A PALEOECOLOGICAL STUDY OF URBAN ABANDONMENT DURING EARLY BRONZE IV IN THE SOUTHERN LEVANT

by

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ABSTRACT

STEVEN PORSON. A Paleoecological study of Urban Abandonment during Early Bronze IV in the Southern Levant. (Under the direction of DR. PATRICIA FALL)

An archaeobotanical study of plant remains from the Near Eastern archaeological site of Tell Abu en-Niʻaj, Jordan ascertains a possible cause for the abandonment of towns during Early Bronze IV. This study assesses the hypothesis that the collapse was caused primarily by a rapid climate change event which led to aridification and made the sedentary agrarian lifestyle more strenuous. To test this, macrofloral remains were identified and counted from seven phases of habitation at the Early Bronze IV village of Tell Abu en-Niʻaj to measure the amount of change between phases. We also consider previous archaeological, botanical and climatological studies in the Near East to assess what factors may have influenced urban abandonment. Our findings suggest climate may have played a significant part in this abandonment. Our main point of evidence comes from a large reliance on barley, rather than wheat, a trend which increases through time at the archaeological site. More work needs to be done comparing the floral trends between sites to assess the full effect of climate on ancient societies in antiquity.

ACKNOWLEDGEMENTS

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Accelerator Mass Spectrometer ^{14}C ages came from the NSF-University of Arizona AMS Laboratory, the Vienna Environmental Research Accelerator and the Oxford University Radiocarbon Accelerator Unit. Suzanne Pilaar Birch (University of Georgia) provided $\delta^{13}C$ values for carbonized seeds, and Elizabeth Ridder (California State University San Marcos) calculated all the $\Delta^{13}C$ values from Tell Abu en-Ni'aj.

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CHAPTER 1. INTRODUCTION

1.1 Research Goals and Significance

The goal of this study is to examine one of the great mysteries of the ancient world, a sudden large-scale urban collapse which occurred 4000 years ago in the Middle East. Collapses of past societies have often been a talking point among anthropologists and archaeologists alike, as there are many possible causes which can lead to such occurrences, and without proper evidence it is often difficult to determine why societies failed. This analysis in particular will examine the abandonment of Early Bronze Age towns in the Southern Levant region of the Near East (ancient Middle East) at an archaeological site called Tell Abu en-Ni'aj. Currently, the leading proposal for the urban abandonments argues that climate change may have played a major part in driving out local inhabitants. This study included a thorough examination of the plausibility of this hypothesis via a botanical study, to see if this hypothesis could be supported.

My research ties in both paleoecology and ethnobotany. I used carbonized seeds from an archaeological site to study the past natural and domestic vegetation and how humans used it. From these data, I could interpret and draw connections between changes in vegetation and past environments, as well as how humans may have adjusted and culturally shifted overtime through different agricultural practices in a period that was likely marked by significant climatic change.

Since the focus of this project is to try to support or deny the current hypothesis of climate change in the Near East, I believe it is important to introduce the significance of understanding this phenomenon. In order to understand the present, it is important to study the past. Climate change is a widely-debated topic today, and predictions for how climate change may impact natural floral distributions and agricultural uses are complex. By looking at a past civilization and seeing the effects shifting climate may have had on its society and agricultural practices, we may be able to get a better understanding of the impacts of climate change and how it may affect modern agriculture today and in the future. Climate studies in the past have proven to be instrumental in constructing our understanding of the rates and long-term effects of climatic shifts, since these are often very difficult to predict. Through changes in agricultural practices in antiquity, we hope to find evidence of significant climate fluctuations as well as the effects of climate on ancient civilizations in our study area.

The specific scope of my research is a focus on seed remains collected from an ancient archaeological village in western Jordan near the border with Israel. I will be using the carbonized seeds collected from an ancient Early Bronze Age tell (mounded archaeological remains from a past village or city) to make inferences about past climate and agricultural practices. I am making some assumptions with this project. Firstly, that I can find information about the climatic variations of the past though a macrofloral analysis. Secondly, that I will be able to find a change in the climate record in the duration that Tell Abu en-Ni‘aj was occupied. My premier hypothesis states that climate change was a contributing factor in the collapse and I will approach this idea from several perspectives.

1.2 Site Background Overview

The site we examined is Tell Abu en-Ni‘aj (also abbreviated as Ni‘aj). It is in the Jordan River Valley between Israel/Palestine and Jordan in an area known as the Levant (Figure 1). The Levant is a region along the eastern Mediterranean coast which comprises several southwest Asian countries and marks the region between the Mediterranean Sea and ancient

Mesopotamia. The Levant is the general term for this region where there was a rise of civilization and agriculture in the Near East. While it has no strict political boundaries, it is comprised of Israel, southern Lebanon, Palestine, Jordan, southern Syria and the Sinai Peninsula. The Southern Levant denotes the southern half of the Levant, an area that gave rise to one of the early great civilizations, in addition to those of Egypt and Mesopotamia. It is currently dominated by a Mediterranean climate in the regions of Lebanon and northern Israel, and an arid desert climate to the south in Jordan, southern Israel and the Sinai. The region features several ecological zones including woodlands, shrub lands, steppe and desert. The area where Niʻaj is located is characterized by a Mediterranean climate today. This climate is denoted by long, dry summers and short, wet winters; however, the southern extent and lower elevation wadis (dry stream beds) of Jordan are more arid than the rest of the region and receive very little precipitation year-round (Fall et al., 1998; Falconer and Fall, 2009; Soto-Berelov et al., 2015). The vegetation seen in the Southern Levant varies with elevation and distance from the Mediterranean Sea. In the Mediterranean climatic zone, you can expect dry shrubs and occasional trees such as *Ziziphus* or *Acacia* in the lowlands, with thicker woodlands supporting *Quercus* or *Pinus* trees atop the foothills and plateaus. However, as you move away from the coast and into the southern wadis you find a transition to smaller shrubs like *Crataegus* and grasses, which can grow with very little water (Wilkinson, 2003; Soto-Berelov et al., 2015).

Geographically, Niʻaj lies in the Jordan Valley, bordered by the Central Hills to the West and the Transjordanian Plateau to the East. Niʻaj also sits on the east side of the Jordan River, which flows from the Sea of Galilee (also known as Lake Kinneret) in the north to the Dead Sea in the south. The Jezreel Valley (also called Yizreel) lies to the west and connects the Jordan Valley to the Mediterranean Sea. The geology of the valley is a three-terraced system, with a granite basin below, sandstone along the hills, and limestone on the tops of the plateaus. In the Jordan River basin, there is a large quantity of Holocene/Pleistocene age alluvium from a combination of fluvial and aeolian sediments (Meadows, 1996; Fall et al., 1998). There are also Pleistocene lacustrine sediments along the floodplain, with Tell Abu en-Niʻaj sitting upon ancient lake sediments (Falconer et al., 2004). The Jordan Valley is a tectonic depression along the Dead Sea Transform, a transform fault between the African and Arabian tectonic plates which runs from Turkey to the Red Sea and formed in the Miocene (Ferry et al., 2007).

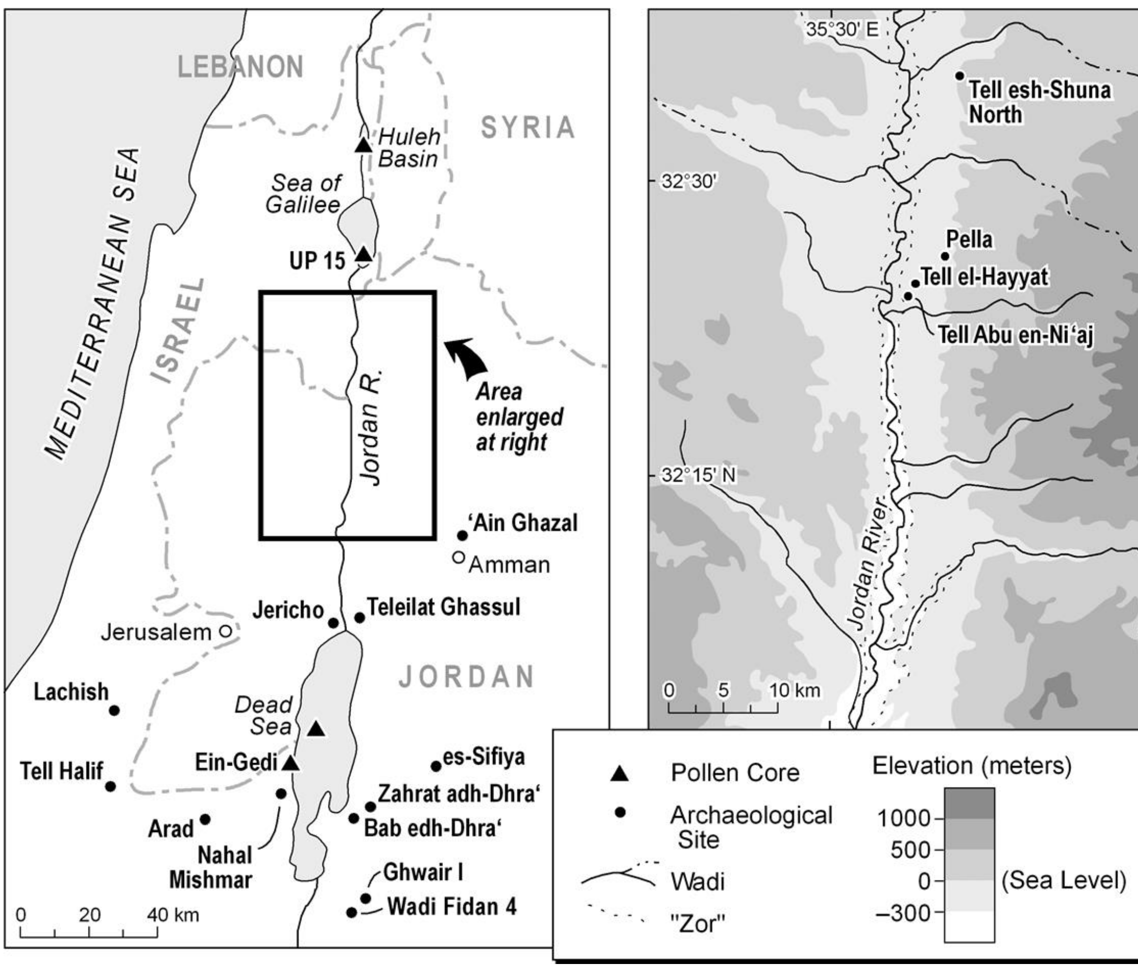

Figure 1. Map of the Southern Levant showing the locations of the Jordan Valley (left) and a zoomed topographic image showing the location of Tell Abu en-Niʻaj (right).

Tell Abu en-Ni'aj measures approximately 2.5 hectares and sits approximately 250 meters below sea level, about five meters above the valley floor (Fall et al., 1998; Falconer et al., 2001; Falconer and Fall, 2017). The buried ruins of the ancient village are composed of a small network of houses situated atop a hill overlooking the modern floodplain of the Jordan River and its surrounding farmlands.

Early Bronze Age IV (EB IV), the time during which this site was occupied, is a period of urban collapse between the region's first era of towns in Early Bronze II/III and a period of reurbanization in the Middle Bronze Age. The Early Bronze IV period began about 4450 cal BP (2500 cal BC) (Falconer and Fall, 2016; Falconer and Fall, 2017; Falconer and Fall unpublished, 2018; Table 1 and Figure 2). The archaeological chronology for this region has in the past been based on pottery typology (Albright, 1962; Tsuneki and Miyake, 1996). However, recent work using radiometric dating techniques has modified the timescale. Until recently, Early Bronze IV (and the occupation of Tell Abu en-Ni'aj) was thought to be only about 200 years long. Using accelerator mass spectrometry and Bayesian analyses, we have now been able to get a more accurate assessment for the beginning and the ending dates of Early Bronze IV, as well as the lengths of the archaeological strata (i.e., phases) that constitute Tell Abu en-Ni'aj (Falconer and Fall, 2016; Falconer and Fall, 2017; Table 1 and Figure 2).

Radiocarbon data suggest the length of Early Bronze IV to be around 500 years, from about 4450 to 3950 cal BP (2500 -2000 cal BC) (Regev et al., 2012; Falconer and Fall, 2016). The last 200 years of Early Bronze Age may have been a time of accelerated change in the region, based on interpretations of about 200-300 years of severe desiccation starting about 2200 cal BC (Weiss et al., 1993).

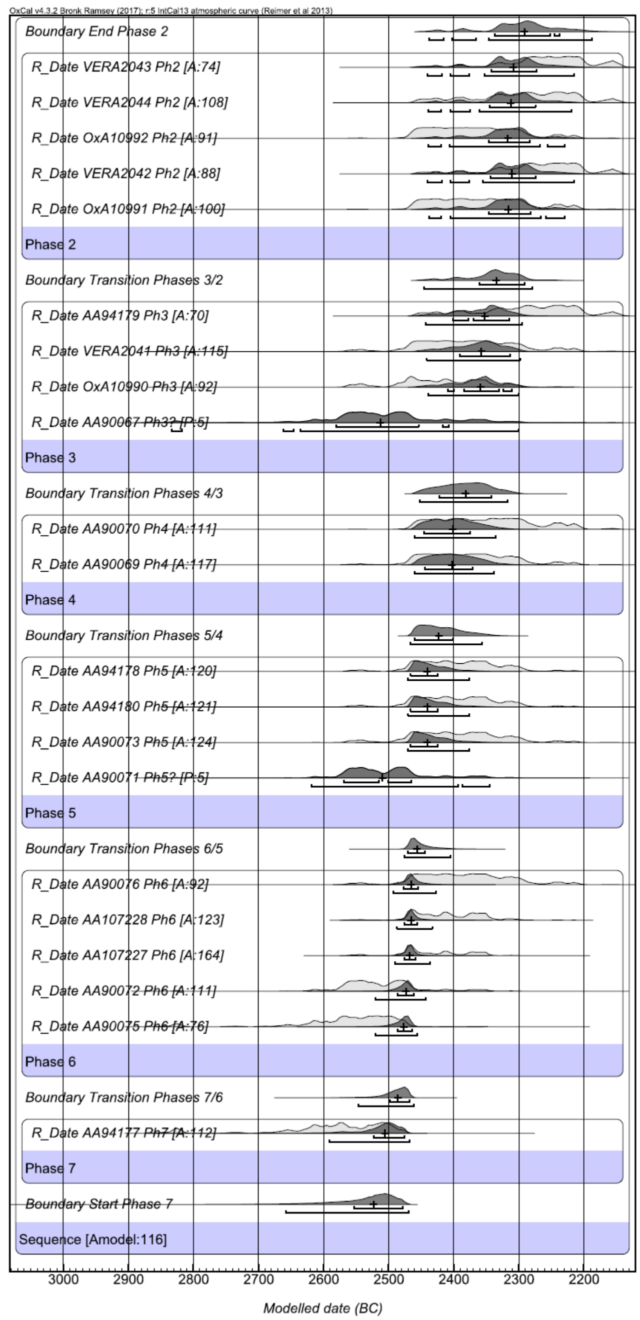

Figure 2. Bayesian sequencing of ^{14}C dates for seed samples from Phases 7–1 at Tell Abu en-Ni'aj, Jordan (from Falconer and Fall, 2016). Light gray curves indicate single-sample calibration distributions; dark curves indicate modeled calibration distributions. Calibration and Bayesian modeling based on OxCal v 4.2.4 (Bronk Ramsey 2009a; Bronk Ramsey 2013 and Lee) using the IntCal13 atmospheric curve (from Reimer et al. 2013).

Table 1. AMS radiocarbon results for seed samples from Tell Abu en-Ni'aj, Jordan (ordered by sample number) (from Falconer and Fall, 2016). Calibration based on OxCal 4.2.4 (Bronk Ramsey and Lee 2013) using the IntCal13 atmospheric curve (Reimer et al. 2013). Stratigraphic phases at Tell Abu en-Ni'aj start with Phase 7 (the earliest, basal stratum) and end with Phase 1 (the latest, uppermost stratum). Context is indicated according to Excavation Unit, Locus and Bag (e.g., C.066.239 = Unit C, Locus 066, Bag 239).

Lab Number	$\delta^{13}C$ ‰	$F^{14}C$	Conventional ^{14}C age yr BP	Calibrated 1σ ranges yr BC (probability)	Calibrated 2σ ranges yr BC (probability)	Median Age Cal yr BC	Archaeological context; Material dated
AA-90067	-23.1	0.6088±0.0042	3986±56	2617-2611 (1.1%) 2581-2456 (65.4%) 2417-2409 (1.8%)	2834-2818 (1.3%) 2662-2647 (1.0%) 2637-2332 (91.5%) 2326-2300 (1.7%)	2513	Phase 4, C.066.239, mudbrick wall *Hordeum*, *Cerealia* grains
AA-90069	-22.7	0.6157±0.0032	3896±42	2464-2339 (68.2%)	2478-2277 (91.2%) 2252-2228 (3.0%) 2222-2210 (1.2%)	2381	Phase 4, C.071.236, burned surface *Hordeum*
AA-90070	-23.0	0.6177±0.0033	3870±42	2456-2417 (16.7%) 2409-2292 (51.5%)	2468-2272 (83.6%) 2258-2207 (11.8%)	2353	Phase 4, C.073.284, ash pit *Triticum* (emmer)
AA-90071	-23.4	0.6092±0.0034	3981±44	2570-2515 (40.5%) 2502-2466 (27.7%)	2620-2391 (89.9%) 2386-2346 (5.5%)	2511	Phase 5, C.075.278, burned surface *Hordeum*
AA-90072	-23.2	0.6088±0.0034	3986±44	2570-2514 (41.8%) 2502-2468 (26.4%)	2621-2399 (91.3%) 2383-2347 (4.1%)	2518	Phase 6, C.091.406, burned surface *Triticum* (emmer)
AA-90073	-23.5	0.6143±0.0034	3915±44	2471-2343 (68.2%)	2564-2533 (3.5%) 2495-2283 (90.6%) 2249-2233 (1.3%)	2398	Phase 5, C.089.386, ash pit *Hordeum*
AA-90075	-22.2	0.6058±0.0033	4026±43	2581-2476 (68.2%)	2836-2816 (3.1%) 2671-2465 (92.3%)	2546	Phase 6, C.086.387, burned surface *Cerealia* grains
AA-90076	-23.4	0.6150±0.0034	3905±45	2468-2340 (68.2%)	2551-2537 (1.2%) 2491-2276 (90.4%) 2253-2228 (2.7%) 2223-2210 (1.1%)	2388	Phase 6, C.106.494, stone-lined hearth *Triticum* (emmer)
AA-94177	-22.8	0.6043±0.0030	4046±39	2622-2551 (38.4%) 2537-2491 (29.8%)	2848-2813 (6.4%) 2692-2690 (0.2%) 2679-2471 (88.9%)	2572	Phase 7, GG.105.331, shallow fire pit *Cerealia* grains
AA-94178	-23.7	0.6145±0.0030	3912±39	2469-2346 (68.2%)	2550-2537 (1.1%) 2491-2286 (93.8%) 2247-2236 (0.5%)	2397	Phase 5, GG.065.185, ash lens *Hordeum*
AA-94179	-24.3	0.6209±0.0030	3828±39	2344-2202 (68.2%)	2458-2416 (7.7%) 2411-2196 (83.4%) 2171-2147 (4.4%)	2281	Phase 3, GG.015.49, burned surface *Prosopis* seeds
AA-94180	-23.4	0.6142±0.0030	3915±39	2470-2391 (45.0%) 2386-2346 (23.2%)	2559-2536 (2.0%) 2491-2287 (93.4%)	2400	Phase 5, GG.100.289, fire pit *Prosopis* seeds
AA-107227	-23.8	0.6126±0.0019	3937±24	2479 -2440 (37.2%) 2420-2404 (11.6%) 2379-2349 (19.4%)	2559-2536 (3.7%) 2491-2342 (91.7%)	2439	Phase 6, GG.098.295 *Pisum*, *Hordeum* & *Triticum* (einkorn)
AA-107228	-23.3	0.6136±0.0019	3924±25	2471-2436 (30.3%) 2421-2404 (14.1%) 2379-2349 (23.8%)	2481-2336 (92.9%) 2323-2307 (2.5%)	2413	Phase 6, C.111.548 *Pisum*, *Hordeum* & *Triticum* (einkorn)
OxA-10990	-23.3	---	3932±38	2480-2395 (47.0%) 2386-2346 (21.2%)	2565-2532 (6.9%) 2496-2296 (88.5%)	2418	Phase 3, K.018.030, clay-lined pit *Hordeum vulgare*; Bronk Ramsey et al. 2002; Regev et al 2012a
OxA-10991	-22.4	---	3877±40	2455-2418 (17.8%) 2408-2299 (50.4%)	2470-2275 (87.1%) 2255-2209 (8.3%)	2364	Phase 2, B.024.172, ash pit *Hordeum*; Bronk Ramsey et al. 2002; Regev et al. 2012a
OxA-10992	-22.8	---	3886±40	2458-2338 (62.5%) 2322-2310 (5.7%)	2472-2278 (90.3%) 2251-2229 (3.7%) 2221-2211 (1.4%)	2348	Phase 2, B.010.063, fire pit *Cerealia* grains; Bronk Ramsey et al. 2002; Regev et al. 2012a
VERA-2041	-22.9±1.4	---	3900±50	2467-2338 (63.1%) 2322-2309 (5.1%)	2559-2536 (1.8%) 2491-2270 (86.7%) 2260-2207 (6.8%)	2381	Phase 3, K.018.030, clay-lined pit *Hordeum*
VERA-2042	-20.0±1.5	---	3820±35	2336-2323 (5.0%) 2308-2201 (63.2%)	2456-2418 (4.4%) 2407-2375 (5.0%) 2367-2362 (0.5%) 2351-2192 (78.5%) 2179-2142 (7.0%)	2264	Phase 2, B.024.172, ash pit *Hordeum*
VERA-2043	-23.7±1.6	---	3810±35	2298-2198 (63.6%) 2164-2152 (4.6%)	2450-2445 (0.4%) 2436-2420 (1.4%) 2405-2378 (3.0%) 2350-2138 (90.7%)	2251	Phase 2, C.037.126, fire pit *Hordeum*, humic acids
VERA-2044	-21.8±1.4	---	3830±40	2389-2386 (0.9%) 2346-2202 (67.3%)	2459-2196 (91.5%) 2170-2148 (3.9%)	2285	Phase 2, B.010.063, fire pit *Triticum* and *Hordeum*, humic acidsa

The Early Bronze IV collapse was marked by a transition from large towns to smaller agro-pastoral communities. Ni‘aj is a smaller settlement than the towns and cities in either EB III or MB I, not possessing the quantity of houses or the large surrounding fortification wall typical of Bronze Age settlements in the region. However, Ni‘aj is much larger than contemporaneous pastoral communities common at this time, and Ni‘aj has clear community structure, which is unusual for this period of urban collapse (Dever, 1995; Fall et al., 1998; Wilkinson, 2003). Many of the pastoral communities were mobile, seasonal settlements, while Tell Abu en-Ni‘aj showed clear indications of sedentism (Fall et al., 1998; Falconer et al., 2001). Additionally, though many small, Early Bronze IV pastoral encampments have been uncovered, few have received a thorough archaeological review. This is in part due to the propensity for pastoral encampments to leave little archaeological evidence behind, making them more difficult to study.

One of the reasons Ni‘aj was chosen for this analysis is because it represents one of the largest villages at the time of the collapse. It is also a site which has not yet had an extensive paleoecological study performed; therefore, our work would hopefully be able to answer some of the key questions about this collapse period more succinctly. Ni‘aj has also already had thorough in-field archaeological surveys, so samples have already been excavated and prepared for analyses. Additionally, Ni‘aj has very well-defined stratigraphic boundaries between seven phases represented in the deposition. Phases signify periods of turnover in a site, when buildings are broken down and rebuilt again. This is the way that tells grow to become large mounds overtime. Because of the well stratified layering, it is possible to get a chronological history of change at the site, much as you would from geologically stratified layers.

CHAPTER 2. LITERATURE REVIEW OF THE NEAR EAST

Many climatic studies have been performed for the Near East in attempts to model the paleoclimate and understand more about how the fertile crescent has evolved (Black et al., 2010; Brayshaw et al., 2010, 2011). Since climate change is one of the leading theories for the cause of the Early Bronze IV collapse, I will discuss some of the primary climate proxy methods that researchers have used to reconstruct the past environment and climate of the region.

Palynology is perhaps the most popular paleoclimate proxy in the region. Bottema (1993) discusses the method of using pollen to interpret climate, for example by examining the arboreal pollen (AP) to non-arboreal pollen (NAP) ratios. This can indicate tree cover for the region as well as give indication of vegetation from the surrounding landscape, which may be interpreted by windblown pollen (Bottema, 1993).

Kaniewski et al. (2008, 2010) rely on pollen to analyze major climate change events throughout the Near East. They examined an event around 4200 cal BP lasting until 3900 cal BP (2250-1950 cal BC) which they called the '4.2 cal kyr BP arid event'. They link this climatic period to a migration from northern Mesopotamia, the collapse of the Akkadian state in the north, such as Syria or Turkey, the First Intermediate Period of Egypt in 4100 cal BP (2150 cal BC), and the abandonment of cities in Pakistan and Palestine. They determined humidity seemed to vary over time, indicating drier conditions existed before 4050 cal BP (2100 cal BC) with a wetter period beginning around 3900 cal BP (1950 cal BC) for the region. Their analyses also provided evidence for a cooler and wetter climate in the Middle Bronze Age, with an abnormally dry climate in the late Early Bronze, evidenced both by decreased rainfall estimates and lacustrine sediment load (Kaniewski et al., 2008; Kaniewski et al., 2010).

Other climate proxy methods which have been used throughout the Levant include sediment analyses; optically stimulated luminescence (OSL) of dunes; charcoal (Wilcox, 1974; Asouti and Austin, 2005; Deckers and Pessin, 2010; Masi et al., 2012; Fall et al., 2015); lake geochemistry (Clapp, 1936; Yechieli et al., 1993; Fall et al., 1998; Enzel et al., 2003, Edwards et al., 2004; Migowski et al.); phytoliths (Parker et al., 2004); plant isotopes (Riehl et al., 2014; Wallace et al., 2015); and speleothems (Fleitmann and Matter, 2009; Orland et al., 2009), which have measured a variety of different vegetative and climatic changes throughout the Holocene at different temporal and spatial scales. The overall trend from these sources seems to be that of a deteriorating condition in the Near East in the late portions of the Early Bronze Age. There are signs of deforestation via charcoals, sea level drops, and more dry-tolerant plants correlating with our predicted range for the EB IV period (Willcox, 1974; Hubbard and Azm, 1990; Enzel et al., 2003; Migowski et al., 2006; Klinge and Fall, 2010; Fall and Falconer, 2016).

One of the more recent fields of research related to our seed-based study involves the use of carbon isotope ratios in carbonized seed deposits. Wallace and colleagues (2015) presented a carbon isotope analysis of wheat and barley samples gathered from archaeological sites in the Near East. They use modern day measurements of ^{13}C: ^{12}C ratios in wheat, 2-row barley, and 6-row barley to correct for variability found by using stable isotopes from different plant species. They include three locations in the Levant, Tell Nebi Mend, Ain Ghazal, and Khirbet Faris, in their analysis (Wallace et al. 2015). This study tests the idea that in the past seeds were being grown in different rainfall regimes. They found that barley's moisture preferences typically fall below the preferred moisture level for wheat, which indicates it is more successful at being sown in drier conditions (Wallace et al., 2015).

Riehl et al. (2014) discuss the Early Bronze IV collapse at 4200 cal BP (2250 cal BC) via an examination of ^{13}C concentration in crop remains (Figure 3). Since ^{13}C is a heavier carbon isotope than ^{12}C, it was absorbed in different quantities in wet versus dry conditions. Their results indicate drought conditions were more frequent over time, showing a relative change in water availability across time and between sites (Riehl et al., 2014). Specifically, stable carbon isotope data for 4200 cal BP (2250 cal BC) show a little peak of $\Delta^{13}C$ early on, and a sharp decline until 4000 cal BP (2050 cal BC), when water conditions return to roughly normal.

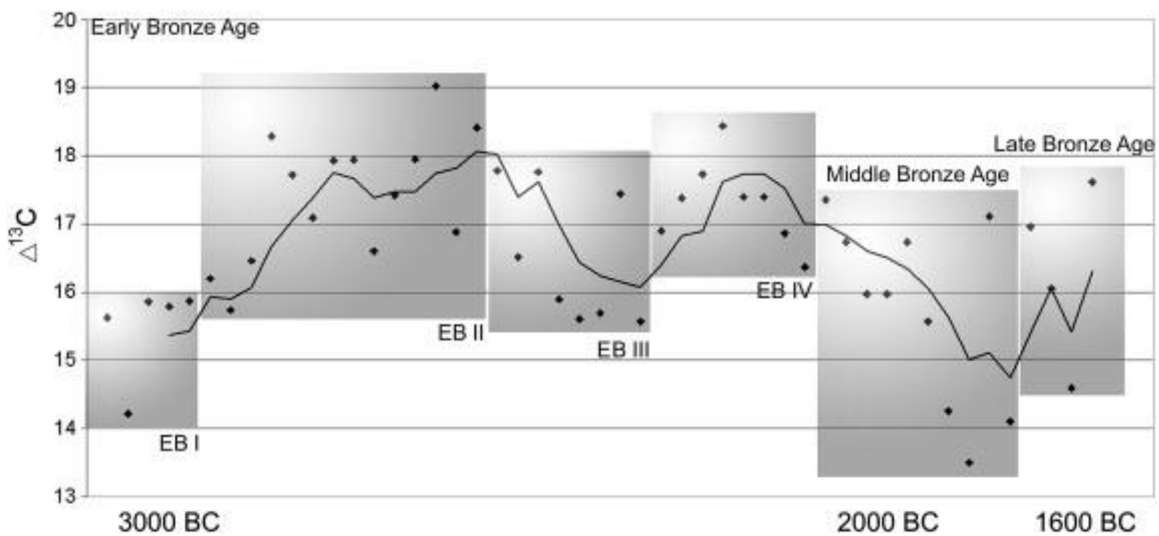

Figure 3. $\Delta^{13}C$ from barley seeds collected throughout the Near East during the Early and Middle Bronze ages (from Riehl, 2012).

These studies, particularly Riehl's, provide background for our study to test the idea that Early Bronze IV was a period of regional drying, as inferred from paleobotanical remains and carbon isotope analysis.

One of the important things to consider when trying to understand ancient societies is that the trends we see in the archaeological record are often the culmination of a myriad of smaller external and internal changes which shaped civilizations over time. While some authors try to pinpoint a single reason for a society's collapse, there are often other compounding factors which acted on the population to drive the society towards abandonment. It is important to take into consideration the wide array of factors which may have played a role in the EB IV collapse. To assess the potential cause for an exodus from settlements, it is important to first understand when and where settlements were established. In the Levant, cities first started being established with the beginning of the Early Bronze Age. People began to settle into larger urban centers in Early Bronze II. While pastoral encampments were always around, there was a trend towards large, often fortified tells with smaller settlements radiating around them, or along potential trade routes (Wilkinson, 2003). This settlement pattern changes drastically at the end of the Early Bronze III period, when most sedentary settlements were abandoned as part of a trend towards increased pastoralism or agro-pastoralism (a mobile lifestyle which still incorporates seasonal agricultural practice) (Dever 1995; Wilkinson, 2003). Archaeological sites dating to Early Bronze IV primarily include pastoral sites, temporary settlements which people would live in seasonally, migrating between winter and summer months. Ni'aj is one of the few villages known from this period, as most tells and khirbets were abandoned (Haiman, 1996; Goren, 1996; Wilkinson, 2003).

The EB IV collapse spanned a wide area, ensnaring many well-known ancient cities. Prominent sites such as Bab edh-Dhra and Numeria, which flourished until a dramatic collapse at the end of the EB III, with only partial use during the beginning of EB IV, are among those that were abandoned (Rast, 1987). Contemporary sites in Israel, such as Tel 'Erani or Tel Lachish, showed signs of sudden abandonment in the EB IV as well, following a previous period of growth and success (Gophna, 1984; Rosen, 1986; Weiss et al., 1993). A study at the famous site of Jericho, in the Jordan Valley, found only several large cemeteries dating to Early Bronze IV

(Robinson, 1995). Evidence suggests, however, that these urban abandonments may not have been synchronous. While some of the sites collapsed early on, sites such as Umm el-Marra, Syria lasted until the middle or end of Early Bronze IV (Schwartz et al., 2012). Archaeologist Ram Gophna (1984) notes that many of the sites which were abandoned during Early Bronze IV were reoccupied in the following centuries and built new settlements atop the archaeological remains from older civilizations. One of the benefits of studying Tell Abu en-Ni‘aj is that this site was never reoccupied following its Early Bronze IV abandonment, so there is less chance for damage to the foundation material.

CHAPTER 3. PREVIOUS ARCHAEOBOTANICAL AND PALAEOENVIRONMENTAL WORK

3.1 Environmental Change in the Levant

Several studies have been done in the Levant to uncover the probable causes of town abandonment seen in the Early Bronze Age, and one of the main focuses has been climate change. A key study which examined on the climate of the region (Soto-Berelov, Fall, Ridder and Falconer 2015) focused on past vegetation of the Southern Levant, looking at our study area between Israel and western Jordan (Figure 4). Soto-Berelov and others modeled potential vegetative cover and how it changed over the region in response to varying temperature and precipitation. The authors used this information to construct a climate cover map, using vegetation thresholds to separate regions of various climate (Figure 5). Additionally, they used archaeological evidence to model the probable climate boundaries over the course of the last ~5400 years. For example, the study includes a model of predicted vegetation around 4000 cal BP (2050 cal BC) as well, which would be around the end of Niʻaj's occupation. Using their climate pattern model, it seems Niʻaj was sitting around the transition to a shrubland and steppe climate. This means it was in the area with one of the lowest precipitation rates at less than ~50mm per year. Typical vegetation here would have included heat and drought tolerant species like *Acacia*. Niʻaj is also surrounded by both Irano-Turanian and Mediterranean climates, which both denote very hot summers, along the upper river valley and the plateaus. However, the Mediterranean biogeographic zones also have a much higher annual precipitation rate, reaching 1,200mm per year. We can see this as plant remains from species such as oak and pine can be found along the valley edges and atop the plateaus (Soto-Berelov et al., 2015). It is important to note that Niʻaj sits about 500 meters from the Jordan River, which is sure to have influenced the microclimate of the region, and likely made living in a region with potentially sub-50mm rainfall more feasible.

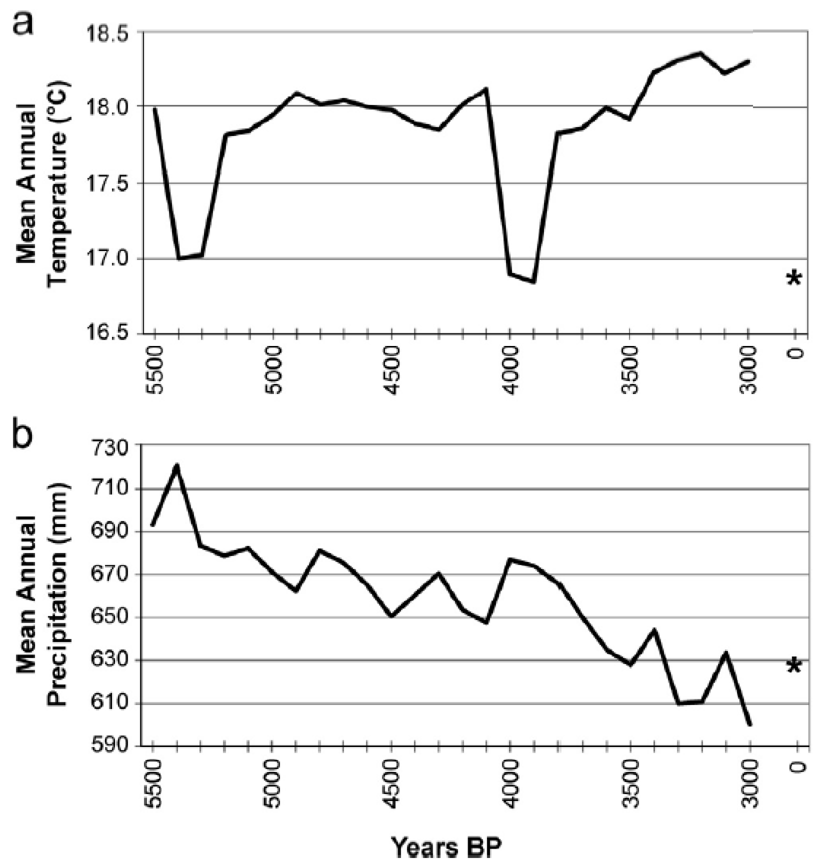

Figure 4. Modeled mean annual temperature (a) and mean annual precipitation (b) for Jerusalem, 5500-3000 calibrated years BP (2550-1050 cal BC) (at one hundred-year intervals) and 0 years BP (modern) (from Soto-Berelov et al., 2015).

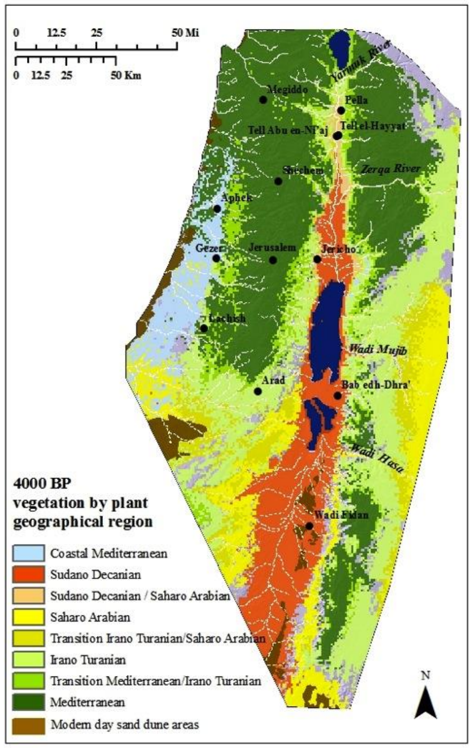

Figure 5. Modeled biogeographic regions along the Southern Levant for 4000 cal BP (2050 cal BC) (from Soto-Berelov et al., 2015).

Finally, modern measurements of temperature and precipitation, gathered in transects over the Southern Levant over the course of 30 years, were used to model how the values would change in the past using a macrophysical climate model (Figure 4). The model works by taking recent data points and projecting them into the past, considering the net effect of any climatic variables such as orbital forcing, volcanic aerosols, evapotranspiration and other factors. In the graphs, they show long-lasting, elevated temperatures in Early Bronze IV, suggesting why civilizations may have transitioned away from cities to more mobile, smaller settlements. We also see a sharp decline around 4000 cal BP (2050 cal BC) of about 1.2°C mean annual temperature from the ~18.0°C norm (Soto-Berelov et al., 2015). This could suggest why populations returned to big cities in the Middle Bronze Age. With the decline in temperature, a more sedentary lifestyle may have become more prosperous. Their study shows that annual precipitation in the region declined at a pretty steady rate of about 3.6mm per hundred years over 2500 years through the Early Bronze Age. Decreased precipitation may have been a key factor which led to the abandonment of cities in the region, as they lost about 70mm overall. Though there are no large swings in temperature and precipitation at the outset of Early Bronze IV, conditions may have been gradually declining over time. What does seem plausible from this, is that the combination of the decrease in temperature and increase in precipitation at 4000 cal BP (2050 cal BC) may have spurred communities to take up city life once again.

One of the main studies which instigated the climate change collapse hypothesis was based on the site of Tell Leilan, Syria. Weiss et al. (e.g., 1993) looked specifically at climate change in the region by analyzing hydrologic features in combination with soil and charred plant remains to interpret the past. Massive cities in the region had experienced similar large-scale abandonment, with populations opting to migrate to new cities or pastoral encampments in the south over a period of only 200 years. Evidence for climate variability stems from a thick layer of windblown sediment carrying tephra deposits during the last active use of three main sites including Tell Leilan. He also noted a lack of earthworm burrows in crop fields to suggest a temporary lack of agricultural use in farmlands, which might suggest the soils had become too dry and inhospitable. He determined climate change to be a driving factor for a three-century long abandonment there since the heavy aeolian dust, compounded by already increased aridity and heavy wind activity, may have turned the region into a dustbowl (Weiss et al., 1993). Additionally, a further study done in the Gulf of Oman found evidence of a dry period evidenced by large aeolian dolomite and calcium carbonate deposits coinciding with the collapse in upper

Mesopotamia (Cullen et al., 2000). These minerals likely were present in the saline lakes and soils from the Levantine river valleys and were heavily eroded, broken down into dust sized particles small enough to be wind-blown that far of a distance (Yechieli et al., 1993; Singer, 2007). This evidence supports Weiss' theory that aridity could be a leading factor to cause collapse. Weiss and others also surmise that the increased migrations of people to the south, a result of the dustbowl event, likely caused a strain on resources due to growing regional population, which could have led to further urban abandonment events (Weiss et al., 1993).

Archaeological studies also have been conducted in the region at Early Bronze IV sites along the Jordan Rift Valley, looking at a variety of archaeological proxies. Khirbet Iskander, an Early Bronze IV site near the Dead Sea, provides evidence of fortification (which is unusual for the period). Falconer and others (1998; 2001) also analyzed evidence from Tell Abu en-Niʻaj, Tell el-Hayyat, a Middle Bronze site also in the Jordan River valley, and another EB IV site, Dhahrat Umm al-Marar. Niʻaj and Marar indicated contrasting components of society during EB IV, with Marar being a 'single-period hilltop village' as opposed to the larger, longer occupied village at Niʻaj, both which sat along the Jordan River floodplain (Falconer et al., 1998; Magness-Gardiner and Falconer, 2001; Jones et al., 2012). Additionally, they found at Niʻaj evidence of animal husbandry involving sheep, goat, pig, and cattle, and cultivation of olive, fig, grape, lentil, pea, chickpea, barley, and emmer wheat (Falconer et al., 1998; Magness-Gardiner and Falconer, 2001). These provided a good baseline for our expectations of the vegetation range and variety of samples we would encounter at Tell Abu en-Niʻaj.

At all of these sites, the ecological changes we see are likely the result of a multitude of smaller environmental modifications made by man over the millennia of their occupation in the region (Fall et al., 2002). This can be seen through their various uses of the environment, such as increased production of more valuable goods such as fruits, oils, or wool. In the Levant, the focus would likely be orchard crops such as olives, grapes, and figs. Though they also harvested a number of other plants, practiced animal husbandry, and metallurgy.

Olives thrived in a Mediterranean climate, on well-drained soils, and olive oil could be stored for long periods of time, so it was very valuable for the people of this region (Wilkinson, 2003). Additionally, olive trees were likely harvested for their wood after oak was depleted (Fall et al., 2002). Fig and grape, domesticated earlier in the Chalcolithic period (Zohary and Spiegel-Roy, 1975), also became commonly domesticated crops, but dates, which prefer warmer, drier climates, were not found in archaeological sites like Hayyat in the northern Jordan Valley. Of the six major orchard crops in the Near East (pomegranates, dates, fig, olive, grape, and sycamore fig), only three of these fruits are found in the northern Jordan Valley: fig, grape, and olive. Fall and others have compared the seed remains on several sites along the Jordan Valley, including Ni'aj. At Ni'aj they analyzed float samples from all seven phases to assess the ratio of wheat to barley, and fig to grape to olive. They also included a seed overview of Hayyat, which indicated a shift in regional crop choice between Early Bronze IV and the Middle Bronze Age towards a higher ratio of wheat to barley (Fall et al., 2002). This analysis compared wheat and barley ratios at each of the sites, as well as ratios of olive to grape seeds in order to evaluate fluctuations in crops in periods with wetter or drier climates.

Fall and others discussed the trend of barley through the EB and MB, with relative barley percentages peaking in Early Bronze IV, and dropping off in the Middle Bronze Age. Wheat seems to show an opposing trend, indicating a preference towards the crop in Early Bronze II and again later in the Middle Bronze Age when the climate is wetter, only switching to barley when climate deteriorates in Early Bronze IV, likely due to barley's high drought and salt tolerance. A large jump in bread wheat from Ni'aj to Hayyat (7 times greater at Hayyat) supports their hypothesis of a change in agricultural practices in the region (Fall et al., 2002; Falconer and Fall 2006). In addition to barley and wheat, they discuss the changing preferences for olives and grapes in the Near East. They found that where people grow barley, which are often the driest and hottest regions, they typically grow grapes, and where wheat is grown, the climate is also suitable for olive. This is apparent in the switch from growing grapes at Ni'aj to olives at Hayyat. Their research appears to be supported by pollen data from the Sea of Galilee and Dead Sea (Fall et al., 2002).

Finally, a comparison of plant crops and animal bone fragments between Ni'aj and Hayyat suggests similar animal husbandry at each site, while the plant fragments showed a preference between different crops grown during and after the Early Bronze IV urban collapse, with farming in the Middle Bronze Age more tailored towards marketable crops such as wheat and olive (Falconer et al. 2004). This could suggest trading with neighboring communities during the Middle Bronze Age and a lack of trading during Early Bronze IV. They also find large variations in seed abundance between phases at Tell Abu en-Ni'aj, showing the importance of looking at phase-specific agricultural changes (Falconer et al. 2004; Falconer and Fall 2007). Our study looked at a much larger number of samples spread throughout each phase to hopefully elucidate the trends present over this timespans.

3.2 Archaeological Seed Identification

Many studies have been done in the past on carbonized seed data, several of which I have referenced below and had used to identify the seeds from my site. The primary seed identification resource I relied upon (Van Zeist and Bakker-Heeres, 1982) gives detailed pictures and measurements of the primary seeds found at each of three archaeological sites. It includes descriptions for each taxon down to the lowest level of nomenclature. This resource uses whole seeds for all non-cereal grains, and whole seeds and fragments for cereals. Some fragments are included in the description for more generalized taxa such as Poaceae (grass). The authors also look at both 2-row and 6-row barley, as well as genera specific spikelets, glume bases, and internodes for select species. They include analyses of seed counts and seed ratios, discuss how the seeds may have gotten there, what they tell us about the site, and what they tell us about each phase.

Helbaek (1959) includes a detailed seed study from a tell in Israel. The author includes grouped seed photos and detailed seed descriptions for each specimen, in which he notes the dimensions of each seed, the physical characteristics, the proposed use and popularity of seeds by time period (Early Bronze Age and Iron Age), and the use and possible distribution throughout the Near East. He also talks about the discrepancies between seeds grown in each age, with particular focus on species of wheat and barley (Helbaek, 1959). McCreery (1979) introduces a preliminary seed study of Bab edh-Dhraʻ and Numeira, Jordan. The study covers a range of seeds, both domestic and wild, and includes species level distinctions (McCreery, 1979).

In his study of Wadi Fidan, Jordan, Meadows (1996) discusses the gathering of seeds from burned dung. One of the important benefits of an archaeobotanical study at Tell Abu en-Niʻaj is their use of manure burning in antiquity. In place of wood, sometimes villages would collect and burn manure to feed their fires. This practice allowed for the carbonization of a much larger quantity and variety of seeds (Miller, 1984). In Meadow's seed survey, he looks at all the major cereals as well as a plethora of other wild and domestic seeds found. He includes several specifications of cereals (indeterminate, wild, and free threshing wheat), definitive versus tentative categorizations (oat versus. Cf oat), non-genus-specific categories (small legumes) and plant fragments (skins, pulp, glumes, terminals, and rachis). He also presents a detailed description of each of the seeds found in his survey (Meadows, 1996).

Finally, I also utilized a Late Bronze Age seed study in Southern France (Bouby et al., 2005). While the age range and location are not the same as those of my study, the methods, explanation of their results, and seed table provided useful comparisons for my study. The culmination of these seed surveys, as well as other select online and textural sources, have helped to form my knowledge of seed identification and determined how I set up my research design. Hopefully by making a similarly designed study my results will be more easily comparable with other regional surveys.

CHAPTER 4. RESEARCH DESIGN

The research question addressed in this study is how carbonized seed data from Tell Abu en-Ni'aj can be analyzed to interpret the cause of the abandonment of cities in Early Bronze IV, between the end of Early Bronze III towns and the reemergence of cities in the Middle Bronze Age. More specifically, this study tests the hypothesis that plant remains from Tell Abu en-Ni'aj provide evidence of a shift to warmer and drier climatic conditions between about 4550 and 4250 cal BP (2600-2300 cal BC), which contributed to the abandonment of Levantine towns.

The research design for this project involves tabulating archaeological seed data to calculate selected measures of vegetation dynamics, including seed ratios, densities, relative frequencies and ubiquity. By comparing these values to those of similar sites within the region it should be possible to determine the dominant crops and wild vegetation as well as the paleoclimatic conditions of the past. I also was able to do analyses such as t-tests and ANOVA to examine the significance of key vegetation categories. Ternary diagrams were useful, similar to the one used in Van Zeist and Bakker-Heeres (1982) to illustrate the change in use of key cultivated crops through time, while ^{13}C could was used to indicated changing water availability to crops. We then both quantitatively analyzed the data and qualitatively interpreted other potential causes for our results in regards to our hypotheses.

My primary task for this project was to tabulate all of the major cereals, fruits, and legumes, as these are the most commonly farmed crops and therefore some of the most indicative plants for climate change. I ultimately included several categories of seeds for analysis, indicated in our tables. These include such categories as 'Cultivated Seeds', 'Wheat', or 'Einkorn'. I went over each of the seeds in detail, including wild and unknown seed fragments, and described the seeds, how they relate spatially and temporally, what they tell us about the site, and their potential usefulness in determining the cause and effects of the EB IV collapse. I also documented all unknown seeds, with a select few samples of interest separated out for future review.

The main distinction I looked to examine are the wheat versus barley counts and grape versus olive counts, because these two seed comparisons could be useful for drawing conclusions about the paleoclimate. The estimated trend at Niʻaj would be towards more barley and more grape, since barley and grapes can be more easily grown in more arid climates, while wheat and olives require more water.

CHAPTER 5. METHODS

5.1 Field Methods

Tell Abu en-Ni‘aj was excavated under permits from the Department of Antiquities of Jordan. A 5 x 5 m grid was used to excavate Tell Abu en-Ni‘aj, as first established in test excavations in fall 1985, and expanded in the two main seasons of excavations in winter 1996/97 and spring 2000. Each grid square or “excavation area” was assigned an alphabetic designation (Figure 6). Each area was excavated in ‘loci;’ each ‘locus’ being a three-dimensional context identified and defined by the excavation supervisor (e.g., a wall, pit, surface, etc.). Each locus was numbered sequentially according to the order in which it was excavated, using a three-digit designation beginning with ‘001.’ Each sample was numbered sequentially beginning with ‘1.’ Thus, the specific context for each sample from Tell Abu en-Ni‘aj was labelled by its excavation area, locus number and bag number (e.g., A.003.16).

Figure 6. Plan of excavation areas at Tell Abu en-Ni'aj showing (a) architectural layout for Phase 4 and (b) topography of the tell with along with each excavated area (from Fall and Falconer unpublished).

Carbonized plant remains were recovered from Tell Abu en-Ni'aj in a non-random sampling strategy by collecting sediment samples from excavated deposits showing evidence of burning, or containing visible carbonized seeds or wood. Samples were taken from hearths, tabuns (cooking ovens), surfaces (floors), storage pits, trash deposits, and other burned sediments. These sediment samples were processed by water flotation to recover plant macrofossils (Falconer and Fall 2006; Klinge and Fall 2010). During the 1985 excavations, each flotation sample was poured into a metal basket with 3.2 mm mesh screen across the bottom; this basket was suspended in a metal tub of water. Each sample was then gently agitated to dissolve the sediment and free the carbonized plant fragments from the soil matrix. Suspended plant material was removed with a large tea strainer (1.6 mm mesh). The smallest seeds were recovered by placing a piece of cheese cloth over the tea strainer. The contents of the metal basket were checked for heavier seeds that may not have floated (e.g., olive stones). Following flotation, plant remains were dried indoors for about 24 hours.

During the 1996/97 and 2000 seasons, we utilised a Flot Tech 2000 flotation machine to mechanically separate the organic material from the sediment matrix (Figure 7). Machine flotation is uses a water bath which vibrates the sediment to remove any dirt, rocks or other dense material, so that the charcoal and seeds which float can be individually removed (Pearsall, 1989). The light fraction floats to the top and is captured in mesh bags and the heavier fraction is recovered on a screen tray. Both fractions were dried; the heavy fraction was sorted in the field for seeds like olive which may not have floated. The light fractions were then shipped to the United States for analyses.

Figure 7. Flot Tech 2000 machine used for water flotation of samples collected in 1996/97 and 2000.

5.2 Laboratory Processing of Carbonized Seeds

All samples were processed at the University of North Carolina Charlotte Paleoecology Lab by pouring the carbonized remains through nested 4 mm, 2 mm, 1 mm and 0.25 mm mesh sieves. All recovered material 0.25 mm or larger was sorted under a binocular microscope (e.g., Zeiss Stemi 305 at 8 to 40x magnification) to separate charcoal fragments from charred seeds. Seed remains were identified using Dr. Fall's personal reference collection and comparative literature (e.g., Delorit 1970; Helbaek 1959; Martin and Barkley 1973; Zohary and Hopf 1973; Zohary 1966; 1975; Zohary and Spiegel-Roy 1975; Van Zeist 1976; Van Zeist 1982; Feinbrun-Dothan, 1978; Van Zeist and Bakker-Heeres 1982; Feinbrun-Dothan, 1986; Hubbard 1992; Jacomet 2006), counted and categorized taxonomically. Seed identification made great use of the work of Van Zeist (e.g., 1982), which details the most common crop plants found in the Near East, including the major wheat and barley species, as well as several common weed species.

This study analyzes data from 123 flotation samples from Tell Abu en-Ni'aj that ranged between 1 and 14 liters each, and averaged about 170 seeds per sample. A sample splitter was used to separate particularly large collections of seeds. The full data set from Tell Abu en-Ni'aj includes more than 20,000 identified carbonized seeds as well as almost 5000 stem fragments. For each sample, I documented several key pieces of information, including the year it was picked, the phase, the locus type, sample ID, area, locus, bag number, floated sample volume, fraction and sieve size, carbon isotope information when it was known and seed counts per taxa (including all genera, fragments, stem fragments and unknowns).

Taxonomic seed counts were used to interpret the wild and domesticated vegetation present and the farming practices used by the people to cultivate crops. To ensure a good coverage of the site, as well as a comprehensive window of change over the course of occupation, I chose samples from several excavation units, which provided carbonized plant remains from all seven stratified phases of occupation at Tell Abu en-Ni‘aj. Table 2 below shows the number of samples sorted for each phase. These carbonized seeds were excavated from contexts such as earthen surfaces and shallow burned depressions with minimal potential for chronological mixing. Harris Matrices were created for three of the most commonly sampled excavation units, AA, G and C (Figure 8), to display the stratigraphic relationships between samples.

Table 2. Numbers of flotation samples per phase which provided carbonized plant remains from Tell Abu en-Ni ‘aj for this study.

Phase	Sample Count
1	14
2	20
3	17
4	22
5	15
6	19
7	16

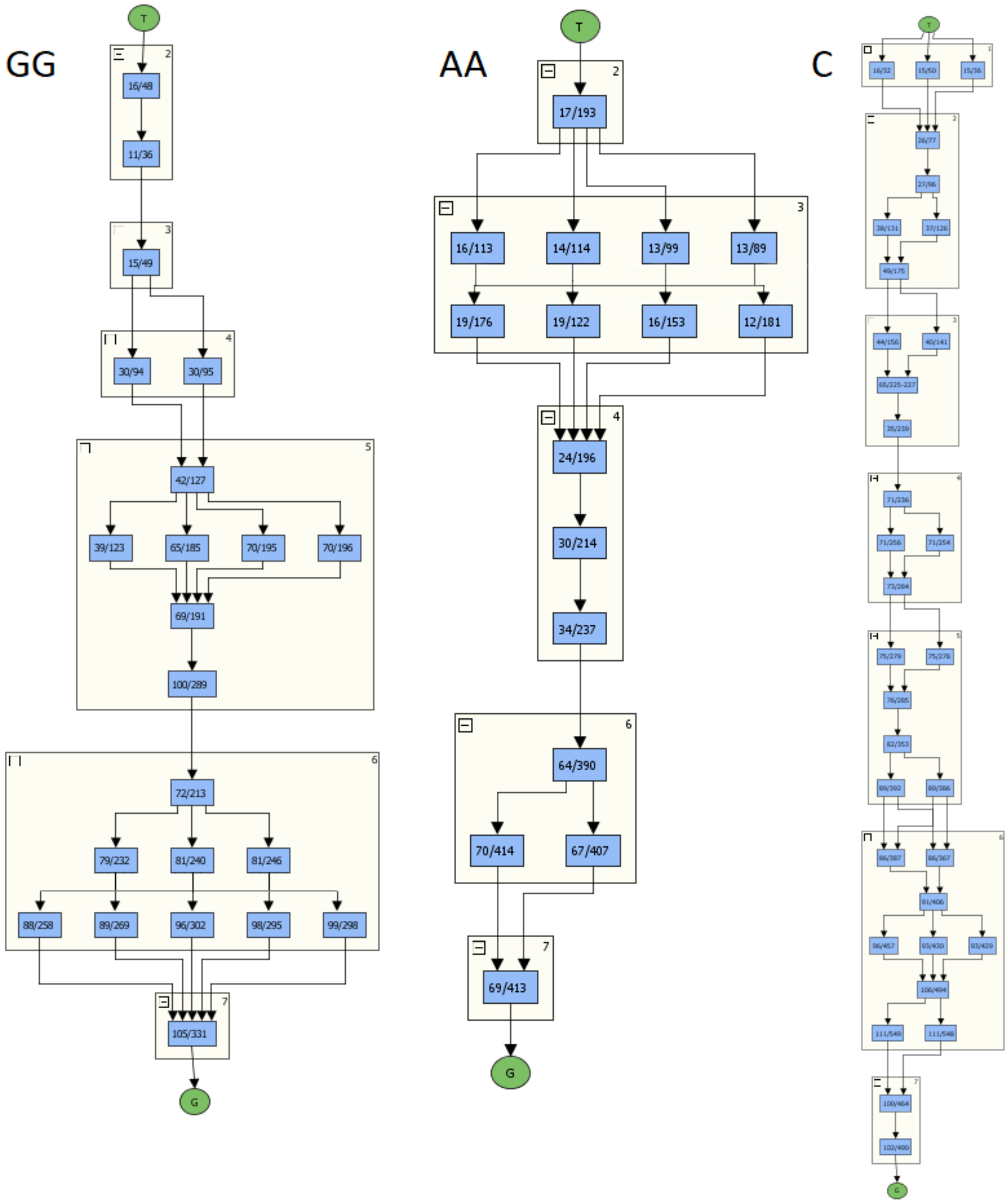

Figure 8. Harris matrices for the 3 excavation areas (Areas GG, AA, and C) from which most of the flotation samples were drawn. Blue boxes represent individual samples (with their locus and bag numbers) and tan boxes represent stratigraphic phases. Made with Harris Matrix Composer; From Tell Abu en-Niʻaj.

Though studies in the past have interpreted Niʻaj as a farming community, it is important to know to what extend trading occurred at the site. This is because the addition of imported crops in a seed study would throw off the counts of locally farmed seeds, which would not tell us about local environmental conditions. It is likely that Niʻaj neither imported or exported seeds, but with drought and high temperatures at the end of Early Bronze it may seem plausible they were reliant on imports. However, we may be able to recognize importation of seeds if there was an abundance of pre-cleaned seeds in the record with no rachis, glumes or spikelet fragments present. As a result, all three of these forms of stem fragments were tabulated along with seed counts to test this hypothesis.

5.3 Trend Analysis

Initial quantitative analysis primarily examined counts of seeds and how their relative proportions change over time. Further quantitative analysis includes interpretation of trends in relative abundances among taxa or plant categories. This study uses several measures of abundance including relative frequencies, densities, ratios and ubiquities. Seed densities are calculated as the number of seeds for any taxon divided by the volume (in liters) of sediment from which the seeds were recovered. Ratios represent the number of seeds of any one taxon divided by the seed count of another, which gives us a direct comparison of the relative abundance of one plant type to another. Relative frequency is expressed as the count of a taxa divided by the total number of seeds in the site or a phase, which gives us a measure of taxon abundance among all plant remains. Ternary diagrams were included as visual representations of relative frequencies. Finally, ubiquity is calculated as the percent of samples in which a taxon is present. This measure allows us to adequately consider the presence of taxon that appear at very high or low frequencies in the data due to differences in variables such as fragmentation rate or the number of seeds produced per plant.

Seed fragments were initially counted separately as a study of fragment to seed counts could have proved enlightening. However, it was decided that our analyses would be better off not considering fragments separately for several reasons. First, many other seed studies base their results on summed counts of whole and fragmented genera. Second, separating taxa into two categories for whole and fragmented seeds would lower the counts of each taxa, sometimes substantially, thereby reducing sample sizes needed for statistical analyses.

This study also makes use of stable carbon isotope (^{13}C) ratios. These ratios are extremely useful as indicators of past water availability, which is a key indicator of climatic change and crop stress (Riehl et al., 2014). Previous analyses of ^{14}C at Tell Abu en-Niʻaj include 20 $\delta^{13}C$ measurements from various cereals, legumes and fruits (Falconer and Fall, 2016), and 12 additional samples were processed for this study. These values were converted by Elizabeth Ridder to values of $\Delta^{13}C$, which provides a relative measure of water availability. With the addition of several new samples, there is room for a new, more comprehensive ^{13}C analysis. Several studies, referenced in this study have also relied upon ^{13}C data (Kaniewski et al., 2008; Riehl et al., 2012, 2014) to provide comparative data on water availability and climatic conditions. In particular, Riehl et al. (2012) shows an estimated trend through the Early Bronze IV period using a cereal-based $\Delta^{13}C$ curve which we can compare to our study at Tell Abu en-Niʻaj (Figure 3).

It is important to understand the chronology of the seven stratified phases of occupation at Tell Abu en-Niʻaj to infer changes in cultivation and natural vegetation through time, as well as to calibrate the values of $\delta^{13}C$ to $\Delta^{13}C$. Radiocarbon chronology for Niʻaj is based on calibration of ^{14}C ages from phases 7-2. After calibration, Falconer and Fall used Bayesian analysis to model the lengths of the seven phases at Niʻaj (Table 1, Figure 2 and Table 3).

Table 3. Modeled phases of occupation at Tell Abu en-Niʻaj. *Date approximated.

Phase	Age Range (cal years BP)	Age Range (cal years BC)	Total Phase Length
1	4242-4200*	2292-2250*	42
2	4285-4242	2335-2292	43
3	4332-4285	2382-2335	47
4	4374-4332	2424-2382	42
5	4407-4374	2457-2424	33
6	4436-4407	2486-2457	29
7	4474-4436	2524-2486	38

The calibrated dates were used for conversion of $\delta^{13}C$ to $\Delta^{13}C$ values. Calibration was done based on the formula shown below from Ferrio et al. (2005) and relies on their values of δ13C of the air.

$$\Delta^{13}C = (\delta^{13}C_{air} - \delta^{13}C_{sample}) / (1+(\delta^{13}C_{sample}/1000))$$

CHAPTER 6. RESULTS

6.1 Methodological Seed Classifications

Barley

The two prominent barley groups distinguished in this study were hulled barley (*Hordeum vulgare*) and naked barley (*Hordeum vulgare* L. var. *nudum*). Hulled and naked barleys were distinguished based on several key characteristics, the most important being seed cross-section. Hulled barley was identified from its highly angular cross-section, with thick longitudinal ridges, a coarser texture and many thin longitudinal ridges. Naked barley was identified from a more rounded seed, a lack of ridges and a smooth exterior. Hulled barley fragments were easier to recognize than naked barley fragments because of their pronounced ridges, which likely attributed to more hulled barleys being identified than naked barley; however, barley fragments which were not clearly identifiable as hulled or naked were classified as undifferentiated barley.

Wheat

Three categories of wheat were recovered from Tell Abu en-Niʻaj: bread wheat (*Triticum aestivum*), emmer wheat (*Triticum dicoccum*) and einkorn wheat *(Triticum monococcum*). Emmer is distinguishable from its triangular cross-sectional profile, steep embryo ridge, flat bottom and slightly rounded tip. Einkorn came in two shapes; one was recognizable from its thin and often highly-skewed cross-sectional profile. A second, less common variety was denoted by a curved base, rounded cross section and highly pointed tip. Bread wheat appeared similar to emmer but was denoted by its thicker cross-sectional profile with puffy, rounded sides. It also was usually a little smaller and wider, with a less pronounced embryo ridge. Though emmer was the most popular wheat crop at Ni‘aj, einkorn and bread wheat were also common occurrences.

Wild Grasses

The most common wild grass found at the site was *Phalaris*, while the next most common were larger grasses such as *Bromus* or *Lolium*. Certain wild grasses, particularly *Avena, Bromus* and *Lolium* were identified from their elongated shape, usually with a vertically-pinching groove down one face, while *Phalaris* was identified by its unique circular-sector shape, thin cross section, and well-preserved embryo. Wild grasses included a diverse range of genera with a wide variety of morphologies.

Cultivated Legumes

Cultivated legumes included lentils (*Lens esculenta*), peas (*Pisum sativum*) and vetches (*Vicia sp.*). The most frequent of these were lentils and peas, which are easily recognizable from their internal texture, which resembles Styrofoam. Seed shape was also a key indicator for each of the cultivated legumes, with peas being almost spherical with a single trench, lentils being oblate with a thin, distinct line around the equator, and broad beans being much larger and comprised of two rounded portions.

Wild Legumes

Most wild legumes are from the genera *Medicago/Onobrychis* and *Prosopis/Acacia* and have a shape and texture similar to the L*eguminosae*, which is fabiform in shape with a smooth exterior and a porous interior. This texture, which seemed typical for all identified legumes except lentils and peas, was used to help define wild legumes. Certain legumes were easier to identify based on the shape of their cotyledon and the placement of their hypocotyl, but some legumes were grouped together to aid in identification. Examples include *Medicago* and *Onobrychis*, which seemed to differ in the thickness of their cotyledon and their shape, which ranged from flat and fabiform in *Medicago* to plump and ovoid in *Onobrychis*. The other common legume was *Prosopis*, which was grouped with *Acacia* based on morphological similarities. Seeds of both taxa are denoted by a teardrop shape, a single circular marking on their outermost face and a range of glossy and rough textures of their interiors, but it is likely that the seeds from Ni'aj are *Prosopis* rather than *Acacia*, based on their large size.

Fruits

Three main varieties of fruit were recovered from the site, including: fig (*Ficus carica*), olive (O*lea europaea*) and grape (*Vitis vinifera*). Fig was easily denoted by its small spherical shape, extremely light weight and hollow interior. Olives were much less common, and only found in fragments at Ni'aj. These were identified by a much thicker seed with a smooth interior and a very rough exterior marked by short longitudinal ridges. Grapes were also uncommon and were identified by two exterior grooves and a hollow interior.

Wild Seeds

There were 71 other identified seed genera in addition to the categories above, which were classified as wild taxa. While the quantities of most of these taxa are quite low, several are represented by more than 50 seeds, including *Anagallis, Chenopodium, Malva* and *Rumex/Polygonum*. Seeds of *Anagallis* were easily identified by their small size (<1mm), triangular cross section and bumpy texture. *Chenopodium* was identified by an oblate shape with a thick ring around its equator. *Malva* was identified based on a unique shape similar to an orange slice, and its small size. Finally, *Rumex/Polygonum* were identified jointly by their equilateral-triangular cross section and thick longitudinal ridges.

Unknowns

There were a handful of unknown seeds found throughout the survey, and 15 of the more unique taxa were drawn and measured for easier future analysis and identification. These select unknown were separately tallied but were grouped as unknown for our analyses.

Stem Fragments

Three major stem fragment pieces were collected: rachis, glumes and spikelets. Spikelets include the base of the seed where it attaches to the stalk, so it often included fragments of glumes and sometimes rachis. Glumes were represented by fragments of the leaf-like bracts on the side of each spikelet and included lemma and palea. Finally, any stalk fragments which contained indications of a rachis were included. Though I did not include other charcoal pieces or culm fragments, I chose these three stem fragments in particular because of the information they can give on seed cultivation. The shape and size of the spikelet and its glumes can provide information as to plant type and how the burned seeds were deposited. The spikelets and glumes from Ni‘aj were found to exhibit a wide variety of sizes, very likely from seeds of the major cereals and barleys as well as from many of the wild grasses.

Notable Omissions

Though a wide array of vegetation types were found at Niʻaj, there are a few genera that were absent here which appeared at other sites. These include chickpea (*Cicer* sp.), pomegranate (*Punica granatum*), and *Ziziphus*. However, carbonized wood identified as *Punica granatum* was found at Tell Abu en-Ni ʻaj (Fall et al. 2015).

6.2 Quantitative Results

Seed count data may be quantified for comparative analysis using our quantitative measures of count, density, ratio, relative frequency and ubiquity. Table 4 presents the overall seed counts, densities, relative frequencies and ubiquities for the major cultigens at Tell Abu en-Niʻaj.

Table 4. Results for each of the standard metrics (count, density, relative frequency, and ubiquity) for each of the major cultivated taxa from Tell Abu en-Niʻaj.

Taxa	Count	Density	Rel. Frequency %	Ubiquity %
Hulled Barley	2957	5.808994	14.34323	87.80488
Naked Barley	387	0.760257	1.877183	58.53659
Emmer Wheat	466	0.915452	2.26038	64.22764
Einkorn Wheat	124	0.243597	0.601475	40.65041
Bread Wheat	37	0.072686	0.179472	15.44715
Grape	44	0.086438	0.213426	19.5122
Olive	45	0.088402	0.218277	8.943089
Fig	729	1.432112	3.62578	60.1626
Total Wheat	912	1.791614	4.423749	77.23577
Total Barley	3871	7.604537	18.77668	93.49593

When calculated for each phase, relative frequencies show general trends in which cultivated taxa increase and wild taxa decrease through time, with cultivated going from around 60% to 80% and wild taxa going from 40% to 20% from Phase 7 to Phase 1 (Figure 9). Cultivated crops also have a higher count and higher density in every phase throughout, staying about two to three times more common in each phase for both analyses.

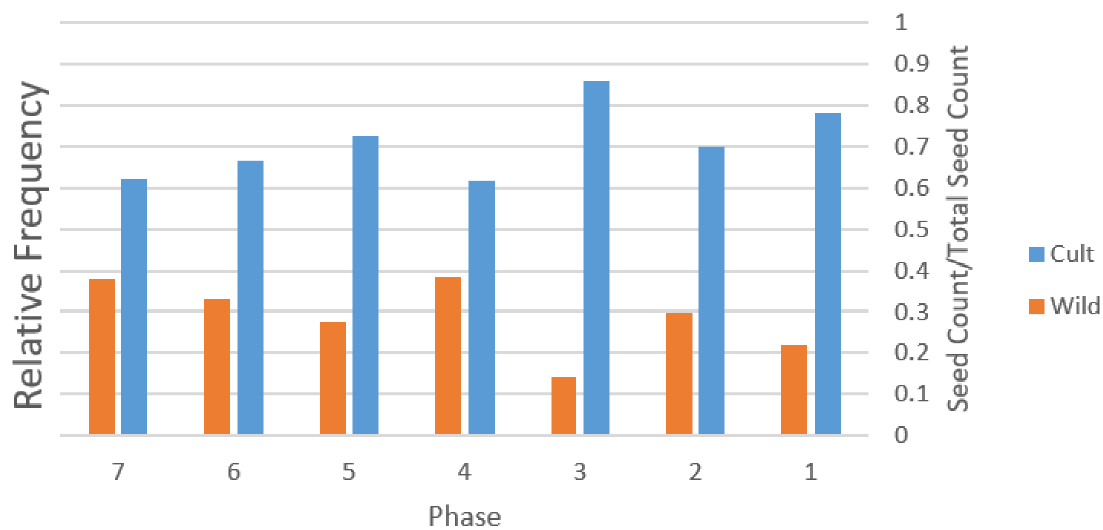

Figure 9. Relative frequencies of cultivated and wild taxa from Tell Abu en-Niʻaj.

When broken into the six main vegetation types (cultivated cereal, wild grass, cultivated legume, wild legume, cultivated fruit, wild other) we see similar trends emerge (Figure 10). Cultivated cereals clearly form the most common seed category recovered at the site, followed in descending order by: wild legumes, wild grass, wild other, cultivated fruit, and cultivated legumes. Between Phases 7 and 1 there is a general decline in the count, density and frequency of every category except cultivated cereals (which increase over time) and the wild legume seed counts and frequency, which increase slightly in Phases 4-2 before dipping again in Phase 1.

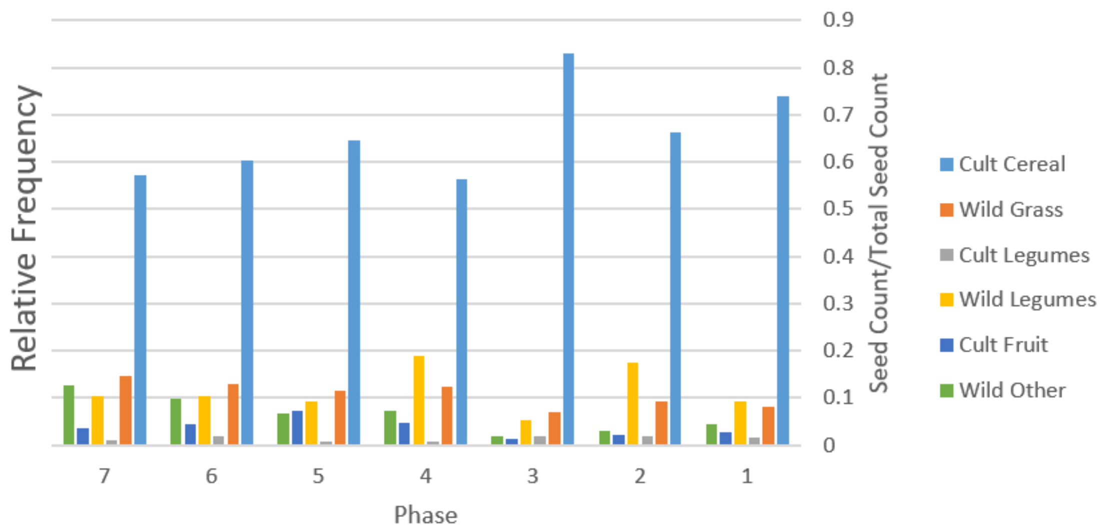

Figure 10. Relative frequencies for six vegetation type categories at Tell Abu en-Niʿaj: cultivated cereal, wild grass, cultivated legume, wild legume, cultivated fruit and other wild taxa.

We used two types of statistical tests to study the effects of temporal variation at our site, two sample t-tests and analysis of variance (ANOVA). These helped to understand the significance of relationships found amongst the major seed categories. All statistical tests were done using the data analysis module in Excel. The t-test analyses were done on two different datasets: total cultivated taxa versus total wild taxa by phase and barley versus wheat by phase. The goal of using a t-test for these relationships was to indicate whether seed count varied significantly aside archaeological phase. The comparative analysis of barley vs. wheat produced a two-tailed p-value of 0.021 (Table 5), while analysis of cultivated vs. wild taxa produced a two-tailed p-value of 0.008 (Table 6).

Table 5: Two-sample t-test results assuming unequal variances by phase for the variables 'barley and wheat counts divided by number of samples per phase' from Tell Abu en-Ni'aj.

	Hordeum	*Triticum*
Mean	31.52379	7.78478
Variance	419.9101	28.56216
Observations	7	7
Hypothesized Mean Difference	0	
df	7	
t Stat	2.965814	
P(T<=t) one-tail	0.010466	
t Critical one-tail	1.894579	
P(T<=t) two-tail	0.020932	
t Critical two-tail	2.364624	

Table 6: Two-sample t-test results assuming unequal variances by phase for the variables 'cultivated and wild taxa counts divided by number of samples per phase' from Tell Abu en-Ni'aj.

	Cultivated taxa	Wild taxa
Mean	115.7877	50.5526
Variance	1986.31	776.904
Observations	7	7
Hypothesized Mean Difference	0	0
df	10	
t Stat	3.283397	
P(T<=t) one-tail	0.004121	
t Critical one-tail	1.812461	
P(T<=t) two-tail	0.008241	
t Critical two-tail	2.228139	

A two-factor ANOVA without replication was chosen to model the codependence in our larger data set which included multiple vegetative classification groups (Table 7). The goal of ANOVA in this case was to test our null hypothesis that the mean seed counts between our vegetation categories (cultivated cereal, wild grass, cultivated legume, wild legume, fruit and wild other) are equal. The results of this test indicate the significance for this classification method as well as for classifying by phase (Seltman, 2009). The returned p-values for our

ANOVA are 0.018 and 4.89×10^{-13} for phase and vegetation type respectively, both well above an acceptable alpha value.

Table 7: A two-factor ANOVA results without replication by phase for six vegetation type categories at Tell Abu en-Ni'aj divided by the seed count of each per phase.

Summary	Count	Sum	Average	Variance
Phase 1	6	43.07143	7.178571	146.9995
Phase 2	6	126.7	21.11667	1001.013
Phase 3	6	157.3529	26.22549	2618.042
Phase 4	6	171.1364	28.52273	1214.279
Phase 5	6	233	38.83333	3059.82
Phase 6	6	204.6842	34.11404	1981.836
Phase 7	6	228.4375	38.07292	2213.73
Cultivated Cereal	7	746.9519	106.7074	1598.376
Wild Grass	7	134.3822	19.19746	115.5494
Cultivated Legume	7	15.48011	2.211445	1.268492
Wild Legume	7	133.0153	19.00219	92.47907
Cultivated Fruit	7	48.08222	6.868889	30.31327
Other Wild	7	86.47067	12.35295	104.3317

ANOVA						
Source of Variation	SS	df	MS	F	P-value	F crit
Rows	4440.029	6	740.0049	3.077423	0.018117	2.420523
Columns	53964.73	5	10792.95	44.8841	4.89E-13	2.533555
Error	7213.876	30	240.4625			
Total	65618.63	41				

Trends in the abundance of wheat and barley were assessed using phase by phase seed count ratios and ubiquities for both taxa. Ratios in the earlier phases have values of about 2:1 to 4:1 in Phases 7-4 then rising to a much higher ratio of 7:1 to 8:1 in Phases 3-2 before falling back to around 3.5:1 in Phase 1 (Figure 11). A comparison of both count and density shows a steep decline in both barley and wheat crop through each phase, while ubiquity shows a much smoother trend. Barley ubiquity shows high values for barley throughout the sequence, with a modest decline in Phase 5 and from Phases 3-1. Wheat ubiquity is generally lower than barley throughout, but still remains in about 80% of all samples in each phase. The wheat ubiquity trend shows a slight peak at Phase 5, after which it begins a steeper decline from Phase 5-1 (Figure 12).

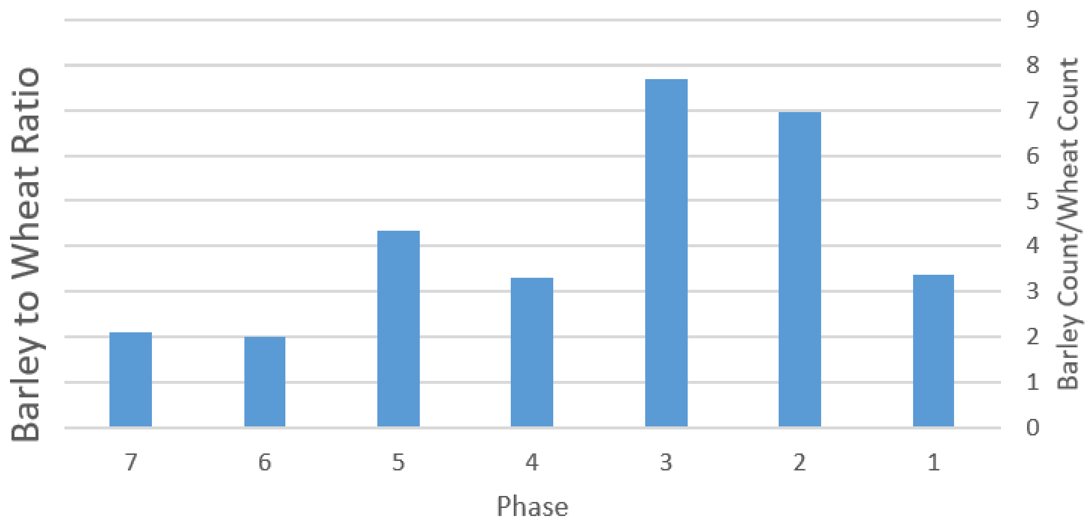

Figure 11. Seed ratios (barley/wheat count) for *Hordeum* and *Triticum* from Tell Abu en-Ni'aj.

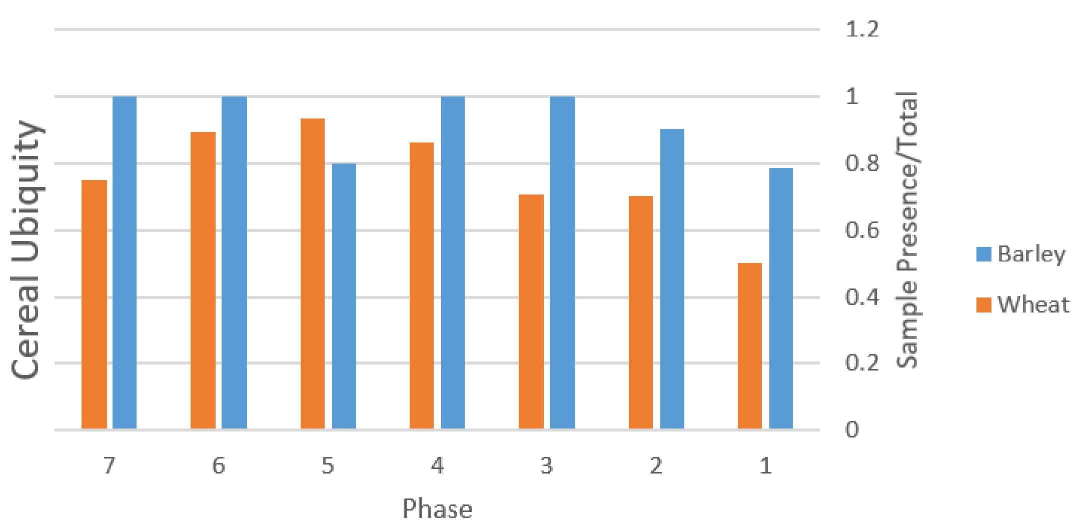

Figure 12. Ubiquities for the cultivated cereal categories *Hordeum* and *Triticum* from Tell Abu en-Ni'aj.

More fine-grained comparative analysis considers trends in abundance among major cereal crops (hulled barley, naked barley, emmer wheat, einkorn wheat and bread wheat) and among fruit crops (fig, grape and olive). For the cultivated cereal analysis, hulled barley is the most ubiquitous crop in every phase, with values of 80% or greater in every phase except Phase 1. Hulled barley also seems to be the only cereal crop to maintain a high count and relative frequency over time, with each other cereal declining steadily from Phase 7-1 (Figure 13). Naked barley is consistently less ubiquitous and shows a decline from Phase 4-1, while Emmer wheat (the most common wheat) seems to echo this trend. The decline in these ubiquities is more pronounced, declining from around 70% in Phases 7-5 to 20% in Phase 1. Einkorn has a lower ubiquity, peaking in Phase 5 at 70% before declining to roughly 10% in Phase 1; while bread wheat has the lowest, starting at only 10% in Phase 7 and declining until it is no longer present in Phase 1.

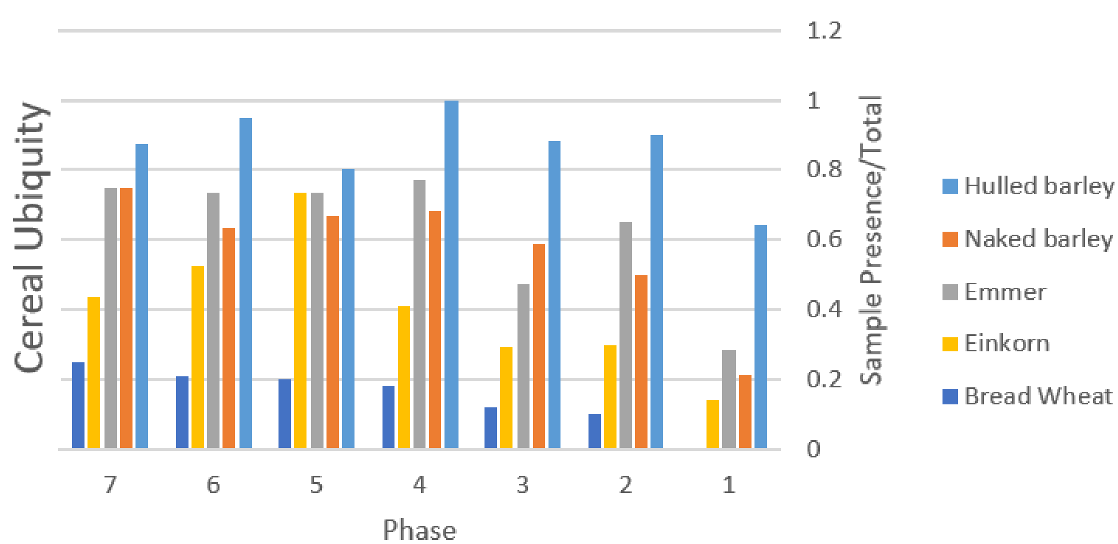

Figure 13. Ubiquities for the five major cereal taxa from Tell Abu en-Ni‘aj.

Ubiquity was the only useful analysis for fruit. Fig showed a general decline from around 80% to 40% ubiquity (Figure 14). Grape ubiquity seems to increase until 35% at Phase 5, after which it starts to gradually decline. Olive ubiquity rises steadily though, from 0 in Phase 7 to around 15% in Phase 1 but this trend is probably a result of skew due to using ubiquity with extremely low individual olive and grape seed counts.

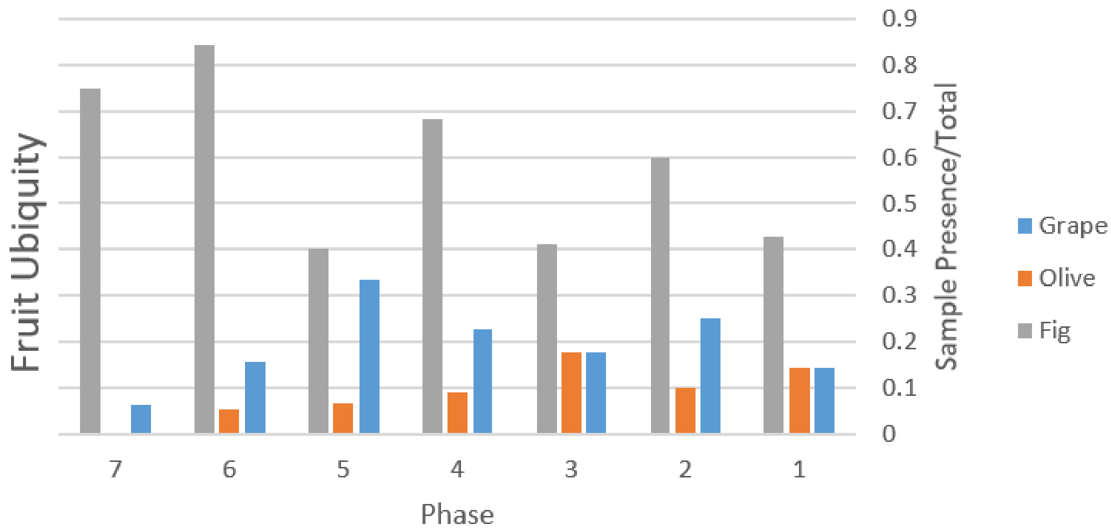

Figure 14. Ubiquities for the fruit taxa *Vitis vinifera, Olea europaea*, and *Ficus carica* from Tell Abu en-Niʻaj.

An analysis of the phase by phase ratios of stem counts to cultivated cereal seeds shows how often cereals are recovered in comparison to how often the stem pieces normally attached to them are recovered (Figure 15). The graph shows perhaps our sharpest distinction between phases of any comparison for Tell Abu en-Niʻaj, with ratios of around 35-60% in the first four phases at the site, dropping to around 10-15% from Phase 3 onward. In the later phases the ratio declines significantly, showing stem fragments were recovered less often relative to the amount of cereal recovered. A ubiquity analysis of the stem fragments confirms this result, showing a near 80% ubiquity in the lower phases, declining towards a roughly 40% ubiquity in the upper phases (Figure 16). The ubiquity analysis also shows that roughly the same trend can be found for each of the three stem fragment types.

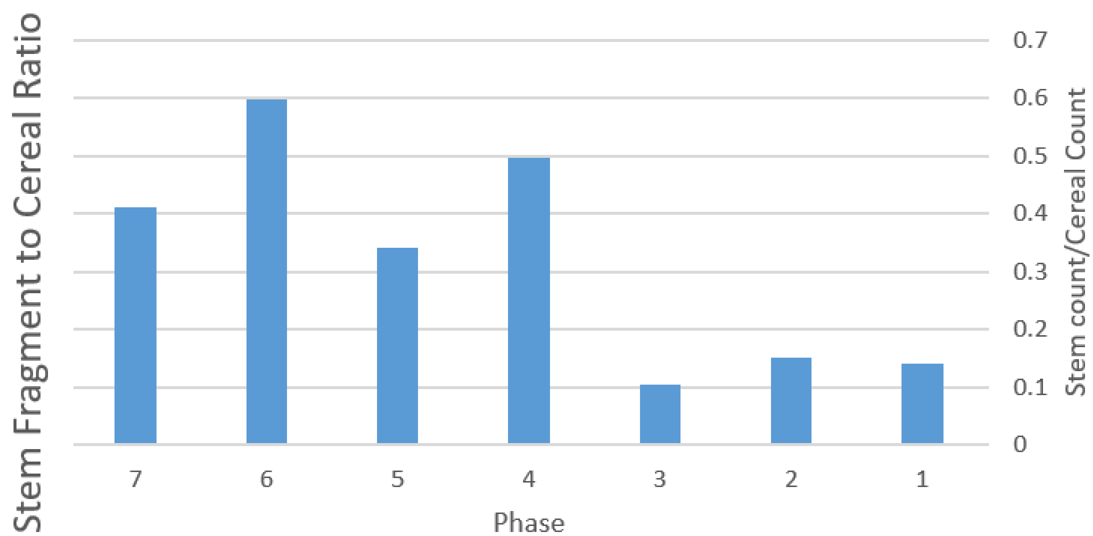

Figure 15. Ratio of stem fragments to total cereals from Tell Abu en-Ni‘aj.

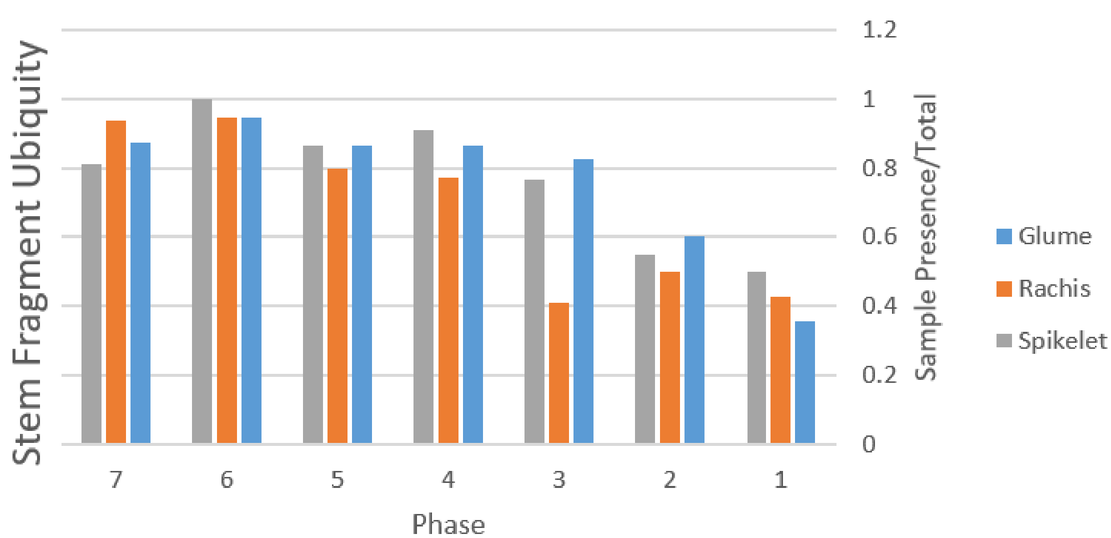

Figure 16. Stem fragment ubiquities from Tell Abu en-Ni‘aj.

Two ternary diagrams were used to compare relative frequencies of major plant categories. The first ternary diagram compares barley, wheat and cultivated legumes plus fruit (Figure 17a). It seems to suggest a definitive trend toward barley, with only minor trends towards either wheat or the cultivated pulses and fruits. The two points farthest to the bottom left of Figure 17a represent two of the last three phases of occupation, which falls in line with our trends of pronounced barley cultivation later at Niʻaj. A second ternary diagram (Figure 17b) compares cultivated cereal, wild grass and wild legumes. In this graph the points for each of the seven phases show an emphasis on the cultivated cereals, with very slight contribution from wild legumes and, to a lesser degree, wild grasses.

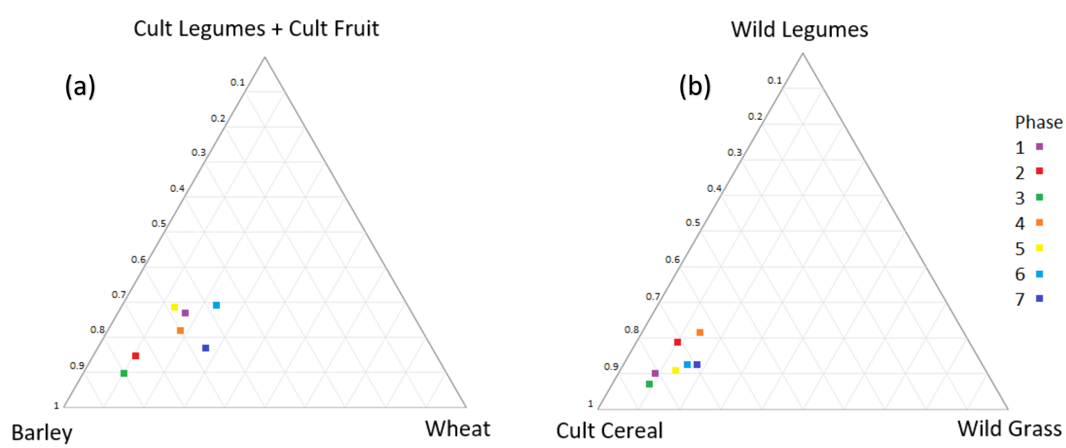

Figure 17. Ternary diagrams illustrating the relative frequencies of (a) barley, wheat and cultivated legumes + cultivated fruits, and (b) cultivated cereal, wild grass and wild legumes from Tell Abu en-Niʻaj. Each cell represents 10% relative frequency.

Carbon 13 ratios from Niʻaj were used to estimate the drought stress experienced by the plants harvested around the site. Values for $\Delta^{13}C$ highlight trends in water availability throughout the occupation of Tell Abu en-Niʻaj (Figure 18). Wheat, barley and cultivated legume $\Delta^{13}C$ provide 32 data points and return an r^2 of 0.031 and p-value of 0.334 for a linear regression model. The scatterplot appears to have a polynomial distribution though so a quadratic regression model was also calculated. This regression increases the r^2 to 0.191 and the p-values to 0.017 and 0.023, making it significant using the 0.05 alpha. The quadratic regression suggests a slight increase in available water in Phases 7-5, followed by a more pronounced decrease in water availability through Phases 5-1 with averages ranging from around 17.5‰ down to 15.5‰.

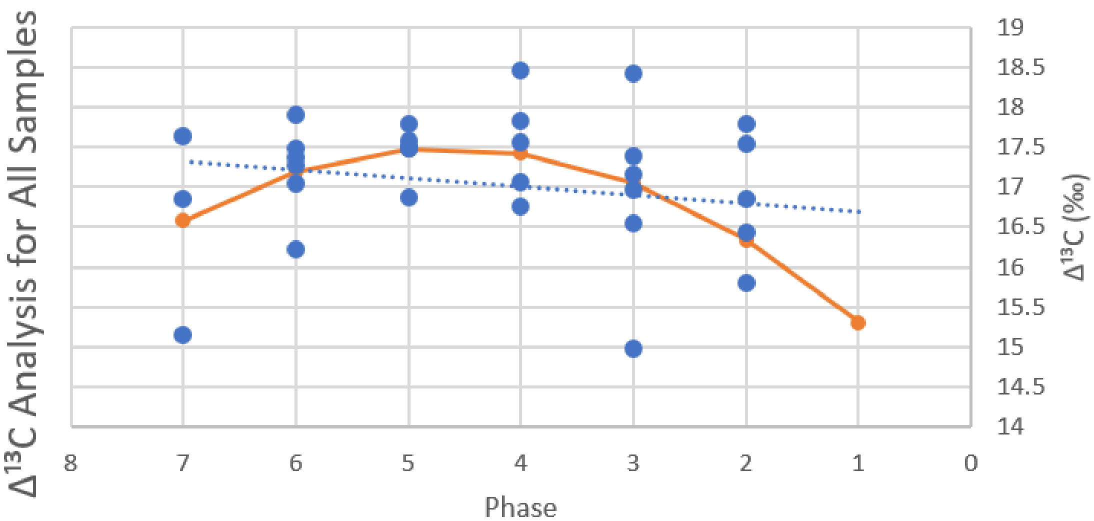

Figure 18. Change in $\Delta^{13}C$ ratios for cultivated taxa at Tell Abu en-Ni‘aj. Both a linear regression and quadratic regression have been fitted to the data to model the trend in $\Delta^{13}C$ through time.

CHAPTER 7. DISCUSSION

To summarize, in my initial hypotheses I anticipated finding primarily the seeds which can survive a warmer and drier climate were farmed at Tell Abu en-Niʻaj. This meant I would find more barley and grape seeds, as opposed to wheat or olive seeds. This seems to have held true, as barley was much more commonly farmed than wheat, and became more frequently farmed as time passed. The shift to barley cultivation also coincides with decreased fruit count through the latter phases at Niʻaj. These shifts could be indicators of a change from a cooler, wetter climate to a warmer, drier climate. The alignment with the settlement and abandonment of towns could suggest a connection between climate and settlement changes. Therefore, it may be possible to suggest climate was a factor in the urban collapses seen in the region. Carbon isotope data may support this idea as well, since there is a trend towards drier conditions later.

The first major trend I examined is total cultivated versus total wild seed counts across the phases. This gives us an idea of the amount of cultivation going on at the site through time. The shift from a lower relative frequency of cultivated crops earlier to a larger proportion in the later phases likely indicates either an increased reliance on cultivated crops or an increase in farmed crops directly around Niʻaj, where their animals grazed. The trend from earliest to latest, Phase 7 to Phase 1, seed counts seems to suggest a decrease in deposition of seeds from both cultivated and wild crops, which could represent a decline in the amount of farming done at the site, a decrease in the use of manure burning (which seems unlikely being how important it was for fires) or a decline in the number of animals kept grazing at the site.

The relative proportions of the six major plant categories (cultivated cereal, wild grass, cultivated legume, wild legume, cultivated fruit and wild taxa) were used to gauge the presence and amount of reliance on certain vegetative groups at our site. It is not surprising that at a permanent settlement such as Ni'aj there is a high reliance on cultivated cereal crops, and the counts and relative frequencies are much higher than any other category. Cultivation was extremely important in order to obtain enough food to feed a sedentary community such as Tell Abu en-Ni'aj. The counts for three of the categories (cultivated legumes, cultivated fruit and wild other) are very low aside from a select few taxa. Overall, this may indicate less reliance on cultivation outside the major cereals. The low total counts of other wild taxa indicate that livestock were primarily grain-fed.

The major trend that we can see from the relative frequencies of these categories is that cultivated cereal seems to dominate the charred remains throughout the EB IV. Specifically, it seems that the wild grass, wild other and cultivated fruit categories become slightly less frequent over time. It seems these are offset by a slight bump in cultivated cereals towards the later end of the EB IV. The standard counts show a similar trend, but with all six groups having a slight dip in the late phases. This trend parallels the one seen for cultivated versus wild seeds, but the fact that this decline is seen in each of the six categories is noteworthy, showing there is a universal decline in deposition of all seed types, aside from barley, in the latter stages of Ni'aj's occupation. The seed density data seems to suggest the same phenomenon of increased reliance on barley cultivation.

Several statistical tests including an ANOVA and two t-tests were used to analyze the major seed groups in our study. The results of these tests show significant distribution between our variables, suggesting our vegetation categories as well as the rates of deposition among genera are significantly distinct. Additionally, phase distinctions appear highly significant for the six-category test. Overall, what we have gauged from these analyses is that our variables of taxa and seed counts are statistically independent. There is also a strong variance in the phase by phase deposition of taxa.

Based on seed counts and relative abundances, barley clearly outnumbers wheats in all 7 phases, and this trend is evident in the barley to wheat ratio plot, with barley being two to three times more common in every phase (Figure 11). Two sample t-tests show significant difference between the counts of each, lending support to the inference of increased barley cultivation (rather than an effect of random chance or sampling). The density analysis also suggests a continuous trend of greater reliance on barley over wheat as time progressed at the site.

Analysis of the cereal taxa (hulled barley, naked barley, emmer wheat, einkorn wheat, and bread wheat) showed similar trends to those of barley versus wheat, with hulled barley being far more popular, and having increased relative frequency toward the later phases, in comparison to all other barley and wheat taxa. This trend is also noted in every ratio comparison between hulled barley and another cereal. This trend towards increased hulled barley count seems to agree with the trend in ancient Europe and the Mediterranean showing a favoring of hulled over naked barleys (Bakels, 2002; Lister and Jones, 2012; Spengler III, 2015). A comparison of emmer versus einkorn wheat suggests einkorn had two peaks towards the middle of Ni‘aj's occupation, where it was starting to come back into favor, but overall the graph does show emmer as more common over time. Again, the density analyses for each of these comparisons supports the inference of increased reliance on barleys through the EB IV. It is interesting that einkorn has low values throughout, since it is suggested to be a good cereal crop for dry-farming regions, being it can be sown in the winter months, which is usually the off season and the season with more rain water (Fall et al., 2002). The lack of this crop may suggest a heavier reliance on irrigation farming or simply be a result of the site's heightened dependence on barleys and emmer wheat over einkorn.

The ratios of specific crops show patterns similar to those of relative frequencies. Once again, the data show hulled barley and emmer being slightly higher respectively and all taxa dipping towards Phase 1. Hulled barley versus emmer compares the ratio of the most common barley to the most common wheat and shows that the most preferred cultivation crop follows the same trend as the total cultivated cereal trend. Finally, barley versus fruit and cultivated cereal versus fruit ratios again indicate trends of increased reliance on cultivated cereals.

Ubiquity returned some very interesting results, while reinforcing some of the earlier trends. The reliance on hulled barley was reflected in its consistently high ubiquity among cultivated cereals, including 100% ubiquity in Phase 4. Emmer, naked barley and einkorn followed in declining ubiquity, while bread wheat was the least common of the cultivated cereal. When comparing trends among barley, wheat and fruit, barley was present in almost all samples, only dipping towards Phase 1 and during Phase 5. This is interesting, since wheat has a moderately high ubiquity overall as well, but hits its highest point in Phase 5, when barley is dipping. This could represent wheat being slightly more favorable earlier in Early Bronze IV, when wheat surpasses barley's ubiquity during Phase 5. However, there is still a much higher count of barley over wheat for this phase, so this likely suggests barley was still more commonly grown. This trend does seem to line up with the quadratic regression model of $\Delta^{13}C$ though, which suggests there may have been less drought stress on crops in Phase 5. This would have been the most lucrative time for wheat cultivation.

A further comparison of barley and fruit ubiquity shows that fruit was still much less common than cereal grains. Fig is the dominant fruit at the site early, with almost 85% ubiquity in Phase 6, which declines towards Phase 1, dipping under 50% ubiquity. In comparison, olive and grape ubiquity never surpass fig ubiquity. Grapes were slightly more ubiquitous than olives throughout, with values approaching 20% total ubiquity. The relatively low counts and ubiquities among fruits may suggest less reliance on fruit crops at Niʻaj.

Our ternary diagrams suggest wild taxa were not incorporated into the seed record as often as cultivated cereals, while barley provides the greatest relative contribution, suggesting significantly more use of grain as animal feed. Though wild vegetation is included in the data set, it is overshadowed by much larger quantities of cultivated taxa.

Stem fragments were also analyzed at our site following my initial hypothesis that stem fragments may be able to give us an indication of the levels of trade carried out at Niʻaj. The premise is that seeds are typically cleaned in the same fields and towns in which they are picked before being stored and exported. Therefore, if Niʻaj was trading seeds we should either see an excess of stem fragments if they exported seed, or an absence of fragments if they imported seed. The ratio of stem fragments to seeds declined particularly between the first four phases and final three phases, possibly suggesting that more seeds were processed off site or imported later in the occupation of Niʻaj; however, it could also be an indication of less manure burning associated with reduced site use starting around Phase 3 (4382 cal BP). It seems likely that seeds were being processes farther and farther from Niʻaj overtime as their reliance on cultivation increased and farmlands stretched further across the floodplain.

Patterns of $\Delta^{13}C$ data show a sizeable overall shift in water availability through time. These results agree with a polynomial, quadratic regression, suggesting a slight increase in available water in the early phases at Niʻaj, followed by a more pronounced decline in the later phases.

It is worth noting that these findings agree very well with $\Delta^{13}C$ trends shown in an in-depth ^{13}C study (Riehl, 2012; Figure 3), which looked at Early to Middle Bronze Age isotope ratios in barleys and wheats at several Near Eastern sites. In combination with archaeobotanical records, Riehl inferred increasing aridity throughout the Early Bronze Age until about 4050 cal BP (2100 cal BC). One factor to consider in our case may be the potential for irrigation. Because of the relative proximity of the Jordan River, farmers at Tell Abu en-Niʻaj may have utilized simple irrigation methods in addition to the use of rainwater, both of which would have been subject to variable water availability due to climate change. The parabolic curve shown in Figure 18 matches his interpretation of the EB IV trend very well, except for a slightly lower maximum (not hitting 17.5‰) and beginning to decline earlier in Early Bronze IV. The results from Niʻaj may agree with the larger pattern with a first pulse of climate stress at the end of Early Bronze III followed by a second wave of drought stress in the mid-late Early Bronze IV. The trend seems to be supported not only by our isotope data, but our raw seed data such as the barley to wheat ubiquity in Figure 12 and past climate models such as in Figure 4.

Our overall results show a recognizable and significant shift over time from crops that would be grown preferably in a more temperate climate to those that are less desirable but could be more easily grown in an arid climate. As stated earlier, the trend seems to correlate with the timeline of urban abandonment seen throughout the Levant.

Studies of soil salinity support the assertion that environmental conditions for wheat growth may not have been ideal in the Jordan Valley. As stated earlier, it was found that the valley soils were highly saline, and this trend seemed to increase during periods of more arid conditions and high erosion (Singer, 2007; Ammari et al., 2013). Tests have been done to assess the effects of salinity on various crops and harvests, and I believe these give further support to the idea that climate change may have played an impact in the abandonments. A recent study of the productivity of wheats and barley shows that on plots of low salinity, both wheat and barley can be harvested in similar yields, but on plots of high salinity, the quantity and quality of wheat seeds is significantly below that of the barley seeds (Setter et al., 2016). This could have led to a preference of barley over wheat in regions of saline soil as harvesting wheat would require the same amount of work as harvesting barley but would provide much less yield. The authors note that barley flowers earlier than wheat as well, and therefore may be more successful in an arid Middle Eastern climate (Setter et al., 2016).

Factors such as the deforestation of the landscape (Willcox, 1974; Klinge and Fall, 2010), a declining trade network from both Egypt and Mesopotamia (Weinstein, 1975; Richard, 1987; Sax et al., 1993; Matney and Algaze, 1995) and warfare (Oates, 2005) could have also played a part in the abandonments. Evidence of deforestation is present in sites across the Southern Levant, and even at our site there is a lack of evidence for trees which could have served as a fuel source (Klinge and Fall, 2010; Fall et al., 2015). Though evidence of warfare is not found at Ni'aj, it clearly led to the destruction and abandonment of several cities in the Northern Levant/Northwestern Mesopotamia (Oates, 2005). The loss of trade too must have been difficult for Levantine cities, which saw decreased specialization in Levantine pottery and metal production into Early Bronze IV (Robinson, 1995).

Aridification, linked to decreased rainfall and increased soil erosion and salinization, was likely a major contributor to driving people away from a city life though. Climatic change likely played a larger role and was more wide-ranging than these other common causes of societal collapse. Climatic variability was noted at a variety of sites and has been seen in the historical record across the Levant, from studies by Dr. Weiss in Syria (Weiss et al., 1993) to several environmental records from the Dead Sea (Enzel et al., 2003; Amitai and Abraham, 2009). These studies show a general shift from wetter to drier climates from Early Bronze III onward.

The evidence from Tell Abu en-Ni'aj shows a shift in agriculture toward more barley overall, with the frequency of barley increasing overtime during Ni'aj's occupation. Other notable changes include decline in einkorn wheat, which is frequently a winter-sown, rain-fed crop which could also be grown in off seasons, and a proclivity for hulled barley. The cultivated crops became more frequent than wild taxa in the latter phases, but both the wild and cultivated taxa counts declined. This may suggest heavy cultivation became more important towards the end of Ni'aj's occupation and that their agriculture was becoming less effective while the decline in stem fragments during this period of low trade may indicate seeds were being processed from farmlands which were becoming increasingly distanced from the settlement. A combination of factors stemming from decreased rainfall, including drying of tributaries, drop in groundwater level, and increased soil erosion would have made it more difficult to grow foods later in Early Bronze IV. These conditions were already present at the end of the Early Bronze III and seem to have worsened by the end of the Early Bronze IV period. A variety of patterns in the seed data from Tell Abu en-Ni'aj clearly show a history of increased reliance on more drought tolerant cereal crops over time. This notable shift in agricultural practice clearly indicates climatic variability must have been a weighty factor in the minds of the people who settled here.

CHAPTER 8. CONCLUSION

Overall, there were several factors that contributed to abandonment of Early Bronze Age towns and a widespread transition to a more mobile, pastoral lifestyle. The data from Tell Abu en-Ni‘aj illustrate that climatic variability, trending towards increased aridification, was a factor that affected the decisions of humans and led to a shift in lifestyle. This effect seems to have occurred rather quickly over the course of Ni‘aj’s occupation. The research presented here considers what may have happened in Early Bronze IV and why early Levantine cities were abandoned. These results can be compared with the other archaeological, paleoecological or paleobotanical studies in the Southern Levant to learn more about the region in this time period. In summation, I hope my work will piece together what happened in our past and help us uncover the scope of past climate change in the Levant and its impacts on both the ancient societies and their environments.

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APPENDIX A: SEED COUNTS FOR FLOTATION SAMPLES FROM TELL ABU EN-NI'AJ

	A.011. 041	C.015. 036	C.015. 050	C.015. 032	D.009. 041	D.016. 51	D.020. 065
Undiff. Cereal	7	0	0	0	90	105	2
Undiff. *Hordeum*	0	2	3	1	1	2	0
Hordeum vulgare	0	0	2	2	7	9	0
Hordeum vulgare var. nudum	0	0	0	0	0	0	0
Undiff. *Triticum*	0	1	1	0	0	1	0
Triticum aestivum	0	0	0	0	0	0	0
Triticum monococcum	0	0	0	0	1	0	0
Triticum dicoccum	0	0	0	0	2	1	0
Triticum spelta	0	0	0	0	0	0	0
Avena sp.	0	0	0	0	0	0	0
Bromus sp.	0	0	0	0	0	0	0
Digitaria sp.	0	0	0	0	0	0	0
Echinaria sp.	0	0	0	0	0	0	0
Echinochloa sp.	0	0	0	0	0	0	0
Eremopyron sp.	0	0	0	0	0	0	0
Festuca sp.	0	0	0	0	0	0	0
Holcus sp.	0	0	0	0	0	0	0
Lolium sp.	0	0	0	0	0	0	0
Panicum sp.	0	0	0	0	0	0	0
Phalaris sp.	0	0	0	0	0	0	0
Undiff. *Poaceae*	0	1	1	0	7	7	0
Lens esculenta	0	0	0	1	0	1	0
Pisum sativum	0	0	0	0	0	0	0
Vicia sp.	0	0	0	0	0	0	0
Undiff. Cult. *Leguminosae*	0	0	0	0	0	0	0
Astragalus sp.	0	0	0	0	0	0	0
Crotalaria sp.	0	0	0	0	0	0	0
Lotus sp.	0	0	0	0	0	0	0
Lupinus sp.	0	0	0	0	0	0	0
Medicago sp./*Onobrychis* sp.	0	0	0	0	0	1	1
Melilotus sp.	0	0	0	0	0	0	0
Prosopis sp./*Acacia* sp.	0	0	0	0	5	7	0
Undiff. Wild *Leguminosae*	1	0	2	0	9	11	0
Ficus carica	4	0	2	1	0	0	0
Olea europaea	0	0	0	0	0	0	0
Pistacia sp.	0	0	0	0	0	0	0
Vitis vinifera	0	0	1	0	1	0	0
Undiff. Glume	4	0	0	0	2	8	0
Undiff. Rachis	0	0	0	0	2	5	0
Undiff. Spikelet	1	0	1	0	3	14	0

	D.023.075	D.024.080	E.016.082	F.005.013	M.004.011	W.005.070	X.009.099
Undiff. Cereal	19	0	15	0	9	61	67
Undiff. *Hordeum*	0	0	0	1	0	1	0
Hordeum vulgare	2	0	5	0	1	7	3
Hordeum vulgare var. nudum	1	0	0	1	0	3	0
Undiff. *Triticum*	0	0	0	0	1	3	0
Triticum aestivum	0	0	0	0	0	0	0
Triticum monococcum	0	0	0	0	0	1	0
Triticum dicoccum	0	0	1	0	0	3	0
Triticum spelta	0	0	0	0	0	0	0
Avena sp.	0	0	0	0	0	0	0
Bromus sp.	0	0	0	0	0	0	0
Digitaria sp.	0	0	0	0	0	0	0
Echinaria sp.	0	0	0	0	0	0	0
Echinochloa sp.	0	0	0	0	0	0	0
Eremopyron sp.	0	0	0	0	0	0	0
Festuca sp.	0	0	0	0	0	0	0
Holcus sp.	0	0	0	0	0	0	0
Lolium sp.	0	0	0	0	0	0	0
Panicum sp.	0	0	0	0	0	0	0
Phalaris sp.	0	0	0	0	0	0	0
Undiff. *Poaceae*	1	0	4	0	1	14	13
Lens esculenta	0	0	0	0	0	0	4
Pisum sativum	0	0	0	0	0	0	1
Vicia sp.	0	0	1	0	0	0	0
Undiff. Cult. *Leguminosae*	0	1	0	0	0	0	0
Astragalus sp.	0	0	0	0	0	0	0
Crotalaria sp.	0	0	0	0	0	0	0
Lotus sp.	0	0	0	0	0	0	0
Lupinus sp.	0	0	0	0	0	0	0
Medicago sp./*Onobrychis* sp.	0	0	3	0	0	1	0
Melilotus sp.	0	0	0	0	1	0	0
Prosopis sp./*Acacia* sp.	0	0	0	0	0	0	0
Undiff. Wild *Leguminosae*	0	1	5	0	1	2	5
Ficus carica	0	0	2	0	0	2	1
Olea europaea	0	0	1	0	0	2	0
Pistacia sp.	0	0	0	0	0	0	0
Vitis vinifera	0	0	0	0	0	0	0
Undiff. Glume	0	0	1	0	0	2	0
Undiff. Rachis	0	2	0	4	0	8	1
Undiff. Spikelet	1	0	2	0	0	2	0

	AA.01 7.193	B.010. 063	B.024. 172	C.024. 060	C.026. 077	C.027. 096	C.037. 126
Undiff. Cereal	96	0	0	356	43	26	25
Undiff. *Hordeum*	7	6	0	8	1	0	4
Hordeum vulgare	17	3	10	165	9	15	4
Hordeum vulgare var. nudum	4	0	0	1	0	0	1
Undiff. *Triticum*	3	0	0	3	0	0	1
Triticum aestivum	1	0	0	0	0	0	0
Triticum monococcum	2	0	0	1	0	0	2
Triticum dicoccum	1	2	0	4	0	1	0
Triticum spelta	0	0	0	0	0	0	0
Avena sp.	0	0	0	0	0	0	0
Bromus sp.	0	0	0	0	0	0	0
Digitaria sp.	0	0	0	0	0	0	0
Echinaria sp.	0	0	0	0	0	0	0
Echinochloa sp.	0	0	0	0	0	0	0
Eremopyron sp.	0	0	0	0	0	0	0
Festuca sp.	0	0	0	0	0	0	0
Holcus sp.	0	0	0	0	0	0	0
Lolium sp.	0	0	0	0	0	0	0
Panicum sp.	0	0	0	0	0	0	0
Phalaris sp.	2	0	0	0	0	0	0
Undiff. *Poaceae*	26	0	0	27	2	2	5
Lens esculenta	1	0	0	7	0	1	4
Pisum sativum	0	0	0	1	3	1	1
Vicia sp.	0	0	0	0	0	0	0
Undiff. Cult. *Leguminosae*	0	0	0	0	0	0	0
Astragalus sp.	0	0	0	0	0	0	0
Crotalaria sp.	0	0	0	0	0	0	0
Lotus sp.	0	0	0	0	0	0	0
Lupinus sp.	0	0	0	0	0	0	0
Medicago sp./*Onobrychis* sp.	19	0	0	1	1	0	2
Melilotus sp.	0	0	0	0	0	0	0
Prosopis sp./*Acacia* sp.	0	0	0	0	0	2	0
Undiff. Wild *Leguminosae*	20	0	0	10	1	1	2
Ficus carica	5	0	0	1	1	0	0
Olea europaea	0	0	0	0	0	0	0
Pistacia sp.	0	0	0	0	0	0	0
Vitis vinifera	1	0	0	1	0	0	0
Undiff. Glume	5	0	0	0	0	0	0
Undiff. Rachis	3	0	0	0	0	0	0
Undiff. Spikelet	10	0	0	0	0	1	4

	C.038.131	C.049.175	DD.017.098	G.020.074	G.021.075	G.020.070	GG.011.036
Undiff. Cereal	17	15	0	224	94	68	31
Undiff. *Hordeum*	2	1	0	26	2	2	2
Hordeum vulgare	5	16	1	92	10	13	23
Hordeum vulgare var. nudum	0	2	0	7	0	2	1
Undiff. *Triticum*	0	0	0	0	0	3	1
Triticum aestivum	0	0	0	0	2	0	0
Triticum monococcum	0	1	0	5	0	3	0
Triticum dicoccum	0	2	0	5	5	4	3
Triticum spelta	0	0	0	0	0	0	0
Avena sp.	0	0	0	0	0	0	2
Bromus sp.	0	0	0	0	0	0	0
Digitaria sp.	0	0	0	0	0	0	0
Echinaria sp.	0	0	0	0	0	0	0
Echinochloa sp.	0	0	0	0	0	0	0
Eremopyron sp.	0	0	0	0	0	0	0
Festuca sp.	0	0	0	0	0	0	0
Holcus sp.	0	0	0	0	0	0	0
Lolium sp.	0	1	0	0	9	0	0
Panicum sp.	0	0	0	0	0	0	0
Phalaris sp.	0	0	1	1	0	0	0
Undiff. *Poaceae*	5	1	0	30	24	3	8
Lens esculenta	4	3	0	1	1	2	1
Pisum sativum	0	0	0	0	1	0	0
68Vicia sp.	0	0	0	0	0	0	0
Undiff. Cult. *Leguminosae*	0	0	0	0	0	0	0
Astragalus sp.	0	0	0	0	0	0	0
Crotalaria sp.	0	0	0	0	0	0	0
Lotus sp.	0	0	0	0	0	0	0
Lupinus sp.	0	0	0	0	0	0	0
Medicago sp./*Onobrychis* sp.	1	0	0	109	5	10	0
Melilotus sp.	0	0	0	1	0	0	1
Prosopis sp./*Acacia* sp.	13	2	21	0	76	22	0
Undiff. Wild *Leguminosae*	1	1	1	44	10	4	18
Ficus carica	0	3	0	1	0	9	1
Olea europaea	2	0	0	0	0	1	0
Pistacia sp.	0	0	0	0	0	0	0
Vitis vinifera	1	0	0	2	0	0	0
Undiff. Glume	1	2	1	9	22	4	3
Undiff. Rachis	0	0	1	61	1	3	4
Undiff. Spikelet	2	3	0	20	35	2	1

	H.007.013	H.009.025	H.018.061	H.022.105	H.022.106	H.023.099	AA.012.181
Undiff. Cereal	1	1	81	18	7	1	18
Undiff. *Hordeum*	0	0	7	2	0	1	0
Hordeum vulgare	0	0	11	7	2	3	5
Hordeum vulgare var. nudum	0	0	3	0	1	1	0
Undiff. *Triticum*	0	0	8	1	0	0	0
Triticum aestivum	0	0	0	0	0	0	0
Triticum monococcum	0	0	0	0	0	0	0
Triticum dicoccum	0	1	4	2	1	0	0
Triticum spelta	0	0	0	0	0	0	0
Avena sp.	0	0	0	3	0	0	0
Bromus sp.	0	1	0	3	0	0	0
Digitaria sp.	0	0	0	0	0	0	0
Echinaria sp.	0	0	0	0	0	0	0
Echinochloa sp.	0	0	0	0	0	0	0
Eremopyron sp.	0	0	0	1	0	0	0
Festuca sp.	0	0	0	0	0	0	0
Holcus sp.	0	0	0	0	0	0	0
Lolium sp.	0	0	17	8	0	0	0
Panicum sp.	0	0	1	0	0	0	0
Phalaris sp.	0	0	0	2	0	0	1
Undiff. *Poaceae*	0	2	26	21	4	0	5
Lens esculenta	0	0	2	0	1	0	11
Pisum sativum	0	0	3	4	0	0	0
69Vicia sp.	0	0	0	0	0	0	0
Undiff. Cult. *Leguminosae*	0	0	0	3	0	0	0
Astragalus sp.	0	0	0	0	0	0	0
Crotalaria sp.	0	0	0	0	0	0	0
Lotus sp.	0	0	0	0	0	0	0
Lupinus sp.	0	0	0	0	0	0	0
Medicago sp./*Onobrychis* sp.	1	0	2	1	0	0	0
Melilotus sp.	0	0	0	0	0	0	0
Prosopis sp./*Acacia* sp.	0	0	4	0	2	16	0
Undiff. Wild *Leguminosae*	2	4	7	3	1	0	0
Ficus carica	4	4	3	9	0	3	2
Olea europaea	0	0	0	0	0	0	0
Pistacia sp.	0	0	0	0	0	0	0
Vitis vinifera	1	0	0	0	0	0	0
Undiff. Glume	0	1	15	1	1	0	5
Undiff. Rachis	0	0	4	7	3	1	0
Undiff. Spikelet	0	0	13	7	0	0	0

	AA.01 3.089	AA.01 3.099	AA.01 4.114	AA.01 6.113	AA.01 6.153	AA.01 9.122	AA.01 9.176
Undiff. Cereal	25	26	0	185	40	70	25
Undiff. *Hordeum*	0	0	0	0	1	4	1
Hordeum vulgare	2	3	3	13	10	35	4
Hordeum vulgare var. nudum	0	0	0	3	1	3	0
Undiff. *Triticum*	0	1	0	9	0	4	0
Triticum aestivum	0	0	0	0	0	0	0
Triticum monococcum	1	0	0	5	0	0	0
Triticum dicoccum	0	1	0	7	2	3	0
Triticum spelta	0	0	0	0	0	0	0
Avena sp.	0	0	0	0	0	0	0
Bromus sp.	0	0	1	0	0	0	0
Digitaria sp.	0	0	0	0	0	0	0
Echinaria sp.	0	0	0	0	0	0	0
Echinochloa sp.	0	0	0	0	0	0	0
Eremopyron sp.	0	0	0	0	0	0	0
Festuca sp.	0	0	0	0	0	0	0
Holcus sp.	0	0	0	0	0	0	0
Lolium sp.	0	0	0	0	0	0	0
Panicum sp.	0	0	1	0	0	0	0
Phalaris sp.	2	0	1	9	1	10	1
Undiff. *Poaceae*	11	2	1	36	7	16	1
Lens esculenta	0	0	1	0	0	1	0
Pisum sativum	1	0	2	5	1	0	0
70Vicia sp.	0	0	0	0	0	0	0
Undiff. Cult. *Leguminosae*	0	0	0	0	0	0	0
Astragalus sp.	0	0	0	0	0	0	0
Crotalaria sp.	0	0	0	1	0	0	0
Lotus sp.	0	0	0	0	0	0	0
Lupinus sp.	0	0	0	0	0	0	0
Medicago sp./*Onobrychis* sp.	0	0	0	5	0	7	1
Melilotus sp.	0	0	0	0	0	0	0
Prosopis sp./*Acacia* sp.	0	2	0	0	5	0	0
Undiff. Wild *Leguminosae*	3	0	0	11	1	4	1
Ficus carica	2	1	0	2	1	0	0
Olea europaea	0	1	0	0	0	0	0
Pistacia sp.	0	0	0	0	0	0	0
Vitis vinifera	0	0	0	0	2	0	0
Undiff. Glume	1	0	3	10	4	6	5
Undiff. Rachis	0	0	0	0	0	8	2
Undiff. Spikelet	0	1	0	3	3	6	8

	C.035.239	C.040.141	C.044.156	C.065.225-227	GG.015.049	K.018.030	K.035.085
Undiff. Cereal	4	182	34	65	7	11	76
Undiff. *Hordeum*	1	11	0	18	0	1	52
Hordeum vulgare	0	166	9	9	2	0	34
Hordeum vulgare var. nudum	0	1	1	8	1	0	16
Undiff. *Triticum*	0	2	0	7	1	1	0
Triticum aestivum	0	0	0	1	0	0	0
Triticum monococcum	0	0	0	2	0	0	1
Triticum dicoccum	0	1	0	1	0	0	3
Triticum spelta	0	0	0	0	0	0	0
Avena sp.	0	0	0	0	0	0	0
Bromus sp.	0	0	0	0	0	0	0
Digitaria sp.	1	0	0	0	0	0	0
Echinaria sp.	0	0	0	0	0	0	1
Echinochloa sp.	0	0	0	0	0	0	0
Eremopyron sp.	0	0	0	0	0	0	0
Festuca sp.	0	0	0	0	0	0	0
Holcus sp.	0	0	0	0	0	0	0
Lolium sp.	0	0	0	0	0	0	0
Panicum sp.	0	0	0	0	0	0	0
Phalaris sp.	0	0	0	8	0	0	1
Undiff. *Poaceae*	2	10	8	12	2	0	0
Lens esculenta	0	5	0	6	0	1	4
Pisum sativum	0	0	3	4	0	0	0
71Vicia sp.	0	0	0	0	0	0	0
Undiff. Cult. *Leguminosae*	0	0	0	0	0	0	0
Astragalus sp.	1	0	0	0	0	0	0
Crotalaria sp.	0	0	0	0	0	0	0
Lotus sp.	0	0	0	0	0	0	0
Lupinus sp.	0	0	0	0	0	0	0
Medicago sp./*Onobrychis* sp.	1	3	0	5	0	1	0
Melilotus sp.	0	0	0	1	0	0	0
Prosopis sp./*Acacia* sp.	0	0	2	0	50	0	0
Undiff. Wild *Leguminosae*	0	2	3	8	5	0	0
Ficus carica	0	0	0	4	0	0	0
Olea europaea	0	0	0	10	0	0	0
Pistacia sp.	0	0	0	0	0	0	0
Vitis vinifera	0	0	0	0	0	0	1
Undiff. Glume	0	2	0	14	9	4	1
Undiff. Rachis	10	0	0	3	0	1	1
Undiff. Spikelet	0	1	2	7	5	1	2

	K.037.113	K.038.142	AA.024.196	AA.030.214	AA.034.237	C.071.236	C.071.254
Undiff. Cereal	114	52	154	6	127	139	135
Undiff. *Hordeum*	13	29	5	0	4	18	10
Hordeum vulgare	71	132	28	3	26	38	24
Hordeum vulgare var. nudum	14	7	5	0	4	25	11
Undiff. *Triticum*	16	1	0	1	3	14	5
Triticum aestivum	1	0	0	0	0	0	3
Triticum monococcum	5	0	0	0	0	5	1
Triticum dicoccum	13	0	0	0	1	16	9
Triticum spelta	0	0	0	0	0	3	0
Avena sp.	0	0	0	0	1	1	0
Bromus sp.	0	0	0	0	0	2	0
Digitaria sp.	0	0	0	0	0	1	0
Echinaria sp.	0	0	0	0	0	0	0
Echinochloa sp.	0	0	0	0	0	0	0
Eremopyron sp.	0	0	0	0	0	0	0
Festuca sp.	0	0	0	0	0	0	0
Holcus sp.	0	0	0	0	0	0	0
Lolium sp.	0	0	0	0	0	0	0
Panicum sp.	0	0	1	2	0	0	2
Phalaris sp.	0	0	4	2	13	26	8
Undiff. *Poaceae*	31	4	23	1	17	26	19
Lens esculenta	1	3	2	0	0	2	4
Pisum sativum	0	0	3	0	0	4	0
72Vicia sp.	0	0	0	0	0	0	0
Undiff. Cult. *Leguminosae*	0	0	0	0	0	0	0
Astragalus sp.	0	0	1	0	0	0	1
Crotalaria sp.	0	0	0	0	0	0	0
Lotus sp.	0	0	0	0	0	0	0
Lupinus sp.	0	0	0	0	0	0	1
Medicago sp./*Onobrychis* sp.	5	0	154	0	0	26	3
Melilotus sp.	1	0	5	0	0	2	0
Prosopis sp./*Acacia* sp.	9	0	0	0	0	0	0
Undiff. Wild *Leguminosae*	4	0	130	1	5	26	17
Ficus carica	1	0	34	2	0	4	0
Olea europaea	1	0	0	0	0	0	14
Pistacia sp.	0	0	0	0	0	1	0
Vitis vinifera	4	0	2	0	0	0	0
Undiff. Glume	15	3	4	2	29	19	26
Undiff. Rachis	20	0	4	2	9	17	14
Undiff. Spikelet	55	7	5	1	31	16	11

	C.071. 256	C.073. 284	GG.03 0.094	GG.03 0.095	H.034. 152	H.040. 163	H.042. 181
Undiff. Cereal	152	111	88	54	8	41	7
Undiff. *Hordeum*	11	3	7	0	0	2	2
Hordeum vulgare	25	55	30	8	4	25	14
Hordeum vulgare var. nudum	13	3	8	5	2	0	0
Undiff. *Triticum*	8	4	2	2	0	0	0
Triticum aestivum	1	0	0	0	0	0	0
Triticum monococcum	7	4	0	0	0	1	0
Triticum dicoccum	13	13	7	3	0	2	3
Triticum spelta	2	0	0	0	0	0	0
Avena sp.	0	0	0	0	0	0	0
Bromus sp.	0	2	0	0	0	0	0
Digitaria sp.	0	0	0	0	0	0	0
Echinaria sp.	0	2	0	0	0	0	0
Echinochloa sp.	0	0	0	0	0	0	0
Eremopyron sp.	0	0	0	0	0	0	0
Festuca sp.	0	0	0	0	0	0	0
Holcus sp.	0	0	0	0	0	0	0
Lolium sp.	0	0	0	0	0	0	0
Panicum sp.	0	0	0	0	0	0	0
Phalaris sp.	7	16	0	1	0	1	0
Undiff. *Poaceae*	22	25	34	4	0	10	1
Lens esculenta	4	2	0	0	0	0	0
Pisum sativum	0	0	1	0	0	0	0
73Vicia sp.	0	0	0	0	0	0	0
Undiff. Cult. *Leguminosae*	0	0	0	0	0	0	0
Astragalus sp.	0	0	0	0	0	0	0
Crotalaria sp.	0	0	0	0	0	0	0
Lotus sp.	1	0	0	0	0	0	0
Lupinus sp.	0	0	0	0	0	0	0
Medicago sp./*Onobrychis* sp.	6	0	3	0	4	2	3
Melilotus sp.	0	0	0	0	0	1	0
Prosopis sp./*Acacia* sp.	0	0	15	0	0	7	119
Undiff. Wild *Leguminosae*	9	4	16	12	4	8	5
Ficus carica	0	3	20	1	1	24	2
Olea europaea	0	0	1	0	0	0	0
Pistacia sp.	0	0	0	0	0	0	0
Vitis vinifera	0	0	3	0	0	1	0
Undiff. Glume	87	72	88	46	0	5	0
Undiff. Rachis	23	77	40	22	0	6	0
Undiff. Spikelet	48	71	53	17	0	13	1

	K.045.159	K.055.185	K.055.192	K.056.201	M.036.157	M.036.164	M.040.165
Undiff. Cereal	7	10	28	37	18	62	14
Undiff. *Hordeum*	0	0	0	1	0	4	0
Hordeum vulgare	1	8	17	15	3	9	3
Hordeum vulgare var. nudum	0	0	3	4	0	3	0
Undiff. *Triticum*	1	0	0	0	0	0	0
Triticum aestivum	0	0	1	0	0	1	0
Triticum monococcum	1	0	1	0	0	0	0
Triticum dicoccum	0	1	3	2	1	6	0
Triticum spelta	0	0	0	0	0	0	0
Avena sp.	0	0	0	0	0	0	0
Bromus sp.	0	0	0	0	0	0	0
Digitaria sp.	0	0	0	0	0	0	0
Echinaria sp.	0	0	0	0	0	0	0
Echinochloa sp.	0	0	0	0	0	0	0
Eremopyron sp.	0	0	0	0	0	0	0
Festuca sp.	0	0	0	0	0	0	0
Holcus sp.	0	0	0	0	0	0	0
Lolium sp.	0	0	0	0	0	0	0
Panicum sp.	0	0	0	0	0	0	0
Phalaris sp.	0	1	3	5	2	1	0
Undiff. *Poaceae*	5	1	6	21	5	12	0
Lens esculenta	0	0	0	0	0	0	0
Pisum sativum	0	0	0	0	0	1	0
74Vicia sp.	0	0	0	0	0	0	0
Undiff. Cult. *Leguminosae*	0	0	0	0	0	0	0
Astragalus sp.	0	0	0	0	0	1	0
Crotalaria sp.	0	0	0	0	0	0	0
Lotus sp.	0	0	0	0	0	0	0
Lupinus sp.	0	0	0	0	0	0	0
Medicago sp./*Onobrychis* sp.	0	0	0	0	7	9	0
Melilotus sp.	0	0	1	1	0	0	0
Prosopis sp./*Acacia* sp.	3	0	0	6	0	11	3
Undiff. Wild *Leguminosae*	0	5	6	0	0	14	2
Ficus carica	2	0	37	0	0	11	0
Olea europaea	0	0	0	0	0	0	0
Pistacia sp.	0	0	0	0	0	0	0
Vitis vinifera	0	0	3	0	0	1	0
Undiff. Glume	4	0	5	6	8	24	4
Undiff. Rachis	3	0	0	8	2	6	0
Undiff. Spikelet	5	0	6	21	2	20	6

	M.042 .187	M.044 .192	M.044 .203	C.075. 278	C.075. 279	C.076. 285	C.082. 353
Undiff. Cereal	85	48	60	84	112	8	11
Undiff. *Hordeum*	5	1	5	16	11	1	0
Hordeum vulgare	22	7	20	9	26	1	0
Hordeum vulgare var. nudum	3	3	2	5	7	0	0
Undiff. *Triticum*	0	1	0	1	1	0	0
Triticum aestivum	0	0	0	0	0	0	0
Triticum monococcum	2	0	2	2	0	1	2
Triticum dicoccum	6	5	1	0	9	0	4
Triticum spelta	0	0	0	0	0	0	0
Avena sp.	0	0	0	0	0	0	0
Bromus sp.	0	0	0	0	0	0	0
Digitaria sp.	0	0	0	0	1	0	0
Echinaria sp.	0	0	0	0	0	0	0
Echinochloa sp.	0	0	0	0	0	0	0
Eremopyron sp.	0	0	0	0	0	0	0
Festuca sp.	0	0	0	0	1	0	0
Holcus sp.	0	0	0	0	0	0	0
Lolium sp.	0	0	0	0	0	0	0
Panicum sp.	0	0	0	1	0	0	0
Phalaris sp.	18	1	0	7	7	2	1
Undiff. *Poaceae*	74	5	28	8	14	2	1
Lens esculenta	1	0	1	0	2	0	0
Pisum sativum	1	1	0	0	2	0	0
75Vicia sp.	0	0	0	0	0	0	0
Undiff. Cult. *Leguminosae*	0	0	0	0	0	0	0
Astragalus sp.	0	0	0	0	1	0	0
Crotalaria sp.	0	0	0	0	0	0	0
Lotus sp.	0	0	0	0	0	0	0
Lupinus sp.	0	0	0	0	0	0	0
Medicago sp./*Onobrychis* sp.	0	4	1	1	6	0	0
Melilotus sp.	0	0	1	1	0	0	0
Prosopis sp./*Acacia* sp.	24	4	0	0	0	0	0
Undiff. Wild *Leguminosae*	9	1	5	5	11	0	0
Ficus carica	5	1	4	5	0	0	0
Olea europaea	0	0	0	1	0	0	0
Pistacia sp.	0	0	0	0	4	0	0
Vitis vinifera	0	0	0	0	0	0	0
Undiff. Glume	6	8	7	15	22	3	9
Undiff. Rachis	10	3	4	18	7	0	3
Undiff. Spikelet	4	21	2	12	27	2	1

	C.083.321	C.089.386	C.089.392	GG.039.123	GG.042.127	GG.065.185	GG.069.191
Undiff. Cereal	2	35	3	420	88	75	413
Undiff. *Hordeum*	0	5	0	6	4	20	14
Hordeum vulgare	0	6	0	211	8	21	101
Hordeum vulgare var. nudum	0	0	0	10	1	5	9
Undiff. *Triticum*	0	0	0	8	1	4	12
Triticum aestivum	1	0	0	4	0	0	0
Triticum monococcum	0	2	0	7	1	1	12
Triticum dicoccum	0	3	0	19	3	2	9
Triticum spelta	0	0	0	0	0	0	2
Avena sp.	0	0	0	0	0	0	0
Bromus sp.	0	0	0	0	0	0	0
Digitaria sp.	0	0	0	0	0	0	0
Echinaria sp.	0	0	0	0	0	0	0
Echinochloa sp.	0	0	0	0	0	0	0
Eremopyron sp.	0	0	0	0	0	0	0
Festuca sp.	0	0	0	0	0	0	0
Holcus sp.	0	0	0	0	0	0	0
Lolium sp.	0	1	0	8	5	0	0
Panicum sp.	0	0	0	0	0	0	0
Phalaris sp.	0	3	0	1	7	1	1
Undiff. *Poaceae*	1	6	5	93	12	13	39
Lens esculenta	0	0	0	1	0	0	2
Pisum sativum	0	0	0	1	1	0	3
76Vicia sp.	0	0	0	0	0	0	0
Undiff. Cult. *Leguminosae*	0	0	0	1	0	0	0
Astragalus sp.	0	0	0	0	0	0	0
Crotalaria sp.	0	0	0	0	0	0	0
Lotus sp.	0	0	0	0	0	0	0
Lupinus sp.	0	0	0	0	0	0	0
Medicago sp./*Onobrychis* sp.	0	0	0	2	0	0	7
Melilotus sp.	0	0	0	0	0	0	0
Prosopis sp./*Acacia* sp.	0	0	0	0	0	2	0
Undiff. Wild *Leguminosae*	0	1	7	22	19	1	10
Ficus carica	0	0	8	0	17	0	0
Olea europaea	0	0	0	0	0	0	0
Pistacia sp.	0	0	0	0	0	0	0
Vitis vinifera	0	4	0	1	0	0	0
Undiff. Glume	0	33	0	26	23	8	20
Undiff. Rachis	0	13	1	30	41	0	30
Undiff. Spikelet	0	23	0	29	10	5	16

	GG.07 0.195	GG.07 0.195	GG.10 0.289	K.076. 261	AA.06 4.390	AA.06 7.407	AA.07 0.414
Undiff. Cereal	155	91	26	29	172	23	240
Undiff. *Hordeum*	2	0	4	1	6	2	4
Hordeum vulgare	24	5	14	12	26	10	56
Hordeum vulgare var. nudum	2	4	5	3	4	3	12
Undiff. *Triticum*	1	1	1	0	3	3	10
Triticum aestivum	0	0	0	1	0	0	3
Triticum monococcum	1	2	0	1	0	3	0
Triticum dicoccum	3	4	2	4	14	4	8
Triticum spelta	0	0	0	0	0	0	1
Avena sp.	0	0	0	0	0	0	0
Bromus sp.	0	0	0	0	7	2	6
Digitaria sp.	0	0	1	0	0	0	1
Echinaria sp.	0	0	0	0	0	0	0
Echinochloa sp.	0	0	0	0	0	0	0
Eremopyron sp.	0	0	0	0	0	0	0
Festuca sp.	0	0	0	0	0	0	0
Holcus sp.	0	0	0	0	0	0	0
Lolium sp.	0	0	0	0	0	0	0
Panicum sp.	0	0	0	0	0	2	0
Phalaris sp.	7	12	17	6	11	3	6
Undiff. *Poaceae*	37	28	29	22	25	9	30
Lens esculenta	2	0	0	1	1	0	29
Pisum sativum	4	0	5	2	0	2	3
77Vicia sp.	0	0	0	0	0	0	0
Undiff. Cult. *Leguminosae*	0	0	0	0	0	0	0
Astragalus sp.	0	0	0	0	0	0	0
Crotalaria sp.	0	0	0	0	0	0	0
Lotus sp.	0	0	0	0	0	0	0
Lupinus sp.	0	0	0	0	0	0	0
Medicago sp./*Onobrychis* sp.	19	13	13	0	0	0	23
Melilotus sp.	0	0	0	0	0	0	0
Prosopis sp./*Acacia* sp.	0	0	57	0	0	0	0
Undiff. Wild *Leguminosae*	56	49	19	0	7	0	18
Ficus carica	25	25	157	0	4	3	10
Olea europaea	0	0	0	0	0	0	0
Pistacia sp.	0	0	0	0	0	0	0
Vitis vinifera	2	1	2	0	0	0	0
Undiff. Glume	67	52	10	11	36	5	20
Undiff. Rachis	75	45	17	5	29	4	30
Undiff. Spikelet	29	26	5	2	54	5	38

	C.086.367	C.086.387	C.091.406	C.093.429	C.093.430	C.096.457	C.106.494
Undiff. Cereal	19	21	16	266	101	64	48
Undiff. *Hordeum*	1	0	4	23	4	1	3
Hordeum vulgare	3	1	1	23	4	3	0
Hordeum vulgare var. nudum	0	0	0	19	0	2	5
Undiff. *Triticum*	0	0	0	7	0	1	19
Triticum aestivum	0	0	0	1	0	0	1
Triticum monococcum	0	0	0	5	2	0	5
Triticum dicoccum	0	0	2	7	0	0	28
Triticum spelta	0	0	1	0	0	0	0
Avena sp.	0	0	0	0	0	0	0
Bromus sp.	0	0	0	0	0	0	0
Digitaria sp.	0	0	0	0	0	1	0
Echinaria sp.	0	0	0	0	0	3	0
Echinochloa sp.	0	0	0	0	0	0	0
Eremopyron sp.	0	0	0	0	0	0	0
Festuca sp.	0	0	0	0	0	0	0
Holcus sp.	0	0	0	0	1	1	0
Lolium sp.	0	0	0	0	0	0	0
Panicum sp.	0	0	0	0	0	0	0
Phalaris sp.	0	0	0	28	0	1	6
Undiff. *Poaceae*	4	5	4	33	8	5	8
Lens esculenta	0	0	1	4	0	0	0
Pisum sativum	0	0	0	0	0	0	0
78Vicia sp.	0	0	0	0	0	0	0
Undiff. Cult. *Leguminosae*	0	0	0	0	0	0	0
Astragalus sp.	0	0	0	0	0	0	0
Crotalaria sp.	0	0	0	0	0	0	0
Lotus sp.	0	0	0	0	0	0	0
Lupinus sp.	0	0	0	0	0	0	0
Medicago sp./*Onobrychis* sp.	0	0	0	1	0	1	0
Melilotus sp.	0	0	0	0	0	0	0
Prosopis sp./*Acacia* sp.	0	0	0	0	0	0	0
Undiff. Wild *Leguminosae*	0	0	1	13	5	6	6
Ficus carica	3	5	1	9	0	0	4
Olea europaea	0	0	0	0	0	0	0
Pistacia sp.	0	1	0	0	0	0	14
Vitis vinifera	0	0	0	4	0	0	0
Undiff. Glume	26	53	34	87	17	6	16
Undiff. Rachis	11	5	9	37	10	10	18
Undiff. Spikelet	8	22	20	70	12	3	43

	C.111.548	C.111.549	D.052.209	GG.072.213	GG.096.302	GG.098.295	GG.099.298
Undiff. Cereal	137	26	102	273	37	19	99
Undiff. *Hordeum*	8	0	0	6	5	1	6
Hordeum vulgare	20	3	3	57	21	3	17
Hordeum vulgare var. nudum	14	0	0	2	4	0	3
Undiff. *Triticum*	2	0	1	1	1	1	4
Triticum aestivum	0	0	0	0	0	0	0
Triticum monococcum	4	0	3	2	0	7	5
Triticum dicoccum	16	1	1	3	2	0	6
Triticum spelta	0	0	0	0	0	0	1
Avena sp.	0	0	0	0	0	0	0
Bromus sp.	0	0	0	6	0	0	1
Digitaria sp.	0	0	0	0	0	0	2
Echinaria sp.	0	0	0	0	0	0	0
Echinochloa sp.	0	0	0	0	0	0	0
Eremopyron sp.	0	0	0	0	0	0	0
Festuca sp.	0	0	0	0	0	0	0
Holcus sp.	0	0	0	0	0	0	0
Lolium sp.	0	0	0	3	0	0	0
Panicum sp.	0	0	0	0	0	0	0
Phalaris sp.	23	1	0	41	4	2	11
Undiff. *Poaceae*	32	7	5	72	17	19	30
Lens esculenta	0	0	0	1	14	0	2
Pisum sativum	7	0	0	1	4	2	1
79Vicia sp.	0	0	0	0	0	0	0
Undiff. Cult. *Leguminosae*	0	0	0	0	0	0	0
Astragalus sp.	0	1	0	0	0	0	1
Crotalaria sp.	0	0	0	0	0	0	0
Lotus sp.	0	0	0	0	0	0	0
Lupinus sp.	0	0	0	0	0	0	0
Medicago sp./*Onobrychis* sp.	3	12	0	0	8	5	7
Melilotus sp.	0	0	0	0	0	0	0
Prosopis sp./*Acacia* sp.	0	0	0	5	64	50	19
Undiff. Wild *Leguminosae*	10	23	0	28	27	23	12
Ficus carica	3	5	0	11	55	23	1
Olea europaea	0	0	0	0	11	0	0
Pistacia sp.	0	0	0	0	0	0	0
Vitis vinifera	0	0	0	0	2	0	1
Undiff. Glume	7	20	27	27	9	5	51
Undiff. Rachis	20	4	18	167	9	5	13
Undiff. Spikelet	28	10	29	19	8	16	49

	K.085. 277	K.089. 303	AA.06 9.413	C.100. 464	C.102. 490	C.107. 501	D.054. 216
Undiff. Cereal	14	60	183	3	6	32	9
Undiff. *Hordeum*	0	4	5	2	0	2	0
Hordeum vulgare	2	3	11	2	1	0	7
Hordeum vulgare var. nudum	1	3	0	2	1	2	0
Undiff. *Triticum*	0	1	20	0	0	7	0
Triticum aestivum	0	2	3	0	0	2	0
Triticum monococcum	0	2	2	0	0	10	0
Triticum dicoccum	2	5	25	0	0	22	2
Triticum spelta	0	0	1	0	0	1	0
Avena sp.	0	0	6	0	0	0	0
Bromus sp.	0	0	3	0	0	0	0
Digitaria sp.	0	0	0	0	0	0	0
Echinaria sp.	0	0	0	0	0	0	0
Echinochloa sp.	0	0	0	0	0	0	0
Eremopyron sp.	0	0	0	0	0	0	0
Festuca sp.	0	0	0	0	0	0	0
Holcus sp.	0	0	0	0	0	0	0
Lolium sp.	0	0	0	0	0	0	0
Panicum sp.	0	0	0	0	0	0	0
Phalaris sp.	0	4	3	1	2	5	1
Undiff. *Poaceae*	0	15	49	2	2	8	4
Lens esculenta	0	5	0	0	0	1	1
Pisum sativum	0	0	2	0	0	1	0
80Vicia sp.	0	0	0	0	1	0	0
Undiff. Cult. *Leguminosae*	0	0	0	0	0	0	0
Astragalus sp.	0	0	0	0	0	0	0
Crotalaria sp.	0	0	0	0	0	0	0
Lotus sp.	0	0	0	0	0	0	0
Lupinus sp.	0	0	0	0	0	0	0
Medicago sp./*Onobrychis* sp.	1	0	1	0	0	0	1
Melilotus sp.	0	0	0	0	0	1	0
Prosopis sp./*Acacia* sp.	0	18	0	0	0	3	14
Undiff. Wild *Leguminosae*	0	8	14	1	1	8	2
Ficus carica	1	1	0	1	3	16	7
Olea europaea	0	0	0	0	0	0	0
Pistacia sp.	0	0	0	0	0	0	0
Vitis vinifera	0	0	0	0	0	0	0
Undiff. Glume	0	48	42	0	0	15	11
Undiff. Rachis	0	8	11	1	1	38	3
Undiff. Spikelet	5	64	35	0	0	52	3

	D.061. 240	GG.08 9.269	GG.10 5.331	K.091. 310	K.091. 313	K.094. 323	K.099. 338
Undiff. Cereal	6	552	12	80	69	105	46
Undiff. *Hordeum*	0	43	2	4	0	7	1
Hordeum vulgare	2	210	0	17	15	88	9
Hordeum vulgare var. nudum	1	45	2	1	5	18	1
Undiff. *Triticum*	0	37	0	6	2	6	0
Triticum aestivum	0	7	0	0	0	0	0
Triticum monococcum	0	26	0	1	2	4	1
Triticum dicoccum	0	50	0	13	3	10	1
Triticum spelta	0	1	0	0	0	0	0
Avena sp.	0	0	0	0	0	13	0
Bromus sp.	0	0	0	0	0	5	0
Digitaria sp.	0	0	0	0	0	1	0
Echinaria sp.	0	0	0	0	0	0	0
Echinochloa sp.	0	0	0	0	0	0	0
Eremopyron sp.	0	0	0	0	0	0	0
Festuca sp.	0	0	0	0	0	0	0
Holcus sp.	0	0	0	0	0	0	0
Lolium sp.	0	0	0	0	0	2	0
Panicum sp.	0	0	0	0	0	0	1
Phalaris sp.	0	58	2	3	2	78	20
Undiff. *Poaceae*	0	109	5	7	2	50	11
Lens esculenta	0	4	0	0	0	0	6
Pisum sativum	0	6	0	0	0	0	0
Vicia sp.	0	0	0	0	0	0	0
Undiff. Cult. *Leguminosae*	0	0	0	0	0	0	2
Astragalus sp.	0	0	0	0	0	0	0
Crotalaria sp.	0	0	0	1	0	3	0
Lotus sp.	0	0	0	0	0	1	0
Lupinus sp.	0	0	0	0	0	0	0
Medicago sp./*Onobrychis* sp.	0	18	5	2	0	24	2
Melilotus sp.	0	0	0	0	0	2	1
Prosopis sp./*Acacia* sp.	27	1	55	0	0	59	6
Undiff. Wild *Leguminosae*	0	42	16	0	2	8	4
Ficus carica	0	47	23	4	1	11	15
Olea europaea	0	0	0	0	0	0	0
Pistacia sp.	0	0	0	0	0	0	0
Vitis vinifera	0	0	2	0	0	0	0
Undiff. Glume	1	52	4	23	25	7	12
Undiff. Rachis	0	164	5	7	12	28	7
Undiff. Spikelet	0	87	3	26	31	20	14

	K.102.346	K.105.355	K.105.356	K.105.363	Total
Undiff. Cereal	57	7	38	23	8321
Undiff. *Hordeum*	3	1	1	3	527
Hordeum vulgare	25	1	17	21	2447
Hordeum vulgare var. nudum	1	0	2	6	387
Undiff. *Triticum*	0	0	0	0	272
Triticum aestivum	0	0	1	0	37
Triticum monococcum	0	0	0	0	170
Triticum dicoccum	6	1	3	4	466
Triticum spelta	0	0	0	0	13
Avena sp.	0	0	0	1	27
Bromus sp.	0	0	0	0	39
Digitaria sp.	3	0	0	0	12
Echinaria sp.	0	0	0	0	6
Echinochloa sp.	0	0	0	0	0
Eremopyron sp.	0	0	0	0	1
Festuca sp.	0	0	0	0	1
Holcus sp.	0	0	0	0	2
Lolium sp.	0	0	0	0	54
Panicum sp.	0	0	0	0	11
Phalaris sp.	18	1	11	6	573
Undiff. *Poaceae*	28	2	7	8	1654
Lens esculenta	0	2	7	8	177
Pisum sativum	0	0	0	1	90
Vicia sp.	0	0	0	0	2
Undiff. Cult. *Leguminosae*	0	0	0	0	7
Astragalus sp.	0	0	0	0	7
Crotalaria sp.	0	0	0	0	5
Lotus sp.	0	0	0	0	2
Lupinus sp.	0	0	0	0	1
Medicago sp./*Onobrychis* sp.	2	0	2	3	590
Melilotus sp.	0	0	0	0	21
Prosopis sp./*Acacia* sp.	5	1	19	9	844
Undiff. Wild *Leguminosae*	5	2	0	3	983
Ficus carica	0	0	2	3	729
Olea europaea	0	0	0	0	45
Pistacia sp.	0	0	0	0	20
Vitis vinifera	0	0	0	0	44
Undiff. Glume	6	10	6	8	1629
Undiff. Rachis	7	2	16	27	1426
Undiff. Spikelet	13	5	4	17	1577

*Samples listed as 'Area.Loci.Bag'. Samples ordered by phase > area > loci > bag.

APPENDIX B: ‘OTHER WILD TAXA’ SEED COUNTS FOR FLOTATION SAMPLES FROM TELL ABU EN-NI‘AJ

A.011.041: 2 *Malva*, 1 *Silene*

C.015.032: 1 *Malva*

D.009.041: 2 *Lepidium*, 2 *Malva*, 1 *Stellaria*, 1 unknown

D.016.051: 1 *Abutilon*, 1 *Bellevalia*, 1 *Euphorbia*, 1 *Scirpus*, 4 *Silene*, 8 unknown

E.016.082: 1 *Galium*

F.005.013: 1 *Malva*, 1 *Plantago*

W.005.070: 2 *Chenopodium*, 2 *Galium*, 1 *Rumex/Polygonum*, 3 unknown

X.009.099: 1 *Amaranthus*, 1 *Anagallis*

AA.017.193: 1 *Anagallis*, 2 *Asteraceae*, 1 *Chenopodium*, 7 *Plantago*, 2 *Scirpus*, 4 unknown

C.024.060: 1 *Chenopodium*, 2 *Malva*, 10 unknown

C.026.077: 1 *Malva*, 1 *Scirpus*, 3 unknown

C.027.096: 1 *Fumaria*, 1 unknown

C.037.126: 2 *Scirpus*

C.049.175: 1 *Boraginaceae*, 1 *Crataegus*, 1 *Plantago*

DD.017.098: 1 *Anagallis*, 1 *Bellevalia*, 1 *Fumaria*, 1 *Galium*

G.020.074: 1 *Aizoon*, 3 *Bupleurum*, 1 *Galium*, 5 *Rumex/Polygonum*, 1 *Scirpus*, 13 unknown

G.021.075: 1 *Bupleurum*, 1 *Convolvulus*, 1 *Galium*, 2 unknown

G.020.070: 2 *Aizoon*, 1 *Amaranthus*, 1 *Amygdaloideae*, 1 *Bupleurum*, 1 *Chenopodium*, 1 *Plantago*, 1 *Rumex/Polygonum*, 2 *Scirpus*, 11 unknown

GG.011.036: 4 *Aizoon*, 1 *Amaranthus*, 1 *Anagallis*, 2 *Carex*, 1 *Fumaria*, 1 *Malva*, 1 *Plantago*, 5 unknown

H.018.061: 1 *Bupleurum*, 2 *Galium*, 1 *Malva*, 1 *Scirpus*, 1 *Spergula*, 5 unknown

H.022.105: 1 *Anagallis*, 1 *Asteraceae*, 3 *Galium*, 2 *Spergula*, 1 unknown

H.022.106: 2 *Bupleurum*, 2 unknown

H.023.099: 1 *Asteraceae*, 1 *Spergula*

AA.012.181: 2 *Boraginaceae*, 1 *Bupleurum*, 6 unknown

AA.013.089: 1 *Aizoon*, 1 *Amaranthus*, 2 *Chenopodium*, 2 *Saponaria*, 1 *Scirpus*, 2 unknown

AA.013.099: 1 *Bellevalia*, 1 *Thymelaea*

AA.014.114: 1 unknown

AA.016.113: 1 *Amaranthus*, 1 *Boraginaceae*, 1 *Thymelaea*, 7 unknown

AA.016.153: 1 *Amaranthus*, 1 *Asteraceae*, 4 unknown

AA.019.122: 2 *Anagallis*, 1 *Carex*, 6 *Chenopodium*, 3 *Galium*, 1 *Malva*, 1 *Plantago*, 2 unknown

AA.019.176: 1 unknown

C.035.239: 1 *Rumex/Polygonum*, 13 unknown

C.040.141: 1 *Arnebia*, 1 *Chenopodium*, 1 *Galium*, 1 *Malva*, 1 *Plantago*, 12 unknown

C.044.156: 1 *Bellevalia*

C.065:225-227: 2 *Boraginaceae*, 1 *Galium*, 1 *Iva*, 1 *Malva*, 1 *Salsola*, 13 unknown

GG.015.049: 1 unknown

K.018.030: 1 *Rumex/Polygonum*

K.037.113: 1 *Galium*, 1 *Rumex/Polygonum*, 2 *Scirpus*, 1 unknown

AA.024.196: 2 *Aizoon*, 3 *Amaranthus*, 7 *Anagallis*, 5 *Asteraceae*, 10 *Bupleurum*, 4 *Chenopodium*, 1 *Malva*, 69 *Plantago*, 4 *Rumex/Polygonum*, 7 *Saponaria*, 2 *Scirpus*, 8 *Sonchus*, 1 *Spergula*, 5 unknown

AA.030.214: 1 *Amaranthus*, 1 *Chenopodium*, 3 unknown

AA.034.237: 2 *Plantago*, 2 *Rumex/Polygonum*, 1 *Saponaria*, 9 unknown

C.071.236: 2 *Abutilon*, 1 *Anagallis*, 1 *Arabis*, 1 *Galium*, 1 *Malva*, 1 *Ornithogalum*, 1 *Plantago*, 3 *Rumex/Polygonum*, 2 *Scirpus*, 1 *Spergula*, 15 unknown

C.071.254: 2 *Boraginaceae*, 2 *Galium*, 1 *Rumex/Polygonum*, 1 *Spergula*, 4 unknown

C.071.256: 2 *Boraginaceae*, 1 *Eleocharis*, 2 *Plantago*, 1 *Potentilla*, 2 *Spergula*, 10 unknown

C.073.284: 1 *Carex*, 4 *Plantago*, 3 *Rumex/Polygonum*, 6 unknown

GG.030.094: 1 *Bupleurum*, 3 *Chenopodium*, 1 *Eleocharis*, 2 *Hieracium*, 2 *Malva*, 3 *Plantago*, 1 *Spergula*, 16 unknown

GG.030.095: 1 *Malva*, 1 *Plantago*, 2 *Scirpus*

H.034.152: 1 *Rumex/Polygonum*

H.040.163: 1 *Berchemia*, 1 *Malva*, 2 *Rumex/Polygonum*, 1 *Scirpus*, 4 unknown

H.042.181: 1 *Rumex/Polygonum*, 1 *Scirpus*, 12 unknown

K.045.159: 1 *Anagallis*, 1 *Croton*, 2 *Rumex/Polygonum*, 1 *Scirpus*, 4 unknown

K.055.192: 1 *Anagallis*, 5 *Malva*, 8 *Rumex/Polygonum*, 3 unknown

K.056.201: 1 *Boraginaceae*, 1 *Croton*, 1 *Plantago*

M.036.157: 1 *Anagallis*, 1 *Arnebia*, 9 unknown

M.036.164: 2 *Abutilon*, 4 *Anagallis*, 3 *Arnebia*, 1 *Bupleurum*, 3 *Carex*, 2 *Malva*, 1 *Plantago*, 1 *Rumex/Polygonum*, 1 *Scirpus*, 15 unknown

M.040.165: 1 unknown

M.042.187: 24 *Amaranthus*, 2 *Anagallis*, 1 *Asteraceae*, 4 *Bupleurum*, 1 *Carex*, 1 *Chenopodium*, 1 *Scirpus*, 16 unknown

M.044.192: 1 *Bellevalia*, 2 *Berteroa*, 1 *Rumex/Polygonum*, 1 unknown

M.044.203: 1 *Anagallis*, 2 *Atriplex*, 2 *Euphorbia*, 1 *Plantago*, 1 *Rumex/Polygonum*, 6 unknown

C.075.278: 1 *Carex*, 1 *Cyperus*, 1 *Ornithogalum*, 3 *Plantago*, 1 *Rumex/Polygonum*, 11 unknown

C.075.279: 1 *Picris/Najas*, 1 *Potentilla*, 1 unknown

C.076.285: 3 unknown

C.083.321: 1 unknown

C.089.386: 1 *Chenopodium*, 2 *Cleome*, 8 *Galium*, 1 *Malva*, 3 *Plantago*, 3 *Rumex/Polygonum*, 1 *Scirpus*, 2 unknown

C.089.392: 1 *Aizoon*, 1 *Lepidium*, 1 *Ranunculus*, 2 unknown

GG.039.123: 1 *Amaranthus*, *Asteraceae*, 1 *Plantago*, 2 *Rumex/Polygonum*, 1 *Thymelaea*, 18 unknown

GG.042.127: 1 *Aizoon*, 1 *Anagallis*, 1 *Bellevalia*, 2 *Carex*, 1 *Malva*, 1 *Plantago*, 1 *Rumex/Polygonum*, 1 *Sonchus*, 9 unknown

GG.065.185: 1 *Chenopodium*, 2 unknown

GG.069.191: 1 *Bassia*, 2 *Plantago*, 2 *Rumex/Polygonum*, 7 unknown

GG.070.195: 1 *Aizoon*, 4 *Anagallis*, 1 *Carex*, 2 *Chenopodium*, 1 *Conium*, 1 *Corispermum*, 2 *Euphorbia*, 2 *Geranium molle*, 1 *Hieracium*, 1 *Lepidium*, 4 *Ornithogalum*, 14 *Plantago*, 13 *Rumex/Polygonum*, 7 *Spergula*, 1 *Torilis*, 25 unknown

GG.070.196. 1 *Anagallis*, 3 *Bellevalia*, 1 *Carex*, 1 *Eleocharis*, 1 *Lithospermum*, 1 *Plantago*, 9 *Rumex/Polygonum*, 1 *Spergula*, 9 unknown

GG.100.289: 15 *Anagallis*, 1 *Bellevalia*, 1 *Capparis*, 5 *Chenopodium*, 2 *Chrysanthemum*, 4 *Fimbristylis*, 2 *Hieracium*, 1 *Lithospermum*, 3 *Malva*, 2 *Plantago*, 75 *Rumex/Polygonum*, 1 *Scirpus*, 12 unknown

K.076.261: 1 *Asteraceae*, 1 *Chenopodium*, 1 *Rumex/Polygonum*, 5 *Scirpus*, 8 unknown

AA.064.390: 1 *Asteraceae*, 2 *Chenopodium*, 1 *Fumaria*, 3 *Plantago*, 3 *Rumex/Polygonum*, 6 unknown

AA.067.407: 1 *Amaranthus*, 5 *Galium*, 1 *Thymelaea*, 2 unknown

AA.070.414: 10 *Bellevalia*, 1 *Boraginaceae*, 1 *Bupleurum*, 3 *Chenopodium*, 1 *Cocculus*, 3 *Galium*, 3 *Malva*, 1 *Plantago*, 3 *Rumex/Polygonum*, 1 *Saponaria*, 2 *Thymelaea*, 41 unknown

C.086.367: 1 *Prunus*?, 3 *Rumex/Polygonum*, 2 unknown

C.086.387: 2 *Plantgo*, 1 *Rumex/Polygonum*

C.091.406: 1 *Plantago*, 1 *Rumex/Polygonum*, 1 unknown

C.093.429: 4 *Anagallis*, 3 *Boraginaceae*, 2 *Chenopodium*, 1 *Chrysanthemum*, 1 *Cynareae*, 1 *Galium*, 2 *Malva*, 4 *Plantago*, 2 *Rumex/Polygonum*, 3 *Scirpus*, 1 *Sherardia*, 30 unknown

C.093.430: 1 *Cirsium*, 1 *Ilex*, 1 *Malva,* 7 *Rumex/Polygonum*, 4 unknown

C.096.457: 1 *Amaranthus*, 1 *Centaurea*, 2 *Plantago*, 1 *Rumex/Polygonum*, 4 unknown

C.106.494: 6 *Anagallis*, 3 *Chenopodium*, 1 *Galium*, 7 *Rumex/Polygonum*, 2 unknown

C.111.548: 1 *Abutilon*, 1 *Boraginaceae*, 1 *Carex*, 2 *Galium*, 1 *Linaria vulgaris*, 6 *Malva*, 3 *Plantago*, 3 *Rumex/Polygonum*, 4 unknown

C.111.549: 3 *Anagallis*, 1 *Arnebia*, 3 *Berberis*, 1 *Chenopodium*, 6 *Malva*, 1 *Rumex/Polygonum*, 2 *Scirpus*, 2 unknown

D.052.209: 1 *Rumex/Polygonum*

GG.072.213: 2 *Amaranthus*, 5 *Anagallis*, 1 *Chenopodium*, 1 *Eleocharis*, 1 *Malva*, 1 *Plantago*, 1 *Rumex/Polygonum*, 25 unknown

GG.096.302: 1 *Amaranthus*, 8 *Anagallis*, 2 *Bassia*, 1 *Chenopodium*, 1 *Malva*, 5 *Plantago*, 10 *Rumex/Polygonum*, 1 *Scirpus*, 8 unknown

GG.098.295: 39 *Anagallis*, 1 *Carex*, 1 *Chenopodium*, 1 *Galium*, 2 *Malva*, 1 *Plantago*, 10 *Rumex/Polygonum*, 2 *Scirpus*, 1 *Scutellaria*, 5 unknown

GG.099.298: 3 *Amaranthus*, 4 *Anagallis*, 4 *Asteraceae*, 1 *Bellevalia*, 2 *Boraginaceae*, 6 *Bupleurum*, 9 *Carex*, 1 *Chenopodium*, 1 *Chrysanthemum*, 1 *Galium*, 2 *Malva*, 2 *Plantago*, 16 *Rumex/Polygonum*, 2 *Scirpus*, 1 *Thymelaea*, 20 unknown

K.085.277: 1 *Asteraceae*, 1 *Carex*, 1 *Cyperus*

K.089.303: 1 *Agrostemma*, 2 *Amygdaloideae*, 39 *Anagallis*, 2 *Asclepias*, 4 *Bupleurum*, 1 *Carex*, 1 *Fimbristylis*, 1 *Galium*, 3 *Myrica*, 26 *Rumex/Polygonum*, 1 *Thymelaea*, 6 unknown

AA.069.413: 46 *Anagallis*, 5 *Chenopodium*, 1 *Malva*, 2 *Plantago*, 6 *Rumex/Polygonum*, 14 unknown

C.100.464: 1 *Anagallis*, 1 unknown

C.107.501: 3 *Amaranthus*, 3 *Anagallis*, 2 *Chenopodium*, 8 *Rumex/Polygonum*, 3 *Scirpus*, 1 unknown

D.054.216: 1 *Aizoon*, 2 *Chenopodium*, 1 *Rumex/Polygonum*

GG.089.269: 2 *Amaranthus*, 3 *Anagallis*, 6 *Arnebia*, 5 *Bellevalia*, 1 *Bupleurum*, 6 *Chenopodium*, 1 *Euphorbiaceae*, 10 *Galium*, 4 *Malva*, 3 *Myrica*, 6 *Plantago*, 56 *Rumex/Polygonum*, 1 *Spergula*, 40 unknown

GG.105.331: 1 *Anagallis*, 1 *Arnebia*, 1 *Asteraceae*, 23 *Bellevalia*, 49 *Bifora*, 1 *Carex*, 1 *Centaurea*, 17 *Chenopodium*, 6 *Fimbristylis*, 3 *Galium*, 2 *Malva*, 1 *Oxalis*, 26 *Rumex/Polygonum*, 1 *Spergula*, 3 unknown

K.091.310: 1 *Rumex/Polygonum*, 5 unknown

K.091.313: 2 *Anagallis*

K.094.323: 5 *Anagallis*, 2 *Arnebia*, 2 *Asclepias*, 3 *Bellevalia*, 2 *Centaurea*, 2 *Chenopodium*, 1 *Cratageus*, 1 *Galium*, 2 *Plantago*, 55 *Rumex/Polygonum*, 23 unknown

K.099.338: 1 *Adonis*, 1 *Amygdaloideae*, 3 *Anagallis*, 2 *Arnebia*, 2 *Galium*, 1 *Plantago*, 6 *Rumex/Polygonum*, 1 *Scirpus*, 7 unknown

K.102.346: 1 *Amaranthus*, 7 *Anagallis*, 1 *Arabis*, 1 *Galium*, 9 *Rumex/Polygonum*, 8 unknown

K.105.355: 2 *Galium*, 2 *Rumex/Polygonum*

K.105.356: 1 *Anagallis*, 6 *Galium*, 1 *Rumex/Polygonum*, 2 *Sorbus*, 1 unknown

K.105.363: 1 *Arnebia*, 2 *Bupleurum*, 9 *Galium*, 2 *Plantago*, 4 *Rumex/Polygonum*, 2 *Scirpus*, 11 unknown