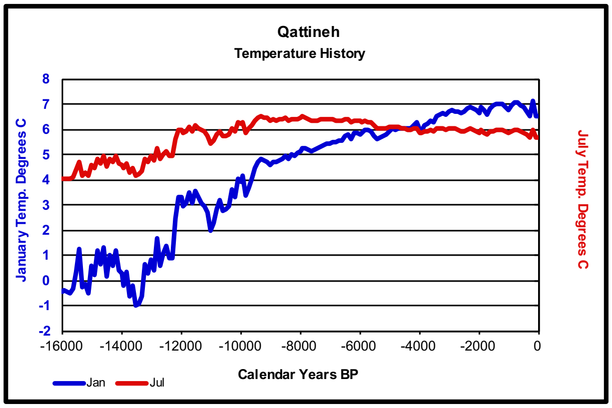

Mina el-Beida
Annual Precip or Evap mm
3500
3000
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

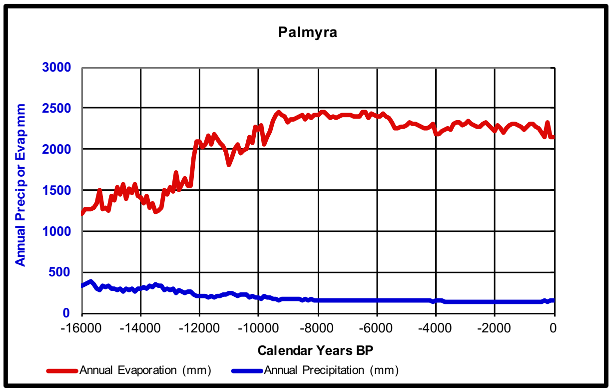

Nabk
Annual Precip or Evap mm
1800
1600
1400
1200
1000
800
600
400
200
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

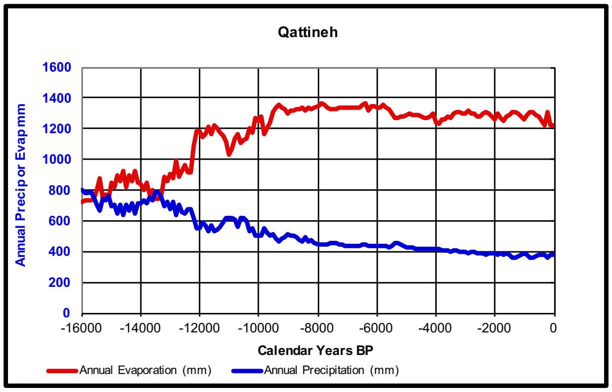

Palmyra
Precipitation History
January Precipitation mm
July Precipitation mm
120
100
80
60
40
20
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

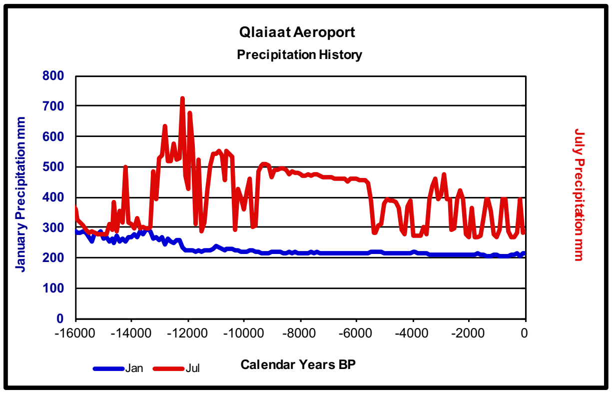

Qattineh
Precipitation History
January Precipitation mm
July Precipitation mm
350
300
250
200
150
100
50
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

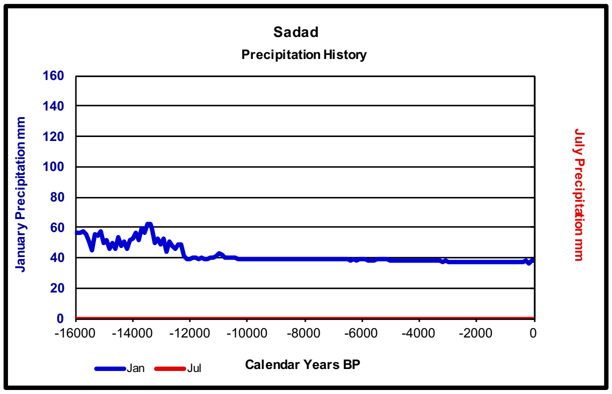

Palmyra
Temperature History
January Temp. Degrees C
July Temp. Degrees C
8
6
4
2
0
-2
-4
-6
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

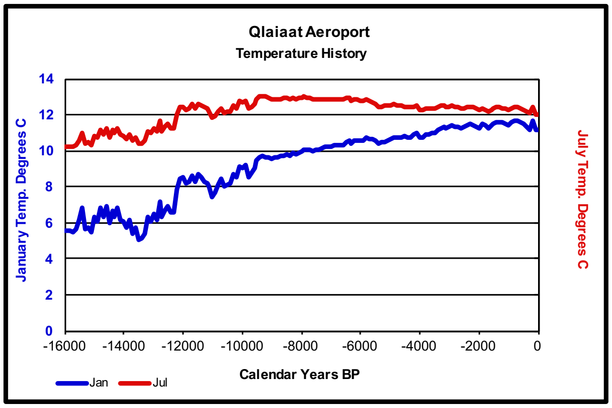

Qattineh
Temperature History
January Temp. Degrees C
July Temp. Degrees C
8
7
6
5
4
3
2
1
0
-1
-2
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

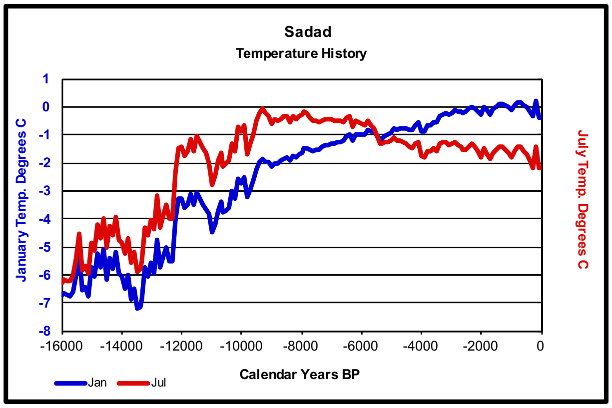

Palmyra
Annual Precip or Evap mm
3000
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

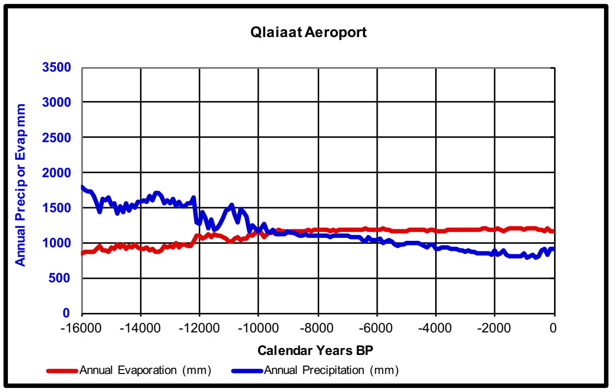

Qattineh
Annual Precip or Evap mm
1600
1400
1200
1000
800
600
400
200
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

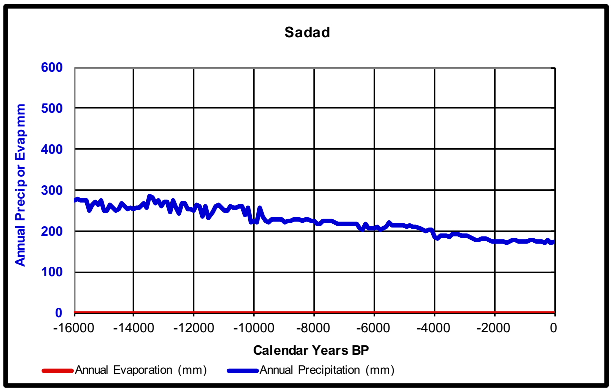

Qlaiaat Aeroport
Precipitation History
January Precipitation mm
July Precipitation mm
800
700
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

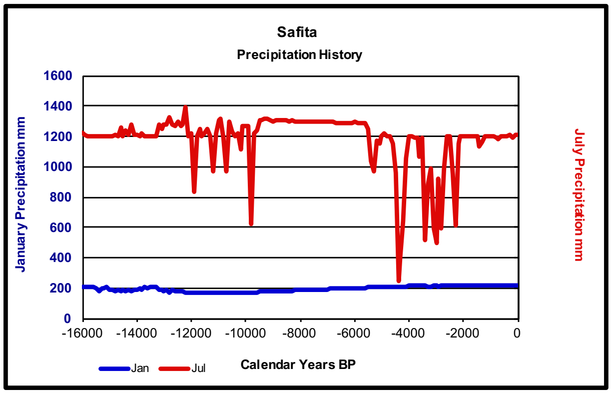

Sadad
Precipitation History
January Precipitation mm
July Precipitation mm
160
140
120
100
80
60
40
20
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

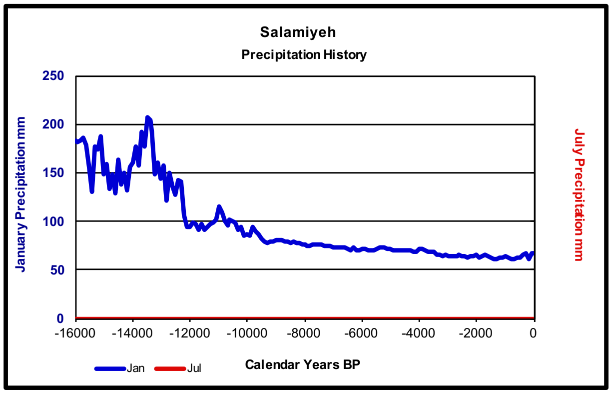

Qlaiaat Aeroport
Temperature History
January Temp. Degrees C
July Temp. Degrees C
14
12
10
8
6
4
2
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

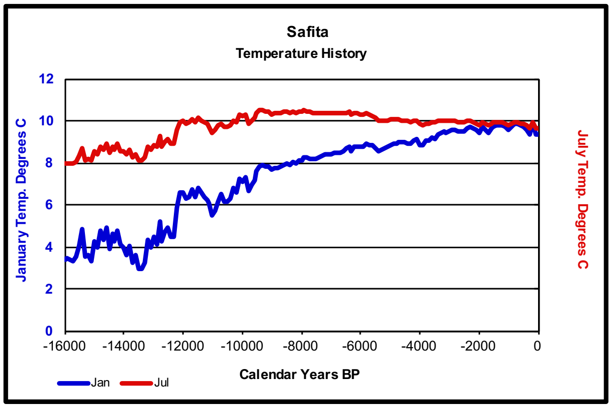

Sadad
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

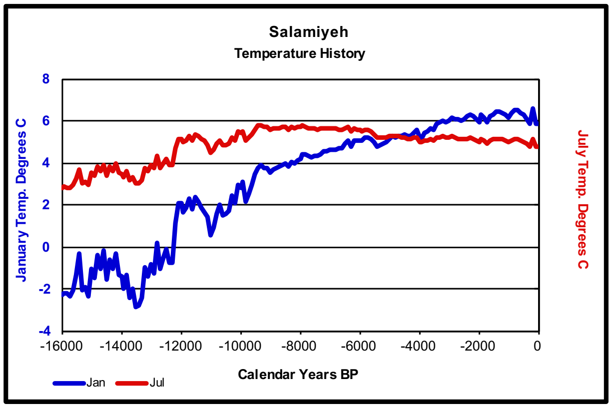

Qlaiaat Aeroport
Annual Precip or Evap mm
3500
3000
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

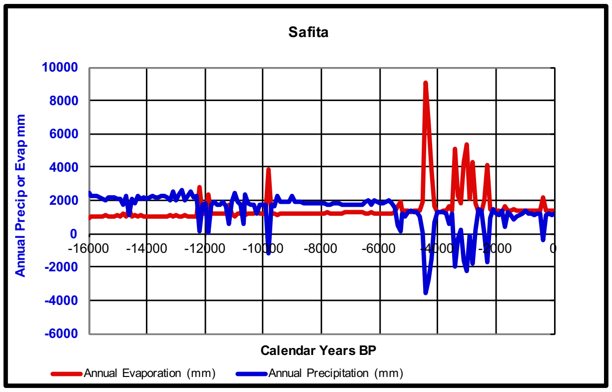

Sadad
Annual Precip or Evap mm
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

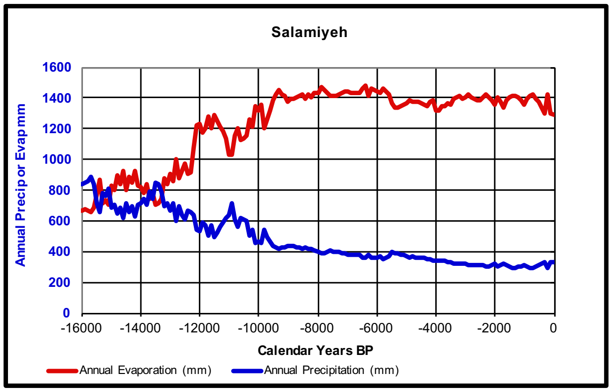

Safita
Precipitation History
January Precipitation mm
July Precipitation mm
1600
1400
1200
1000
800
600
400
200
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

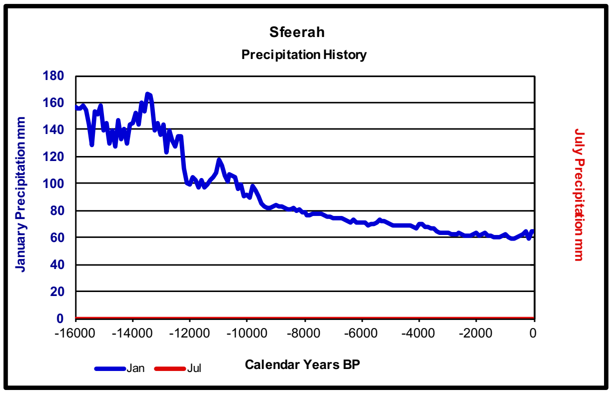

Salamiyeh
Precipitation History
January Precipitation mm
July Precipitation mm
250
200
150
100
50
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

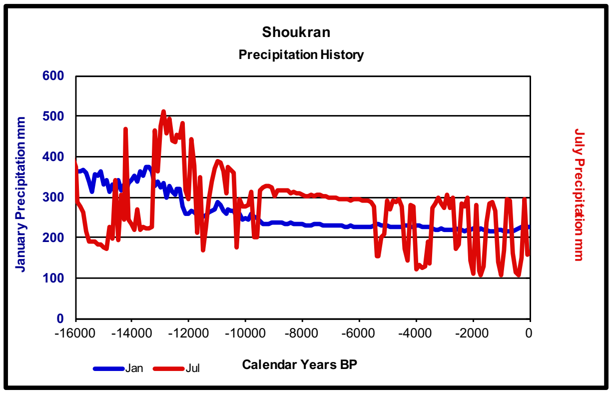

Safita
Temperature History
January Temp. Degrees C
July Temp. Degrees C
12
10
8
6
4
2
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

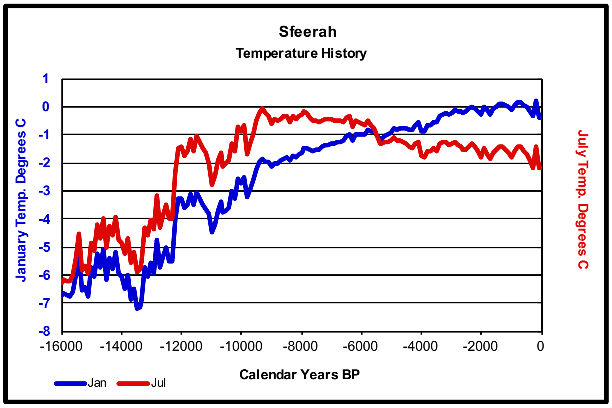

Salamiyeh
Temperature History
January Temp. Degrees C
July Temp. Degrees C
8
6
4
2
0
-2
-4
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

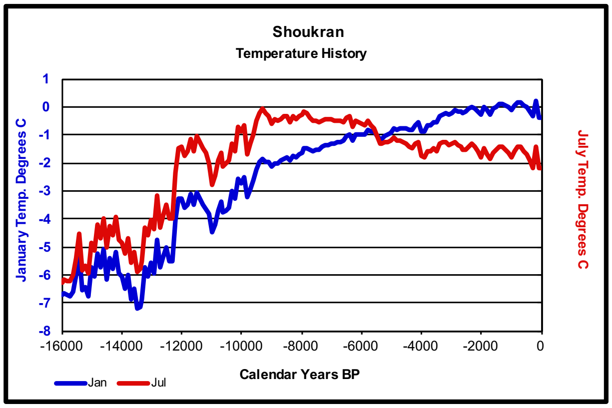

Safita
Annual Precip or Evap mm
10000
8000
6000
4000
2000
0
-2000
-4000
-6000
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

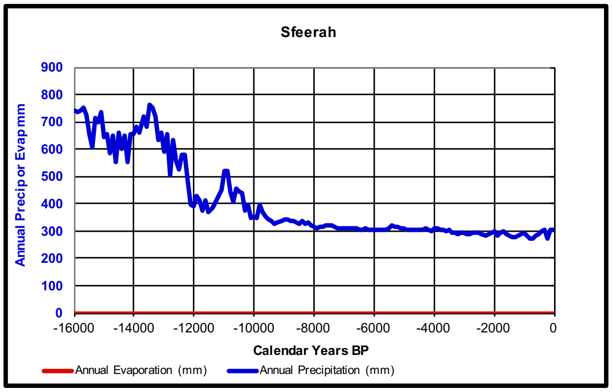

Salamiyeh
Annual Precip or Evap mm
1600
1400
1200
1000
800
600
400
200
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

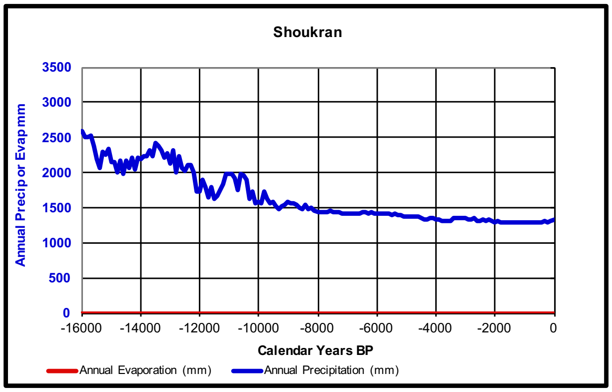

Sfeerah
Precipitation History
January Precipitation mm
July Precipitation mm
180
160
140
120
100
80
60
40
20
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

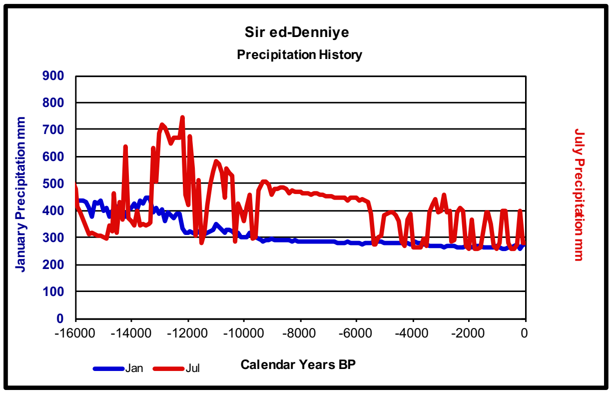

Shoukran
Precipitation History
January Precipitation mm
July Precipitation mm
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

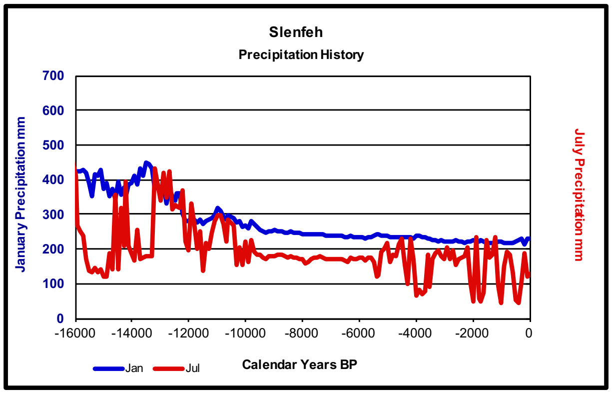

Sfeerah
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

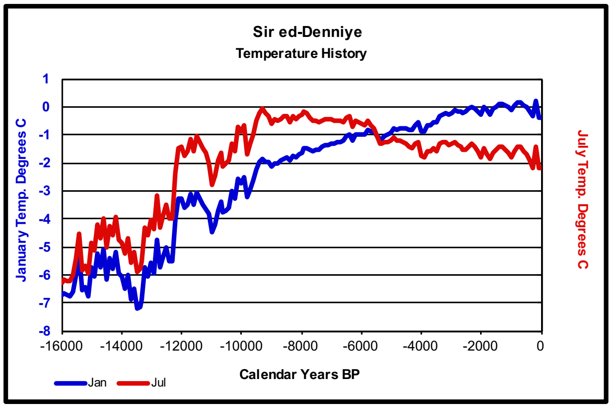

Shoukran
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

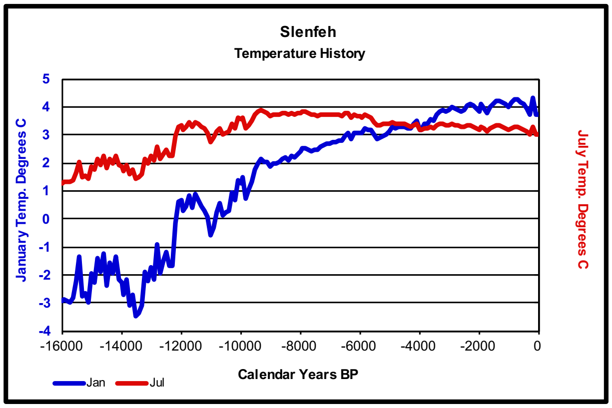

Sfeerah
Annual Precip or Evap mm
900
800
700
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

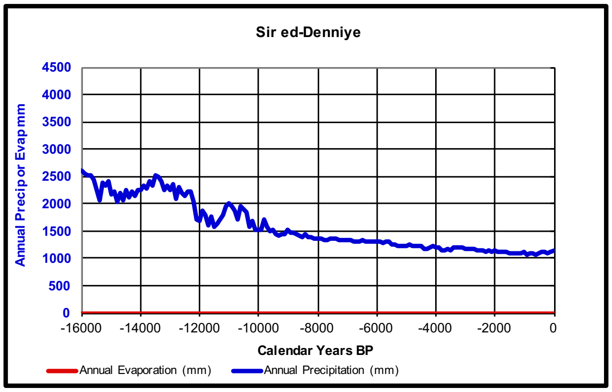

Shoukran
Annual Precip or Evap mm
3500
3000
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

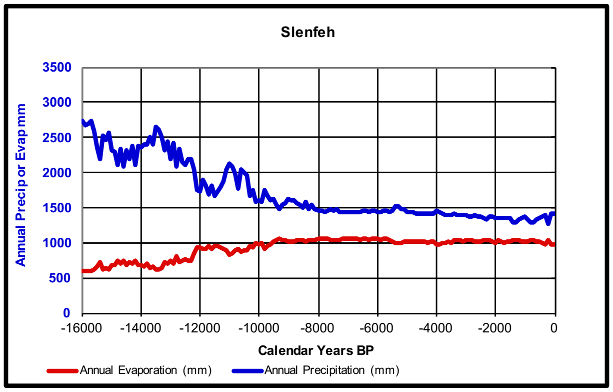

Sir ed-Denniye
Precipitation History
January Precipitation mm
July Precipitation mm
900
800
700
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

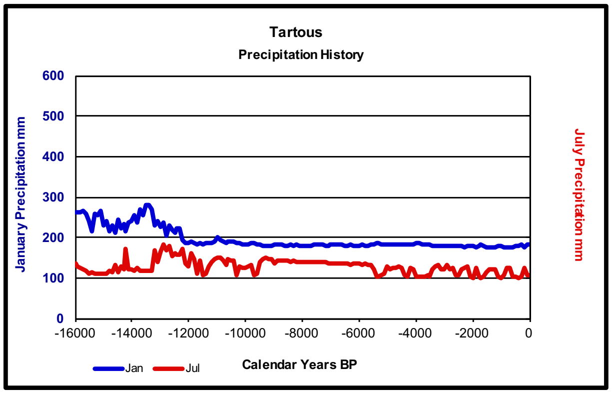

Slenfeh
Precipitation History
January Precipitation mm
July Precipitation mm
700
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

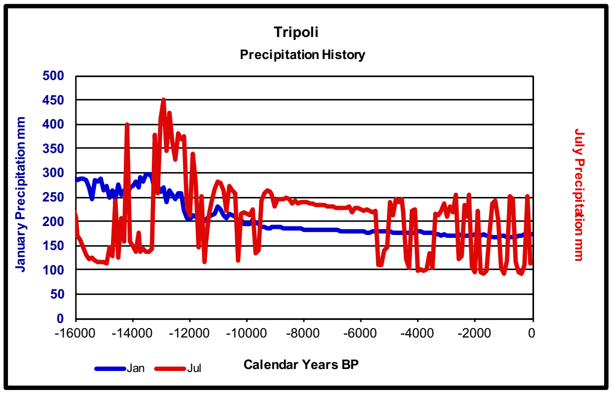

Sir ed-Denniye
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

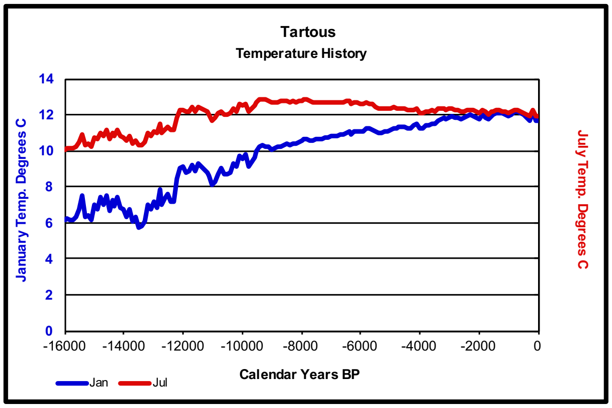

Slenfeh
Temperature History
January Temp. Degrees C
July Temp. Degrees C
5
4
3
2
1
0
-1
-2
-3
-4
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul

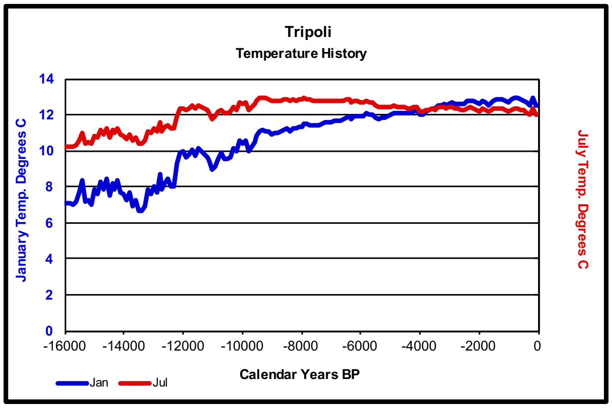

Sir ed-Denniye
Annual Precip or Evap mm
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

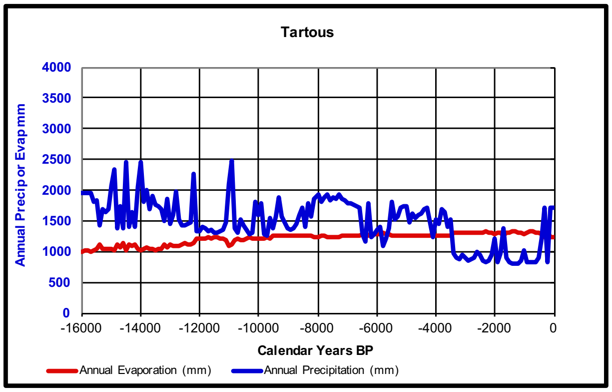

Slenfeh
Annual Precip or Evap mm
3500
3000
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

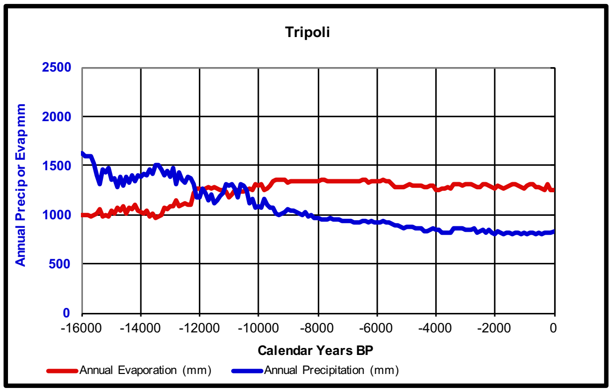

Tartous
Precipitation History
January Precipitation mm
July Precipitation mm
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

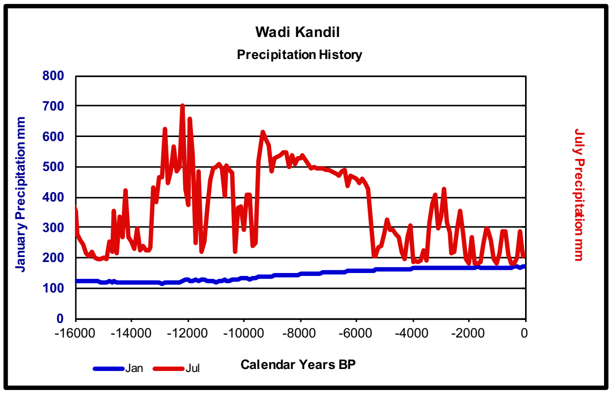

Tripoli
Precipitation History
January Precipitation mm
July Precipitation mm
500
450
400
350
300
250
200
150
100
50
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

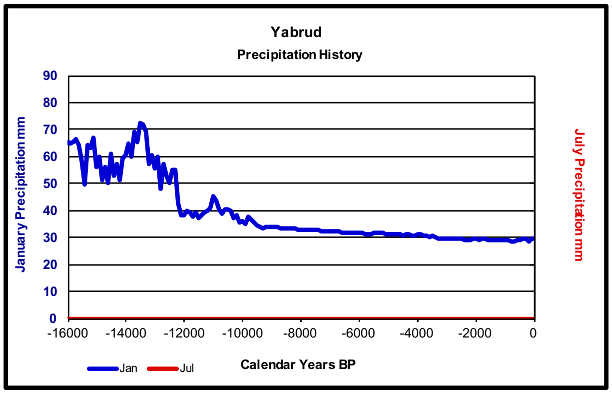

Tartous
Temperature History
January Temp. Degrees C
July Temp. Degrees C
14
12
10
8
6
4
2
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

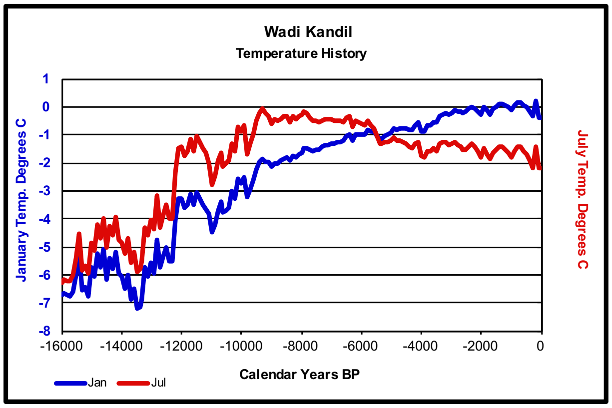

Tripoli
Temperature History
January Temp. Degrees C
July Temp. Degrees C
14
12
10
8
6
4
2
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Jan
Jul
Calendar Years BP

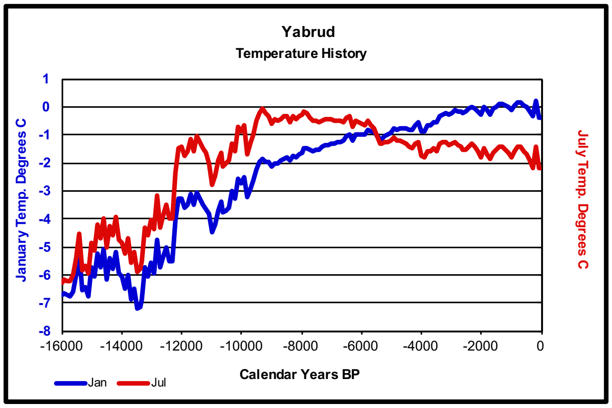

Tartous
Annual Precip or Evap mm
4000
3500
3000
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

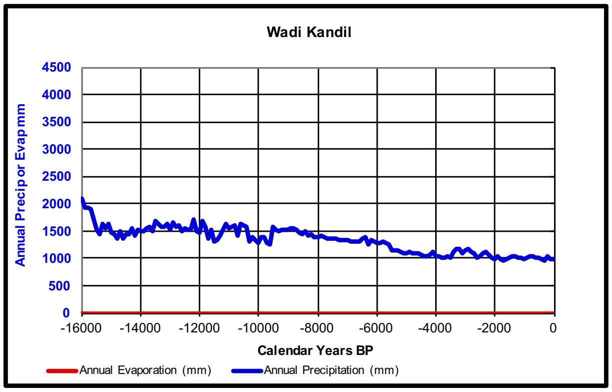

Tripoli
Annual Precip or Evap mm
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

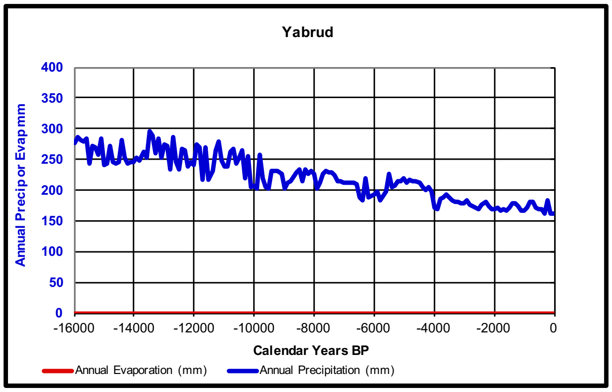

Wadi Kandil
Precipitation History
January Precipitation mm
July Precipitation mm
800
700
600
500
400
300
200
100
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul


Yabrud
Precipitation History
January Precipitation mm
July Precipitation mm
90
80
70
60
50
40
30
20
10
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul


Wadi Kandil
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul


Yabrud
Temperature History
January Temp. Degrees C
July Temp. Degrees C
1
0
-1
-2
-3
-4
-5
-6
-7
-8
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Jan
Jul


Wadi Kandil
Annual Precip or Evap mm
4500
4000
3500
3000
2500
2000
1500
1000
500
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)


Yabrud
Annual Precip or Evap mm
400
350
300
250
200
150
100
50
0
-16000
-14000
-12000
-10000
-8000
-6000
-4000
-2000
0
Calendar Years BP
Annual Evaporation (mm)
Annual Precipitation (mm)

APPENDIX 4
CLIMATE AND TOPOGRAPHY COMPARISON TABLES

Climate Comparison Table

Map ID	UTM East (36N)	UTM North (36N)	MCM Value (mm)	CNRM Value (mm)	HadGEM Value (mm)
CC1	772663.6603	4006881.096	1022	877	1200
CC2	825233.681	4006685.048	580	474	680
CC3	888834.3992	4003278.337	324	242	362
CC4	892893.3551	4003347.717	317	239	357
CC5	851920.256	4005307.349	434	319	455
CC6	869038.6183	4003654.27	375	274	392
CC7	875466.0815	3999604.957	350	275	398
CC8	869654.5486	4001606.331	370	271	389
CC9	896008.9305	4000811.844	310	234	349
CC10	898268.6485	4000355.956	308	234	347
CC11	769022.1127	3996053.014	1091	774	1059
CC12	808069.3821	3994842.112	712	542	769
CC13	828754.7124	3985872.635	517	378	549
CC14	834005.9902	3984212.523	489	343	496
CC15	800852.1591	3985243.477	772	593	865
CC16	814247.8277	3983207.717	634	445	647
CC17	791910.3737	3980939.918	913	694	1013
CC18	902847.6544	3981299.035	288	234	342
CC19	816887.2782	3977834.318	615	434	634
CC20	859179.7235	3973088.324	381	245	352
CC21	764212.1479	3975230.717	1215	864	1299
CC22	809950.8241	3974906.654	681	462	681
CC23	848346.601	3974157.88	422	274	395
CC24	761804.7312	3968279.108	1194	841	1232
CC25	763658.8442	3969852.872	1063	827	1231
CC26	784815.2824	3970703.239	1181	835	1246
CC27	835958.0682	3967232.807	386	326	473
CC28	796697.1402	3965300.645	961	675	1013
CC29	902693.4313	3965622.922	282	212	302
CC30	763633.3607	3965149.458	1203	777	1185
CC31	856522.5749	3961163.985	943	240	349
CC32	794686.246	3962318.633	344	837	1252
CC33	901654.1395	3960950.077	661	195	279
CC34	770001.0239	3964133.348	394	965	1409
CC35	795720.2736	3962495.535	307	727	1116
CC36	885231.1554	3956773.438	296	201	293
CC37	869619.7561	3959799.311	316	215	312
CC38	815332.4882	3957841.707	280	594	878
CC39	853927.2059	3958544.717	297	251	361
CC40	892741.4082	3954850.844	1092	194	276

Map ID	UTM East (36N)	UTM North (36N)	MCM Value (mm)	CNRM Value (mm)	HadGEM Value (mm)
CC41	880682.2617	3955626.692	1112	203	292
CC42	912956.3785	3954192.261	337	186	262
CC43	892244.7412	3952049.422	315	194	277
CC44	753964.3863	3951148.767	1204	682	1030
CC45	758039.4664	3950233.645	960	720	1087
CC46	869460.0947	3948385.195	304	221	316
CC47	880134.4628	3948413.005	323	200	285
CC48	778442.2051	3946466.042	346	937	1391
CC49	796909.3288	3948621.441	666	566	853
CC50	815528.281	3941401.766	1188	529	794
CC51	888090.4366	3942086.244	658	191	268
CC52	876665.5585	3942940.864	1017	202	287
CC53	865585.4255	3945010.465	656	225	324
CC54	814838.826	3944706.177	317	561	850
CC55	778545.6133	3943797.637	1057	911	1362
CC56	815962.9742	3937790.007	989	503	749
CC57	757590.0706	3937859.461	362	644	975
CC58	884142.9802	3934519.132	1054	195	274
CC59	788539.7347	3937229.293	688	1030	1506
CC60	755128.7581	3936144.654	691	643	977
CC61	856269.8801	3932324.981	287	242	347
CC62	782574.2898	3932550.402	285	1048	1558
CC63	811415.1697	3928866.626	582	470	704
CC64	811289.1256	3926470.06	283	468	699
CC65	904473.977	3927481.383	292	178	248
CC66	909908.9141	3923705.892	974	175	247
CC67	820902.7783	3925145.017	311	373	548
CC68	912890.6002	3924691.058	354	172	244
CC69	900571.6261	3921125.162	415	181	253
CC70	768005.8423	3916517.766	293	643	969
CC71	877407.3499	3915155.385	287	211	294
CC72	861839.4837	3916429.287	558	245	343
CC73	849350.6729	3911878.36	578	257	362
CC74	900455.9132	3912446.52	432	187	261
CC75	907172.0717	3912929.946	617	174	246
CC76	825426.2045	3912582.122	416	349	502
CC77	823736.1197	3914239.086	932	354	515
CC78	844365.7091	3914150.893	949	267	378
CC79	821482.293	3910852.517	297	356	522
CC80	849629.6616	3907421.994	304	278	379
CC81	795180.4722	3910385.263	731	945	1372

Map ID	UTM East (36N)	UTM North (36N)	MCM Value (mm)	CNRM Value (mm)	HadGEM Value (mm)
CC82	767785.8983	3909543.258	303	646	972
CC83	896332.5382	3910549.869	300	190	266
CC84	880412.1433	3906140.119	284	209	293
CC85	812407.1961	3905703.566	290	428	624
CC86	881698.5625	3901174.341	309	214	299
CC87	889036.0645	3899601.926	486	205	287
CC88	910679.8802	3899867.13	452	185	255
CC89	898735.3341	3901840.852	293	190	270
CC90	878976.7216	3898316.277	689	218	306
CC91	837950.7755	3898141.411	708	293	409
CC92	843163.7328	3896804.025	988	275	380
CC93	887615.9534	3890776.498	266	212	293
CC94	824131.8215	3888908.098	963	476	688
CC95	822985.8532	3888361.247	276	511	729
CC96	777130.6242	3884678.788	958	967	1462
CC97	899527.8283	3885097.363	571	197	273
CC98	834514.1952	3883991.203	997	362	508
CC99	805072.1507	3886490.481	629	842	1240
CC100	892982.6021	3885681.265	458	202	281
CC101	766116.4945	3886352.595	257	851	1274
CC102	803384.0695	3882509.121	421	903	1323
CC103	830147.9712	3881832.371	335	417	590
CC104	846635.5151	3882006.987	323	346	481
CC105	907190.1313	3881967.71	927	190	263
CC106	852855.2871	3878264.985	1015	269	369
CC107	869552.8273	3878203.337	299	240	337
CC108	874570.1289	3879290.537	253	229	319
CC109	806603.0797	3876774.22	255	758	1098
CC110	799617.2016	3877737.61	394	893	1301
CC111	880875.8362	3874549.011	251	217	300
CC112	907173.4925	3874944.934	834	186	256
CC113	857047.0075	3872228.877	1012	282	394
CC114	904877.4917	3874835.816	321	191	260
CC115	904541.4249	3869661.638	285	189	258
CC116	812636.6657	3870219.167	981	687	999
CC117	796147.3363	3868770.747	548	909	1321
CC118	872199.248	3870979.579	436	233	324
CC119	885784.6023	3870204.016	263	208	289
CC120	799476.4536	3866470.28	316	870	1268
CC121	837329.7876	3867884.497	281	389	548
CC122	851415.4223	3863429.111	477	303	428

Map ID	UTM East (36N)	UTM North (36N)	MCM Value (mm)	CNRM Value (mm)	HadGEM Value (mm)
CC123	894935.3113	3863507.72	930	197	270
CC124	870869.0481	3862181.966	782	232	320
CC125	882841.7783	3863268.095	783	212	291
CC126	783332.6882	3860785.042	606	853	1261
CC127	845542.0771	3862122.769	314	336	477
CC128	811827.8636	3858036.667	916	685	987
CC129	811108.5897	3857251.187	432	687	992
CC130	826217.6384	3854672.689	375	476	690
CC131	868949.8722	3853597.813	555	229	314
CC132	780507.5115	3856387.31	458	847	1224
CC133	848754.6034	3855803.99	258	311	441
CC134	854826.6041	3851386.283	276	278	382
CC135	828801.8964	3850019.02	246	438	626
CC136	840359.2979	3848959.735	252	349	494
CC137	889455.7252	3847716.689	250	198	265
CC138	876993.8182	3848450.456	242	207	280
CC139	906816.0654	3849036.625	238	169	222
CC140	878799.9029	3840985.802	467	191	254
CC141	906310.1919	3841039.452	753	158	205
CC142	900021.7187	3837722.633	576	153	200
CC143	877552.58	3834822.119	735	179	238
CC144	827653.5207	3835570.073	914	377	539
CC145	795474.719	3830292.792	316	714	990
CC146	813185.1159	3831296.482	902	519	727
CC147	796945.6049	3828634.122	235	693	963
CC148	774735.6866	3826800.835	816	675	956
CC149	847362.9697	3828620.536	282	258	351
CC150	776440.5476	3826083.411	538	675	955
CC151	866771.0028	3822671.429	482	190	249
CC152	817065.1261	3822447.589	243	432	599
CC153	788225.5553	3824501.451	225	723	1002
CC154	852511.5726	3825557.279	794	235	317
CC155	913447.6451	3822587.467	213	125	159
CC156	811367.4	3824895.192	213	512	709
CC157	900029.8578	3819385.063	224	130	167
CC158	788876.1449	3817552.669	212	741	1011
CC159	876599.0403	3815210.175	734	156	200
CC160	891815.9024	3811929.396	221	132	167
CC161	901596.431	3812673.198	226	121	155
CC162	791963.9082	3810817.349	208	738	984
CC163	878367.3384	3814434.451	315	151	195

Map ID	UTM East (36N)	UTM North (36N)	MCM Value (mm)	CNRM Value (mm)	HadGEM Value (mm)
CC164	834051.6908	3806947.005	248	307	412
CC165	902388.2719	3808216.534	214	119	151
CC166	903071.4869	3809736.667	442	119	152
CC167	877424.0568	3810409.072	222	147	187
CC168	846018.9389	3804256.016	227	201	258
CC169	862147.5722	3805091.647	453	166	210
CC170	814712.614	3806376.552	211	378	508
CC171	902788.3161	3806091.893	216	118	148
CC172	907086.8902	3806078.738	333	116	147
CC173	813996.7746	3802629.709	827	365	483
CC174	890847.3343	3802380.096	584	121	154
CC175	875032.4071	3799750.073	220	138	172
CC176	830962.5249	3802057.26	260	299	406
CC177	780431.1413	3799759.755	257	828	1096
CC178	801379.9935	3795796.605	819	511	660
CC179	862933.0701	3798395.004	396	153	193
CC180	910361.1532	3795334.832	263	112	138
CC181	908627.7759	3795171.463	836	111	137
CC182	777084.9053	3793998.893	252	874	1172
CC183	822617.5929	3794538.497	909	308	406
CC184	911383.5937	3794650.342	410	112	138
CC185	771331.387	3790038.153	273	885	1166
CC186	905402.8375	3790353.104	428	111	135
CC187	751223.4688	3787858.641	525	980	1328
CC188	822424.6977	3784806.79	848	395	518
CC189	846804.1245	3786345.721	273	162	203
CC190	806842.9251	3780113.409	669	492	660
CC191	820710.781	3780512.058	261	448	597
CC192	751245.0015	3780256.987	405	1103	1471
CC193	854020.8955	3779612.703	264	168	202
CC194	788699.4102	3779208.578	808	455	590
CC195	888520.4276	3775457.696	277	103	126
CC196	825820.4556	3774524.18	268	483	625
CC197	900504.8411	3775033.949	961	112	133
CC198	760738.4197	3773370.176	282	1044	1375
CC199	911098.8943	3774712.074	1203	107	128
CC200	904471.5476	3775520.657	943	111	134

Topography Comparison Table

Map ID	UTM East (36N)	UTM North (36N)	ASTER Value (m asl)	SRTM Value (m asl)	GMTED Value (m asl)	GTOPO30 Value (m asl)
TC1	869558.1	4002291.4	338	346	347	315
TC2	890559.4	4003677.5	344	353	353	360
TC3	813411.9	4005107.9	477	490	486	390
TC4	811115.9	4004405.9	450	459	482	432
TC5	819767.7	4004623.5	724	728	738	687
TC6	769064.1	4004664.6	341	358	355	175
TC7	774040	4002570.9	92	106	125	146
TC8	832053.7	4005557.9	410	415	417	411
TC9	773646.4	3998388.5	401	408	366	300
TC10	768143.4	3997172.8	24	26	26	27
TC11	899584.2	3998294.3	319	328	328	333
TC12	766839.5	3996526.1	6	5	3	1
TC13	879268.8	3993183.1	434	443	446	440
TC14	794612.3	3994733.9	459	465	460	430
TC15	851526.2	3989526.7	287	301	301	294
TC16	909512.4	3988817.8	354	361	364	400
TC17	892598.6	3990633.2	488	497	494	491
TC18	828518.9	3988078.2	386	389	396	395
TC19	874994.5	3990911.9	375	383	383	373
TC20	878388.1	3986617.7	329	336	337	409
TC21	876585.5	3986164.7	300	307	309	307
TC22	813868.7	3985838.6	216	221	222	229
TC23	856945.9	3981094.5	267	270	269	267
TC24	810719.2	3982062.3	273	279	257	220
TC25	819208.8	3983300.1	216	227	226	305
TC26	882312.8	3981790.1	311	326	324	325
TC27	826542.4	3983300.7	418	422	426	432
TC28	897848.4	3981602.5	577	579	579	579
TC29	771578.2	3977901.4	490	496	484	487
TC30	844925.7	3976975.8	332	339	338	335
TC31	897756.7	3977593.5	570	574	573	560
TC32	842059.3	3978458.9	345	353	350	351
TC33	793484.8	3978871.6	435	441	447	455
TC34	801770.4	3973483.6	242	244	242	199
TC35	896427.1	3975662.9	475	485	513	525
TC36	762853.6	3972661.4	176	180	175	388
TC37	846830.2	3969069.1	365	369	373	376
TC38	764875.1	3972421.3	262	267	307	500
TC39	794118.1	3968680.4	562	570	582	707
TC40	896520.1	3966204.4	390	393	388	390

Map ID	UTM East (36N)	UTM North (36N)	ASTER Value (m asl)	SRTM Value (m asl)	GMTED Value (m asl)	GTOPO30 Value (m asl)
TC41	808156.7	3968085.5	424	425	412	441
TC42	878355.5	3967427.3	255	270	270	267
TC43	798375.9	3964951.9	223	231	226	231
TC44	775589.9	3959439.5	329	324	287	206
TC45	843420.1	3954779.7	460	467	466	469
TC46	902714.5	3956029.7	267	269	272	272
TC47	781683.5	3955194.2	568	575	591	465
TC48	828476.8	3953335.6	585	594	588	588
TC49	848871.6	3952066	408	417	416	411
TC50	778997.9	3946875.4	540	548	554	506
TC51	883008.9	3945152.4	261	275	274	279
TC52	905208.4	3946498.5	283	289	290	306
TC53	830237.5	3945427.4	552	559	551	543
TC54	835896.3	3943266.9	523	534	534	529
TC55	824746.3	3945196.1	610	612	610	576
TC56	905012.8	3945223.2	290	295	296	294
TC57	789261.1	3940962.9	1042	1046	1079	1133
TC58	876716.9879	3941129.647	291	311	319	310
TC59	860027.5836	3939433.237	435	446	447	424
TC60	912544.7559	3937994.109	322	336	333	325
TC61	756223.3212	3939315.874	96	103	109	108
TC62	902661.4748	3936824.545	311	313	310	297
TC63	906372.0866	3932324.665	336	335	335	329
TC64	911704.7624	3933252.685	338	343	342	329
TC65	839535.5728	3934348.082	394	407	401	380
TC66	769062.6867	3929390.997	73	94	80	57
TC67	817495.9249	3931241.864	396	404	402	403
TC68	832769.2432	3925136.54	377	386	390	418
TC69	775812.4706	3925024.257	233	246	253	217
TC70	895340.045	3925786.724	334	347	345	352
TC71	905257.7586	3922776.542	373	370	372	381
TC72	866972.4371	3922578.569	381	392	390	386
TC73	768256.7087	3923700.893	26	29	34	38
TC74	772261.3993	3921944.283	89	106	104	90
TC75	861818.4595	3924004.535	376	384	383	376
TC76	818947.7679	3918019.399	218	222	217	222
TC77	801213.9249	3917550.214	164	170	170	166
TC78	854070.3205	3915858.846	440	448	447	412
TC79	827470.002	3913162.587	282	288	290	282
TC80	902396.9082	3907119.31	455	468	470	479
TC81	773675.0084	3909132.767	118	130	150	175

Map ID	UTM East (36N)	UTM North (36N)	ASTER Value (m asl)	SRTM Value (m asl)	GMTED Value (m asl)	GTOPO30 Value (m asl)
TC82	771515.7962	3907335.464	163	161	167	224
TC83	888155.5004	3908091.194	530	531	536	547
TC84	792898.7087	3904240.64	1147	1154	1148	1001
TC85	848278.4267	3905218.597	403	411	412	412
TC86	801850.4592	3903798.772	684	692	787	599
TC87	897593.702	3902968.212	509	519	525	559
TC88	890935.787	3905174.747	536	542	540	535
TC89	861799.9472	3903446.829	554	562	565	563
TC90	912600.9321	3905399.262	519	525	525	523
TC91	805538.0365	3900963.295	216	225	225	217
TC92	848069.5413	3899089.238	399	405	409	465
TC93	777035.0138	3900624.98	310	289	352	493
TC94	875266.1553	3897300.523	466	474	474	471
TC95	787743.461	3898607.598	950	947	930	873
TC96	882506.2211	3893554.86	523	521	520	516
TC97	900643.3915	3894323.442	595	605	607	622
TC98	859918.2588	3891607.847	425	434	443	479
TC99	850278.568	3887708.341	296	301	303	329
TC100	768285.0111	3889440.083	171	184	183	216
TC101	864387.4807	3888895.323	531	539	549	595
TC102	864843.0497	3886672.317	500	521	511	568
TC103	815302.0079	3887573.536	451	451	482	439
TC104	885580.6793	3885418.487	577	585	586	577
TC105	872822.6513	3881053.632	463	472	473	486
TC106	792118.9127	3882492.558	852	853	851	880
TC107	827483.0083	3883540.667	337	343	348	371
TC108	906471.2131	3879019.531	743	744	744	762
TC109	841304.062	3876832.734	407	418	418	414
TC110	826320.415	3879668.8	397	402	386	407
TC111	826034.3926	3874798.576	390	388	388	391
TC112	839966.0286	3873177.04	380	384	379	376
TC113	816006.2594	3872524.986	372	275	374	373
TC114	896836.3547	3872194.49	689	691	697	713
TC115	847351.3203	3872119.996	463	471	478	469
TC116	907948.6741	3867734.208	831	844	853	898
TC117	796615.7043	3865742.168	502	508	543	540
TC118	828861.9206	3868607.32	386	394	396	395
TC119	774562.0549	3863321.035	191	196	209	175
TC120	775065.1312	3861879.894	201	205	203	174
TC121	889245.3824	3863298.773	755	765	760	764
TC122	842408.3312	3860788.549	466	472	477	467

Map ID	UTM East (36N)	UTM North (36N)	ASTER Value (m asl)	SRTM Value (m asl)	GMTED Value (m asl)	GTOPO30 Value (m asl)
TC123	848654.5035	3859743.318	503	510	511	508
TC124	884183.7809	3860543.987	682	698	698	722
TC125	804937.7719	3856316.254	574	572	569	497
TC126	884245.1594	3857857.515	713	715	716	745
TC127	789592.6884	3857233.383	204	209	229	65
TC128	768029.0227	3856354.816	12	16	21	14
TC129	849766.3607	3851428.445	548	558	559	567
TC130	832153.1394	3852637.738	460	466	466	470
TC131	826046.3763	3853613.402	499	504	501	508
TC132	814692.3593	3851651.508	730	729	724	607
TC133	824393.9589	3848851.319	555	566	560	575
TC134	827570.3975	3848764.788	508	514	514	518
TC135	846323.8417	3848195.531	540	555	558	565
TC136	855050.3461	3850169.298	588	595	598	594
TC137	892031.3411	3844955.185	802	821	822	814
TC138	783733.5921	3843711.329	41	45	45	53
TC139	888817.0199	3844310.082	832	846	841	816
TC140	889121.7585	3845757.256	903	907	899	880
TC141	834324.9742	3846252.253	475	482	482	486
TC142	836166.9189	3844181.479	494	502	503	521
TC143	884751.6436	3843105.34	888	896	888	863
TC144	810482.8305	3841960.586	435	436	433	444
TC145	855906.6505	3840143.573	719	727	724	727
TC146	908201.8399	3836165.547	670	676	675	579
TC147	782996.391	3829258.28	83	86	88	157
TC148	814488.8753	3830473.327	583	591	592	603
TC149	817767.097	3825272.645	518	521	524	518
TC150	843744.7601	3828235.432	676	683	685	687
TC151	827775.9249	3826500.002	524	532	530	539
TC152	848826.9329	3826957.747	747	749	751	759
TC153	843792.1655	3822751.716	696	704	707	709
TC154	789070.6764	3821542.85	627	625	635	639
TC155	911160.4584	3824451.965	584	587	586	592
TC156	890374.7604	3823159.709	704	701	703	739
TC157	799042.2641	3822623.042	1508	1515	1557	1600
TC158	843837.6212	3824816.231	690	697	700	702
TC159	843431.8145	3817665.726	721	731	733	739
TC160	902896.1371	3818750.275	608	611	613	636
TC161	805197.0278	3817170.671	1509	1502	1389	1285
TC162	799634.5837	3814789.502	1922	1917	1917	1908
TC163	764575.6796	3816125.965	39	50	47	117

Map ID	UTM East (36N)	UTM North (36N)	ASTER Value (m asl)	SRTM Value (m asl)	GMTED Value (m asl)	GTOPO30 Value (m asl)
TC164	863974.1501	3813313.442	831	837	838	870
TC165	811577.7726	3806516.969	662	664	683	706
TC166	774999.3217	3803708.661	1302	1321	1343	1442
TC167	768673.804	3803539.353	758	759	671	658
TC168	866434.1917	3804704.067	880	888	886	898
TC169	876895.6204	3803907.802	833	830	832	841
TC170	839646.8469	3805267.479	118	1207	1189	1166
TC171	843678.7505	3805801.555	979	976	986	969
TC172	902913.2226	3801062.129	678	679	683	729
TC173	871326.9219	3801410.09	871	874	872	892
TC174	913716.1293	3795305.355	784	800	803	822
TC175	782291.303	3795806.014	2556	2569	2492	2286
TC176	898779.1759	3794464.271	743	755	756	779
TC177	764824.6928	3791413.819	1266	1255	1250	1254
TC178	782984.1	3789007.029	2133	2149	2063	1949
TC179	814271.2928	3788134.397	1442	1442	1435	1451
TC180	881088.5969	3787083.232	813	814	814	824
TC181	846291.9237	3786684.841	1234	1247	1244	1246
TC182	913258.7709	3787359.304	1128	1140	1117	1346
TC183	816381.8603	3785476.207	1675	1676	1656	1678
TC184	862027.0884	3785573.214	1301	1299	1311	1406
TC185	742991.8394	3784549.642	79	79	117	212
TC186	888689.764	3787127.205	800	803	805	799
TC187	762871.4563	3786406.435	1485	1479	1493	1752
TC188	812126.6897	3781384.789	1804	1812	1874	2018
TC189	816417.4343	3783857.327	1669	1678	1697	1719
TC190	778843.948	3780831.244	1516	1523	1477	1363
TC191	807646.6932	3780484.812	1690	1696	1687	1608
TC192	881946.0064	3779570.553	1074	1105	1167	1167
TC193	868761.7964	3777335.006	990	990	982	959
TC194	799181.4148	3777477.947	1049	1051	1061	1066
TC195	812847.3601	3777993.881	2134	2135	2094	2092
TC196	780620.538	3780159.664	1484	1484	1484	1500
TC197	825009.8643	3779055.621	2227	2226	2206	2261
TC198	892104.2259	3776131.557	882	893	895	900
TC199	889715.0102	3776387.689	855	870	871	869
TC200	782509.2627	3773420.363	1060	1059	1060	1053

APPENDIX 5
DERIVED CLIMATE DATA

Station Data

ID	Name	UTM East (36N)	UTM North (36N)
CS1	Abde	775389.33	3823902.9
CS2	Ammourine	804631.21	3911462.39
CS3	Annazah	777785.21	3896156.82
CS4	Ariha	825344.84	3967749.39
CS5	Armanaz	813386.55	3998430.45
CS6	Bailaneh	1016319.07	3990224.48
CS7	Banias	766852.6	3895827.9
CS8	Bardah	876315.72	3983117.37
CS9	Bouka	753879.3	3935427.3
CS10	Breij	845459.41	3794023.18
CS11	Darkush	804801.97	3985905.26
CS12	Dreikeesh	786083.61	3864206.93
CS13	Edleb	826618.31	3982243.71
CS14	Ein-Eido	774261.15	3951578.72
CS15	Ein el-Kroum	795534.44	3911159.33
CS16	el-Jeed	800969.41	3939111.86
CS17	el-Khafseh	955971.55	4018064.72
CS18	el-Rouge	808682.82	3978262.94
CS19	el-Sin	768477	3902538.8
CS20	Friklos	874222.55	3836259.61
CS21	Halbe	779980.71	3824040.42
CS22	Hama	838999.42	3893797.64
CS23	Hassia	844885.67	3809559.1
CS24	Hawret Amoureen	806375.06	3913743.48
CS25	Hermel	811687.55	3810611.55
CS26	Homs	840569.81	3851626.75
CS27	Jabboul	903541.61	4001012.44
CS28	Jisr el-Shoggour	799955.48	3969073.49
CS29	Jooreen	794438.12	3944448.35
CS30	Karatat	757479.9	3967733.7
CS31	Kassab	767986.8	3979152.2
CS32	Khan Sheikuun	828665.88	3926753.79
CS33	Khanasser	905072.58	3967706.52
CS34	Khirb el-Teen	823440.05	3843230.7
CS35	Lattakia	751158.5	3935350.4
CS36	Maaret el-Numan	830567.96	3949050.07
CS37	Mashtal Hilu	797091.73	3863447.1
CS38	Massiaf	803741.68	3883660.34
CS39	Mina el-Beida	750939.9	3943116.8
CS40	Nabk	843504	3771728.07
CS41	Palmyra	986515.56	3835924.7
CS42	Qattineh	832646.97	3842447.34
CS43	Qlaiaat Aeroport	775191.44	3830559.5
CS44	Sadad	860829.37	3802382.5
CS46	Salamiyeh	867848.65	3880470.45
CS47	Sfeerah	891824.68	4000479.76
CS48	Shoukran	768284	3847011.9
CS49	Sir ed-Denniye	777722.43	3807316.37
CS50	Slenfeh	788094.21	3944240.88
CS51	Tartous	763226.5	3863520.7
CS52	Tripoli	757239.6	3815610.3
CS53	Wadi Kandil	757802.8	3956638.3
CS54	Yabrud	835503.98	3762552.3

Annual Precipitation (mm)

ID	Name	1350 BCE	1250 BCE	1150 BCE	1050 BCE	950 BCE	850 BCE	750 BCE
CS1	Abde	954.1	948.8	944.2	944.8	937.5	938.6	930.5
CS2	Ammourine	515.5	512.8	507	507	503.2	502	497.3
CS3	Annazah	1087.7	1077	1074.9	1071	1044.2	1061.7	1072.6
CS4	Ariha	535.7	529.1	529.8	525	512.9	518.7	515.9
CS5	Armanaz	637.1	632.2	630	627.6	622.9	621.9	616.5
CS6	Bailaneh	228.7	228.6	224.2	225.2	227.2	223.5	220.2
CS7	Banias	887.8	878.3	877.8	872.3	854	862.9	858.8
CS8	Bardah	292.9	289.4	292.1	288.1	282.8	285	283.8
CS9	Bouka	921.1	919.6	906.2	908.2	909.9	901.8	894.4
CS10	Breij	197.7	197.1	196.4	196.5	196.3	195.4	193.4
CS11	Darkush	636.3	624.4	637.2	623.8	602.3	615.9	616.2
CS12	Dreikeesh	1290.9	1288	1275.6	1282.4	1290.7	1274.4	1248.8
CS13	Edleb	504.2	501	499.8	499.1	493.5	495.9	492
CS14	Ein-Eido	1185.6	1174.1	1216.6	1183.3	1151.6	1186.2	1220.5
CS15	Ein el-Kroum	1607.1	1575.5	1614	1578.8	1525.2	1560.6	1564.6
CS16	el-Jeed	863	863.1	854.9	858.8	860.6	855.4	842.8
CS17	el-Khafseh	239	238.7	237.1	236.6	238.3	235.3	233.8
CS18	el-Rouge	605.2	597.4	602.9	594.5	581.3	588.3	587.6
CS19	el-Sin	890.9	863.7	911	868.5	821.1	856.2	879
CS20	Friklos	202.3	201.4	202.8	201.5	199.7	201.3	202
CS21	Halbe	810.3	810.4	805.1	797.9	803.1	793.9	798
CS22	Hama	360.9	359	360.3	357.9	355.5	356.2	356.2
CS23	Hassia	164.6	163.8	171.6	169.7	164.8	173	177.7
CS24	Hawret Amoureen	532.1	529.6	524.5	525.3	519.9	520.9	516.4
CS25	Hermel	259.1	257.3	259.5	257.4	253.6	256.4	256.6
CS26	Homs	503.6	500.5	500.8	498.1	493.7	494.6	492.2
CS27	Jabboul	306.6	304.9	304.6	303.1	301.3	301	299.4
CS28	Jisr el-Shoggour	708.4	703.1	702.7	702.6	691.2	698.7	693.2
CS29	Jooreen	1060.5	1013.4	1101.3	1084.7	983.9	1083	1071.4
CS30	Karatat	1015.4	1012.8	993.2	994	997.4	983.5	983
CS31	Kassab	1649.4	1641.3	1634.4	1627.8	1614.9	1617	1619.9
CS32	Khan Sheikuun	386.9	387.8	381.2	384.1	386.4	382.1	377.4
CS33	Khanasser	243.4	241.4	242.4	240.4	237.5	238.4	237.1
CS34	Khirb el-Teen	635.8	628.8	634.5	628.4	613.1	623.7	623.9
CS35	Lattakia	833.6	829.8	834	823.8	820.3	820.2	823.2
CS36	Maaret el-Numan	399.8	398	396.5	394.5	391.8	392.9	392.8
CS37	Mashtal Hilu	1206.8	1200.7	1183.4	1196.4	1185.4	1187.8	1168
CS38	Massiaf	1326.1	1306.5	1319.9	1309.3	1261.3	1298.3	1299.6
CS39	Mina el-Beida	956.2	960.8	911	927.1	951.7	911.9	892
CS40	Nabk	158.2	158.2	153.3	154.4	156.8	152.1	149
CS41	Palmyra	139.3	138.4	139	137.9	136.4	137.1	137
CS42	Qattineh	403.9	399.6	402	398.5	389.8	395	394.1
CS43	Qlaiaat Aeroport	903.7	898.2	896.1	879.7	883.9	868.3	871.1
CS44	Sadad	192.4	191.6	187.6	187.9	189.5	185.3	182
CS46	Salamiyeh	322.8	319.6	320.2	317	312.9	313.8	312.6
CS47	Sfeerah	292.9	290.7	294.3	291.6	286.3	290.7	291.6
CS48	Shoukran	1358.2	1352.4	1355.3	1346.1	1335.8	1341	1344.8
CS49	Sir ed-Denniye	1197.3	1186.5	1196.9	1174.6	1162.9	1163.9	1171.4
CS50	Slenfeh	1402.5	1391.1	1401	1390.3	1364.8	1383	1385.9
CS51	Tartous	906.1	877.1	949.2	886.4	846	875.1	895.7
CS52	Tripoli	860.2	855.8	860.9	852.1	842.2	849.5	855.9
CS53	Wadi Kandil	1170.2	1182.4	1104.7	1132.9	1179.4	1113.6	1082.2
CS54	Yabrud	181.8	182	178.9	178.7	183.1	177	174

Growing Season Precipitation (mm)

ID	Name	1350 BCE	1250 BCE	1150 BCE	1050 BCE	950 BCE	850 BCE	750 BCE
CS1	Abde	759.1	748.1	740.9	729.9	723.6	711.5	696.5
CS2	Ammourine	510.7	501	494.4	483.2	479.9	466.8	454.3
CS3	Annazah	1357.3	1333.1	1302.1	1274.7	1273.6	1230	1201.5
CS4	Ariha	538.3	529.7	516.2	508.4	508.5	490.5	474.7
CS5	Armanaz	656.8	634.8	659.2	629.6	600.1	610.8	602.7
CS6	Bailaneh	375.5	371.2	364.4	363.5	360.1	355.6	347.1
CS7	Banias	842.1	829.1	800.3	789.3	793.6	759.4	734.4
CS8	Bardah	373.3	364.9	367.8	358.1	349.4	348.1	341.9
CS9	Bouka	677.2	671.2	661	655.1	655.5	642.3	631.7
CS10	Breij	240.7	240.3	233.3	235	237.9	230.6	223.1
CS11	Darkush	616.3	606.6	590.4	582.8	581.9	562.7	545.4
CS12	Dreikeesh	1241.2	1223	1232.6	1211.7	1190.6	1189	1169.1
CS13	Edleb	467.8	462.7	463.6	457.7	452.8	450.5	444.1
CS14	Ein-Eido	1088	1073.4	1070.4	1053	1041.6	1032.7	1021.7
CS15	Ein el-Kroum	1580.3	1567.3	1575.4	1560.9	1542.7	1546.5	1535.4
CS16	el-Jeed	1014.1	980.8	1066.2	1008.6	943	996.2	999.5
CS17	el-Khafseh	251.6	244.6	252.7	242.6	233.5	237.2	236.7
CS18	el-Rouge	571.1	557.7	557.1	541.4	530.6	524.4	516
CS19	el-Sin	881.1	867.6	835.7	823.2	827.1	794.8	778.4
CS20	Friklos	207.9	205.2	208.6	204	200	202.6	204.5
CS21	Halbe	611.5	603.8	600.6	592.3	586.1	581.4	575.3
CS22	Hama	1287.8	322.2	323.8	320.9	317.6	318.6	317.9
CS23	Hassia	167.2	168.4	183.5	180.1	174.1	190.2	204.5
CS24	Hawret Amoureen	514.9	505	505.8	493.5	486.1	479.5	469.1
CS25	Hermel	263.6	261.6	264.3	261.3	258	259.8	259.9
CS26	Homs	507.4	495	506.4	490	473.9	478.6	474
CS27	Jabboul	339	329.5	340	328.2	313.6	321.1	319.4
CS28	Jisr el-Shoggour	599.6	593	596.3	588	580.7	579.7	572.8
CS29	Jooreen	1018.4	1010.9	1014.3	1006.2	997	996.5	986.1
CS30	Karatat	839.7	829.4	799.7	791.2	798.8	765	744.3
CS31	Kassab	1417.8	1400.3	1399.1	1377.4	1363.4	1353.6	1340.6
CS32	Khan Sheikuun	399.1	389.3	403.9	387.8	375.1	379	374.5
CS33	Khanasser	313.3	304.8	315.3	303.6	291.4	296.7	294.5
CS34	Khirb el-Teen	538.5	530.6	529.4	520	513.5	509.1	502.8
CS35	Lattakia	624.1	618.3	605.3	600.8	601.8	587.7	577
CS36	Maaret el-Numan	373.2	362.5	375.8	356.5	341.9	350.7	356.5
CS37	Mashtal Hilu	1240.4	1227.4	1210.9	1202	1196.4	1176	1149.2
CS38	Massiaf	1325.2	1308.9	1304.6	1287.7	1273.5	1264.9	1250.5
CS39	Mina el-Beida	670.8	663.6	632.6	629.3	640.6	604.6	579
CS40	Nabk	199.3	198.7	182.4	185.6	192.5	177.4	166.9
CS41	Palmyra	181.3	179.3	178.5	176.2	174.6	173.2	171.7
CS42	Qattineh	342	337.6	332.3	327.9	326.8	319.5	312.7
CS43	Qlaiaat Aeroport	698.4	689.7	680.1	671.8	667.8	656.6	645.9
CS44	Sadad	201.3	194.2	190.1	184	179.5	173.6	165.8
CS46	Salamiyeh	366.1	355.1	359.9	346.4	334.3	335.6	332.6
CS47	Sfeerah	291.7	286.8	298.3	289.5	280.1	287.9	291.1
CS48	Shoukran	1242.4	1228.6	1229	1211.9	1199.6	1193.5	1182.9
CS49	Sir ed-Denniye	1023	1009.9	1009.2	994.7	981.7	978	969.2
CS50	Slenfeh	1546.6	1528.6	1542.6	1518.8	1496	1499.5	1488.7
CS51	Tartous	697.6	689.6	680.3	672	668.9	658.6	651
CS52	Tripoli	665.2	656.8	651	642.4	636.9	629.4	621
CS53	Wadi Kandil	879.5	870.2	852.7	844.6	847	822.2	798.9
CS54	Yabrud	208.9	197.3	211.1	194.2	180.4	185	182.9

Annual Temperature (°C)

ID	Name	1350 BCE	1250 BCE	1150 BCE	1050 BCE	950 BCE	850 BCE	750 BCE
CS1	Abde	19.71	19.73	19.65	19.7	19.77	19.7	19.67
CS2	Ammourine	18	18.05	17.91	17.99	18.11	17.99	17.95
CS3	Annazah	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS4	Ariha	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS5	Armanaz	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS6	Bailaneh	18.14	18.19	18.04	18.13	18.26	18.13	18.07
CS7	Banias	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS8	Bardah	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS9	Bouka	19.26	19.29	19.19	19.25	19.34	19.25	19.22
CS10	Breij	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS11	Darkush	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS12	Dreikeesh	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS13	Edleb	17.63	17.68	17.54	17.62	17.74	17.62	17.57
CS14	Ein-Eido	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS15	Ein el-Kroum	18.21	18.25	18.12	18.2	18.31	18.2	18.15
CS16	el-Jeed	17.34	17.38	17.25	17.33	17.44	17.33	17.28
CS17	el-Khafseh	18.07	18.13	17.98	18.07	18.19	18.06	18.01
CS18	el-Rouge	18.51	18.56	18.42	18.5	18.62	18.5	18.45
CS19	el-Sin	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS20	Friklos	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS21	Halbe	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS22	Hama	17.69	17.74	17.6	17.68	17.8	17.68	17.63
CS23	Hassia	15.62	15.66	15.54	15.61	15.71	15.61	15.57
CS24	Hawret Amoureen	17.98	18.02	17.89	17.97	18.08	17.97	17.92
CS25	Hermel	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS26	Homs	17	17.04	16.92	16.99	17.1	16.99	16.95
CS27	Jabboul	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS28	Jisr el-Shoggour	18.48	18.53	18.4	18.47	18.58	18.47	18.43
CS29	Jooreen	17.95	18	17.86	17.94	18.05	17.94	17.89
CS30	Karatat	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS31	Kassab	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS32	Khan Sheikuun	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS33	Khanasser	18.49	18.55	18.39	18.48	18.61	18.48	18.43
CS34	Khirb el-Teen	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS35	Lattakia	19.54	19.57	19.48	19.53	19.61	19.53	19.5
CS36	Maaret el-Numan	16.96	17.02	16.86	16.95	17.08	16.95	16.9
CS37	Mashtal Hilu	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS38	Massiaf	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS39	Mina el-Beida	19.43	19.47	19.37	19.43	19.51	19.43	19.4
CS40	Nabk	12.86	12.9	12.78	12.85	12.96	12.85	12.81
CS41	Palmyra	18.76	19.81	18.66	18.75	18.88	18.75	18.7
CS42	Qattineh	16.2	16.24	16.12	16.19	16.29	16.19	16.15
CS43	Qlaiaat Aeroport	19.49	19.52	19.43	19.48	19.56	19.48	19.45
CS44	Sadad	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS46	Salamiyeh	16.72	16.76	16.63	16.71	16.82	16.71	16.66
CS47	Sfeerah	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS48	Shoukran	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS49	Sir ed-Denniye	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS50	Slenfeh	12.93	12.97	12.86	12.92	13.01	12.92	12.88
CS51	Tartous	19.46	19.49	19.4	19.45	19.53	19.45	19.42
CS52	Tripoli	20.02	20.6	19.97	20.02	20.09	20.02	19.99
CS53	Wadi Kandil	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS54	Yabrud	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Growing Season Evaporation (mm)

ID	Name	1350 BCE	1250 BCE	1150 BCE	1050 BCE	950 BCE	850 BCE	750 BCE
CS1	Abde	93.19	93.33	92.47	92.76	93.31	92.5	92.04
CS2	Ammourine	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS3	Annazah	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS4	Ariha	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS5	Armanaz	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS6	Bailaneh	133.02	133.53	131.66	132.64	134.01	132.44	131.66
CS7	Banias	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS8	Bardah	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS9	Bouka	92.5	92.68	91.6	92	92.74	91.73	91.23
CS10	Breij	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS11	Darkush	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS12	Dreikeesh	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS13	Edleb	114.09	84.84	112.97	113.84	115.13	113.73	113.14
CS14	Ein-Eido	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS15	Ein el-Kroum	115.4	115.84	114.47	115.22	116.34	115.15	114.66
CS16	el-Jeed	112.38	112.72	111.63	112.21	113.14	112.1	111.6
CS17	el-Khafseh	132.99	133.65	131.88	132.98	134.49	133.02	132.45
CS18	el-Rouge	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS19	el-Sin	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS20	Friklos	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS21	Halbe	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS22	Hama	142.08	142.65	140.94	141.92	143.34	141.86	141.27
CS23	Hassia	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS24	Hawret Amoureen	120.33	120.93	119.67	120.61	121.77	120.84	120.62
CS25	Hermel	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS26	Homs	108.06	108.83	107.53	108.66	109.99	109.08	108.98
CS27	Jabboul	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS28	Jisr el-Shoggour	114.21	114.68	113.77	114.49	115.37	114.72	114.67
CS29	Jooreen	107.49	107.93	107.01	107.66	108.56	107.83	107.77
CS30	Karatat	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS31	Kassab	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS32	Khan Sheikuun	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS33	Khanasser	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS34	Khirb el-Teen	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS35	Lattakia	117.21	117.39	117.08	117.36	117.7	117.45	117.39
CS36	Maaret el-Numan	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS37	Mashtal Hilu	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS38	Massiaf	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS39	Mina el-Beida	97.81	97.92	96.97	97.26	97.87	96.95	96.45
CS40	Nabk	121.27	121.62	121.88	122.17	122.43	122.73	123.18
CS41	Palmyra	187.29	187.93	185.22	186.44	188.44	186.02	184.92
CS42	Qattineh	107.68	108.03	106.82	107.46	108.41	107.35	106.89
CS43	Qlaiaat Aeroport	93.53	93.76	93.47	93.79	94.18	93.95	93.93
CS44	Sadad	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS46	Salamiyeh	112.46	113.33	111.88	113.14	114.67	113.54	113.22
CS47	Sfeerah	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS48	Shoukran	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS49	Sir ed-Denniye	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS50	Slenfeh	79.4	79.68	78.93	79.39	80.03	79.41	78.85
CS51	Tartous	108.25	108.44	108.22	108.48	108.78	108.6	108.56
CS52	Tripoli	105.37	105.46	104.47	104.76	105.33	104.42	103.93
CS53	Wadi Kandil	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS54	Yabrud	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Growing Season Crop Evaporation (mm)

ID	Name	1350 BCE	1250 BCE	1150 BCE	1050 BCE	950 BCE	850 BCE	750 BCE
CS1	Abde	111.83	111.99	110.97	111.32	111.97	111	110.45
CS2	Ammourine	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS3	Annazah	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS4	Ariha	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS5	Armanaz	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS6	Bailaneh	159.62	160.23	157.99	159.16	160.82	158.92	158
CS7	Banias	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS8	Bardah	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS9	Bouka	111	111.22	109.92	110.4	111.29	110.08	109.48
CS10	Breij	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS11	Darkush	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS12	Dreikeesh	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS13	Edleb	136.9	101.81	135.56	136.61	138.15	136.48	135.77
CS14	Ein-Eido	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS15	Ein el-Kroum	138.48	139.01	137.36	138.27	139.6	138.18	137.6
CS16	el-Jeed	134.85	135.26	133.95	134.65	135.76	134.52	133.92
CS17	el-Khafseh	159.59	160.38	158.26	159.58	161.39	159.62	158.94
CS18	el-Rouge	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS19	el-Sin	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS20	Friklos	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS21	Halbe	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS22	Hama	170.49	171.18	169.13	170.3	172.01	170.24	169.52
CS23	Hassia	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS24	Hawret Amoureen	144.39	145.12	143.6	144.74	146.13	145.01	144.74
CS25	Hermel	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS26	Homs	129.68	130.6	129.04	130.39	131.98	130.9	130.78
CS27	Jabboul	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS28	Jisr el-Shoggour	137.05	137.62	136.53	137.38	138.45	137.67	137.61
CS29	Jooreen	128.99	129.52	128.41	129.19	130.27	129.4	129.32
CS30	Karatat	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS31	Kassab	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS32	Khan Sheikuun	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS33	Khanasser	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS34	Khirb el-Teen	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS35	Lattakia	140.65	140.87	140.5	140.83	141.24	140.94	140.87
CS36	Maaret el-Numan	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS37	Mashtal Hilu	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS38	Massiaf	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS39	Mina el-Beida	117.37	117.5	116.36	116.71	117.44	116.34	115.74
CS40	Nabk	145.52	145.94	146.25	146.6	146.92	147.28	147.82
CS41	Palmyra	224.75	225.52	222.26	223.73	226.13	223.22	221.9
CS42	Qattineh	129.21	129.64	128.19	128.95	130.09	128.82	128.27
CS43	Qlaiaat Aeroport	112.24	112.52	112.16	112.55	113.01	112.74	112.72
CS44	Sadad	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS46	Salamiyeh	134.95	136	134.25	135.77	137.61	136.25	135.86
CS47	Sfeerah	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS48	Shoukran	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS49	Sir ed-Denniye	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS50	Slenfeh	95.28	95.62	94.72	95.26	96.04	95.29	94.62
CS51	Tartous	129.9	130.13	129.86	130.17	130.53	130.32	130.27
CS52	Tripoli	126.44	126.55	125.36	125.71	126.39	125.3	124.71
CS53	Wadi Kandil	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS54	Yabrud	N/A	N/A	N/A	N/A	N/A	N/A	N/A

Growing Season Water Stress (mm)

ID	Name	1350 BCE	1250 BCE	1150 BCE	1050 BCE	950 BCE	850 BCE	750 BCE
CS1	Abde	-35.92	-37.18	-36.88	-38.32	-39.61	-39.85	-40.8
CS2	Ammourine	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS3	Annazah	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS4	Ariha	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS5	Armanaz	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS6	Bailaneh	-122.08	-123.11	-121.55	-122.82	-124.81	-123.37	-123.29
CS7	Banias	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS8	Bardah	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS9	Bouka	-43.28	-44.1	-43.82	-44.89	-45.73	-45.85	-46.31
CS10	Breij	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS11	Darkush	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS12	Dreikeesh	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS13	Edleb	-90.13	-55.54	-89.2	-90.84	-92.87	-91.43	-91.36
CS14	Ein-Eido	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS15	Ein el-Kroum	19.55	17.72	20.18	17.83	14.67	16.47	15.95
CS16	el-Jeed	-33.45	-37.18	-27.34	-33.79	-41.46	-34.9	-33.97
CS17	el-Khafseh	-134.43	-135.92	-132.99	-135.32	-138.04	-135.9	-135.27
CS18	el-Rouge	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS19	el-Sin	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS20	Friklos	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS21	Halbe	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS22	Hama	-41.71	-138.96	-136.75	-138.22	-140.25	-138.38	-137.73
CS23	Hassia	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS24	Hawret Amoureen	-92.9	-94.62	-93.02	-95.39	-97.52	-97.05	-97.83
CS25	Hermel	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS26	Homs	-78.94	-81.1	-78.4	-81.39	-84.59	-83.03	-83.38
CS27	Jabboul	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS28	Jisr el-Shoggour	-77.1	-78.32	-76.9	-78.59	-80.38	-79.7	-80.33
CS29	Jooreen	-27.15	-28.43	-26.99	-28.56	-30.56	-29.75	-30.71
CS30	Karatat	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS31	Kassab	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS32	Khan Sheikuun	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS33	Khanasser	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS34	Khirb el-Teen	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS35	Lattakia	-78.24	-79.04	-79.97	-80.75	-81.06	-82.17	-83.16
CS36	Maaret el-Numan	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS37	Mashtal Hilu	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS38	Massiaf	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS39	Mina el-Beida	-50.29	-51.14	-53.1	-53.79	-53.39	-55.88	-57.84
CS40	Nabk	-125.59	-126.07	-128.02	-128.04	-127.67	-129.53	-131.13
CS41	Palmyra	-206.62	-207.59	-204.42	-206.11	-208.66	-205.9	-204.73
CS42	Qattineh	-95.01	-95.88	-94.96	-96.15	-97.41	-96.87	-97
CS43	Qlaiaat Aeroport	-42.39	-43.55	-44.16	-45.37	-46.23	-47.08	-48.13
CS44	Sadad	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS46	Salamiyeh	-98.33	-100.48	-98.27	-101.12	-104.17	-102.68	-102.6
CS47	Sfeerah	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS48	Shoukran	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS49	Sir ed-Denniye	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS50	Slenfeh	59.38	57.24	59.54	56.62	53.57	54.65	54.25
CS51	Tartous	-60.14	-61.16	-61.83	-62.97	-63.64	-64.47	-65.17
CS52	Tripoli	-59.92	-60.87	-60.26	-61.46	-62.7	-62.37	-62.61
CS53	Wadi Kandil	N/A	N/A	N/A	N/A	N/A	N/A	N/A
CS54	Yabrud	N/A	N/A	N/A	N/A	N/A	N/A	N/A

APPENDIX 6
STATISTICS TABLES AND GRAPHS

ENTIRE STUDY AREA

X^2-Test Values for Entire Study Area (Precipitation)

Observed Values

	1350 BCE	1250 BCE	1150 BCE	1050 BCE	950 BCE	850 BCE	750 BCE	Total
Very Low (1)	11	12	9	10	15	10	10	77
Low (2)	174	171	160	123	121	163	192	1104
Moderate (3)	728	762	637	693	728	868	849	5265
High (4)	2659	2653	2347	2347	2354	2671	2686	17717
Very High (5)	2884	2858	3021	3001	2956	3279	3254	21253
Total	6456	6456	6174	6174	6174	6991	6991	45416

Expected Values

	1350 BCE	1250 BCE	1150 BCE	1050 BCE	950 BCE	850 BCE	750 BCE	Total
Very Low (1)	10.946	10.946	10.468	10.468	10.468	11.85	11.853	77
Low (2)	156.936	156.936	150.081	150.081	150.081	169.942	169.942	1104
Moderate (3)	748.433	748.433	715.741	715.741	715.741	810.455	810.455	5265
High (4)	2518.517	2518.517	2408.507	2408.507	2408.507	2727.223	2727.223	17717
Very High (5)	3021.168	3021.168	2889.203	2889.203	2889.203	3271.528	3271.528	21253
Total	6456	6456	6174	6174	6174	6991	6991	45416

P =	0.00000001014

X^2-Test Values for Entire Study Area (Hydrogeology)

Observed Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
No Groundwater	1954	2066	2469	6489
Irregular Groundwater	3363	3231	3412	10006
Regular Groundwater	1143	880	1115	3138
Total	6460	6177	6996	19633

Expected Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
No Groundwater	2135.127	2041.591	2312.283	6489
Irregular Groundwater	3292.353	3148.121	3565.526	10006
Regular Groundwater	1032.521	987.288	1118.191	3138
Total	6460	6177	6996	19633

P =	0.0000000000028

X^2-Test Values for Entire Study Area (Water Courses)

Observed Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
Perennial/Large	310	347	353	1010
Intermittend/Moderate	624	507	599	1730
Wadi/Small	788	641	769	2198
Total	1722	1495	1721	4938

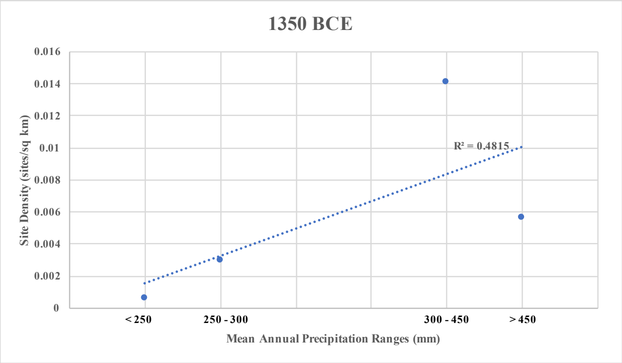
Expected Values

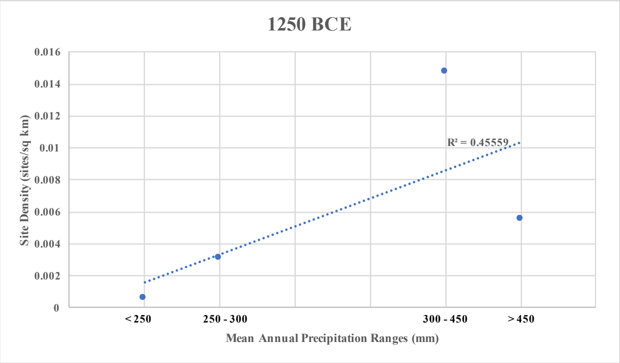
	Late Bronze Age	Iron Age I	Iron Age II	Total
Perennial/Large	352.211	305.782	352.007	1010
Intermittent/Moderate	603.293	523.765	602.942	1730
Wadi/Small	766.496	665.454	766.051	2198
Total	1722	1495	1721	4938

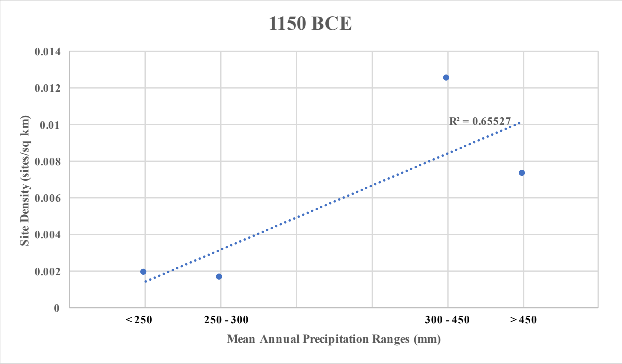
P =	0.00946

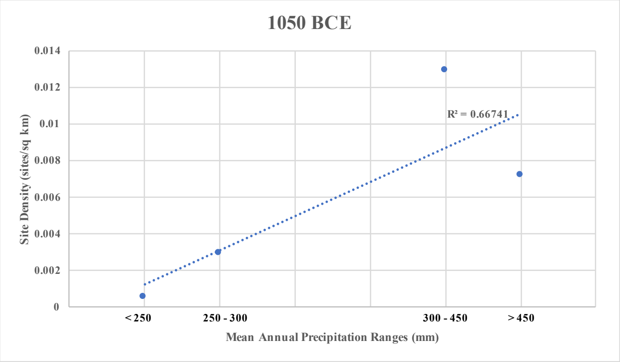
Regression Analysis for Entire Study Area

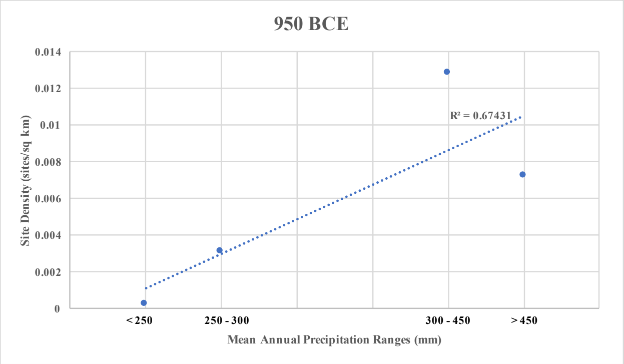
Precipitation

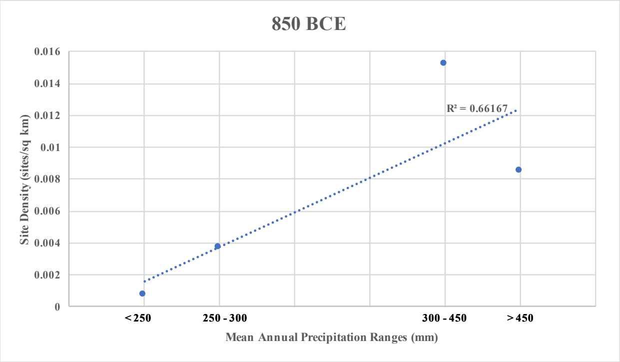


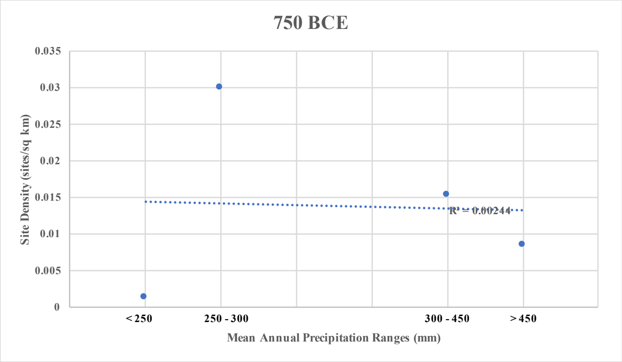






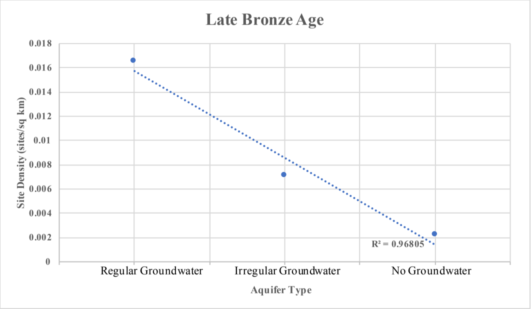


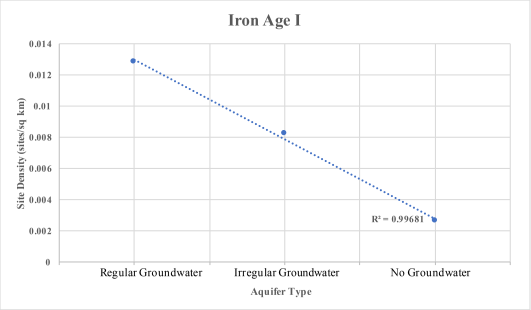


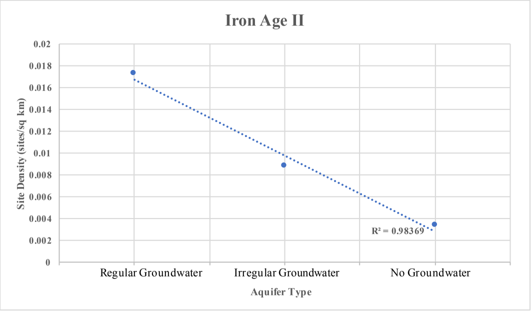


Regression Analysis for Entire Study Area

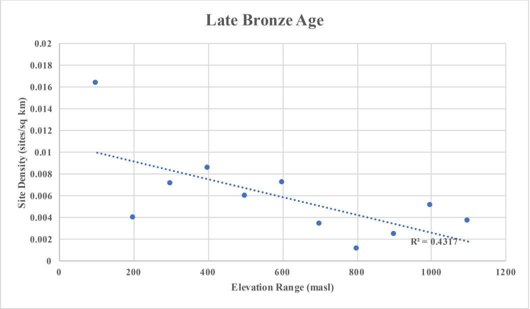
Hydrogeology

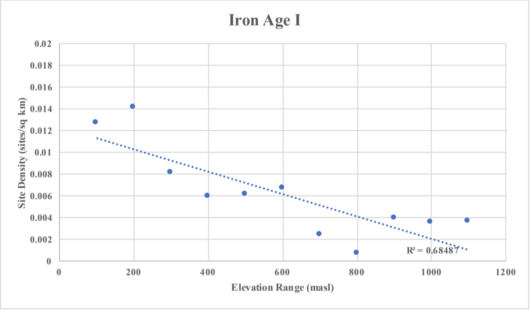


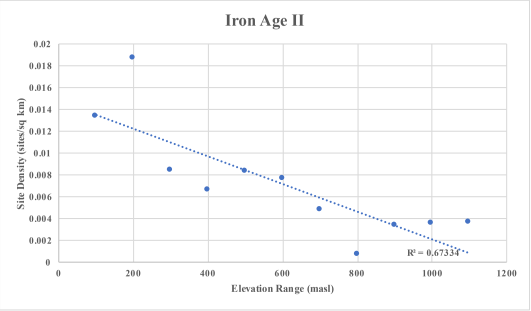




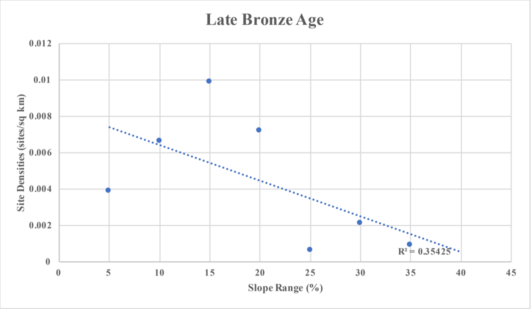
Elevation

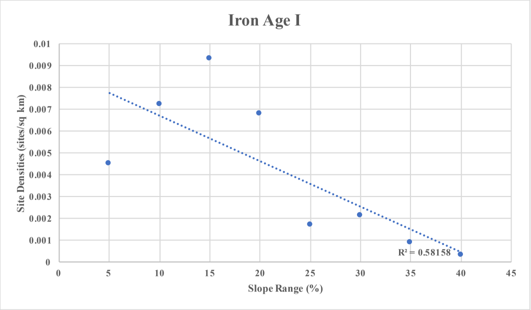


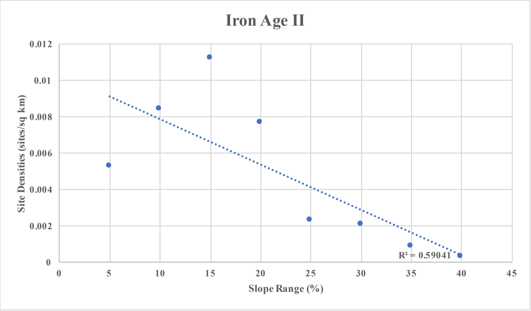




Slope







NORTHERN COAST

X^2-Test Values for Northern Coast (Water Courses)

Observed Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
Perennial/Large	0	0	0	0
Intermittent/Moderate	19	3	3	25
Wadi/Small	15	6	6	27
Total	34	9	9	52

Expected Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
Perennial/Large	0	0	0	0
Intermittent/Moderate	16.346	4.327	4.327	25
Wadi/Small	17.654	4.673	4.673	27
Total	34	9	9	52

P =	0.3016

JABLEH PLAIN

X^2-Test Values for Jableh Plain (Hydrogeology)

Observed Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
No Groundwater	0	0	0	0
Irregular Groundwater	4	13	18	35
Regular Groundwater	187	117	118	492
Total	191	130	206	527

Expected Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
No Groundwater	0	0	0	0
Irregular Groundwater	12.685	8.634	13.681	35
Regular Groundwater	178.315	121.366	192.319	492
Total	191	130	206	527

P =	0.0061

X^2-Test Values for Jableh Plain (Water Courses)

Observed Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
Perennial/Large	0	0	0	0
Intermittent/Moderate	33	21	35	89
Wadi/Small	40	29	46	115
Total	73	50	81	204

Expected Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
Perennial/Large	0	0	0	0
Intermittent/Moderate	31.848	21.814	35.338	89
Wadi/Small	41.152	28.186	45.662	115
Total	73	50	81	204

P =	0.9354

AKKAR PLAIN

X^2-Test Values for Akkar Plain (Water Courses)

Observed Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
Perennial/Large	53	47	49	149
Intermittent/Moderate	29	27	28	84
Wadi/Small	23	39	53	115
Total	105	113	130	348

Expected Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
Perennial/Large	44.957	48.382	55.661	149
Intermittent/Moderate	25.345	27.275	31.379	84
Wadi/Small	34.698	37.342	42.959	115
Total	105	113	130	348

P =	0.0490623

NORTHERN PLATEAU

X^2-Test Values for Northern Plateau (Precipitation)

Observed Values

	1350 BCE	1250 BCE	1150 BCE	1050 BCE	950 BCE	850 BCE	750 BCE	Total
Very Low (1)	0	0	0	0	0	0	0	0
Low (2)	0	0	0	0	0	0	0	0
Moderate (3)	25	35	174	198	220	213	209	1074
High (4)	840	839	907	886	882	936	956	6246
Very High (5)	278	269	673	670	652	655	639	3836
Total	1143	1143	1754	1754	1754	1804	1804	45416

Expected Values

	1350 BCE	1250 BCE	1150 BCE	1050 BCE	950 BCE	850 BCE	750 BCE	Total
Very Low (1)	0	0	0	0	0	0	0	0
Low (2)	0	0	0	0	0	0	0	0
Moderate (3)	110.038	110.038	168.859	168.859	168.859	173.673	173.673	1074
High (4)	639.941	639.941	982.26	982.026	982.026	1010.020	1010.020	6246
Very High (5)	393.022	393.022	603.114	603.114	603.114	620.307	620.307	3836
Total	1143	1143	1754	1754	1754	1804	1804	11156

P =	1.58^{-79}

X^2-Test Values for Northern Plateau (Hydrogeology)

Observed Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
No Groundwater	1025	1579	1630	4234
Irregular Groundwater	118	174	174	466
Regular Groundwater	0	0	0	0
Total	1143	1753	1804	4700

Expected Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
No Groundwater	1029.673	1579.192	1625.135	4234
Irregular Groundwater	113.327	173.808	178.865	466
Regular Groundwater	0	0	0	0
Total	1143	6177	6996	4700

P =	0.83

X^2-Test Values for Northern Plateau (Water Courses)

Observed Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
Perennial/Large	28	35	35	98
Intermittend/Moderate	123	139	143	405
Wadi/Small	107	145	151	403
Total	258	319	329	906

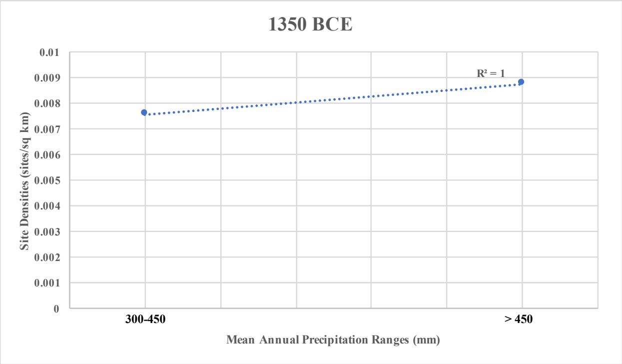
Expected Values

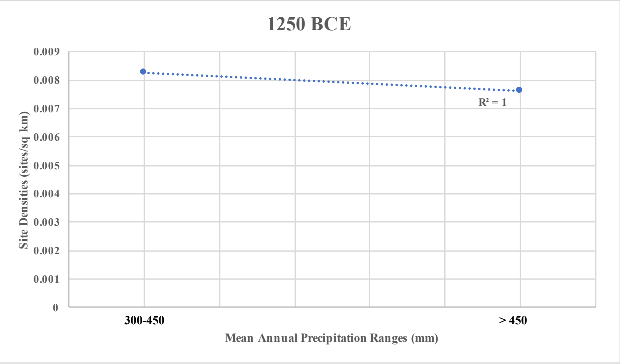
	Late Bronze Age	Iron Age I	Iron Age II	Total
Perennial/Large	258.108	319.108	329.108	98
Intermittent/Moderate	258.447	319.447	329.447	405
Wadi/Small	258.445	319.445	329.445	403
Total	1722	1495	1721	906

P =	7.1558^{-276}

Regression Analysis for Northern Plateau

Precipitation


1350 BCE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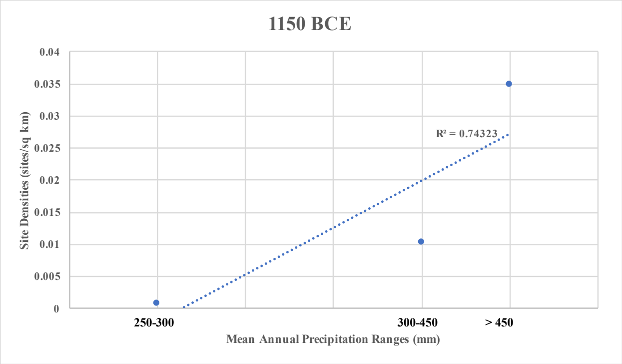
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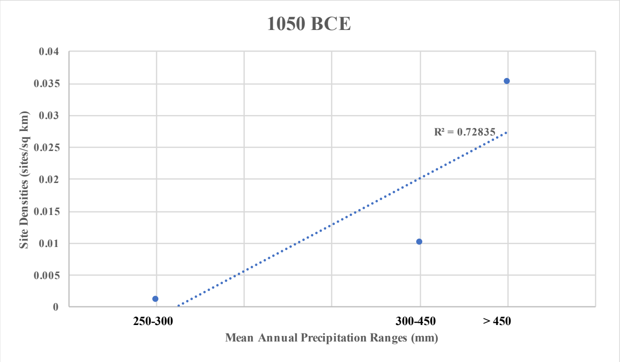
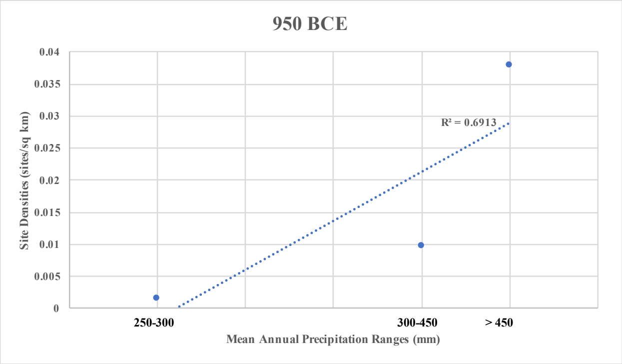
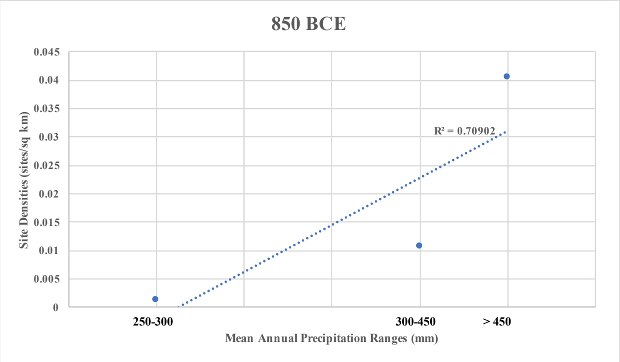
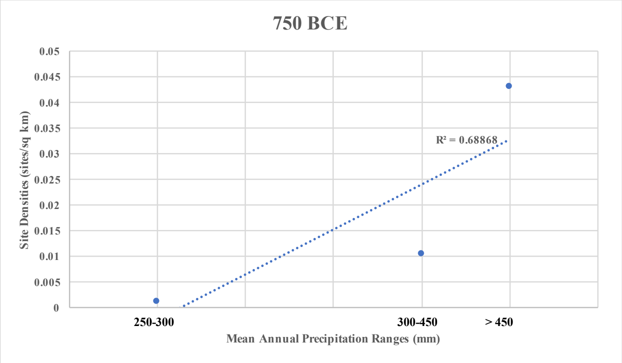

1050 BCE

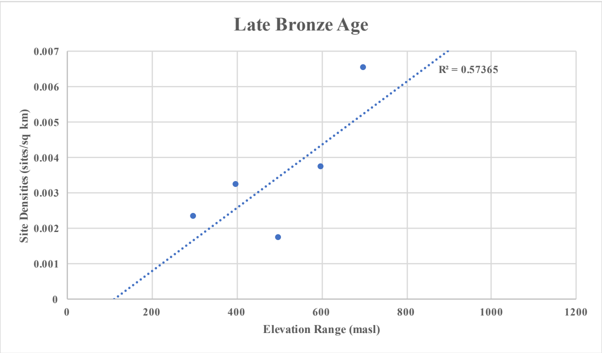

950 BCE

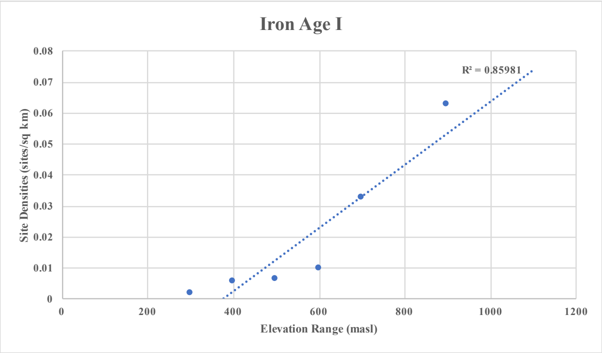

850 BCE

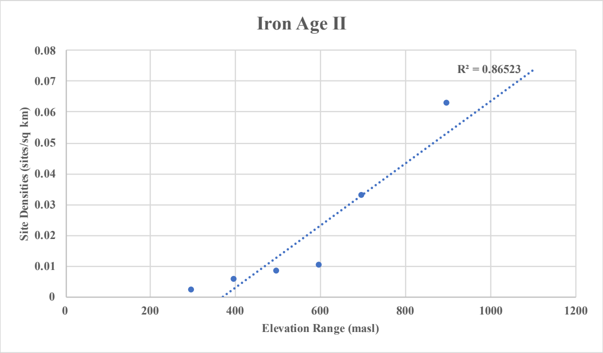

750 BCE

Regression Analysis for Northern Plateau

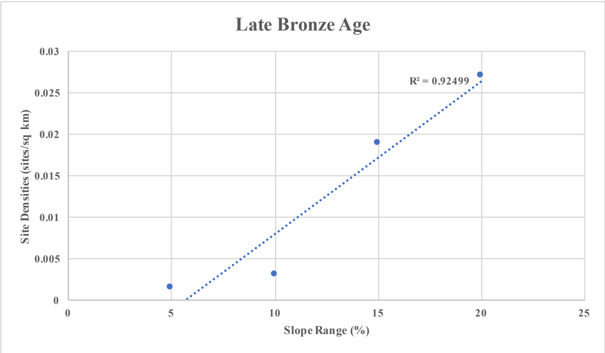
Elevation

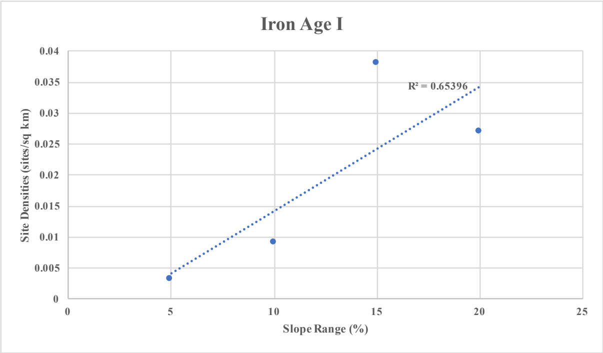


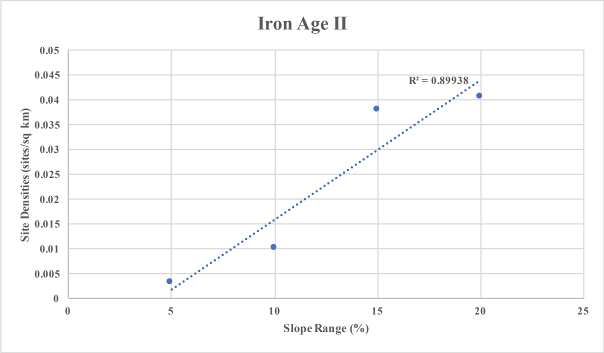




Slope







LOWER ORONTES

X^2-Test Values for Lower Orontes (Precipitation)

Observed Values

	1350 BCE	1250 BCE	1150 BCE	1050 BCE	950 BCE	850 BCE	750 BCE	Total
Very Low (1)	0	0	0	0	0	0	0	0
Low (2)	15	9	33	15	12	17	29	119
Moderate (3)	101	104	90	99	101	99	94	688
High (4)	438	437	419	423	417	424	423	2981
Very High (5)	591	595	776	781	788	844	838	5213
Total	1143	1143	1318	1318	1318	1318	1384	9012

Expected Values

	1350 BCE	1250 BCE	1150 BCE	1050 BCE	950 BCE	850 BCE	750 BCE	Total
Very Low (1)	0	0	0	0	0	0	0	0
Low (2)	16.517	16.517	19.012	19.012	19.012	19.964	19.964	130
Moderate (3)	87.412	87.412	100.619	100.619	100.619	105.658	105.658	688
High (4)	378.744	378.744	435.969	435.969	435.969	457.801	457.801	2981
Very High (5)	662.326	662.326	762.398	762.398	762.398	800.576	800.576	5213
Total	1145	1145	1318	1318	1318	1804	1804	9012

P =	5.48962^{-9}

X^2-Test Values for Lower Orontes (Hydrogeology)

Observed Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
No Groundwater	221	267	327	815
Irregular Groundwater	924	1053	1058	3035
Regular Groundwater	0	0	0	0
Total	1145	1320	1385	3850

Expected Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
No Groundwater	242.383	279.429	293.188	815
Irregular Groundwater	902.617	1040.571	1091.812	3035
Regular Groundwater	0	0	0	0
Total	1143	6177	6996	4700

P =	**0.02**

X^2-Test Values for Lower Orontes (Water Courses)

Observed Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
Perennial/Large	57	84	88	229
Intermittend/Moderate	65	59	65	189
Wadi/Small	171	145	145	461
Total	293	288	298	879

Expected Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
Perennial/Large	293.261	288.261	298.261	229
Intermittent/Moderate	293.215	288.215	298.215	189
Wadi/Small	293.524	288.524	298.524	461
Total	293	288	298	879

P =	2.1283^{-264}

MIDDLE ORONTES

X^2-Test Values for Middle Orontes (Precipitation)

Observed Values

	1350 BCE	1250 BCE	1150 BCE	1050 BCE	950 BCE	850 BCE	750 BCE	Total
Very Low (1)	0	0	0	0	1	0	0	1
Low (2)	116	119	82	63	64	100	117	661
Moderate (3)	572	593	343	366	377	524	515	3290
High (4)	1298	1292	937	949	966	1221	1218	7881
Very High (5)	964	946	702	686	656	804	799	5557
Total	2950	2950	2064	2064	2064	2649	2649	17390

Expected Values

	1350 BCE	1250 BCE	1150 BCE	1050 BCE	950 BCE	850 BCE	750 BCE	Total
Very Low (1)	0.169	0.169	0.119	0.119	0.119	0.152	0.152	1
Low (2)	112.131	112.131	78.453	78.453	78.453	100.689	100.689	661
Moderate (3)	558.108	558.108	390.486	390.486	390.486	501.162	501.162	3290
High (4)	1336.915	1336.915	935.387	935.387	935.387	1200.504	1200.504	7881
Very High (5)	942.677	942.677	659.554	659.554	659.554	846.492	846.492	5557
Total	2950	2950	2064	2064	2064	2649	2649	17390

P =	**0.01368556**

X^2-Test Values for Middle Orontes (Hydrogeology)

Observed Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
No Groundwater	546	109	401	1056
Irregular Groundwater	1449	1194	1324	3967
Regular Groundwater	955	761	925	2641
Total	2950	2064	2650	7664

Expected Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
No Groundwater	406.472	284.392	365.136	1056
Irregular Groundwater	1526.964	1068.357	1371.679	3967
Regular Groundwater	1016.564	711.251	913.185	2641
Total	2950	2064	2650	7664

P =	1.95^{-39}

X^2-Test Values for Middle Orontes (Water Courses)

Observed Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
Perennial/Large	156	165	165	486
Intermittend/Moderate	296	200	266	762
Wadi/Small	355	210	301	866
Total	807	575	732	2114

Expected Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
Perennial/Large	185.526	132.190	168.284	486
Intermittent/Moderate	290.886	207.261	263.852	762
Wadi/Small	330.588	235.549	299.864	866
Total	807	575	732	2114

P =	**0.001322324**

UPPER ORONTES

X^2-Test Values for Upper Orontes (Precipitation)

Observed Values

	1350 BCE	1250 BCE	1150 BCE	1050 BCE	950 BCE	850 BCE	750 BCE	Total
Very Low (1)	11	12	9	10	15	10	10	77
Low (2)	43	43	44	45	43	45	45	308
Moderate (3)	29	28	29	29	28	30	29	202
High (4)	82	85	82	86	88	88	87	598
Very High (5)	251	248	211	205	201	202	204	1522
Total	416	416	375	375	375	375	375	2707

Expected Values

	1350 BCE	1250 BCE	1150 BCE	1050 BCE	950 BCE	850 BCE	750 BCE	Total
Very Low (1)	11.833	11.833	10.667	10.667	10.667	10.667	10.667	77
Low (2)	47.332	47.332	42.667	42.667	42.667	42.667	42.667	308
Moderate (3)	31.042	31.042	27.983	27.983	27.983	27.983	27.983	202
High (4)	91.898	91.898	82.841	82.841	82.841	82.841	82.841	598
Very High (5)	233.894	233.894	210.842	210.842	210.842	210.842	210.842	1522
Total	416	416	375	375	375	375	375	2707

P =	0.994563983

X^2-Test Values for Upper Orontes (Hydrogeology)

Observed Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
No Groundwater	0	0	0	0
Irregular Groundwater	417	376	376	1169
Regular Groundwater	1	1	1	3
Total	418	377	377	1172

Expected Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
No Groundwater	0	0	0	0
Irregular Groundwater	416.930	376.035	376.035	1169
Regular Groundwater	1.069	0.965	0.965	3
Total	418	377	377	1172

P =	0.996441491

X^2-Test Values for Upper Orontes (Water Courses)

Observed Values

	Late Bronze Age	Iron Age I	Iron Age II	Total
Perennial/Large	14	14	14	42
Intermittend/Moderate	57	54	54	165
Wadi/Small	62	52	52	166
Total	133	120	120	373

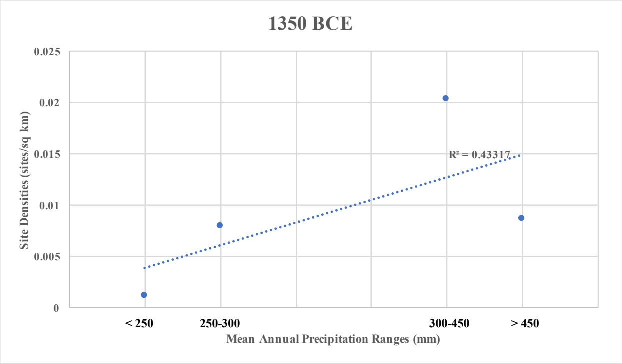
Expected Values

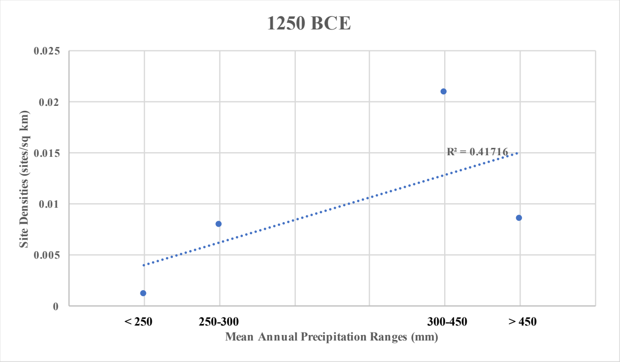
	Late Bronze Age	Iron Age I	Iron Age II	Total
Perennial/Large	14.976	13.512	13.512	42
Intermittent/Moderate	58.834	53.083	53.083	165
Wadi/Small	59.190	53.405	53.405	166
Total	133	120	120	373

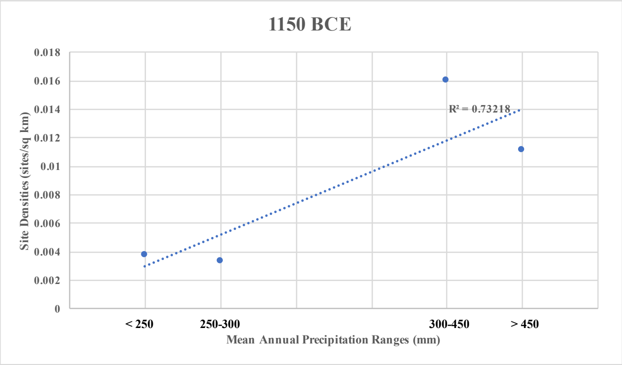
P =	0.982889178

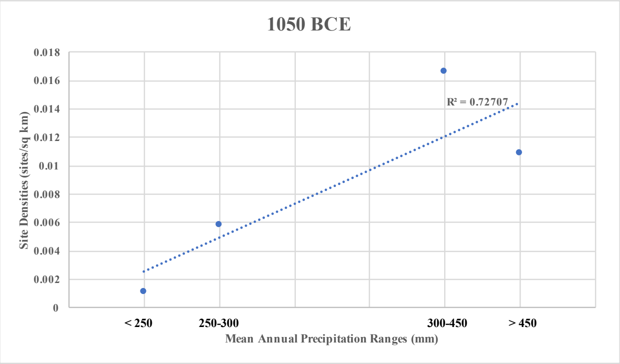
Regression Analysis for Upper Orontes

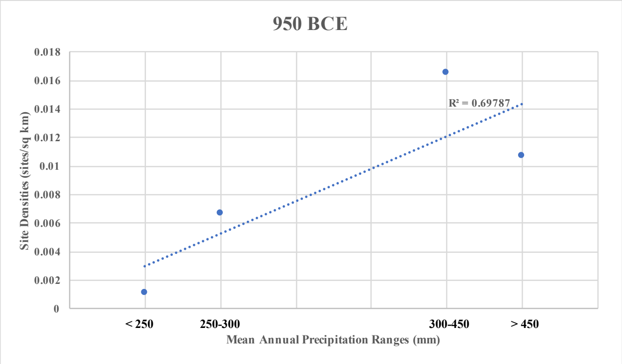
Precipitation

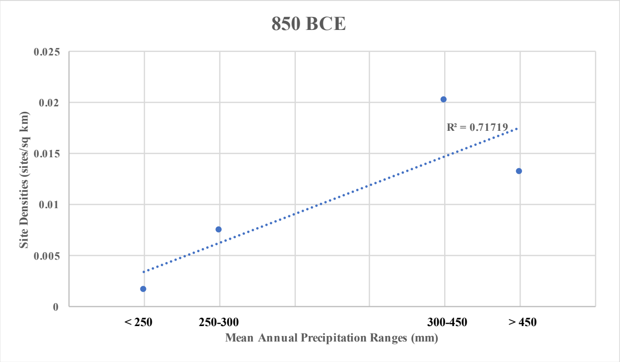

1350 BCE

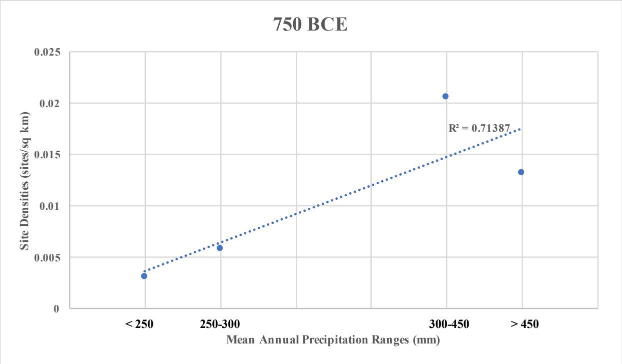

1250 BCE


1150 BCE


1050 BCE

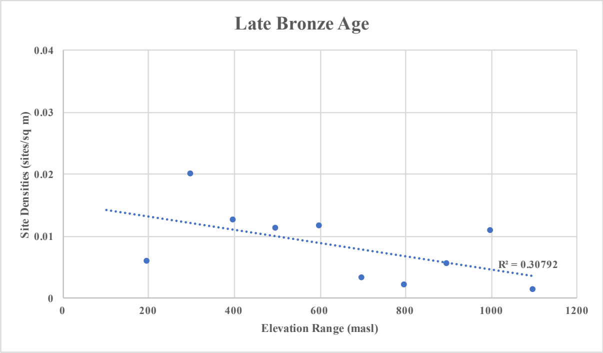

950 BCE

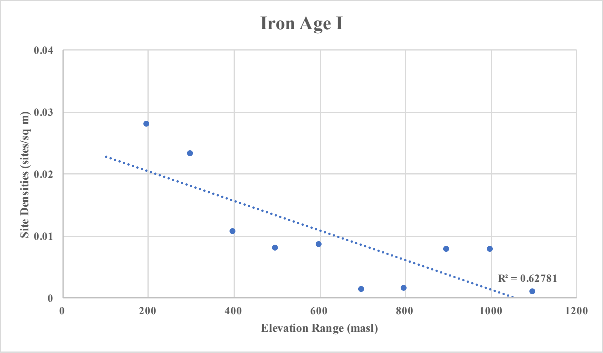

850 BCE

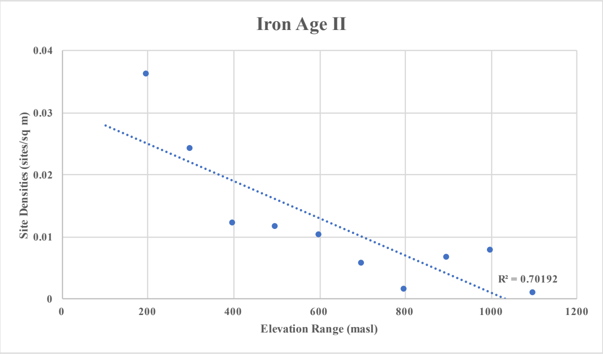

750 BCE

Regression Analysis for Upper Orontes

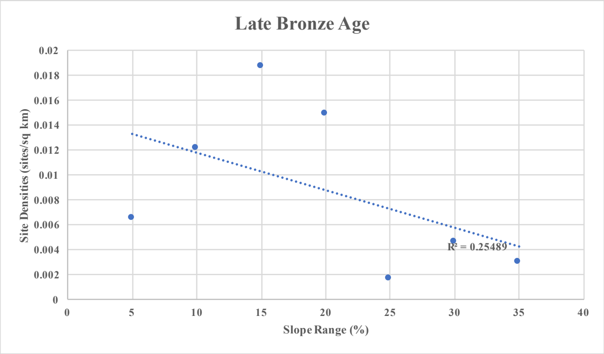
Elevation

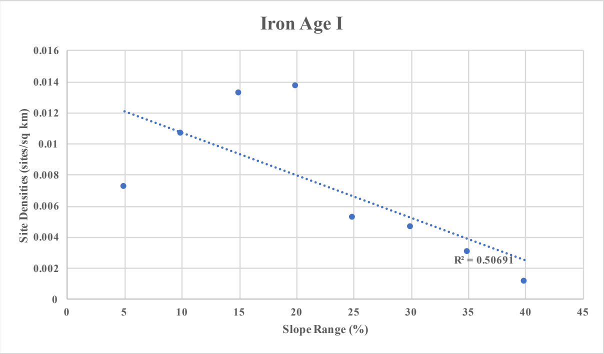

Late Bronze Age

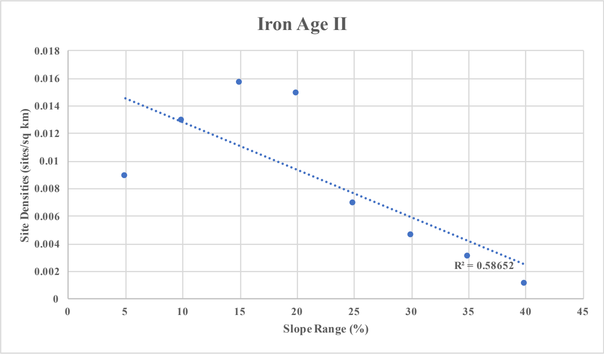

Iron Age I


Iron Age II

Slope


Late Bronze Age


Iron Age I


Iron Age II

APPENDIX 7
ARCHAEOLOGICAL MATERIALS

AKKAR PLAIN

Chronology		Tell Kazel		Tell ‘Arqa	
Archaeological Period	Approx. Date Range	Architectural Contexts	Faunal/ Botanical Data	Architectural Contexts	Faunal/ Botanical Data
Late Bronze Age IIA	1350 -	**Area IV Level 6** temple Cypriot/Aegean imports (violent destruction)		**Level 11** badly preserved architecture Cypriot/Aegean imports	
	1325 -				
	1300 -				
Late Bronze Age IIB		**Area II Level 6** Large Residence (violent destruction) **Area IV Level 5** temple, residences Cypriot/Aegean imports local LH-style ceramics Handmade Burnished Ware (violent destruction)			
	1275 -				
	1250 -				
	1225 -				
	1200 -				
Iron Age IA		**Area II Level 5** domestic structures, modest size storage activities no imports local LH-style ceramics (violent destruction) **Area IV Level 4** no occupation **Area IV Level 3** temple (violent destruction)		Settlement Continuity?	
	1175 -			Settlement Hiatus	
Iron Age IB	1150 -				
	1125 -				
	1100 -				
	1075 -				
	1050 -				
	1025 -				
	1000 -				
	975 -				
Iron Age IC	950 -				
	925 -				
	900 -				
Iron Age IIA		**Area I** building, potter’s quarter many storage jars Cypriot imports **Area II** badly preserved remains **Area IV** no occupation		**Level 10E** dense occupation **Level 10C-D** construction of rampart, decrease in settlement density **Level 10A-B** abandonment use as cemetery	
	875 -				
	850 -				
	825 -				
	800 -				
Iron Age IIB	775 -				
	750 -				
	725 -				
	700 -				
Sources		Badre 2003, 2006, 2009, 2011; Badre *et al.* 2005; Badre and Gubel 1999; Badre *et al.* 1990, 1994; Capet 1994; Capet and Gubel 2000; Döpper 2014; Dunand *et al.* 1964; Dunany and Saliby 1957; Jung 2007; Lehmann 2013		Charaf 2004, 2007-2008, 2008, 2011; Hawkins 1976-1980; Thalmann 1978a, 1978b, 1983, 1997, 2006, 2010	

Chronology		Tabbat al-Hammam		Tell Simiriyan	
Archaeo-logical Period	Approx. Date Range	Architectural Contexts	Faunal/ Botanical Data	Architectural Contexts	Faunal/ Botanical Data
Late Bronze Age IIA	1350 -	Settlement Hiatus (?) only two fragments of Cypriot ceramics		several superimposed floors, wall fragments (violent destruction) Cypriot imports	
	1325 -				
	1300 -				
Late Bronze Age IIB	1275 -				
	1250 -				
	1225 -				
	1200 -				
Iron Age IA	1175 -	Settlement Hiatus (?)		Settlement Hiatus (?)	
	1150 -				
Iron Age IB	1125 -				
	1100 -				
	1075 -				
	1050 -				
	1025 -				
	1000 -				
	975 -				
	950 -				
Iron Age IC	925 -				
	900 -				
Iron Age IIA	875 -	wall fragments relatively high percentages of Cypriot imports			
	850 -				
	825 -				
	800 -				
Iron Age IIB	775 -				
	750 -				
	725 -				
	700 -				
Sources		Braidwood 1940		Braidwood 1940	

Jableh Plain

Chronology		Tell Tweini		Tell Sukas	
Archaeological Period	**Approx. Date Range**	**Architectural Contexts**	**Faunal/Botanical Data**	**Architectural Contexts**	**Faunal/ Botanical Data**
Late Bronze Age IIA	**1350 -**	**Level 7 A-C** Houses 2 and 6 local ware storage jars, plates, bowls Cypriot and Aegean imports (violent destruction)	einkorn/emmer wheats dominant barley/bread wheat less frequently olives ubiquitous lentils/grapes only rarely sheep, goat, cattle most important only little wild game, no pig frequent Nile perch	**Period J** Complexes I and II additional fragmentary remains occasional Cypriot/Aegean imports ceramic deposits at Southern Harbor	
	1325 -				
	1300 -				
Late Bronze Age IIB	**1275 -**				
	1250 -				
	1225 -				
	1200 -				
Iron Age IA	**1175 -**	**Level 6G-H** little architecture no Cypriot/Aegean imports (exact length unknown)	einkorn/emmer wheats dominant barley/bread wheat less frequently olives ubiquitous lentils/grapes only rarely cattle more prominent in public contexts proportions of fish remains increasing		
	1150 -			**Period H2** Complex I, Complex V domestic structures, additional archtectural remains reuse of Period J ovens local LH-style ceramics Cypriot imports	sheep, goat, cattle, pig, donkey, gazelle, birds, fish, shells
Iron Age IB	**1125 -**				
	1100 -	**Level 6E-F** new structures; large building grinding implements, storage jars, drinking vessels, loom weights (violent destruction)			
	1075 -				
	1050 -				
	1025 -				
	1000 -				
	975 -				
	950 -				
Iron Age IC	**925 -**				
	900 -				
Iron Age IIA	**875 -**	**Level 6 C-D** several buildings; possible sanctuary			
	850 -	**Level 6 A-B** increased density; cultic structure increase in Cypriot imports		**Period H1** Complexes V-VII	
	825 -				
	800 -				
Iron Age IIB	**775 -**				
	750 -				
	725 -				
	700 -				
Sources		al-Maqdissi *et al.* 2008, 2010; Bretschneider and Hameeuw 2008; Bretschneider and van Lerberghe 2008a, 2008b; Bretschneider *et al.* 1999, 2004, 2008, 2011, 2012, 2014; Linseele 2008, 2010; Linseele *et al.* 2013; Vandorpe 1999; Vansteenhuyse 2008, 2010; Vansteenhuyse and Bretschneider 2011; Vansteenhuyse *et al.* 2002, 2008		Abu-Assaf 1997; Buhl 1983; Lund 1986; Riis 1970, 1996	

Chronology		Tell Siano		Tell Daruk		Arab al-Mulk	
Archaeological Period	**Approx. Date Range**	**Architectural Contexts**	**Faunal/ Botanical Data**	**Architectural Contexts**	**Faunal/ Botanical Data**	**Architectural Contexts**	**Faunal/ Botanical Data**
Late Bronze Age IIA	**1350 -**	Occupation inicated by ceramic finds		**Layers 28-24 (?)** no architectural remains Cypriot imports		**Period C lower (?)** no architectural remains Cypriot and Aegean imports	
	1325 -						
	1300 -						
Late Bronze Age IIB	**1275 -**						
	1250 -						
	1225 -						
	1200 -						
Iron Age IA	**1175 -**	Settlement Hiatus (?)		**Layers 23-?** Mixed Iron Age deposits few Cypriot imports		**Period C upper (?)**	
	1150 -						
Iron Age IB	**1125 -**						
	1100 -						
	1075 -						
	1050 -						
	1025 -						
	1000 -						
	975 -						
	950 -						
Iron Age IC	**925 -**						
	900 -						
Iron Age IIA	**875 -**	**Level VI** small domestic structure					
	850 -						
	825 -						
	800 -						
Iron Age IIB	**775 -**	large, H-shaped fortified structure					
	750 -						
	725 -						
	700 -						
Sources		al-Maqdissi 2004; Bounnai and al-Maqdissi 1992, 1993, 1998; Singer 1999		Oldenburg and Rohweder 1981		Oldenburg and Rohweder 1981	

Chronology		Qal‘at ar-Rus		Tell Iris	
Archaeo-logical Period	**Approx. Date Range**	**Architectural Contexts**	**Faunal/ Botanical Data**	**Architectural Contexts**	**Faunal/ Botanical Data**
Late Bronze Age IIA	**1350 -**	stone-built grave chamber (mixed Middle/Late Bronze Age ceramics) earth floor with grinding implements (late Late Bronze Age ceamics)		series of small rooms (violent destruction)	
	1325 -				
Late Bronze Age IIB	**1300 -**				
	1275 -				
	1250 -				
	1225 -				
Iron Age IA	**1200 -**	Settement Hiatus (?)		Settlement Hiatus	
	1175 -				
Iron Age IB	**1150 -**				
	1125 -				
	1100 -				
	1075 -				
	1050 -				
	1025 -				
	1000 -				
	975 -				
Iron Age IC	**950 -**				
	925 -				
Iron Age IIA	**900 -**	beaten earth surface with typical Iron Age II ceramics		earliest reoccupation ca. 9th-8th century BCE	
	875 -				
	850 -				
	825 -				
Iron Age IIB	**800 -**				
	775 -				
	750 -				
	725 -				
	700 -				
Sources		al-Maqdissi 2004; Bretschneider *et al.* 2004		al-Maqdissi and Souleiman 2004; Saadé 1990	

LOWER ORONTES

Chronology		Tell Qarqur	
Archaeo-logical Period	**Approx. Date Range**	**Architectural Contexts**	**Faunal/Botanical Data**
Late Bronze Age IIA	**1350 -**	**Stratum 10** ceramic maerials in Area B	
	1325 -		
Late Bronze Age IIB	**1300 -**		
	1275 -		
	1250 -		
	1225 -		
Iron Age IA	**1200 -**	**Stratum 9** Area A potentially earliest remains of citadel gate Area B large courtyard several storage silos some mudbrick walls, foundations, floors large building in Step Trench Area D thiik deposits of ash layers, collapsed walls several floors with storage bins	
	1175 -		
Iron Age IB	**1150 -**		
	1125 -		
	1100 -		
	1075 -		
	1050 -		
	1025 -		
	1000 -		
	975 -		
Iron Age IC	**950 -**		
	925 -		
Iron Age IIA	**900 -**	**Stratum 8** Area A citadel gate Area B fragmentary architecture, domestic installations Area E massive foundations of large building hoard with large number of luxury objects Area D no architecture ceramic evidence	sheep and goat dominant cattle and pig also important equids, birds, fish, turtle, crab
	875 -		
	850 -		
	825 -		
Iron Age IIB	**800 -**		
	775 -		
	750 -		
	725 -		
	700 -		
Sources		Arter 2003; Casana *et al.* 2008; Dornemann 1998a, 1998b; Dornemann 2000, 2003, 2008a, 2008b, 2008c, 2008d, 2008e, 2008f, Dornemann and Casana 2008a, 2008b; Dornemann *et al.* 2008; Lundquist 1983	

Chronology		Tell ‘Acharneh		Rasm et-Tanjara	
Archaeo-logical Period	**Approx. Date Range**	**Architectural Contexts**	**Faunal/ Botanical Data**	**Architectural Contexts**	**Faunal/ Botanical Data**
Late Bronze Age IIA	**1350 -**	**Area WO** large structure many storage jars (violent destruction) small quantities of Late Bronze Age ceramics from Lower City		Cemetery (?)	
	1325 -				
Late Bronze Age IIB	**1300 -**				
	1275 -				
	1250 -				
	1225 -				
Iron Age IA	**1200 -**	only ceramic evidence			
	1175 -				
Iron Age IB	**1150 -**				
	1125 -				
	1100 -				
	1075 -				
	1050 -				
	1025 -				
	1000 -				
	975 -				
Iron Age IC	**950 -**				
	925 -				
Iron Age IIA	**900 -**	**Area SNO** fragmentary remains **Area TE** large structure, paved courtyard earth-pebble glacis on slope **Area SR** domestic structure **Area PN** defensive glacis **Area WO** large structure **Area VB** fragmentary rooms, paved street **Area CVB** domestic structure in lower level large building in upper level		**Aramaean Stratum (?)** potential evidence for luxury items (evidence extremely fragmentary)	
	875 -				
	850 -				
	825 -				
Iron Age IIB	**800 -**				
	775 -				
	750 -				
	725 -				
	700 -				
Sources		Cooper 2006; Cooper and Fortin 2006; Fortin 2000, 2003, 2006a, 2006b, 2006c, 2006d, 2006e; Fortin and Cooper 2013		Athanassiou 1977; Mazzoni 2001a, 2005a; Nougayrol 1962; Shaath 1986; Stucky 1971; Wicke 2008	

Middle Orontes

Chronology		Hama	
Archaeo-logical Period	Approx. Date Range	Architectural Contexts	Faunal/Botanical Data
Late Bronze Age IIA	1350 -	**Perid G** mostly domestic remains in southern and southwestern areas large structure in central area, plastered floors, large-scale storage activities Cypriot imports	
	1325 -		
	1300 -		
Late Bronze Age IIB	1275 -		
	1250 -		
	1225 -		
	1200 -		
Iron Age IA	1175 -		
	1150 -	**Period F2** scattered and damaged wall foundations in south patches of floors, plaster fragments potentially two separate buildings in southeast, badly damaged, storage activities (violent destruction)	
Iron Age IB	1125 -		
	1100 -		
	1075 -		
	1050 -		
	1025 -	**Period F1** fragmentary walls of two structures in south badly damaged wall fragments, floor patches in southeast remains badly damaged by later construction possible evidence for architectural sculpture (?)	
	1000 -		
	975 -		
	950 -		
Iron Age IC	925 -		
	900 -		
Iron Age IIA	875 -	**Period E** Building I, citadel gate Building II palace, large-scale storage, architectural sculpture Building III palace or temple, architectural relief sculpture Building IV potential storage structure Building V potential storage structure (violent destruction)	
	850 -		
	825 -		
	800 -		
Iron Age IIB	775 -		
	750 -		
	725 -		
	700 -		
Sources		Dornemann 1997; Fortin 2001; Fugmann 1958; hawkins 1972-1975; Ingholt 1940, 1942; Matthiae 2008; Mazzoni 2009; Riis 1948; Riis and Buhl 1990; Thuesen 1988; Ussishkin 1966	

Chronology		Tell Mishrifeh	
Archaeological Period	Approx. Date Range	Architectural Contexts	Faunal/Botanical Data
Late Bronze Age IIA	1350 -	destruction of palaces	barley, wheat, olive
	1325 -	**Area T1** large building/residence domestic assemblage **Area C** ceramic production area **Area K Level 11** Buildings 5, 6 **Area Q** domestic occupation	barley predominant over wheat large quantities of olives especially high proportions of steppe-habitat animals
	1300 -		
Late Bronze Age IIB	1275 -		
	1250 -		
	1225 -		
	1200 -		
Iron Age IA	1175 -	**Area K Phase 9** Building 4 earth floors, refuse pits **Area K Phase 8** Building 1 large structure, domestic and economic functions **Area K Phase 5-4** Buildings 2, 3 dense occupation, domestic and economic functions **Area H Phase 6** various pits	considerable increase in numbers of grape grape and olive are ubiquitous predominance of barley, also wheat and legumes slightly lower proportions of steppe-habitat animals
	1150 -		
Iron Age IB	1125 -		
	1100 -		
	1075 -		
	1050 -		
	1025 -		
	1000 -		
	975 -		
	950 -		
Iron Age IC	925 -		
	900 -	**Areas G, H, T** Buildings 2, 4, 6, craft workshops, silos, open spaces weaving implements **Area C Phase II/b** ‘Aramaean Palace’, large structure **Area C Phase II/a** ceramics workshop **Area J Phase 6** cemetery **Area J Phase 5** central storage facility, many large silos, granary, warehouse **Area K Phase 8-4** Building 1 **Area K Phase 3-2** no architectural remains	
Iron Age IIA	875 -		
	850 -		
	825 -		
	800 -		
Iron Age IIB	775 -		
	750 -		
	725 -		
	700 -		
Sources		al-Maqdissi 2002, 2003a, 2003b, 2009; al-Maqdissi and badawi 2002; al-Maqdissi and Morandi Bonacossi 2005, 2009; Besana *et al.* 2008; Da Ros 2015; Döpper 2014; du Mesnil du Buisson 1935; Fiorentino and Caracuta 2007; Luciani 2002, 2003, 2006; Maritan *et al.* 2005; Morandi Bonacossi 2002, 2003, 2006, 2007a, 2007b, 2008a, 2008b, 2009, 2016; Peña-Chocarro and Rottoli 2007; Pfälzner 2006; Riehl 2007; Schmidt 2015; Shabo 2015; Vila and Gourichon 2007	

Chronology		Tell Nebi Mend		Tell al-Nasriyah	
Archaeo-logical Period	**Approx. Date Range**	**Architectural Contexts**	**Faunal/ Botanical Data**	**Architectural Contexts**	**Faunal/ Botanical Data**
Late Bronze Age IIA	**1350 -**	**Trench I** domestic structures, streets **Trench II** administrative building administrative documents **Trench III** large building religious or public function	predominance of sheep and goat		
	1325 -				
	1300 -				
Late Bronze Age IIB	**1275 -**				
	1250 -				
	1225 -				
	1200 -				
Iron Age IA	**1175 -**	**Trench III** domestic structures	slight decrease in porportions of sheep and goat increase of steppe-habitat animals		
	1150 -				
Iron Age IB	**1125 -**				
	1100 -				
	1075 -				
	1050 -				
	1025 -				
	1000 -				
	975 -				
	950 -				
Iron Age IC	**925 -**				
	900 -				
Iron Age IIA	**875 -**	**Trench III** industrial complex **Trench V** Building B paved courtyards, domestic and storage functions		**Area D** remains of monumental structure **Area E** possible public structure storage jars, ovens, tools **Area F** large structure storage functions	
	850 -				
	825 -				
	800 -				
Iron Age IIB	**775 -**				
	750 -				
	725 -				
	700 -				
Sources		Bourke 1991, 1993, 2012; Grigson 2015; Grigson *et al.* 2015; Parr 1983, 1991, 2006-2008; Pézard 1931; Whincop 2003, 2007		al-Maqdissi *et al.* 2009, 2010a, 2011; De Dapper 2010; Faivre 2010, 2013; Parayre 2010	

NORTHERN COAST

Chronology		Ras Shamra		Ras al-Bassit	
Archaeological Period	**Approx. Date Range**	**Architectural Contexts**	**Faunal/ Botanical Data**	**Architectural Contexts**	**Faunal/ Botanical Data**
Late Bronze Age IIA	**1350 -**	**Level 1** Royal Quarter Residential Quarters Temples in Acropolis (abandonment, partial destruction)	sheep, goat, cattle	administrative building modest residential structures (violent destruction)	evidence for land clearing and cereal cultivation
	1325 -				
	1300 -				
Late Bronze Age IIB	**1275 -**				
	1250 -				
	1225 -				
	1200 -				
Iron Age IA	**1175 -**	Royal Palace (?) ‚Four aux tablettes‘ Armorer‘s House and House with Portico (?) re-use, subdivision, animal shelter		**Earliest Phase** poor domestic structures, storage silos Handmade Burnished Ware local LH-style ceramics (violent destruction) **Second Phase** larger houses local LH-style ceramics	
	1150 -				
Iron Age IB	**1125 -**	Settlement Hiatus			
	1100 -				
	1075 -				
	1050 -				
	1025 -				
	1000 -				
	975 -				
Iron Age IC	**950 -**				
	925 -				
Iron Age IIA	**900 -**			**First Phase** various installations, silos **Second Phase** more important structures, expansion of settlement few Aegean imports	
	875 -				
	850 -				
	825 -				
Iron Age IIB	**800 -**				
	775 -				
	750 -				
	725 -				
	700 -				
Sources		Callot 2008; Caubet 1992; Margueron 1977; Vila 2004, 2008; Yon 1992, 2006		Braemer 1986; Courbin 1981, 1982, 1983, 1986, 1990, 1993; Darcque 2004; du Piêd 2006-2007; Lehmann 2013	

Chronology		Ras ibn Hani	
Archaeological Period	**Approximate Date Range**	**Architectural Contexts**	**Faunal/Botanical Data**
Late Bronze Age IIA	**1350 -**	Northern Palace (violent destruction)	
	1325 -		
	1300 -		
Late Bronze Age IIB	**1275 -**	Southern Palace (abandonment, partial destruction) Cypriot/Aegean imports	
	1250 -		
	1225 -		
Iron Age IA	**1200 -**	Northern Complex/Southern Complex below Lower Level/Lower Level domestic structures, immediate reoccupation Handmade Burnished Ware local LH-style ceramics	
	1175 -		
	1150 -		
Iron Age IB	**1125 -**	Northern Complex/Southern Complex Lower Level/Upper Level	
	1100 -		
	1075 -		
	1050 -		
	1025 -	Northern Complex/Southern Complex Upper Level/Upper Level (?)	
	1000 -		
	975 -		
Iron Age IC	**950 -**	no architectural remains Cypriot imports	
	925 -		
	900 -		
Iron Age IIA	**875 -**		
	850 -		
	825 -		
Iron Age IIB	**800 -**		
	775 -		
	750 -		
	725 -		
	700 -		
Sources		Badre 1983; Bounni 1982; Bounni *et al.* 1976, 1978, 1979, 1981, 1998; Bounni and Lagarce 2004; Cornelius and Niehr 2004; du Piéd 2006-2007, 2011; Lagarce and Lagarce 1988; Lehmann 2013	

Chronology		Minet el-Beida		Qal‘at Siryani	
Archaeological Period	**Approximate Date Range**	**Architectural Contexts**	**Faunal/ Botanical Data**	**Architectural Contexts**	**Faunal/ Botanical Data**
Late Bronze Age IIA	**1350 -**	habitation quarters craft workshops large warehouses large quantities of Cypriot imports		surface ceramics indicate dense habitation	
	1325 -				
	1300 -				
Late Bronze Age IIB	**1275 -**				
	1250 -				
	1225 -				
	1200 -				
Iron Age IA	**1175 -**				
	1150 -				
Iron Age IB	**1125 -**				
	1100 -				
	1075 -				
	1050 -				
	1025 -				
	1000 -				
	975 -				
Iron Age IC	**950 -**				
	925 -				
Iron Age IIA	**900 -**				
	875 -				
	850 -				
	825 -				
Iron Age IIB	**800 -**				
	775 -				
	750 -				
	725 -				
	700 -				
Sources		Astour 1970; Marchegay 2004; Schaeffer 1931, 1932, 1933; Schaeffer and Dussaud 1929; Yon 1993-1997		Courtois 1963	

NORTHERN PLATEAU

Chronology		Tell Afis	
Archaeo-logical Period	Approx. Date Range	Architectural Contexts	Faunal/Botanical Data
Late Bronze Age IIA	**1350 -**	**Phase VIII**	barley, wheat, grape goat, sheep
	1325 -		
Late Bronze Age IIB	**1300 -**	**Phase VII** Building F **Phase VI** industrial complex	
	1275 -		
	1250 -		
	1225 -	**Phase Vb** Buildings A, B, E residential structures storage activities (violent destruction)	
	1200 -		
Iron Age IA	**1175 -**		barley, wheat, lentil, olive smaller proportions of goat, sheep cattle, pig in significant proportions
	1150 -	**Phase Va** squatter occupation	
Iron Age IB	**1125 -**	**Phase IVc-a** permanent settlement, irregular urban layout Buildings A, B storage facilities	
	1100 -		
	1075 -		
	1050 -		
	1025 -	**Phase IIId-a** progressive urbanization storage activities Temple AIII (?) Cypriot imports	
	1000 -		
	975 -		
	950 -		
Iron Age IC	**925 -**	**Phase IIc-a** progressive urbanization storage activities Temple AIII.2-1 (?) **Phase Ic-b** Temple AII Area B Building D Courtyard G Terrace J (?)	
	900 -		
Iron Age IIA	**875 -**		smaller proportions of goat, sheep cattle, pig in significant proportions
	850 -		
	825 -		
	800 -		
Iron Age IIB	**775 -**	**Phase Ia** Temple AI Annex H Area B Building D Area B city wall Courtyard G abandonment	
	750 -		
	725 -		
	700 -		
Sources		Affanni 2005, 2010; Amadasi Guzzo 2009, 2014; Archi and Venturi 2012, 2013; Baffi and Peyronel 2014; Bontaz 1997; Cecchini 1998, 2000a, 2000b, 2002, 2011, 2014; Cecchini *et al.* 2008; Cecchini and Mazzoni 1998; Ciafardoni 1987; D'Amore 1998; Giannessi 2000; Matthiae 1979a; Mazzoni 1987, 1990, 1992, 1998, 2001b, 2005b, 2008, 2010a, 2010b, 2012a, 2012b, 2014a, 2014b; Minniti 2014; Soldi 2009; Venturi 2000, 20007, 2010, 2011, 2013, 2014, 2015; Wachter-Sarkady 1998	

Chronology		**Tell Tuqan**		**Tell Mardikh**	
Archaeo-logical Period	**Approx. Date Range**	**Architectural Contexts**	**Faunal/ Botanical Data**	**Architectural Contexts**	**Faunal/ Botanical Data**
Late Bronze Age IIA	**1350 -**	some form of occupation		Ishtar temple and temple on the acropolis some kind of small settlement on acropolis	
	1325 -				
Late Bronze Age IIB	**1300 -**				
	1275 -				
	1250 -				
	1225 -				
Iron Age IA	**1200 -**	Settlement Hiatus (?) **Area L** only some badly preserved walls and scattered ceramics			
	1175 -				
Iron Age IB	**1150 -**				
	1125 -				
	1100 -			**Area E Lervel 6** modest rural structures	
	1075 -				
	1050 -				
	1025 -				
	1000 -				
	975 -				
Iron Age IC	**950 -**				
	925 -				
	900 -	**Area D Level 7** paved area **Area D Level 6** wall fragments, open space **Area D Level 6** House D1 **Area Q** dense urban agglomeration **Area F** monumental gateway		**Area E Level 5**	
Iron Age IIA	**875 -**				
	850 -				
	825 -				
Iron Age IIB	**800 -**			**Area E Level 4b**	
	775 -				
	750 -				
	725 -				
	700 -				
Sources		Baffi 2006, 2008, 2011a, 2011b; Baffi and Peyronel 2014; Baffi *et al.* 2014; Fiorentino 2014; Matthiae 1979, 1983, 2014; Minniti 2014		Lehmann 2013; Matthiae 2014; Mazzoni 1992	

Chronology		Tell Mastuma		Tell Deinit	
Archaeological Period	Approx. Date Range	Architectural Contexts	Faunal/ Botanical Data	Architectural Contexts	Faunal/ Botanical Data
Late Bronze Age IIA	**1350 -**	Settlement Hiatus			
	1325 -				
Late Bronze Age IIB	**1300 -**				
	1275 -				
	1250 -				
	1225 -				
Iron Age IA	**1200 -**				
	1175 -				
Iron Age IB	**1150 -**				
	1125 -				
	1100 -				
	1075 -				
	1050 -				
	1025 -				
	1000 -			Potential Occupation (?) pyxides from Deinit and other sites	
	975 -				
Iron Age IC	**950 -**				
	925 -				
Iron Age IIA	**900 -**	**Stratum I-2** dense agglomeration of small- and medium-sized houses, small city gate local ware storage, jars, plates, cooking vessels, bowls, cups, kraters, jugs/ juglets, etc complete absence of fine wares and other luxury items			
	875 -				
	850 -				
	825 -				
Iron Age IIB	**800 -**			**Deinit V** **'Aramaean Period'** some architectural remains luxury items, including seals and pyxides	
	775 -				
	750 -				
	725 -				
	700 -				
Sources		Egami 1988; Egami *et al.* 1988, 1984; Iwasaki et al 2009; Nishiyama and Yoshizawa 1997; Tsumoto 1997; Wada 1994, 2009a, 2009b, 2009c; Wakita 2009; Wakite *et al.* 1994, 1995; Yasuda 1997		Mazzoni 2001, 20015; 2012; Shaath 1985, 1986, 2007, 2012; Wicke 2008	