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Extensification in a Mediterranean semi-arid marginal zone: An archaeological case study from Early Iron Age Jordan's Eastern Karak Plateau

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A B S T R A C T

The extensification of agricultural systems into marginal lands is a common response to environmental, economic, and political pressures for more cultivable land. Yet the course that extensification takes in particular instances is unpredictable given the choices available to producers. This article investigates an instance of extensification during the late second millennium BCE on the semi-arid Eastern Karak Plateau in west-central Jordan. Architectural, faunal, and archaeobotanical evidence is presented from Khirbat al-Mudayna al-'Aliya, one of several communities that participated in an extensified settlement system on the edge of the Wadi al-Mujib and its tributaries. Producers practiced agriculture and pastoralism in a low-intensity subsistence economy that supported a nucleated settlement of households. Faunal analysis determined goats were kept, and wild animals supplemented diets. Archaeobotanical analysis of charred plant remains from storage bins in a building destroyed by fire indicated that barley was stored in a semi-processed state and that harvesting by uprooting was practiced, thus resulting in the maximization of the straw harvest. The riparian zone beneath the settlement was a key venue for subsistence activities. This Early Iron Age example contrasts with later episodes of extensification whose settlement systems were more dispersed and agro-pastoralist regime more integrated.

1. Introduction

A key issue in discussions of preindustrial agricultural development (e.g., Boserup, 1965; Brookfield, 2001) is why, when, and how producers extend production into marginal lands where yield is potentially lower than other regions, a practice defined as extensification. Extensification into the semi-arid margins of settlement poses particular challenges for sedentary agro-pastoral producers. Although subsistence production is often possible, such contexts can exhibit high temperatures, low precipitation with high inter-annual variability, nutrient poor soils, and a propensity for droughts and famine (Wallén, 1967). Extensification on marginal lands is often explained as a response to one or more "push" factors such as climate change, population growth, land shortages, market or imperial demands, or socio-political factors such as territorial conflicts or agrarian policies (Chen, 2006; Tachibana et al., 2001; Walsh et al., 2002). In different ways, "push" factors make marginal land less economically marginal by either raising its marginal utility (e.g. higher crop prices, political or economic incentives, etc.), or by lowering the satisfaction threshold in terms of the expected return on labor (i.e. working harder for less).

These same "push" factors are also frequently cited as explanations for intensification, and indeed, in the case of marginal lands, there is some debate as to whether extensification is an alternative to intensification or a step along the same path (Brookfield, 2001: 200). To some extent this difference relates to the nature of the marginal lands in question. Extensification in upland forest or rain forest usually requires deforestation and hence is closely linked to land-degradation (Pichón, 1996; Tachibana et al., 2001; Walsh et al., 2002). In contrast, extensification in semi-arid lands, of necessity, often results in capital investments in water and soil management facilities (e.g. terraces, cisterns, check dams, diversion walls, etc.), even if these

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investments are realized incrementally (Doolittle, 1984, 1988). It is therefore important to be clear by what is meant by intensification. Scholars have typically distinguished between the intensification of production and the intensification of productivity. The former refers to an increase in inputs, usually labor and/or capital, against fixed land (Brookfield, 1972: 31–32), while the latter refers to an increase in output per unit of labor as the result of innovation (Brookfield, 1984: 6–17; Renfrew, 1982: 266). Distinguishing these two forms of intensification from each other, and from population growth, in archaeological contexts is very difficult since one can seldom measure inputs and outputs directly (Morrison, 1994).

For these reasons, the increased use of marginal lands is of particular interest to archaeologists since evidence for their occupation could be seen as evidence for the intensification of production. This is because, all else being equal, attaining equivalent returns on marginal land would require more inputs of labor or capital than would be the case on less marginal land (Doolittle, 1988: 255–56). This is particularly the case with economic rather than ecological marginality. Of interest is land where crop yields and/or herd by-products will provide returns close to, but not less than, the sum total of subsistence needs, the minimum requirements of social reproduction and the inputs of production (Blaikie and Brookfield, 1987: 19–21). Beyond balancing inputs and outputs, production also facilitates, and is embedded in, a set of preferential lifeways whose attainment may require trade-offs between access to key resources, competing land-uses and maximizing agricultural or pastoral output. From this perspective, economic marginality is relative to particular modes of existence up to the ecological margin of total crop or herd failure. This is relevant to the question of whether or not the expansion of settlement onto semi-arid margins (i.e. extensification) always requires the 'push' factors associated with the intensification of production. Because the definition of marginal land varies with different preferential lifeways, one cannot presume that the extension of settlement onto semi-arid land always requires an external 'push.'

With the exception of run-off irrigation agriculture in the Negev Highlands of Israel (Ashkenazi et al., 2012), investigations of the pre-modern use of semi-arid zones in the Middle East have been more concerned with irrigation or pastoral nomadism than with rain-fed agro-pastoralism. Studies that have been carried out often follow the general literature in emphasizing external "push" factors when explaining extensification (e.g. Haiman, 2012; Rosen, 2000; Wilkinson, 2006). Alternatively, some studies have emphasized the 'pull' of non-agricultural income sources, such as mining or overland trade (e.g., Barker et al., 2007; Finkelstein, 1995). Much less attention has been given to the implications of differences in the organization and orientation of agro-pastoral systems.

The archaeological investigation of agro-pastoral systems in Jordan is a case in point. Evidence accumulated over the past sixty years of excavations and surveys have identified periods of intensified sedentary settlement practices and increased output of agricultural production. These periods contrast with episodes of abatement, which often includes the withdrawal or collapse of polities, the disintensification of production, and a dispersal of population centers. In its most influential formulation (LaBianca, 1990, 2007), the intensification and abatement paradigm explains intensification in terms of external demand (e.g. markets and imperial tribute) and external investment, while abatement is explained in terms of indigenous risk reducing strategies. While this paradigm accounts broadly for long-term changes evidenced in the archaeological record, it does not offer sufficient temporal or spatial precision to understand particular agro-pastoral systems during specific historical episodes. In particular, the diverse patchwork of environmental zones that constitute Jordan's landscape (Cordova, 2007) are treated as uniformly marginal, while agro-pastoral systems are presumed to intensify or abate uniformly along a continuum of greater or lesser reliance on pastoralism. Neither synchronic nor diachronic differences in the form that settlement takes in semi-arid lands can be accounted for within this cyclical paradigm (cf. Barker, 2012).

Such differences can be observed when examining Jordan's thin longitudinal semi-arid strip that lies between the eastern end of the Mediterranean Basin and the western edge of the Arabian Desert. This zone saw intermittent agricultural extensification over five millennia of history. Some of these episodes occurred, as one might anticipate, during periods when the Levant experienced increased population growth and the appearance of new markets for raw materials and finished goods, usually during imperial interventions led by the Roman, Byzantine, and Mamluk Empires. However, there are other instances of extensification in periods when such "push" factors were minimal or non-existent.

One instance that will be explored in detail below takes place at the end of the second millennium BCE, the early Iron Age, a period of relatively low political and economic complexity in the Southern Levant following the region-wide collapse of Bronze Age polities throughout the Eastern Mediterranean (Ward and Joukowsky, 1992). On the Eastern Karak Plateau in west-central Jordan, multiple small agro-pastoral settlements established themselves in the eleventh century BCE, lasting less than a century before their abandonment. Architectural, faunal and archaeobotanical evidence from one settlement, Khirbat al-Mudayna al-'Aliya (KMA hereafter) demonstrates how the community's producers organized a low-intensive, non-specialized agro-pastoralist economy around a thin riparian zone in a wadi canyon beneath the settlement. The nucleated settlement pattern associated with the early Iron Age contrasts markedly with later Iron Age, Roman and Byzantine settlement patterns in the same semi-arid zone, which are characterized by a mix of forts and dispersed farmsteads and towers. To foreshadow our conclusions, we argue that while "push" factors work well as an explanation in cases where extensification on the Eastern Karak Plateau represents a form of intensification of production, as in the later Iron Age, Roman and Byzantine periods, they work much less well when applied to the nucleated settlements of the early Iron Age. This evidence supports our general point that both extensification and marginality can mean rather different things depending upon the orientation and organization of any given agro-pastoral system.

2. Study area: the Karak Plateau

The Karak Plateau is an uplifted 875 square kilometer slice of west-central Jordan bordered by the Dead Sea on the west, the massive canyons of Wadi al-Mujib on the north, the Wadi al-Hasa on the south, and the Arabian Desert on the east (Fig. 1). On the plateau, both elevation and precipitation decrease from west to east. The western half of the plateau ranges from 1200 to 900 m asl in elevation and averages up to 400 mm of precipitation per annum, while on the eastern half elevations decline from 900 to less than 700 m asl and precipitation recedes to an average of less than 250 mm per annum, before transitioning to a fully arid, Irano-Turanian, steppic zone (el-Sherbini, 1979: 174; Table 2). Fertile Red Mediterranean soils are abundant on the western half of the plateau, but give way to calcareous Yellow Mediterranean and steppic soils to the east.

Mitigating the Eastern Karak Plateau's semi-arid conditions are riparian zones found at the bottom of deep wadi canyon systems, the al-Mujib and its tributaries on the plateau's north edge, and the al-Hasa system on its south edge (Fig. 2). These riparian zones contain lush microclimates created by run-off precipitation and perennial aquifers that together refuel stream systems that drain

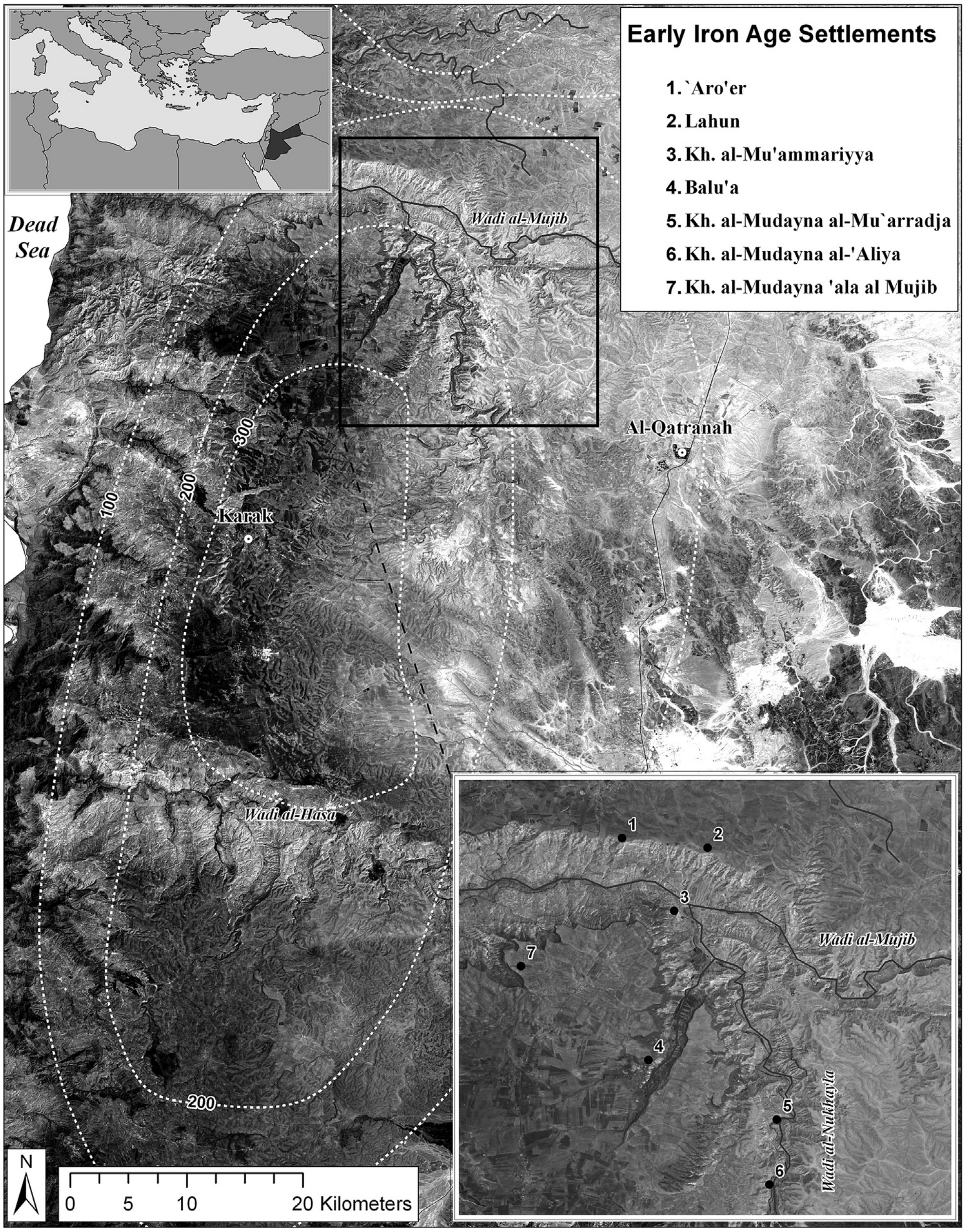

Fig. 1. Map of Jordan's Karak Plateau noting Early Iron Age settlements next to the Wadi al-Mujib (Image: A. Wilson).

west into the Dead Sea in the Jordan Valley (Fig. 3). These resources could be used for watering herds, collecting water for human consumption, floodwater farming, and orchard growing. Sediment traps have formed through alluvial processes on some banks, creating soil beds where small-scale agriculture can be practiced. These riparian zones are very narrow and accessing them is challenging due to the steep descent from the plateau to the canyon floor. Today, small-scale agricultural producers and pastoralists use the zone frequently. Wild fauna, including crabs (*Potamon potamios*) and various kinds of fish and birds are present throughout the zone.

Archaeological survey projects and excavations demonstrate that the Karak Plateau has seen almost continuous, if highly variable, occupation since the Paleolithic Period, with more than 1000 identified settlements, ranging from large settlements to farmsteads and artifact scatters (Clark et al., 1994; Hill, 2006; Jacobs, 1983; Miller, 1991; Parker, 2006; Worschech, 1990). Some of these settlements ($n = 537$) have been identified in semi-arid and arid zones along the Eastern Karak Plateau (Parker, 2006: 25–108). These survey data indicate that episodes of agricultural extensification occurred during periods of imperial control in Jordan, such as under the Assyrian (Routledge, 2004: 184–212), the Late Roman and Byzantine (Parker, 2006), and Mamluk (Brown, 1984) empires. However, these data also demonstrate that extensification occurred during periods when regionally integrated polities were absent, such as during the Early Bronze II–III (c. 3100-2300 BCE) and early Iron (c. 1200–1000 BCE) Ages.

3. Materials and methods: Khirbat al-Mudayna al-'Aliya

KMA is a 2.2 ha settlement approximately 19 km northeast of the modern town of al-Karak located on the Eastern Karak Plateau

Table 1
Identification of all bones recovered at KMA.

Common name	Scientific name	NISP	Percent	MNI
Freshwater crab	*Potamon potamios*	100	23	27
Bony fish	Osteichthyes	1	+	1
Heron or stork	Ardeidae/Ciconiidae	1	+	1
Perching bird	Passeriformes	1	+	1
Unidentifiable birds	Aves	10	2	–
Rodent	Rodentia	12	3	2
Possible hedgehog	cf. Erinaceidae	1	+	1
Domestic dog	*Canis familiaris*	3	1	2
Red deer	*Cervus elaphus*	1	+	1
Domestic cattle	*Bos taurus*	11	3	1
Pig	*Sus scrofa*	6	1	1
Domestic goat	*Capra hircus*	10	2	3
Domestic sheep	*Ovis aries*	8	2	2
Sheep or goat	*Ovis/Capra* sp.	229	53	7
Equid	*Equus sp.*	36	9	6
Mammal, not further identifiable	Mammalia	1798	–	–
Total identifiable		430		28
Grand Total		2229		

(UTMG: 773.4/464.5) (Fig. 4). The settlement is positioned on a promontory 250 m above the juncture of the Wadi al-Mukhayris and the southern extension of the Wadi al-Mujib (known locally as the Wadi al-Nukhayla). AMS radiocarbon dating of organic samples ($n = 29$) indicates that the settlement was occupied for no more than a century during what is known as the Iron Age IB period (Bloch-Smith and Nakhai, 1999; Herr, 2009). Bayesian modeling using OxCal places the building construction phase at KMA between 1105 and 1016 BCE ($p = 2$ sigma). Final settlement abandonment is based on burnt organic evidence excavated in storage bins in buildings 100 and 500. This evidence is modeled between 1001 and 921 BCE and 1011–941 BCE, respectively ($p = 2$ sigma).

Archaeological investigations at KMA were conducted between 1994 and 2004, comprising five seasons of mapping and excavation (Routledge, 2000, 2004: 96–108, 2008; Routledge and Porter, 2007). Because most of the settlement's stone architecture is visible on the surface, its fortification walls and most of its buildings could be mapped without excavation, providing an overview of the settlement's layout and the location and size of individual buildings (Fig. 4). Nine of an estimated 35–45 discrete buildings were

Table 2
Identification and quantities of cereal, fruit, and legume species identified in flotation samples at KMA. Unit 4J41 and B1 are storage bin deposits in Building 100.

Unit	4J41	4J41	4J41	4J41	4J41	4J41	4J41	2G87	4J41	4J41	4J41	4J41	4J41	4J41	4J41	4J41	4J41	B1	B1	B1	
Locus	6	11	13	13	11	13	13	7	13	13	13	11	13	13	13	13	11	8	8	7	
Sample number	6	12	14	15	16	17	19	20	22	24	25	26	27	28	29	30	31	32	33	35	Total
Cereals–Grain																					
Triticum turgidum L. subsp. *dicoccum* (Schrank) Thell type grain								1			1										2
Triticum indet grain								1								1					2
Hordeum sp. (hulled straight grains)			44	44	34	20	19		37	10	16	3	22	15	50	3		53	1		371
Hordeum sp. (hulled cf. straight grains)				80		43	16		47	48	53	7	48	37	20	7	11	98	27	1	543
Hordeum sp. (indet straight grains)				2					2		3	1	2		3						16
Hordeum sp. (hulled indet gains)		10	84	99	66	191	26	1	60	98	281	22	101	50	108	25	10	100	328	2	1662
Hordeum indet grain		6	29	15	8	46	26		13	8	46	19	47	30	35	18	8	19	34	8	415
Hordeum cf. var. *nudum* (straight grains)						1															1
Hordeum sp. (cf. twisted grains)				5	1	3			1		2		1	5	1			8			27
cf. *Hordeum* indet grain					8		2					8			8						26
Triticum / *Hordeum* grain			3		1						8										12
cf. *Avena* sp. grain					1		2									4					7
Cereal indet grain		1	4	3	4		5	3		8	3		12	8	2			3	21		77
Cereals–Chaff																					
Triticum cf. *dicoccum* glume base			2																		2
Triticum indet glume base														6							6
Triticum turgidum conv. *durum* (Desf.) MacKey rachis internode											8										8
Hordeum vulgare subsp. *distichum* rachis internode					28	4				33		64					80				209
Hordeum vulgare cf. subsp. *distichum* rachis internode		12			52		4		8	82	16	64	2				96				336
Hordeum indet rachis internode		15	12		132		4		8	152		112		10	4		216		16	4	685
Hordeum indet lemma base									4												4
Avena sp. lemma base							2						2				8				12
Avena sativa L. floret base					12				4	16							8				40
Terminal spikelet indet											8										8
Culm node		11	3		32	1	5			153	16	16	2	4					16	4	263
Culm base - wild/weed plant				2			2			32		32			4	4					76
Culm base - cereal					4					8		8									20
Chaff indet		1						1		8											10
Fruits																					
Ficus carica L.	3	11		3	4	32	8	9	24	8	72	8	8	14	28		8	48	128	16	432
Vitis vinifera L.	1		3			4		24	1					1	1			4	6		45
Legumes																					
Lens culinaris Medik		1	1					1													5
Vicia ervilia / *Lathyrus sativus*		2																			2
Large legume indet									1					2		4			1		8
Total items	4	70	185	253	387	345	121	39	210	664	532	364	247	182	264	66	446	336	578	35	

Fig. 2. Canyon riparian zone below Khirbat al-Mudayna al-Mu'arradjeh in January, 2011 (Image: B. Porter).

sufficiently visible on the surface to allow the detailed (1:50) mapping of their interior rooms and doorways. In five of these buildings, a total of eight 5 × 5 m excavation units were opened. In addition, three further excavation units were opened in non-domestic contexts including the settlement's large communal courtyard. All excavated soils were sieved through five-millimeter mesh screens and all visible artifacts were collected and retained for analysis. In addition, soil samples ranging from 3 to 50 L were retained from each depositional context and subjected to water flotation for the recovery of charred archaeobotanical remains and microartifacts.

Excavation inside buildings yielded a total of 2229 fragments of animal skeletons. Subsequent analysis identified all bones to the lowest possible taxonomic category (Table 1). Morphological and taphonomic features were recorded where visible, including butchering scars, age-related information, and burning. Quantifiable variables on the bones, fragment counts, weight, and metric measurements were recorded. Unfortunately, the small size and fragmentary character of the assemblage prevented the determination of animal sizes, age profiles, and kill-off patterns. The Number of Identified Specimens (NISP) was used for relative abundance calculations (see e.g. Klein and Cruz-Uribe, 1984). Bone measurements were taken following the guidelines established by von den Driesch (1976) in order to record individual animal or average species size.

The systematic sampling strategy for the recovery of charred plant remains resulted in the collection of 534 samples that were subject to water flotation. The flots were collected in graduated

Fig. 3. Canyon riparian zone below Khirbat al-Mudayna al-'Aliya in July, 2011 (Image: B. Porter).

sieves of 1 mm and 300 μm mesh, and the remaining heavy residue retained in a 1 mm mesh. Flots and heavy residue were dried and the heavy residue sorted by eye for organic remains and artifacts. A preliminary assessment of the flots was made by scanning each size fraction under a low power microscope (×7–×45) and recording the abundance of the main classes of charred plant material present. The majority of samples were found to contain very little or no charred plant remains. Samples from storage bins found in buildings at either ends of the settlement (Building 100 and 500) were found to be rich in charred plant material because the buildings experienced a dramatic burning episode just prior to or immediately following their abandonment. A study of 19 samples from grain storage bins in Building 100 was performed (Tables 2 and 3). One sample from unit 2G87 (sample 20) was also included in this study as one of the few samples from outside of Buildings 100 or 500 to contain anything other than a minimal amount of charred plant material. The mean sediment volume of the 20 samples was 7.5 L. Initial examination of the samples from Building 500 indicated the presence of a similar range of crop types and cereal plant components to those present in Building 100, although full analysis of these samples has not yet been completed.

All cereal grain, chaff and wild/weed plant seeds from the flots selected for analysis were identified to the lowest possible taxonomic category. Thirteen crop taxa were identified in 7299 records (Table 2). Nomenclature follows Zohary (1966) and Zohary and Hopf (2004). Quantification of crop material was carried out using the 'diagnostic zones' approach as recommended by Jones (1988). Wild/weed plant seeds ($n = 35$ different taxa) were identified where they occurred in at least 10% of the samples selected for analysis (Table 3). This has a basis in ecological studies and ensures ecological indicator species that are often present at low levels have a chance of being represented (Jones, 1991).

4. Results

4.1. Architecture evidence

The architectural mapping of KMA demonstrated that it consisted of buildings attached to a fortification wall arrayed around a large courtyard that constituted more than one third of the total area of the settlement (Fig. 4). The western side was the only one not protected by steep slopes, and here an additional fortified zone

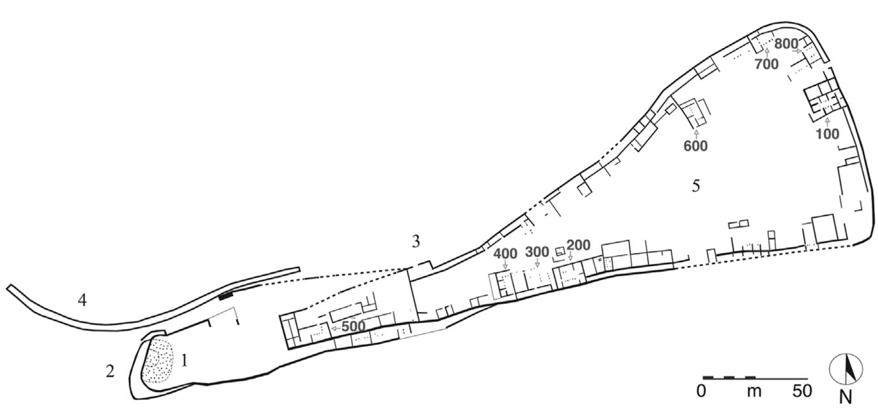

Fig. 4. Map of KMA denoting Buildings 100 through 800: tower (1), moat (2), a possible gated entrance (3), paved pathway (4), and courtyard (5) (Image: B. Routledge).

Table 3
Identification and quantities of wild or weed plant species identified in flotation samples at KMA. The seed of the plant is always referred to unless stated otherwise. Unit 4J41 and B1 are storage bin deposits in Building 100.

Unit	4J41	4J41	4J41	4J41	4J41	4J41	4J41	2G87	4J41	4J41	4J41	4J41	4J41	4J41	4J41	4J41	4J41	B1	B1	B1	
Locus	6	11	13	13	11	13	13	7	13	13	13	11	13	13	13	13	11	8	8	7	
Sample number	6	12	14	15	16	17	19	20	22	24	25	26	27	28	29	30	31	32	33	35	Total
Wild plants																					
Papaver cf. *argemone*	16																8	4		4	32
Atriplex sp.		1								4											5
Suaeda asphaltica / *aegyptica*	4	5					2		6		4										21
cf. *Suaeda asphaltica* / *aegyptica*		1																			1
Salsola sp.	2																				2
Caryophyllaceae type			2																		2
Silene sp.		1			2			1		4											8
Vaccaria pyramidata Medik.				2							4								16		22
Polygonaceae type	2		2		2				2						4						12
*Polygonum patulum*M.Bieb.				1		4	2		2							4					13
Polygonum sp. (trigonus)	2	1	4	3	2	8	8		24	16	28		16	6	8			8			134
Malva parviflora / *oxyloba*		1																			1
cf. *Malva parviflora* / *oxyloba*			2				2							2			8				14
Brassicaceae type		1																			1
Cardamine cf. *hirsuta*													2						16	4	22
Fabaceae type	4	4	12		6		2	2	10	4	4		6			4			32	8	98
Trigonella monspeliaca L.			4					1													5
Trigonella / *Astragalus*	2	7	2	1			10	3		8	4	8	4	8	4		9	4			74
Trifolium sp.	2									16				4						4	26
Trifolium / *Melilotus* sp.	2				6					16				4						4	32
Euphorbia sp.		3																			3
cf. *Euphorbia* sp.					2		2														4
Erodium sp.	2		2												4		24			24	56
Apiaceae type			4														8				12
Bubleurum lancifolium Hornem.						4							2		4			4			14
Asteraceae type									2												2
Carex sp.					2					4							8				14
Aegilops sp.			1	1												1					3
Lolium sp.								1									8		16		25
cf. *Lolium* sp.												8									8
Phalaris cf. *minor*	2	1		1	2		4			8	12				4		8				42
Phleum exaratum / *subulatum*		2																		4	6
Bromus sp.		1			4		2			4	4						8				23
Hordeum vulgare subsp. *spontaneum* (K. Koch) Thell		1	2	2		4	2		3				2	2		4					22
Hordeum cf. *spontaneum*			1	2		1	2		2	9	1			4			24	4			50
Hordeum sp. wild type		2	4		8			1	14	29	36	16		4			25	4	16		159
Poaceae type (<2 mm)		5	18		2		8	1		20	4	16		8	4	4		16	16	4	126
Poaceae type (>2 mm)	2	3	11	3	4	12	2	2	4		4	8	1						48		104
Muscari sp.		3	8	1	4	4	2		2	20	4	24	4	10		20	16	4	16	4	146
Total items	18	32	67	14	38	33	46	11	61	134	97	56	33	42	28	17	130	40	144	52	

was constructed with a fosse, a ten-meter high tower and no other evident buildings. On the eastern side, a set of three cisterns for water storage was cut on the edge of the steep cliff between the settlement and the riparian zone.

The nine buildings drawn in detail were similar in design, laid out with an internal courtyard framed by monolithic stone pillars. The layout of these buildings is recognizable as a variation of an Iron Age architectural design termed the “four-room house,” well known from excavations in Israel and Palestine (Holladay, 1997). The domestic nature of these buildings was supported by the presence of ovens, as well as food processing and grain storage facilities. Understanding most of the visible architecture to represent discrete houses leads one to estimate the population of KMA at 175–360 residents. This amount is based on a mean domestic group size of 5–8 members. This average would be on the high end for ancient Near Eastern domestic groups, but is in keeping with the very large house sizes at KMA (Routledge, 2000: 60–62). The mapped buildings ranged in area from 71 to 239 square meters, with much of the extra space in larger buildings being dedicated to storage. This suggests that there was differentiation in levels of wealth between households at KMA (Porter, 2013).

Grain storage facilities were particularly prominent in the settlement’s two largest buildings, 100 and 500. In both cases, rooms were designed to provide semi-subterranean storage. In Building 100, the central portions of two rooms (102 and 106) were sunk beneath the surrounding ground surface and then lined with stone walls. In Building 500, house walls were founded on bedrock, but two large bins (504a and 508b) were constructed by framing natural recesses in the bedrock, so again grain storage was semi-subterranean relative to the outer walls of the house. This was likely done to either control storage temperatures or to protect the stored grain from burrowing pests. The position of these storage bins deep within their respective houses, and the labyrinthine route by which they were accessed, suggests that these grain stores were closely attached to, and controlled by, individual households (Fig. 5). These features are defined as grain bins because two of the bin-rooms (106 and 504a) still contained significant quantities of carbonized barley when excavated (see below).

4.2. Material culture

Almost all recovered material culture was associated with subsistence. Ceramic vessels were the most abundant object type

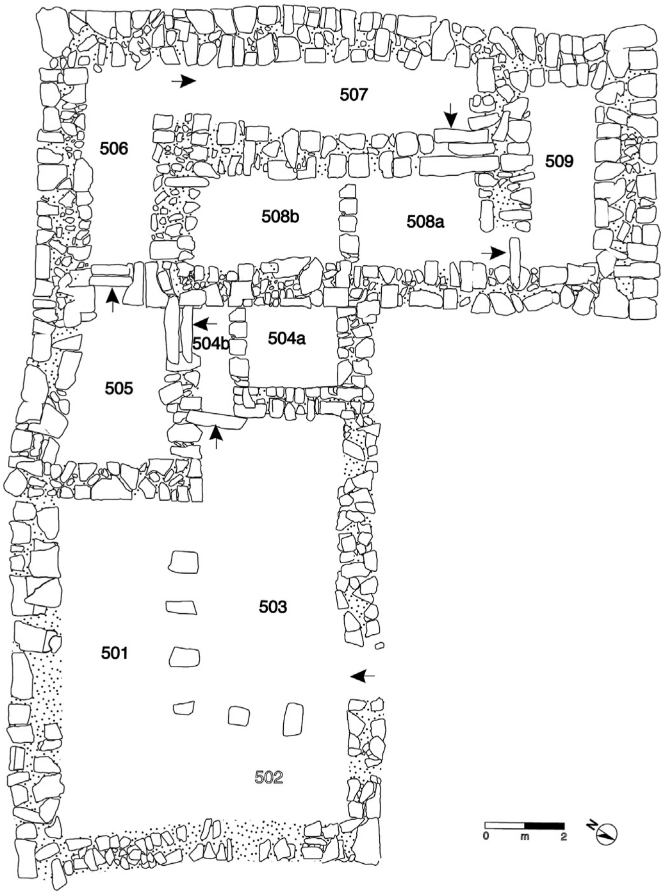

Fig. 5. KMA's Building 500 (Image: B. Routledge).

excavated at KMA (Routledge, 2000: Figs. 5–7, 2008). The vessel assemblage consisted of forms focused on food and liquid storage (e.g., storage jars), food production (kraters) and consumption (bowls). In form and decoration, this assemblage is most similar to those found in immediately neighboring Early Iron Age settlements in west-central Jordan (see Section 5.2 below). Published parallels to the KMA assemblage from other settlements show a distinct fall-off pattern negatively correlated with distance, suggesting strongly regional stylistic traditions (Porter, 2011; Routledge et al., 2014). Select vessel forms are similar to those found in secure eleventh- and early tenth-century phases at Deir 'Alla (Phases E–H) in the Jordan Valley and at various settlements west of the Jordan Valley (e.g., Beer Sheba Strata VII–VI; Gezer Strata XI–X; Hazor Strata Xb–IXb; 'Izbet Sartah Strata II–I; Megiddo Strata VI–V; Qasile Strata XII–X; Ta'anach Strata IIA and IIB). Instrumental neutron activation analysis and petrographic analysis of thin sections determined that while most of this assemblage was produced using clay sources adjacent to the settlement, a significant minority of the pottery included argillaceous rock inclusions that most likely originated immediately west or north-west of the settlement (<10 km). Interestingly, these differences in clay origin do not correlate with differences in vessel form, function or decoration (Routledge et al., 2014). This in turn suggests that the movement of ceramic vessels to KMA occurred for reasons other than sub-regional specialization and exchange. Refiring experiments suggest very consistent, well-controlled, firing at moderate temperatures (700–800 °C), consistent with skilled local production (Routledge et al., 2014).

Ground stone tools and vessels related to grain processing are the next most abundant artifact class, occurring with much less frequency than pottery. Only three metal objects were recovered, all being small, copper-based and too heavily mineralized to allow further analysis of their composition. Several small-beads of calcite crystal were also recovered, a number of which appear to be roughed out blanks, suggesting small-scale, on-site production.

4.3. Faunal assemblage

Faunal analysis resulted in the identification of 408 non-human specimens to the taxonomic level of family or below from the total collection of over 2000 specimens (Table 1) (Lev-Tov et al., 2011). The assemblage consisted primarily of remains from domesticated mammals, including sheep (*Ovis aries*), goats (*Capra hircus*), cattle (*Bos taurus*), pigs (*Sus scrofa*), equids (*Equus* sp.), dogs (*Canis familiaris*), and a camel (*Camelus* cf. *dromedarius*). The most common species present were sheep and goats. Most of the bones of these two species are morphologically indistinguishable (cf. e.g. Boessneck et al., 1964; Prummel and Frisch, 1986). The 7% of the sheep/goat bones that could be speciated were made up of eight sheep and ten goat elements. This evidence is too limited to draw

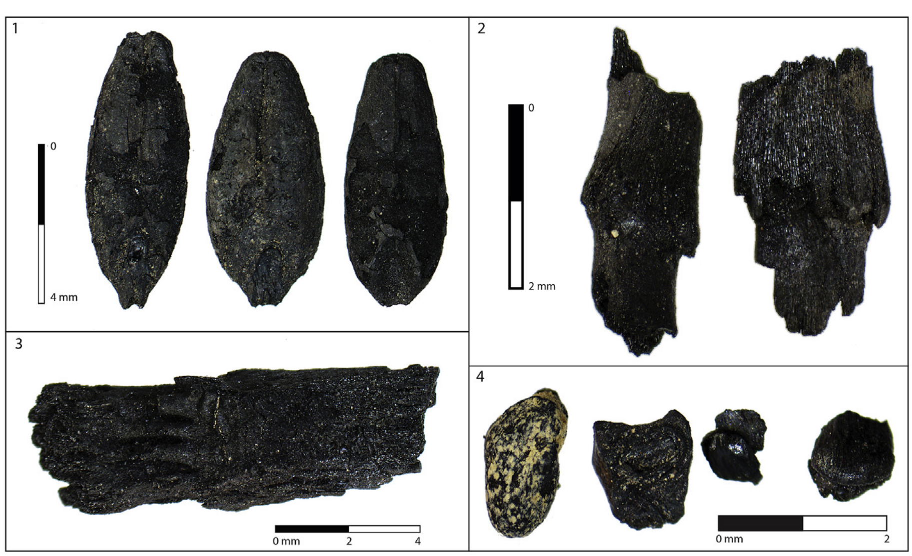

Fig. 6. Archaeobotanical evidence from a storage bin in Building 100 (Locus 11). 1) Barley grains; 2) grass culm nodes; 3) a grass stem, probably of a cereal; and 4) a Trigonella weed seed and three barley rachis internodes (Image: A. Farahani).

firm conclusions although the slight preference for goats would be expected in an unspecialized, subsistence-level, economy focused on herd security in an arid or semi-arid environment (cf. Redding, 1981; Tchernov and Horwitz, 1990).

Equid (horses, asses, onagers, etc.) bones were also present. The total number of equid bones, 35, is greater (8% of identifiable bones) than at several broadly contemporary settlements in the region (e.g. at Tell Hesban; cf. von den Driesch and Boessneck, 1995: 72), albeit it is possible that many of the elements emanated from a single individual. The camel bone may be intrusive since camels are rare in the Levant prior to the latter half of the first millennium BCE (Wapnish, 1997) and since it is a single find. However, von den Driesch and Boessneck (1995: 72) report the presence of three camel bones from Iron Age levels at Tel Hesban, although they do not differentiate between early and late Iron Age.

Wild animal species were also present in KMA's faunal assemblage. The assemblage included at least four wild animal species likely to have been taken for food. Four of the five species, a red or fallow deer, one or more small bird taxa, a heron or stork, and unidentified fish are present as either single bone finds or as just a few bones. A distal tibia from a cervid was recovered. The bone seems large for a fallow deer, but red deer populations were apparently extirpated from Jordan by the beginning of the Neolithic (von den Driesch and Boessneck, 1995: 87). Red deer have been identified at Iron Age settlements contemporary to KMA, such as Shiloh (Hellwing et al., 1993: 311). If a red deer, the bone could have been brought to the site within a skin. Von den Driesch and Boessneck (1995: 87) suggest such an origin for three red deer lower limb bones found in the Middle Islamic (13th-15th centuries CE) settlement of Hesban. If the bone is indeed from a large fallow deer, as is most likely the case, it probably originated from an animal hunted in the riparian zone. Fallow deer were present in Jordan until they were extirpated during the early 20th century (von den Driesch and Boessneck, 1995: 86–87; Qumsiyeh, 1996: 205).

The sole species with greater numbers of fragments is the freshwater crab (*P. potamios*). A total of 100 crab claws were recovered during excavation, constituting 4.5% of all fauna recovered and 24.5% of the identified specimens. Further carapace and claw fragments have also been recovered from the heavy fraction of flotation samples. Twenty percent of the crab claws showed clear evidence of having been burned, even in contexts where other bones were not burned. While freshwater crabs may roam as far as 100 m from their stream bed (Gherardi et al., 1988: 241), they do not climb cliff faces, hence their presence at a settlement 250 m above the wadi bottom cannot be explained by burrowing activities (contra Toplyn in Parker, 2006: 497–498). Rather, the freshwater crabs were harvested and brought to the settlement as a food source (see Lev-Tov et al., 2011: 77 for further discussion).

The few wild species present in the assemblage may reflect a supplemental role of garden hunting or at least occasional and opportunistic "hunting" and trapping of animals. In garden hunting, animals that are attracted to crop fields are killed both in order to protect the plants and as a logistically easy way of supplementing a diet, since certain animal species would be encountered in fields while crops were tended (cf. Neusius, 1996). Red deer may be one such species, and, if, as it is argued, the wadi bottomlands were seasonally used by KMA residents, the waterfowl (heron or stork) could be included among species found in or near fields. The fish and crabs could have been opportunistically trapped during times of wadi use as well.

4.4. Archaeobotanical assemblage

Archaeobotanical analysis focused on charred plant materials in storage bins found in Building 100 (Tables 2 and 3; Fig. 6). These bins burned just prior to or immediately following abandonment. Preservation of charred cereal grains in these samples was good, with the epidermis of grains often intact and with grains exhibiting low levels of distortion. The majority of charred cereal grains present within the samples were identified as cultivated hulled barley (*Hordeum vulgare* L.). A small number were identified as possible 'twisted' grains characteristic of the lateral spikelets of the 'six-row' barley type (*Hordeum* cf. *vulgare* subsp. *vulgare*). 'Straight' grains, characteristic of both the two- (*H. vulgare* subsp. *distichum*) and six-row barley types, were present in the majority of samples. The recovery of only 'two-row' barley chaff, with no chaff of the 'six-row' barley type being present, indicates that it was most likely the 'two-row' barley type that was cultivated, although the presence of the 'six-row' variety cannot be ruled out. Also recovered were small quantities of common oat grains and chaff (*Avena sativa* L.), emmer wheat grain and chaff (*Triticum turgidum* L. subsp. *dicoccum* (Schrank) Thell) and durum wheat chaff (*T. turgidum* conv. *durum* (Desf.) MacKey), as well as lentil (*Lens culinaris* Medik), fig (*Ficus carica* L.), grape (*Vitis vinifera* L.), bitter vetch or grass pea (*Vicia ervilia* / *Lathyrus sativus*), and a large indeterminate pulse type. The association of barley rachis internodes, cereal culm bases, wild/weed plant culm bases, and wild/weed plant seeds of various sizes in the Building 100 storage bins indicates that the barley was likely to have been placed into storage in a semi-clean state. It is likely that chaff will be somewhat underrepresented in the storage bin assemblage overall in comparison to grain, due to grain surviving the effects of charring more readily than chaff (Boardman and Jones, 1990). The ratio of barley grain to barley rachis internode varies in the individual storage bin samples from 0.07:1 to 110.5:1, with low ratios of grain to rachis internode present in the upper storage bin deposit (locus 11) and high ratios of grain to rachis internode present in all but one of the samples from the lower storage bin deposit (locus 13). The variations in the ratios of barley grain to rachis internode between locus 11 and locus 13 may be related to the effects of the fire which destroyed the storeroom, with lighter rachis internodes being lifted by the fire and therefore more likely to be deposited stratigraphically above the heavier cereal grains. Overall a higher proportion of chaff is present in the storage bin deposits from Building 100 than would be expected for fully processed cereals.

5. Discussion

5.1. Nucleated settlement and agro-pastoral production

Faunal and archaeobotanical analysis indicates that the KMA settlement organized their subsistence according to a combination of grain agriculture and pastoralism (i.e., agro-pastoralism) that was low in intensity with no evidence for product specialization. Equids served as beasts of burden in transport or in agricultural production. The presence of wild animals in the assemblage indicates that expedient harvesting played an important role in KMA's animal economy, although the extent to which such practices were organized formally remains undetermined. Wild animals were likely harvested on an ad hoc basis in places and during periods of the year when producers were preoccupied with agriculture and pastoralism (Lev-Tov et al., 2011: 77–78). Altogether, this broad spectrum of species represented in the faunal assemblage strengthens the idea that KMA's animal economy was locally oriented and unspecialized in its organization.

A broad spectrum of crop types was also represented in the archaeobotanical assemblage including barley, wheat, oat, fruits and legumes. The predominance of barley in the storage bin deposits is unsurprising as barley has a higher tolerance for drought and poor soils. The storage of barley in a semi-processed state would be consistent with crops intended for use as animal fodder, as cereals intended for human consumption would be more likely to have been stored as clean grain. The hulled variety of barley is also preferred in traditional farming communities as animal feed or for brewing with the naked variety of barley more likely to be used as human food (Zohary and Hopf, 2004). It should be noted, however, that further processing of the hulled barley in order to obtain clean grain for human consumption could have been carried out at a later date and no direct evidence for the use of cereals as animal fodder, such as cereal remains in charred dung, was recovered. A further indication of the likely importance of cereals for use as animal fodder however is provided by the presence of culm (straw) bases from both cereals and wild plants, suggesting harvesting by uprooting of the crop (Hillman, 1981: 148), which would have resulted in the maximization of the straw harvest. The storage of products from the early stages of processing also suggests that cultivation was probably local as imported grain would be expected to have been fully cleaned prior to transportation.

The community's use of the Wadi al-Nukhayla's riparian zone is reflected in several lines of evidence. The presence of sedge seeds (*Carex* sp.) as well as the tentative identification of hairy bittercress seeds (*Cardamine* cf. *hirsuta*), in association with barley grain in three of the samples from the Building 100 storage bins, suggests the possible cultivation of barley in moist soils. These taxa could also represent plants collected as roofing or flooring material or animal fodder rather than weeds harvested along with the crops, although the presence of these taxa would still indicate the use of plant resources from the riparian zone. Similarly, evidence for crab consumption indicates the riparian zone was used for the harvesting of wild fauna, where many of the same species are still observable today. In addition, while cisterns occur adjacent to the settlement, the wadi's perennial water sources would have been essential for watering village herds. Movement between the settlement and the riparian zone must have therefore been a regular occurrence, one that tethered both the residents and the herds of KMA to the vicinity of the wadi insofar as those herds were based within the village. Foddering, nucleation and the intense exploitation of the wadi's circumscribed riparian zones were likely to have been intimately linked at KMA. The nucleation of settlement at KMA and the circumscribed nature of the wadi's riparian zones would have made the close integration of pastoralism and agriculture difficult if conflict over land-use was to be avoided. There would have certainly been opportunities for post-harvest stubble grazing in the summer and the concomitant contribution of animal manure to fields prior to autumn plowing (Halstead, 1987, 1996). However, herd sizes would be severely constrained if animals were dependent on wadi-based grazing that did not endanger crops.

One solution would be to collectivize village flocks in order to control their movement (and also free up agricultural and building construction labor). The settlement's architectural form, with heavy fortifications protecting households arranged around a large open courtyard, may reflect this collectivization if the courtyard served as penning space for village-based herds. This function has been argued for similar courtyards in early Iron Age settlement in the northern Negev on the basis of soil micromorphology (Shahack-Gross and Finkelstein, 2008). However, such an arrangement also suggests that herds returned regularly to the village for the sake of security, rather than ranging to maximize their use of pasture. This reduced grazing mobility would cancel out many of the benefits of village herd collectivization. In particular, reduced herd mobility would have increased food stress in August and September, when both natural pasturage and field stubble are in short supply (Tully et al., 1988). It would have also increased herd vulnerability during drought years.

Foddering would have been one means of mitigating these risks, stabilizing the herd's food supply and allowing for the maintenance of larger village-based herds than would be the case for free-ranged herds that returned nightly to the village. Insofar as early Iron Age settlers maintained nucleated settlements focused on the circumscribed riparian zones of the Wadi al-Mujib and its tributaries, foddering would seem to have been a necessary practice. This was all the more true if the residents of KMA shared the resources of their wadi with neighboring settlements, as is hypothesized.

5.2. Extensification into semi-arid zones during the Early Iron Age

KMA was one of several early Iron Age settlements that were founded on the edges of the al-Mujib canyon and its tributaries. These settlements include, from north to south, Aro'er, Lahun, Khirbat al-Mudayna as-Saliya, Khirbat al-Mudayna al-Mujib, Khirbat al-Mu'ammariyya, Balu'a, Khirbat al-Mudayna al-Mu'arradjeh, and finally KMA (Fig. 1). No faunal or archaeobotanical evidence has been published from these other settlements, so it is impossible at this time to compare agricultural and pastoralist routines with those identified at KMA. However, these settlements do share numerous features in terms of position, layout, architecture and material culture, particularly decorated ceramic vessels (Porter, 2011: 38–41; Figs. 5–8).

Each of the settlements for which a plan can be reconstructed consists of a fortified ring of buildings enclosing a central space. These settlements range between 1.0 (al-Mudayna al-Mu'arradjeh) and 2.2 (KMA) hectares (Routledge, 2004: Table 5.2), with no one settlement appearing to have held political or economic dominance over the others. These settlements also show fairly regular spacing of ca. 5–6 km with no clear evidence for intervening early Iron Age satellite settlements or farmsteads.

This distinct settlement pattern of contemporary, short-lived, highly defensible and nucleated settlements located along the edges of the Wadi al-Mujib and its main tributaries shows that the occupation of KMA was one component of a very specific, regional episode of extensification. Explaining why this consistent and brief episode of extensification occurred in the manner and at the time that it did leads to a consideration of the role that different kinds of "push" factors played in extensification.

5.2.1. Climate change

A wide-range of environmental proxy records now point to the end of the second millennium BCE as a period of significant climate change in the Eastern Mediterranean (Drake, 2012; Riehl et al., 2012; Roberts et al., 2011). For example, precipitation curves reconstructed from the isotopic composition of speleothems from Soreq Cave in the Southern Levantine Central Highlands indicate that starting after 1500 BCE, precipitation levels were lower than previous Early and Middle Holocene levels, with some minor fluctuations in amount (Bar-Matthews et al., 1998). Additional palynological and sedimentological cores from the western side of the Dead Sea likewise indicate that the end of the second millennium BCE was characterized by increased aridity (Neumann et al., 2007, 2010). Similar trends have also been argued on the basis of alluvial pollen and stable isotopes from western Syria and Turkey for the period from 3150 to 2800 cal yr BP (~1200–850 BCE) (Kaniewski et al., 2010; Riehl et al., 2012; Roberts et al., 2011). In the long-term, this represents the last of three major climate oscillations between 5300 and 2800 cal yr BP that mark the transition from the Mid-Holocene to the modern arid conditions of the Late Holocene (Riehl et al., 2012; Roberts et al., 2011).

While evidence for this late second millennium BCE episode of aridification may be growing, its impact on agro-pastoral production is far from clear. Studies of modern subsistence farmers and

Fig. 7. Map of Jordan's Karak Plateau identifying Late Bronze Age settlements documented in Miller's survey (Image: A. Wilson).

pastoralists suggest that while adaptations to climate change can be modeled as rational attempts by households to reduce risk, these decisions depend heavily on contextual factors such as household wealth, labor supply and family structure (Mace, 1993; West, 2009). With regard to the earlier, more dramatic, episode of aridification in the Levant at the end of the third millennium BCE, the point has frequently been made that the socio-economic outcomes of this episode were neither linear nor uniform (Riehl, 2012).

Connecting extensification in west-central Jordan to late second millennium BCE climate change is further complicated by the fact that the relevant archaeological time scales are finer than those of the environmental proxies. The entire cycle of early Iron Age settlement foundation and abandonment occurs well within this three hundred and fifty year period of increasing aridity. In addition, producers at the end of the mid-Holocene were already living in a landscape defined by severe anthropogenic deforestation and erosion (Barton et al., 2010; Cordova, 2007: 192–195). Hence, it is difficult to predict the practical impact of moderate climate change under these circumstances.

What is clear is that early Iron Age settlement patterns do not suggest a gradual dispersal away from higher rainfall zones on the western half of the Karak Plateau. Figs. 7 and 8 illustrate the distribution of Late Bronze Age and Early Iron Age settlements, respectively, identified in Miller's survey of the entire Karak Plateau (Miller, 1991). A comparison between these maps indicates that settlements were distributed throughout the plateau regardless of precipitation amounts and soil quality. Indeed, if anything, these patterns suggest that during the Early Iron Age nucleation and settlement density were higher along the Wadi al-Mujib and its tributaries than in the higher rainfall zones to the west and south. If aridification played a role in late second millennium settlement extensification in west-central Jordan, it did so by increasing the

Fig. 8. Map of Jordan's Karak Plateau identifying Early Iron Age settlements documented in Miller's survey (Image: A. Wilson).

relative attractiveness of the wadis' well-watered riparian zones rather than by forcing settlers out to the margins of the plateaus.

5.2.2. Population growth

The early Iron Age is a period of regional population growth, both in west-central Jordan and in the Levant as a whole. Much of this growth is credited to a combination of population movement and wide-spread sedentarization of pastoral nomadic populations (LaBianca, 1990; Stager, 2001). Under a Boserupian model of agricultural change (Boserup, 1965), one might expect early Iron Age extensification on the Karak Plateau to be driven by this increase in the sedentary population during the early Iron Age.

One problem with a Boserupian explanation is that despite growth, population densities remain quite low during the early Iron Age since growth began from the extremely low levels of population density reached during the Late Bronze Age. Fig. 7 shows the 29 Late Bronze Age settlements identified during a vehicular survey of the Karak Plateau, while Fig. 8 shows 25 Early Iron Age settlements, with only a difference of four settlements (Miller, 1991: 308–309). Granted, only settlements where more than five ceramic vessel sherds were recovered during survey are considered here (For a complete list of Late Bronze and Early Iron Age settlements, see Miller, 1991: 308–309). The available evidence makes it admittedly difficult to estimate carrying capacities on the Karak Plateau under Late Bronze Age and early Iron Age production regimes. However, the much higher population densities supported in the same region during the later Iron Age, or at many other points in the premodern past, makes it hard to accept that population pressure on resources necessitated the settlement of the Karak Plateau's semi-arid margins.

A form of population pressure may help explain the spread of settlement along the Wadi al-Mujib and its tributaries. While KMA is the only settlement for which radiocarbon dates are available, published ceramic vessels from several neighboring settlements suggests that some, such as Lahun and Balu'a, may have been founded slightly earlier than others such as KMA. Hence, it is possible that new settlements were founded along the al-Mujib watershed as the result of "budding off" from older settlements. While the cause of village fissioning is far from certain, the regular spacing of settlements and their orientation to circumscribed riparian zones suggests that resource availability could have played a role in encouraging the foundation of new settlements at other points in the wadi system. Population pressure in this sense may be the proximate cause of settlement foundation, however, the ultimate cause is a preference for nucleated settlement and access to the resources in the wadi riparian zones.

5.2.3. Political economy

In synthesizing his pioneering archaeological surveys of Transjordan in the 1930s, Nelson Glueck suggested that settlements such as KMA were border forts defending a 13th century BCE kingdom of Moab in keeping with expectations drawn from the Hebrew Bible's account of the Israelite Exodus (e.g., Numbers 21–36) (e.g., Glueck, 1940: 167–172). While his overall synthesis has been systematically undermined (e.g., van der Steen, 2009), Glueck's interpretation of KMA as a border fort has persisted and has been given an extensive restatement in a recent article by Finkelstein and Lipschits (2011). While rejecting both the chronology and biblical content of Glueck's synthesis, Finkelstein and Lipschits point to the isolated locations and prominent fortifications of early Iron Age settlements along the Wadi al-Mujib as evidence for the existence of a complex polity centered on Balu'a and protected by a ring of border fortresses, including KMA. In Finkelstein and Lipschits's model, the proximate cause of early Iron Age settlement on marginal land in the Eastern Karak Plateau is the military sponsorship of a centralized polity. The ultimate cause, they argue, is the growth of copper mining and smelting operations in the Wadi Faynan, immediately south of the Dead Sea and southwest of the Karak Plateau (Levy et al., 2012). Finkelstein and Lipschits speculate that the existence of overland trade routes in copper from Wadi Faynan provided the surplus wealth necessary for the development of a centralized polity on the Karak Plateau while at the same time generating interests that required military protection in the form of fortified settlements.

The excavated evidence from KMA raises two problems for Finkelstein and Lipschits's political model of settlement on the Eastern Karak Plateau. The first is that within KMA's admittedly very substantial fortifications, one finds standard domestic dwellings strongly oriented towards storage within a subsistence regime closely tied to local resources rather than specialization and exchange. This carries over to the second problem, which is the near absence of evidence for trade, non-local production or other extra-settlement contacts. This is particularly notable in terms of the very small number of metal objects recovered in excavations at KMA.

Where the regional political economy may come into play is in the abandonment of KMA and related settlements along the Wadi al-Mujib and its tributaries during the first half of the tenth century BCE. Radiocarbon dating now makes clear that the abandonment of KMA is closely contemporary with a major shift in the scale of copper smelting in the Wadi Faynan, marked by the abandonment of small-scale production sites like Khirbat al-Jariya and the massive expansion of production at the central smelting site of Khirbat an-Nahas (Ben-Yosef et al., 2010). In relative chronological terms, rural settlement abandonment at the end of the Iron Age IB period is also widely attested in Israel and Palestine, although this interpretation of the archaeological record has been contested (Faust, 2003, 2007; Finkelstein, 2005). In both cases, this evidence has been interpreted as the result of late 10th century BCE state-formation, with populations being consolidated in larger centers for the sake of security and surplus extraction, while the production of key commodities was centralized to facilitate their control. Hence, KMA may be indicative of state-formation not in its foundation but in its abandonment.

5.3. Extensification episodes on the Eastern Karak Plateau over time

Early Iron Age settlement on the Wadi al-Mujib and its tributaries shows a clear preference for nucleation, strongly fortifiable locations, generous settlement spacing and proximity to the diverse resource base of the riparian zones of wadi bottoms. The failure of "push" factors, such as climate, population or political economy to account for this episode of extensification leads one to focus on the pull of an open frontier with distinct and circumscribed resources. The low density of settlement in west-central Jordan, combined with the unstable and underdeveloped nature of regional political and economic structures, favored settlement foundation in unoccupied frontier zones as a pathway to socioeconomic differentiation in the Early Iron Age (Routledge, 2004: 112–113).

The early Iron Age was not the first time that these changes occurred. During the Early Bronze Age II–III period (c. 3100–2300 BCE) nucleated settlement on the Eastern Karak Plateau was even more pronounced than in the early Iron Age (Fig. 9). Settlements are fewer and much larger during this period (Chesson et al., 2005; Jones, 2006), although there are also numerous cairns and small megalithic features that may point to a poorly understood pastoral nomadic component to the population (Worschech, 2002). Much as in the early Iron Age, Early Bronze Age settlements exhibit a subsistence economy based on agro-pastoralism supplemented by small-scale gathering of animal and plant resources found in the riparian zones of the Wadi al-Mujib and its tributaries (Charles, n.d.; Chesson et al., 2005; Makarewicz, 2005). Lejjun is a 10 ha fortified settlement whose occupation is dated by two long-lived radiocarbon dates with a 2-sigma range of 3087–2917 calBC (Charles, n.d.; Chesson et al., 2005: 20–25, 27–33; Jones, 2006). These dates have been re-calibrated by the present authors to a two-sigma range using the IntCal09 calibration curve and modeled as a single combined phase in OxCal 4.01. Lejjun is adjacent to 'Ain Lejjun, a spring with significant flow volume at the head of the Wadi al-Nukhayla. Subsequent to Lejjun's abandonment, the 5.5 ha settlement of Khirbat al-Minsahlat (Chesson et al., 2005: 19–20; 33–37; Makarewicz, 2005) was settled during the Early Bronze III/IV periods. Three radiocarbon dates on long-lived samples have two sigma ranges between 2866 and 2307 calBC, with the highest probability of overlap falling between 2600 and 2400 BCE (Chesson et al., 2005: 36). Khirbat al-Minsahlat also appears to have been fortified and is situated adjacent to the Wadi Hmoud, a seasonal water course without active springs but in a higher rainfall zone (c. 300 mm/yr) northwest of Lejjun.

Attested crops include cereals (barley being preferred over wheat), chick pea, lentil, olive, and grape (Chesson et al., 2005: Table 2). Faunal analysis (Chesson et al., 2005: 37–43; Makarewicz, 2005) indicates that sheep and goats were by far the most popular animals, with goats being slightly favored over sheep. Cattle are more common at both Lejjun and al-Minsahlat than at KMA, while pigs are similar in their rarity, being absent from Lejjun and constituting $<1\%$ of the assemblage at al-Minsahlat. While also constituting a small percentage of the assemblage, the wild taxa present at both Lejjun and al-Minsahlat are interesting in that they indicate the exploitation of wild resources available in both the steppes and the adjacent wadi systems. This includes gazelle, roe

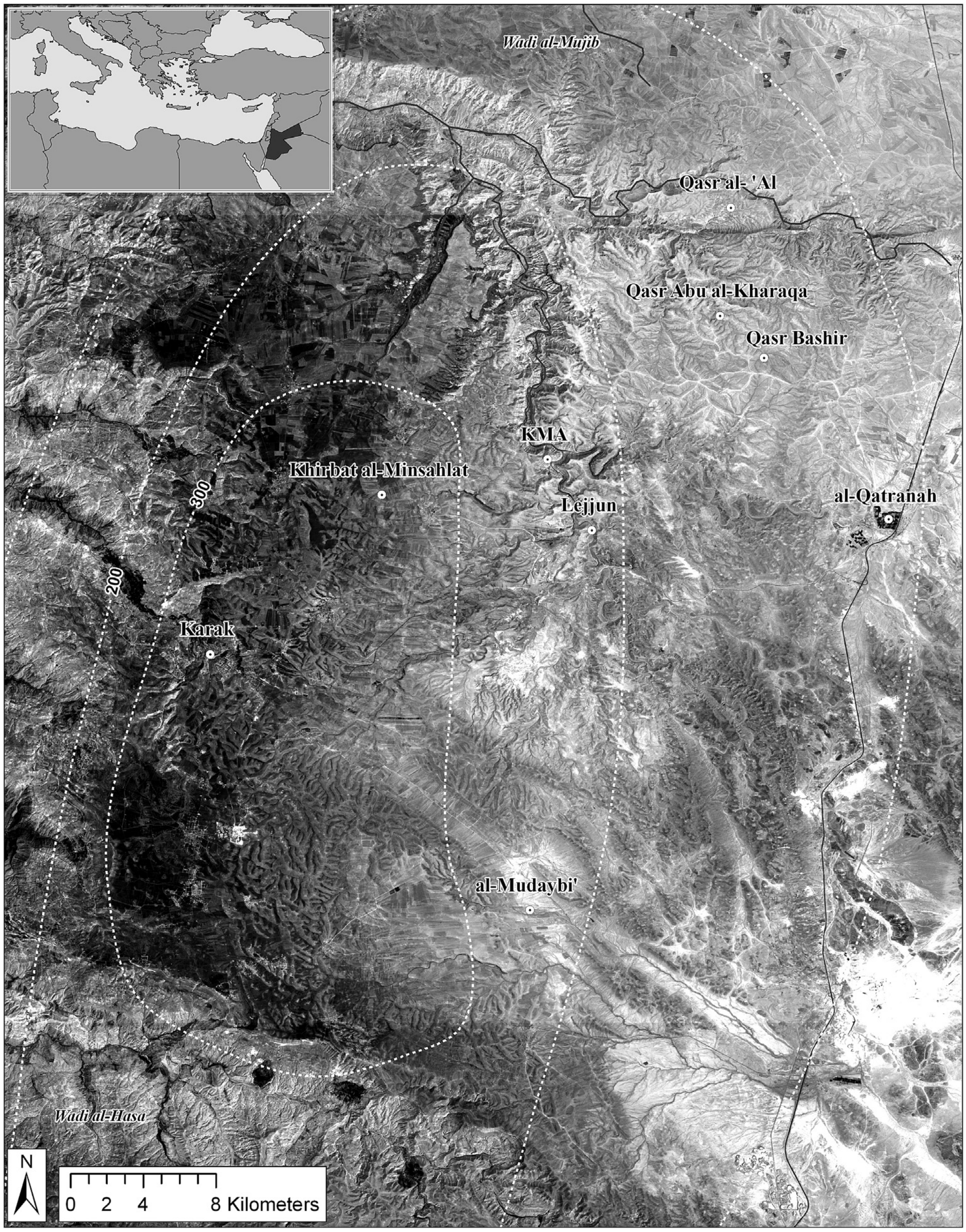

Fig. 9. Map of Jordan's Karak Plateau identifying some Early Bronze Age, Iron Age, Classical, and Islamic settlements mentioned in the text (Image: A. Wilson).

deer, oryx, various birds and, in the case of al-Minsahlat, freshwater crab.

Like the Early Iron Age, Early Bronze Age settlement on the Eastern Karak Plateau favored nucleation, fortification, generous settlement spacing and the use of local wild resources to supplement domestic crops and animals. Whether this also included village-based herding supported by foddering is less clear (Charles, n.d.). Much as in the early Iron Age, Early Bronze Age settlement density on the Western Karak Plateau was unlikely to have required extensification to the east unless there was already an overriding commitment to nucleation, local resource exploitation and exclusive, rather than nested, settlement territories.

In contrast to the Early Bronze and early Iron Age episodes of extensification, settlement on the Eastern Karak Plateau in later centuries demonstrates a different pattern. Four later episodes, in the Iron Age IIC the 7th–6th centuries BCE (Routledge, 1996, 2004: 192–201), Nabataean-Early Roman (c. 100 BCE–106 CE), Late Roman through Byzantine (c. 284–551 CE) (Parker, 2006), and Middle Islamic (c. 1250–1516 CE) (Brown, 1984) periods, occurred while the Karak Plateau was under the sway of external empires, the Assyrian, Roman, Byzantine, and Mamluk Empires, respectively. In each of these cases settlement is characterized by a combination of military forts and dispersed farmsteads and towers extending to the very edge of the desert margins.

The subsistence practices at the Roman legionary fort of Lejjun (c. 284–551 CE), sitting adjacent to the Early Bronze Age settlement, appear surprisingly similar to the strategies already seen for nucleated settlements in the Early Bronze and early Iron Ages (Parker, 2006). Rather than being provisioned, wheat, barley and olives are clearly being cultivated near the settlement, with the barley showing limited cleaning consistent with foddering (Crawford in Parker, 2006). Legumes, grapes and figs are also common and likely cultivated locally, although direct evidence for this is lacking. Possible indications of either external provisioning, or intensive irrigation, are the presence of date and peach pits. The presence of a small number of trade amphorae that probably contained wine is another indication of some external provisioning of the fort. Unsurprisingly, animal husbandry is dominated by goats and sheep. As with the earlier settlements, cattle and pigs follow in much smaller quantities, although now chickens are also present as a significant minority (Toplyn in Parker, 2006). Resource gathering in both steppic and riparian zones is also attested by small numbers of gazelles, hares, birds and freshwater crabs (Toplyn in Parker, 2006).

An important difference between these later settlement episodes and the Early Bronze and Early Iron Age episodes is the multiple very small settlements found dispersed away from the riparian zones of the major wadis, reaching east to the edge of the desert steppe (Clark, Koucky and Parker in Parker, 2006). While these dispersed settlements include clear secondary forts, such as Qasr Bishir, Qasr al-'Al and Qasr Abu al-Kharaqa, as well as pastoral-related stone rings and campsites, at least 83 are settlements consisting of one or two rectangular buildings sometimes surrounded by a boundary wall (Clark, Koucky and Parker in Parker, 2006; Routledge, 2004: Figs. 9.3–9.5). While some scholars have assigned an exclusively military role to these sites as signaling towers, their large number and frequent association with terraces and check dams suggests an agricultural role (Routledge, 1996; contra Parker, 2006). The dispersal of such settlements away from the riparian zones of the major wadis means that they occupied extremely marginal land with significant soil moisture deficits and very few wild resources to supplement diets. Furthermore, the single household isolates were more vulnerable to predation and could not spread risk and pool resources as effectively as multi-household nucleated settlements. What they could do was occupy more of the landscape more intensively, exploiting micro-catchments through investment in landesque capital such as terracing and check dams. In other words, they held the potential to increase both overall and per capita production on the Eastern Karak Plateau. At the same time, it is also clear that dispersed settlement was more risk laden than nucleated settlement. For this reason, dispersed settlements were linked to state-sponsored forts, both for the military protection that these forts supplied and for what they represented in terms of the increased demand of a more densely settled and managed landscape on the Western Karak Plateau.

6. Conclusion

Architectural, faunal, and archaeobotanical evidence demonstrate that KMA's households organized themselves in a nucleated arrangement focused around the distinct resource base of circumscribed riparian zones in the Wadi al-Nukhayla. This pattern was repeated by similar early Iron Age settlements elsewhere along the Wadi al-Mujib and its tributaries and has parallels with earlier, Early Bronze Age settlements along the same wadi systems. In neither case do population densities, nor political or economic developments in the better watered portions of the Karak Plateau provide a clear impetus that would explain the founding of nucleated settlements in the semi-arid Eastern Karak Plateau in terms of the "push" factors discussed earlier.

While the Eastern Karak Plateau would be considered agriculturally marginal in most systems of land classification, such universal criteria are not necessarily relevant to understanding early Iron Age settlement. For people already committed to living in highly defendable, nucleated settlements, and seeking a stable water supply and a diverse resource base on which to build a resilient subsistence economy, the wadi edges of the Eastern Karak Plateau offered many advantages despite low rainfall and poor soils. In this context, there is no simple equation between, for example, rainfall and the marginal utility of land, nor is there any need for "push" factors as the wadis provide their own "pull."

Therefore, early Iron Age lifestyles imposed strict limits on the scale of agro-pastoral production, the size and spacing of settlements, as well as herd and human population levels. Going beyond these limits meant spreading out on the landscape, investing in landesque capital, living less autonomously in terms of markets and centralized powers and doing so with fewer options in terms of spreading and mitigating risk. In contrast to earlier nucleated settlement systems, dispersed settlement on the Eastern Karak Plateau were tied to the "push" factors of market and tribute demand, and perhaps also population pressure. This is marked by the fact that it is always co-terminus with peak settlement densities on the Western Karak Plateau as well as evidence for state investment in the eastern frontier as typified by the building of forts.

While considerably more research is needed on the settlement and settlement systems discussed in this paper, one interesting outcome of this longitudinal study is to illustrate how different producers can develop the same landscape in very different ways. From this perspective, marginal land ceases to be a stable category, but always and only exists in relation to the mode of settlement and system of production through which human beings (and other animals) engage with that land.

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