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The Origins of Agriculture in the Near East

by Melinda A. Zeder

The emerging picture of plant and animal domestication and agricultural origins in the Near East is dramatically different from that drawn 16 years ago in a landmark article by Bar-Yosef and Meadow. While in 1995 there appeared to have been at least a 1,500-year gap between plant and animal domestication, it now seems that both occurred at roughly the same time, with initial management of morphologically wild future plant and animal domesticates reaching back to at least 11,500 cal BP, if not earlier. A focus on the southern Levant as the core area for crop domestication and diffusion has been replaced by a more pluralistic view that sees domestication of various crops and livestock occurring, sometimes multiple times in the same species, across the entire region. Morphological change can no longer be held to be a leading-edge indicator of domestication. Instead, it appears that a long period of increasingly intensive human management preceded the manifestation of archaeologically detectable morphological change in managed crops and livestock. Agriculture in the Near East arose in the context of broad-based systematic human efforts at modifying local environments and biotic communities to encourage plant and animal resources of economic interest. This process took place across the entire Fertile Crescent during a period of dramatic post-Pleistocene climate and environmental change with considerable regional variation in the scope and intensity of these activities as well as in the range of resources being manipulated.

Introduction

Eighteen years ago, a week-long seminar was held in Santa Fe, New Mexico, that, much like the Wenner-Gren Mérida conference featured in this special issue of *Current Anthropology*, focused on the context, timing, and possible causes of the emergence of agriculture in different world areas. Sponsored by the School of American Research, this seminar resulted in the publication of an influential edited volume, *Last Hunters, First Farmers: New Perspectives on the Prehistoric Transition to Agriculture* (Price and Gebauer 1995), a comprehensive global overview of agricultural origins. The contribution by Ofer Bar-Yosef and Richard Meadow, in particular, provided a richly detailed account of the transition from foraging to farming in the Near East (Bar-Yosef and Meadow 1995). The scope and breadth of the Bar-Yosef and Meadow article likely explains why it has been the most authoritative and most widely cited synthesis of Near Eastern agricultural origins. This work, then, serves as an ideal benchmark against which to measure advances in our understanding of Near Eastern plant and animal domestication and agricultural emergence in the years between the Santa Fe and Mérida conferences.

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Near Eastern Agricultural Origins: 1995

While comprehensive in its geographic scope, Bar-Yosef and Meadow (1995) had a special emphasis on the Levant, especially on the southern Levant (figs. 1, 2). Decades of survey and excavation, especially in the parts of the Levant that fell within the borders of modern Israel, had yielded a remarkably detailed and well-controlled archaeological record of the transition from foraging to farming in this part of the Near East. Similar coverage had not yet been accomplished in other parts of the Fertile Crescent. When the Bar-Yosef and Meadow article was published, documenting domestication in plants and animals required the detection of morphological modifications caused by domestication. In cereals, the marker of choice was the development of a tough rachis, a change in the plant's dispersal mechanism thought to arise when humans sowed harvested cereal grains. In pulses, the primary domestication marker was an increase in seed size, a response to seedbed pressures that allowed sown seeds to germinate more quickly and shade out competing seedlings. In animals, archaeozoologists relied primarily on the demonstration of overall body-size reduction, held to be a rapid response to herd management.

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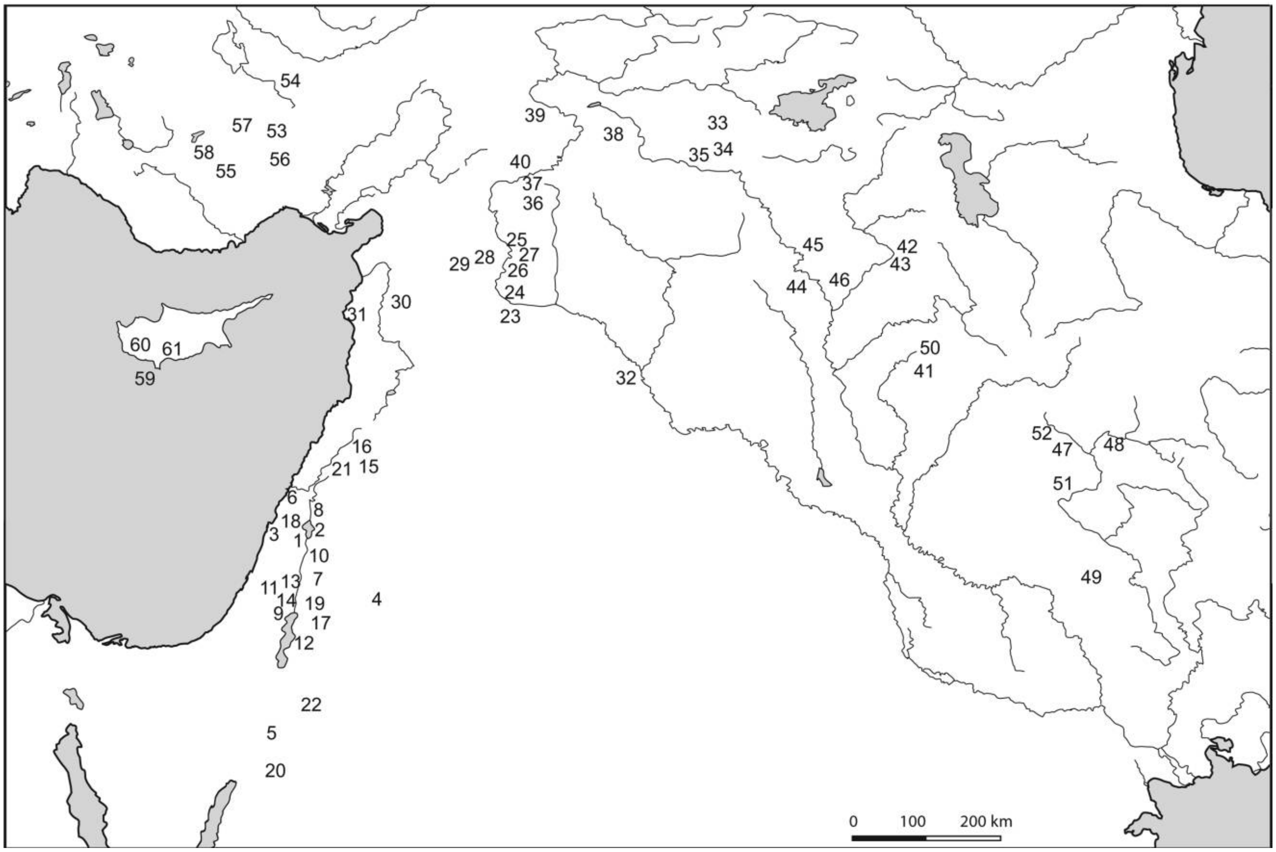

Figure 1. Distribution of main Late Epipaleolithic and Neolithic sites in the Near East. *1*, Ohalo II; *2*, Ein Gev IV; *3*, Neve David; *4*, Kharaheh IV; *5*, Beidha; *6*, Hayonim; *7*, Wadi al-Hammeh 27; *8*, Ain Mallaha; *9*, Jericho; *10*, Iraq ed Dubb; *11*, Hatoula; *12*, Dhra; *13*, Netiv Hagdud; *14*, Gigal I; *15*, Aswad; *16*, Ghoraife; *17*, Wadi el-Jilat 7; *18*, Yiftah'el; *19*, Ain Ghazal; *20*, Basta; *21*, Ramad; *22*, Khirbet Hammam; *23*, Abu Hureyra; *24*, Mureybit; *25*, Dja'de; *26*, Jerf el Ahmar; *27*, Kosak Shamali; *28*, Halula; *29*, Qaramel; *30*, Tel el-Kerkh; *31*, Ras Shamra; *32*, Bouqras; *33*, Hallan Çemi; *34*, Demirköy; *35*, Körtik; *36*, Göbekli Tepe; *37*, Nevali Çori; *38*, Çayönü; *39*, Cafer Höyük; *40*, Grittle; *41*, Palegawra; *42*, Shanidar cave; *43*, Zawi Chemi Shanidar; *44*, Qermez Dere; *45*, Nemrik; *46*, M'lefaat; *47*, Asiab; *48*, Ganj Dareh; *49*, Ali Kosh; *50*, Jarmo; *51*, Guran; *52*, Sarab; *53*, Pinarbassi A; *54*, Aşikli Höyük; *55*, Suberde; *56*, Can Hasan III; *57*, Çatal Höyük; *58*, Erbaba; *59*, Aetokremnos; *60*, Mylouthikia; *61*, Shillourokambos.

Based on these criteria, crop domestication was thought to have originated in the southern Levant during the Pre-Pottery Neolithic A (PPNA) period, around 11,500–11,000 cal BP (fig. 2). Animal domestication seemed to have been a delayed development, with different livestock species brought under domestication in different parts of the region (from the Levant to the Zagros), beginning with goats sometime during the Middle Pre-Pottery Neolithic B (PPNB), around 10,000 cal BP, followed by sheep, with cattle and pigs domesticated later still. While livestock and some crop plants may have been domesticated in other parts of the Fertile Crescent, the southern Levant was thought to be the home of initial cultivation from which domesticates and domestic technology spread quickly into the rest of the Fertile Crescent through an "uneven series of movements affecting different areas at different times" (Bar-Yosef and Meadow 1995:41). The coalescence of disparate elements of this subsistence system into an agricultural economy was thought to have occurred over a 2,000-year period, from about 10,000 to 8000 cal BP, during which

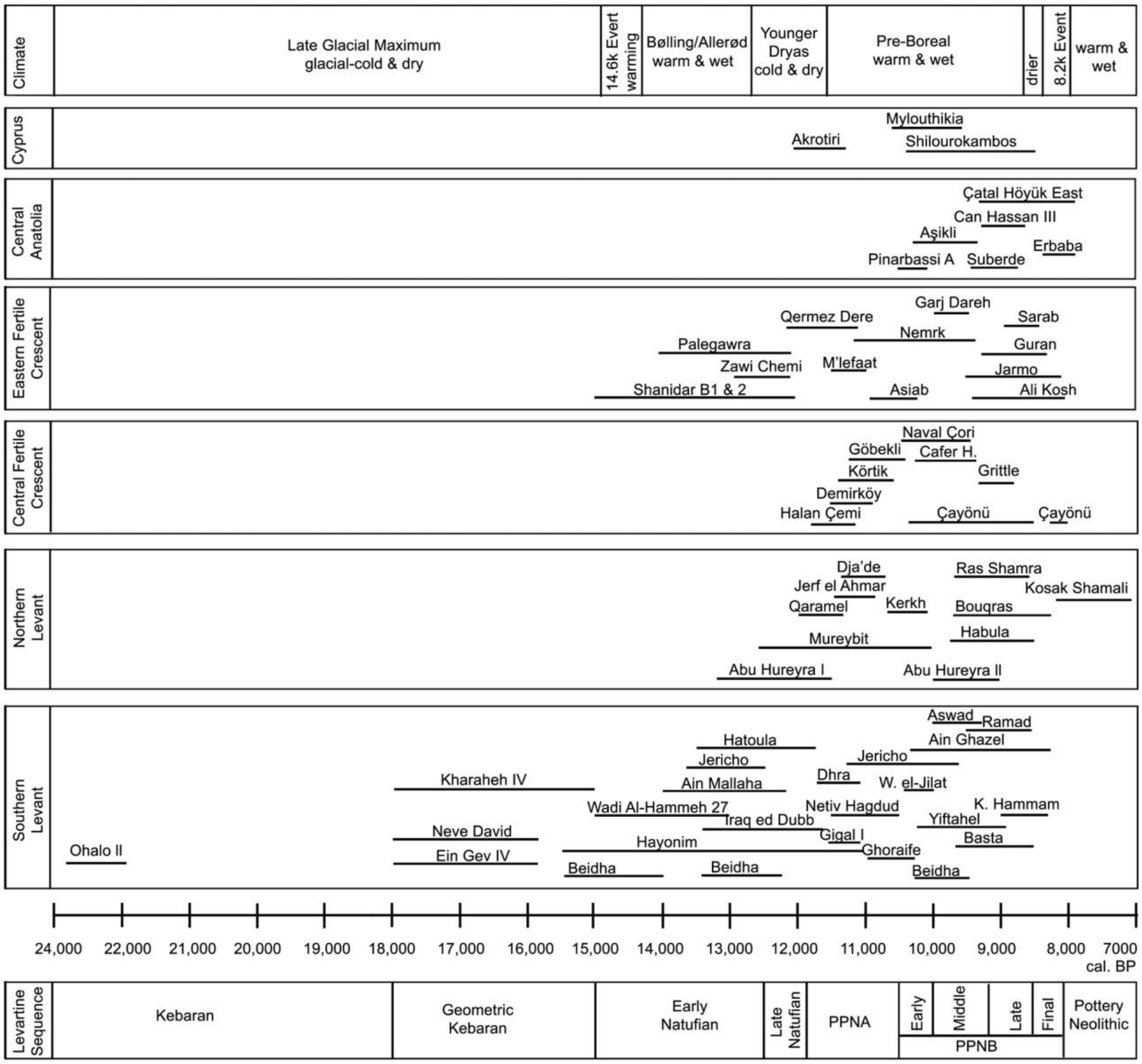

Figure 2. Time line of Near Eastern sites, Levantine chronology, and climatic conditions compiled using information from Aurenche et al. (2001); Bar-Yosef and Meadow (1995); Byrd (2005); Kuijt and Goring-Morris (2002); Nesbitt (2002); and Willcox (2005). PPNA, PPNB = Pre-Pottery Neolithic A and B, respectively.

time it gradually became the dominant subsistence economy throughout the region.

Near Eastern Agricultural Origins: 2010

In the 16 years since publication of Bar-Yosef and Meadow (1995), there has been an exponential increase in information on this transition not only from the southern Levant but also from other parts of the Fertile Crescent that had not been as thoroughly explored in 1995. A number of new archaeobiological approaches to documenting domestication have been developed that are providing powerful new insights into the initial phases of domestication in both plants and animals. Also contributing to the emerging picture of Near Eastern agricultural origins are genetic analyses that have identified the progenitors of Near Eastern domestic crops and livestock species and defined the likely geographic regions of their domestication. More widespread use of small-sample accelerator mass spectrometry (AMS) radiocarbon dating has made it possible to directly and precisely date the remains of domestic plants and animals, greatly enhancing the temporal control of our understanding of this transition. The result is a vastly changed picture of the origins of agriculture in the Near East.

New Archaeological Insights into Plant Domestication

Cereals. When Bar-Yosef and Meadow (1995) was written, the presence of a few large domestic grains of einkorn (*Triticum monococcum* cf. *monococcum*) and rye (*Secale* cf. *cereale*) from Epipaleolithic levels at Abu Hureyra I had raised the possibility that initial cereal domestication occurred in the northern Levant during the Younger Dryas climatic downturn (Hillman, Colledge, and Harris 1989). Subsequent AMS dating of these grains found that, as suspected, most were intrusive from Middle PPNB levels. However, three grains of domestic-morphotype rye were found to date to between 13,000 and 12,000 cal BP, and on the basis of this early date, Hillman argued that these grains represented the earliest morphologically altered domestic cereals in the Near East (Hillman 2000; but see Nesbitt 2002:118–119). Hillman acknowledged that grains consistent in size with domestic varieties are known to occur in low numbers in wild cereals but argued that the probability of finding these rare mutant forms within archaeological assemblages of collected wild rye was essentially zero (Hillman 2000:382). If rye was domesticated at this early date, however, it does not seem to have made much of a mark on Near Eastern subsistence economies. With the onset of warmer and wetter climatic conditions in the Early Holocene, the utilization of this cool-climate cereal first declined and then ceased altogether in the Middle Euphrates (Willcox, Fornite, and Herveux 2008). Domesticated rye is not seen again for another 2,000 years, when it is found in low numbers in central Anatolia at Can Hasan III (ca. 9400 cal BP; Hillman 1978). Never a prominent component of Near Eastern cereal crops, modern domestic rye traces its heritage to European wild rye (Weiss, Kislev, and Hartmann 2006).

Arguments advanced in 1995 for the appearance of morphologically altered domestic barley and emmer during the PPNA in the southern Levant have been largely overturned in the intervening years (Weiss and Zohary 2011). When Bar-Yosef and Meadow (1995) went to press, the handful of tough-rachis barley *Hordeum vulgare* ssp. *distictum* found among the thousands of brittle-rachis wild barley grains *H. vulgare* ssp. *spontaneum* recovered at Gigal and Netiv Hagdud in the southern Levant seemed likely candidates for the earliest domesticated cereal crop. Although this evidence was questioned at the time by Kislev (1989, 1992), who maintained that the low proportion of tough-rachis barley in the Netiv Hagdud assemblage was consistent with the representation of this morphotype in wild stands, others seemed more comfortable with the attribution of these cereal remains as domestic (i.e., Bar-Yosef and Meadow 1995:66–67; Hillman and Davies 1992; Zohary 1992). There is now a more general consensus that tough-rachis grains must constitute at least 10% of a cereal assemblage before it can be considered domestic (Tanno and Willcox 2006*a*; Weiss, Kislev, and Hartmann 2006). This means that the barley recovered from these early sites (where tough-rachis varieties constitute about 4% of the total barley recovered) more likely represent intensively collected and possibly cultivated morphologically wild cereals (Kislev 1997; Weiss, Kislev, and Hartmann 2006). The application of AMS dating to carbonized material recovered from new excavations at Tell Aswad has moved up the dates of the more securely identified domesticated emmer and barley from this site. Originally thought to date to the PPNA (ca. 11,500 cal BP), the levels that yielded these domestic cereals are now known to date to the end of the Early and beginning of the Middle PPNB (ca. 10,300–10,000 cal BP; Stordeur 2003; Willcox 2005).

Nesbitt's comprehensive evaluation of the evidence for the appearance of domesticated cereals in the Near East concludes that the evidence for morphologically altered cereal domesticates before about 10,500 cal BP is either too poorly documented or too poorly dated to be accepted as marking the initial threshold of cereal domestication (Nesbitt 2002). The earliest securely identified and dated domestic emmer (*Triticum turgidum* ssp. *dicoccum*) and einkorn (*T. monococcum* ssp. *monococcum*) grains and chaff, according to Nesbitt, come from sites in the Upper Euphrates valley (Nevali Çori, Cafer Höyük, and possibly Çayönü) that date to the Early PPNB, at about 10,500–10,200 cal BP. Nesbitt contends that securely identified and dated domestic barley is not seen until the Middle PPNB, when it is found throughout the Fertile Crescent and Anatolian Plateau.

Additional evidence for the late or at least delayed appearance of morphologically domestic cereals in the Near East is provided by Tanno and Willcox (2006*a*), who document the gradual increase in the proportion of tough-rachis domestic morphotypes among wheat and barley recovered from sites in the Middle and Upper Euphrates valley. Domestic morphotypes constitute only 10% of the single-grained einkorn recovered from Nevali Çori (ca. 10,200 cal BP), barely meeting the threshold for demonstrating the presence of domestic cereals. Only 35% of the barley recovered from somewhat later levels at Aswad (10,200–9500 cal BP) and a little over 50% of the barley recovered from Ramad (9500–8500 cal BP) are nonshattering varieties. Even as late as 7500 cal BP, domestic morphotypes constitute only around 60% of the two-grained einkorn recovered from Kosak Shamali, a variety that Willcox postulates represents a second domestication of diploid wheats (Willcox 2005:537).

Pulses. Although substantial quantities of lentils had been recovered from PPNA sites in both the southern and the northern Levant by 1995, the absence of clear morphological markers of domestication (i.e., larger seed sizes) precluded Bar-Yosef and Meadow from drawing any conclusions about their domestic status. However, Weiss, Kislev, and Hartmann (2006; also Weiss and Zohary 2011) and Tanno and Willcox

(2006*b*; also Willcox, Buxó, and Herveux 2009; Willcox, Fornite, and Herveux 2008) have subsequently concluded that the hundreds of lentils found in storage bins at Netiv Hagdud and Jerf el Ahmar are unlikely to represent wild, unmanaged plants. Wild lentils, they argue, are not a common component of Near Eastern plant communities, and the yield of seeds per plant, at about 10–20, is very low. Moreover, wild lentils have an exceptionally high rate of seed dormancy; only about 10% of wild lentil seeds germinate after sowing. Thus, the quantity of lentils recovered from these of PPNA sites suggests that lentils were likely being transplanted from wild patches, aggregated in new environments, and tended by humans. Weiss, Kislev, and Hartmann (2006) also argue that these early lentils had undergone a lowering in the rate of seed dormancy and an increase in the number of seeds per plant, initial steps toward domestication that would not be archaeologically detectable.

Similarly, Tanno and Willcox (2006*b*) maintain that the chickpeas (*Cicer* sp.) recovered from Tel el-Kerkh (ca. 10,200 cal BP) in northwestern Syria represent an early stage in the cultivation of this well-known Near Eastern crop plant. While these are not definitively domestic morphotypes, the high degree of morphological variability of the chickpeas from this site, together with the rarity and sparseness of wild chickpea stands (which do not grow in the region today), is again suggestive of intentional transplanting and cultivation. A similar case is made for the faba beans (*Vicia faba*) recovered from this site (Tanno and Willcox 2006*b*). Although not as large as modern faba beans, they are very similar to the faba beans recovered in large numbers from the Late PPNB (ca. 8800 cal BP) at Yiftah'el (Garfinkel, Kislev, and Zohary 1988), which are almost certainly cultivated varieties. In fact, the large-seeded modern variety of faba bean is not seen in the Near East until about AD 1000 (Tanno and Willcox 2006*b*).

Figs. Recently, Kislev, Hartmann, and Bar-Yosef (2006*a*) have argued that the earliest morphologically altered plant domesticate in the Near East was neither a cereal nor a pulse but a tree crop. The presence of parthenocarpic figs at the PPNA site of Gigal in the southern Levant (ca. 11,400–11,200 cal BP) has been interpreted as a clear indication of human selection for this mutant infertile fig variety that remains on the tree longer and develops sweeter, softer fruit. Other researchers have noted, however, that parthenocarpy is known among wild female fig trees (Denham 2007; Lev-Yadun et al. 2006) and therefore, as with the presence of tough-rachis varieties or larger cereal grains in low quantities, their occurrence in an archaeobotanical assemblage cannot be considered definitive proof of domestication. Kislev, Hartmann, and Bar-Yosef (2006*b*) have responded that if, as their critics contend, these figs represent the selective harvest of mutant figs from wild fig trees, at least some seeded varieties would be expected to have been collected along with these rare, naturally occurring parthenocarpic figs. Instead, all of the nine carbonized fruits and 313 single druplets recovered from Gigal represent this infertile variety. Domestication of this shrubby pioneer plant, they maintain, could be accomplished by replanting cut branches of trees that naturally produce these sweeter fruits. Such an activity underscores the degree to which people were likely modifying local environments and biotic communities as well as their willingness to invest in nurturing resources, such as slowly maturing trees, with delayed rewards.

Plant management. There is, in fact, increasing evidence that humans were actively modifying local ecosystems and manipulating biotic communities to increase the availability of certain economically important plant resources for hundreds of years before the manifestation of morphological indicators of plant domestication (Weiss, Kislev, and Hartmann 2006; Willcox, Buxó, and Herveux 2009; Willcox, Fornite, and Herveux 2008). First, the presence of distinctive complexes of weedy species characteristic of fields under human cultivation suggests that humans were actively tilling and tending wild stands of einkorn and rye at both Abu Hureyra and nearby Mureybit during the Late Epipaleolithic (ca. 13,000–12,000 cal BP; Colledge 1998, 2002; Hillman 2000: 378). Increases in this weed complex at Qaramel (ca. 11,500 cal BP) and Jerf el Ahmar (ca. 11,000 cal BP) signals an intensification of plant cultivation in the Middle Euphrates during the ensuing PPNA period (Willcox, Fornite, and Herveux 2008). Willcox, Fornite, and Herveux (2008; also Willcox, Buxó, and Herveux 2009) also interpret the increase in the quantity of wild einkorn in Early Holocene assemblages from the Middle Euphrates sites as additional evidence of human management of this plant. Wild einkorn *T. monococcum* ssp. *baeoticum* is not well adapted to the chalky soils of the Middle Euphrates, and it would not have responded well to the rising temperatures of the Early Holocene. Today the region is too hot and arid for wild einkorn, which can be found only on basalt lava flows 100 km north of Jerf el Ahmar. The dramatic increase in the representation of wild einkorn in Middle Euphrates assemblages over the course of the PPNA to Early PPNB could happen, these authors argue, only if people were actively tending plants transplanted from preferred habitats, altering local microhabitats, removing competition, and artificially diverting water to tended plants (Willcox, Fornite, and Herveux 2008:321). A subtle increase in the thickness and breadth of barley and einkorn grains from these sites without a corresponding increase in grain length is interpreted as a plastic response to cultivation (Willcox 2004). The progressive decrease in indigenous plants of the Euphrates floodplain and the concurrent adoption of and increase in morphologically wild representatives of founder crops such as barley, emmer, lentils, chickpeas, and faba beans have also been used to argue that humans were modifying local plant communities and managing morphologically wild but cultivated cereals and pulses (Willcox, Buxó, and Herveux 2009; Willcox, Fornite, and Herveux 2008). In addition to the quantities of lentils recovered from PPNA sites such as Netiv Hagdud and Gigal, the large number of morphologically wild barley and wild oats (*Avena sterilis*) recovered from these sites (e.g., 260,000 grains of wild barley and 120,000 of wild oats from a single granary at Gigal) suggests that people in the southern Levant were also cultivating plants of economic interest (Weiss, Kislev, and Hartmann 2006).

A study of plant assemblages from the northern Fertile Crescent by Savard, Nesbitt, and Jones (2006) demonstrates that people in the more eastern parts of the Fertile Crescent were also intensively utilizing a wide variety of plant resources, with considerable regional variation in the plant species exploited. Late Epipaleolithic residents of Hallan Çemi, for example, utilized a diverse range of plant species with a special focus on valley-bottom plants such as sea club-rush (*Bolboschoenus maritimus*) as well as dock/knotgrass, large-seeded legumes, and, to a lesser extent, almonds (*Amygdalus* sp.) and pistachio (*Pistacia* sp.). A similar assemblage was found at Demirköy, a nearby site occupied shortly after Hallan Çemi, where a number of as yet unidentified small-seeded grasses, small-seeded barleys (*Hordeum murinum*), and some wild barley (*H. vulgare* cf. *spontaneum*) were also recovered. The plant assemblages from roughly contemporary sites in steppic environments of northern Iraq (Qermez Dere and M'lefaat) are dominated by large-seeded legumes, followed by small-seeded grasses, with small-seeded legumes and wild cereals (barleys and einkorn/rye) also represented.

The antiquity of this broad-spectrum plant-exploitation strategy stretches back at least to the Late Glacial Maximum (ca. 23,000 cal BP), as evidenced by the remarkably well-preserved plant assemblage recovered from the waterlogged Levantine site of Ohalo II, which contained a diverse array of large- and small-seeded grasses and legumes (Piperno et al. 2004; Weiss et al. 2004). There is some indication that the intensive exploitation of this complex of small- and large-seeded cereals, legumes, and other locally available plant resources may reach as far back as the Middle Paleolithic (Albert et al. 2003; Lev, Kislev, and Bar-Yosef 2005). It is still an open question when, over the course of this long period of increasingly intense utilization of plant resources, humans began to actively modify local ecosystems and biotic communities to encourage the availability of economically important plants. But it is clear that by at least 11,500 years ago, humans had brought a number of plant species under cultivation and that except for the manifestation of certain morphological traits seen in later-domesticated varieties, these plants might arguably be considered domesticated crops.

The delayed expression of domestication-induced morphological changes in managed plants (at 10,500–10,000 cal BP in cereals and later still in pulses) may be attributable to the frequent importation of new wild plants when cultivated crops failed (Tanno and Willcox 2006*a*). It is also possible that early harvesting practices may not have encouraged the morphological changes to cereal dispersal mechanisms once thought to be a first-line marker of cereal domestication. Beating ripened grain heads into baskets, for example, or harvesting cereals before they were fully ripe or even gleaning shattered heads of grain from the ground might have led to the retention of the brittle rachis in cultivated cereals (Hartmann, Kislev, and Weiss 2006; Lev-Yadun, Gopher, and Abbo 2006; Tanno and Willcox 2006*a*; Willcox and Tanno 2006). The appearance of morphological change in these founder crops is, then, most likely an artifact of a change in management or harvesting practices of cultivated crops and not a leading-edge indicator of plants being brought under human control.

New Archaeological Insights into Animal Domestication

Caprines. The utility of morphological markers as leading-edge indicators of livestock domestication is even more problematic. This is especially true of body-size reduction, the primary marker used to document animal domestication for the past 30 years. Recent analysis of modern and archaeological skeletal assemblages from the Zagros region has shown that sex and, to a lesser extent, temperature are the most important factors affecting body size in both sheep (*Ovis aries*) and goats (*Capra hircus*). Domestic status, on the other hand, has no effect on the size of female caprines and only a limited effect on males, manifested as a decrease in the degree of sexual dimorphism (Zeder 2001, 2005). This work has also shown that apparent evidence of domestication-induced body-size reduction in Near Eastern archaeological assemblages is not, as had been assumed, the result of a morphological response to human management. Instead, the apparent shift toward smaller animals is an artifact of the different culling strategies employed by hunters, whose interest in maximizing the return of the hunt often results in an archaeological assemblage dominated by large prime-age males (Stiner 1990), and herders, who seek to maximize the long-term growth of a herd by culling young males and delaying the slaughter of females until they have passed peak reproductive years (Redding 1981). Because of various taphonomic factors and methodological practices, the herder's harvest strategy produces an archaeological assemblage dominated by smaller adult females (Zeder 2001, 2008). Comparing assemblages of hunted prey animals primarily made up of large adult males with those of harvested managed animals dominated by smaller females led to the erroneous conclusion that domestication-induced body-size reduction had taken place.

The consistent size difference between the skeletal elements of male and female caprines, however, makes it possible to compute sex-specific harvest profiles for sheep and goats that are capable of distinguishing the herding harvest signature from the hunter's prey strategy. In the central Zagros, the herding signature of young-male harvest and delayed female slaughter is first detected within the highland natural habitat of wild goats among the goat remains from the site of Ganj Dareh, directly dated to 9900 cal BP (Zeder 1999, 2005). The same signal was also detected in the goats from the site of Ali Kosh, located outside the natural habitat of wild goats on the lowland piedmont of southwestern Iran and first occupied at about 9500 cal BP. Progressive changes in the size and shape of goat horns has been noted over the 1,000-year occupation of this site (Hole, Flannery, and Neely 1969). These changes were a direct response to human management that arose when humans assumed control over breeding and eliminated the selective pressure for large horns used in mate competition. The unequivocal signatures of goat management documented in the central Zagros are not, however, the earliest evidence of caprine management in the Near East. As with plants, it now seems that the leading edge of animal management stretches back at least 1,000 years before the manifestation of archaeologically detectable morphological change in managed animals.

Perkins (1964) interpreted the younger age profile of the sheep from the site of Zawi Chemi Shanidar in the northwestern Zagros as evidence of sheep domestication in the Late Epipaleolithic (ca. 12,000–11,500 cal BP). A new analysis of this assemblage finds a prey profile focused on 2–3-year-old male sheep that is, as Perkins noted, a departure from the prime-adult-male strategy detected for goats in Mousterian and Upper Paleolithic levels at nearby Shanidar cave (Zeder 2008). But this demographic profile is also not consistent with the herd-management signature of young-male and delayed female harvest detected for goats at Ganj Dareh and Ali Kosh. A similar focus on 2–3-year-old males has been reported at the roughly contemporary site of Hallan Çemi, 300 km to the northwest of Zawi Chemi and part of the same Taurus/Zagros "round-house tradition" (Redding 2005; Rosenberg et al. 1998). Redding interprets this demographic pattern as a prime-male hunting strategy practiced under conditions of intensive pressure on local wild herds. The eradication of local males by sedentary hunters, he argues, created a vacuum that attracted younger males with less-established home territories from outside regions. This "male sink" effectively assured a continuous supply of preferred prey while preserving a local population of females and young. Although this strategy does not entail the same degree of intentional control over herd demographics found in managed herds, it certainly signals an attempt at increasing the availability of prey by setting a precedent for the slaughter of young males and the preservation of female breeding stock characteristic of herd management. The demographic profile of the sheep remains from Körtik Tepe, a somewhat later (ca. 10,900 cal BP) site located 50 km to the south of Hallan Çemi, has also been interpreted as a transitional strategy between game management and herd management (Arbuckle and Özkaya 2006).

The transition from hunting to herding appears to have been complete by about 10,500 cal BP at Nevali Çori, where, using lower-resolution demographic profiling methods, Peters and collaborators have detected changes in the age and sizes of caprines consistent with the harvest of herded caprines (Peters, von den Driesch, and Helmer 2005; Peters et al. 1999). Sheep seem to have been the initial early focus of herd management here, with managed goats introduced from elsewhere at about 10,200 cal BP (Peters, von den Driesch, and Helmer 2005:111). Helmer's (2008) recent reconsideration of the faunal remains from Cafer Höyük, (ca. 10,300–9500 cal BP), which focuses on sex ratios and harvest profiles, leads him to conclude that sheep (and likely goats) at this site, though morphologically wild, were not hunted animals, as he had originally thought (Helmer 1991). Instead, he maintains that these were "agriomorphic" herded animals, a new term he coins for "domestic animals which are morphologically close to wild ones" (Helmer 2008:169).

At Aşikli Höyük in central Anatolia (ca. 10,200–9500 cal BP), Buitenhuis (1997; also Vigne, Buitenhuis, and Davis 1999) has detected demographic evidence for management of morphologically wild caprines, predominately sheep. Arbuckle's (2008) analysis of faunal remains from Suberde, a site roughly contemporaneous with the latest occupation phases at Aşikli Höyük and the initial occupation of Çatal Höyük (ca. 9500–8900 cal BP), questions the original interpretation of this site as a "hunters' village" (Perkins and Daly 1968). Demographic patterns detected among the caprines at this site (again mostly sheep) are instead argued to represent an early and perhaps transitional form of management of morphologically unaltered animals. Management of morphologically domesticated sheep and goats is found in central Anatolia by 9500 cal BP in basal occupation levels of Çatal Höyük (Russell and Martin 2005).

Moving farther south, the first appearance of goats in the assemblage from Abu Hureyra (ca. 9600 cal BP) is accompanied by demographic data that suggest culling strategies similar to those detected at Ganj Dareh (Legge 1996; Legge and Rowley-Conwy 2000). Goats dominate the assemblage from the site after about 9300 cal BP, reversing a many-millennia emphasis on hunted gazelle. A similar replacement of a once-dominant focus on gazelles by one on goats is seen first in the Jordan Valley during the Middle PPNB (10,000–9200 cal BP), with an emphasis on gazelle still evident on the Mediterranean coastal plain until the Final PPNB/Pre-Pottery Neolithic C (ca. 8500 cal BP; Horwitz 2003; Horwitz et al. 1999; Sapir-Hen et al. 2009). Horwitz interprets demographic patterns observed in morphologically wild goats from Middle PPNB sites in the Jordan Valley (composed of immature males and adult females) as evidence of an ongoing process of independent domestication (Horwitz 1993, 2003). Other researchers have argued that these managed goats were introduced from outside the region (Bar-Yosef 2000; Peters et al. 1999). Managed sheep were a late arrival in the Levant, appearing sometime around 9200 cal BP (Horwitz and Ducos 1998). The introduction of managed sheep was also delayed in the eastern arm of the Fertile Crescent, where a shift toward adult-female-dominated assemblages appears in both highland and lowland sites in the Zagros at about 9000 cal BP (Zeder 2008).

Cattle. The outlines of cattle (*Bos taurus*) domestication in the Near East are still sketchy. Although cattle remains from

Early and Middle PPNB (11,000–10,000 cal BP) sites in the upper and Middle Euphrates valley fall within the size range of wild aurochs (*Bos primigenius*), Helmer finds evidence for a reduction in the degree of sexual dimorphism at several sites (especially at Halula and Dja'de, but less so at Cafer Höyük and Aswad) that he links to an ongoing process of domestication (Helmer 2008; Helmer and Gourichon 2008; Helmer et al. 2005). Cattle from contemporary sites in the same region (i.e., Mureybit III, Jerf el Ahmar, and Göbekli) are still highly sexually dimorphic and are thus seen as representing wild, hunted cattle. Domestic cattle spread slowly out of this heartland of initial domestication, reaching the southernmost reaches of the Levant only during the Late PPNB (9500–9000) at the earliest (Horwitz et al. 1999) and the southern Zagros around 8500 cal BP (Hole, Flannery, and Neely 1969:303).

In the 1960s, Perkins argued for a center of cattle domestication in central Anatolia on the basis of an initial study of remains from Çatal Höyük (Perkins 1969). The analysis of a large sample of remains from the renewed excavations at the site, however, does not support this conclusion (Russell, Martin, and Buitenhuis 2005). Çatal Höyük cattle show no evidence of body-size reduction, as had been claimed by Perkins, and are dominated by older male animals in earlier levels (ca. 9400–8500 cal BP). Final occupation levels at the site (ca. 8500–8300 cal BP) see a shift toward a female-dominated profile, although the continued emphasis on animals older than 4 years of age raises doubts about the domestic status of these animals.

Pigs. In pigs (*Sus scrofa*), a reduction in the size of molars, especially in the length of the M3, is thought to be an early marker of domestication (Flannery 1983). Changes in molar lengths in pigs have been linked to a neotonization of skull morphology, which itself is believed to be an artifact of the selection for reduced aggression in animals undergoing domestication. A similar morphological response is also seen in dogs, where juvenilization of skull morphology is thought to result in tooth crowding and size reduction. Like pigs, dogs are animals thought to have entered into domestication through a commensal route initiated when less wary individuals approached human habitations to scavenge for food (Zeder, forthcoming). It is hard to know, then, whether the initial changes in skull, jaw, and tooth morphology seen in these animals reflect the initiation of a true domestic partnership with humans or simply an adaptation to anthropogenic environments required of commensal animals. The large litter sizes of wild pigs and the demographic partitioning of wild boar herds may result in prey profiles that mimic what might be expected with management, complicating the application of demographic modeling to distinguish between hunting and herding of pigs.

Redding has reported that pigs at Hallan Çemi show some evidence of tooth-size reduction (Redding and Rosenberg 1998). He also interprets an increase in the numbers of pigs through time at the site and data on age and sex as indicative of a developing association between humans and wild boar (Redding 2005; Rosenberg et al. 1998; Rosenberg and Redding 2000). The larger data set from nearby Çayönü clearly shows gradual change in multiple indexes (tooth size, age structure, and biometry) thought to reflect a gradual process in which pigs moved from a wild to a commensal to a fully domestic status (Ervynck et al. 2001). Helmer's (2008) recent reevaluation of the Cafer Höyük fauna leads him to conclude that on the basis of demographic patterns, domestic pigs were present at the site by 10,300 cal BP.

As with sheep and cattle, pigs seem to have spread slowly down the western and eastern arms of the Fertile Crescent. Domestic pigs are thought to have been present in Middle PPNB levels at Aswad (Helmer and Gourichon 2008), but they did not reach the southernmost end of the Levantine corridor until about 9000–8500 cal BP (Horwitz et al. 1999). Domestic pigs have been identified at Jarmo in the northwestern Zagros by 9000 cal BP (Flannery 1983), but they did not reach lowland southwestern Iran until 6000 cal BP (Hole, Flannery, and Neely 1969). Swine are not evident in central Anatolia until sometime after about 8500 cal BP (Martin, Russell, and Carruthers 2002).

New Genetic Insights into Plant and Animal Domestication

Plants. Heun et al.'s (1997) study of domestic einkorn, one of the first multilocus genetic analyses of Near Eastern founder crops, concluded that this crop plant had a monophyletic origin. This work traced the ancestry of all modern domestic einkorn to a single wild population growing on Karacadağ volcano in southeastern Turkey, only a few kilometers from archaeological sites that have yielded the earliest evidence of single-grained einkorn domestication. A monophyletic origin of this domestic cereal is consistent with a highly localized and relatively rapid domestication process (Brown et al. 2008). A subsequent study by Kilian et al. (2007), however, contends that the wild race named by Heun et al. (1997) as the ancestor of domestic einkorn is instead a closely related sister group. This more distant relationship and the high level of genetic diversity evident in domestic einkorn, they maintain, argues against a monophyletic origin of this early cereal crop. Their study does not find support for a polyphyletic model in which multiple geographically and genetically distinct races were separately brought under domestication (see Jones 2004). Instead, they propose a "dispersed specific model" in which multiple local populations of the originally more widely distributed sister race of wild einkorn were taken under cultivation and eventually domesticated multiple times by communities across a broad area. This model is more in line with archaeological evidence indicating that multiple communities from southeastern Turkey to the Middle Euphrates were involved in a protracted process of cultivation of both local and imported wild progenitors of later crop plants (Willcox 2005). Heun, Haldorsen, and Vollan (2008) have since defended their initial determination of a monophyletic origin of single-grained einkorn in southeastern Turkey. They also suggest, however, that the Middle Euphrates may have been the site of the domestication of a now extinct two-grained variety of wheat from *Triticum urartu*, a more arid-adapted wheat that commonly contains two-grained spikelets.

Similarly, earlier genetic analyses of domestic emmer had concluded that this crop plant had a monophyletic origin with the closest living wild population found in the same Karacadağ region identified as the home of einkorn domestication (Özkan et al. 2002). Subsequent studies now point to at least two separate domestications of emmer (Brown et al. 2008). The geographic distance and degree of cultural independence between these events are unclear. In addition to a major domestication event at Karacadağ, Özkan et al. (2005) now think that there may have been another secondary domestication of a population near the Kartal Mountains 300 km to the west of Karacadağ. They find no evidence that populations from the southern Levant were involved in emmer domestication, although there is some indication that populations in Iraq and Iran may have contributed to the gene pool of domesticated emmer (Özkan et al. 2005:1057). Luo et al. (2007) agree that emmer was most likely first domesticated in southeastern Turkey, but they also propose that there was subsequent hybridization and introgression into domesticated emmer from wild emmer in the southern Levant. A less likely scenario for the results of their analysis is that a population of wild emmer was independently domesticated in the southern Levant and later absorbed into the gene pool of domesticated emmer from southeastern Turkey.

Initial indications of a single domestication of barley in the Jordan Valley (Badr et al. 2000) have also recently been revised to accommodate a second domestication of this crop. Morell and Clegg's (2007) study of wild and traditional races of cultivated barley from the Levant to western China has found evidence of the domestication of a variety of barley ancestral to landraces grown in Central and East Asia. Thought to have occurred in the Zagros, this second, geographically quite distinct domestication corresponds well to archaeological evidence that finds domesticated barley in Zagros sites at about 10,000 years ago (van Zeist et al. 1984).

There is also a concordance between archaeological and phylogeographic evidence for pulse domestication. The wild chickpea population genetically closest to domestic chickpeas was found growing at the far western end of the current distribution of this plant in southern Turkey (Sudupak, Akkaya, and Kence 2004), the closest wild samples to Tel el-Kerkh, which, as noted above, yielded early evidence for cultivation of this important Near Eastern pulse crop. Genetic evidence also points to the initial domestication of lentils somewhere in southeastern Turkey or northern Syria (Ladizinsky 1989), where there is early evidence for the initial chickpea cultivation. The appearance of quantities of cultivated lentils at contemporary sites such as Gigal suggests that this pulse crop spread quickly out of the homeland of initial domestication into the southern Levant (Weiss, Kislev, and Hartmann 2006). A separate southern Levantine domestication of a variety of lentils no longer represented among modern domestic lentils cannot, however, be ruled out.

Animals. While there are multiple genetically distinguishable lineages in all major livestock species (Bradley 2006), the degree to which these different lineages represent spatially and temporally discrete "domestication events" in which different populations were brought under domestication independently of one another is not entirely clear (Dobney and Larson 2006). In domestic goats, for example, there now appear to be as many as six highly divergent maternal lineages. These include the three lineages originally identified by Luikart et al. (2001, 2006)—a dominant A lineage and smaller B and C lineages—and three additional lineages (D, F, and G) identified in the past few years (Chen et al. 2005; Joshi et al. 2004; Naderi et al. 2007; Sultana, Mannen, and Tsuji 2003). The divergence of these lineages has considerable time depth (ca. 100,000–500,000 years), suggesting that each represents a different segment of a larger wild goat population brought under domestication (Naderi et al. 2007). A genetic analysis of a large sample of modern wild bezoar (*Capra aegargrus*) goats from Iran, Iraq, and Turkey finds all six major domestic maternal lineages represented in present-day bezoar populations (Naderi et al. 2008), patterning that, as Naderi et al. (2008) argue, traces its roots to the Early Holocene. The weak phylogeographic structure of the domestic lineages among these bezoars is seen as an artifact of human translocation of animals during the initial phases of the domestication process, before the morphological modifications that separate wild from domestic goats arose. Evidence of rapid population growth among bezoars belonging to the C lineage resembles that found in domestic goats in Iran and is not seen among bezoars that do not belong to domestic lineages. This pattern is taken as a further sign of human-mitigated demographic control and protection of bezoars before complete isolation of managed animals from wild ones. Bezoars belonging to the now-dominant A domestic matriline are concentrated in eastern Turkey, conjectured to be the most likely region of initial management of A-lineage goats. While C-lineage bezoars are most frequently found in southern and central Iran, the C-lineage bezoars most closely related to C-lineage domestic goats were found in southeastern Anatolia. These bezoars are thought to be the descendents of animals translocated from southern Iran that, along with A-lineage goats, were the first herded goats to leave the homeland of initial management, animals whose remains are found at sites such as Nevali Çori at 10,200 cal BP.

This study indicates, then, that all six modern maternal lineages of domestic goats were brought under initial human management in a region that stretches from the eastern Taurus to the southern Zagros and Iranian Plateau. Although this process apparently involved individual communities taking local populations of wild goats under control, the geographic proximity of these populations and the evident human-mitigated movement of animals across this region suggests that these activities were part of a more broad-based, culturally connected set of economic strategies. Persistence of the genetic signature of these activities among modern bezoars adds support to archaeological indications of a long period of active and intentional human management of animals before the manifestation of archaeologically detectable morphological change in managed animals.

Sheep also show a polyphyletic signature, with three domestic lineages all thought to be derived from different populations of wild mouflon *Ovis orientalis*, an animal with a current range that extends from Anatolia to southeastern Iran (Bruford and Townsend 2006; Hiendleder et al. 2002; Pedrosa et al. 2005). As in goats, one lineage dominates and is proposed to have originated among sheep whose descendents are now found in eastern Turkey and western Iran. Another lineage is thought to have arisen from a more eastern population of *O. orientalis* (Hiendleder et al. 2002), while a third is also thought to have Turkish roots (Pedrosa et al. 2005).

Three and perhaps four of the five maternal lineages of domestic taurine cattle were also likely domesticated in the Fertile Crescent (Bradley and Magee 2006). One lineage (T3) is the primary variety that spread throughout Europe (Troy et al. 2001). The T1 lineage, the dominant lineage in North Africa, has been argued to represent an independent African domestication of local wild cattle (Bradley and Magee 2006: 324). Subsequent analysis, however, suggests that like the T3 variety, the T1 lineage also likely arose in the Near East and subsequently spread to North Africa through trade and human migration (Achilli et al. 2008).

While Near Eastern wild boar haplotypes are not represented among modern domestic swine (Larson et al. 2005), ancient-DNA analysis points to at least four different lineages of Near Eastern domestic pigs, two of which were found among Neolithic assemblages in western Europe (Larson et al. 2007). Near Eastern matrilines of domestic pigs are replaced by domestic swine with maternal origins from European wild boar by about 6000 cal BP.

A New Picture of Agricultural Origins in the Near East

The emerging picture of plant and animal domestication and agricultural origins in the Near East is dramatically different from that drawn 16 years ago in the landmark Bar-Yosef and Meadow (1995) article. In 1995, there appeared to have been at least a 1,500-year gap between initial crop domestication (ca. 11,400 cal BP) and livestock domestication (ca. 10,000 cal BP). It now seems that plant and animal domestication occurred at roughly the same time, with signs of initial management of morphologically wild future plant and animal domesticates reaching back to at least 11,500 cal BP, if not earlier.

At the time this influential article was published, it appeared that the southern Levant was the core area for initial domestication, and a case could be made that all subsequent crop and livestock domestication in other parts of the Fertile Crescent followed on the precedent of the crops, domestic technology, and the Neolithic way of life introduced from this core region. Since then, the spotlight has shifted to the central Fertile Crescent, especially the upper reaches of the Tigris and Euphrates rivers, which appears to be the homeland of the initial domestication of a number of founder crops (einkorn, emmer, pulses) and three, if not four, livestock species (sheep, pigs, cattle, and possibly goats). By the late 1990s, a compelling case could be made that this region was a "cradle of agriculture" in a true Vavlovian sense (Lev-Yadun, Gopher, and Abbo 2000). Genetic and archaeobiological evidence generated since then paints a much less focused, more diffuse picture of agricultural origins. The emergence of agriculture in the Near East now seems to have been a pluralistic process with initial domestication of various crops and livestock occurring, sometimes multiple times in the same species, across the entire region.

In 1995, morphological change in both plants and animals marked the threshold between wild and domestic. We now know that morphological change may have occurred quite late in the domestication process and can no longer be considered a leading-edge indicator of domestication. In cereals, the transition from brittle to tough rachises may actually have been the result of changes in harvest timing and technology that took place well after people began sowing harvested seed stock. In pulses, seed-size change lagged behind changes in seed dormancy and plant yield that cannot be detected in the archaeological record. In animals, the impact of human management on body size is now known to have been restricted to a decrease in the degree of sexual dimorphism; alterations in skull morphology may have resulted from a developing commensal relationship rather than a two-way domestic partnership; and changes in horn size and form may, like changes in rachis morphology, have reflected a change in management practice rather than the initiation of animal management. In fact, in both plants and animals, archaeologically detectable morphological indicators of domestication may have occurred only once managed plants and animals were isolated from free-living populations and the opportunity for introgression or restocking managed populations with wild ones was eliminated. While some may prefer not to call a plant or an animal a domesticate until this separation has occurred, concentrating solely on this late stage of the process will not help us understand how it began.

When Bar-Yosef and Meadow published their synthesis article, it seemed to have taken up to 2,000 years after initial domestication of both plants and animals for fully developed agricultural economies to coalesce across the entire Fertile Crescent. With the removal of morphological change as a leading-edge indicator of domestication, this process seems to have taken longer still. Stable and highly sustainable subsistence economies based on a mix of free-living, managed, and fully domesticated resources now seem to have persisted for 4,000 years or more before the crystallization of agricultural economies based primarily on domestic crops and livestock in the Near East.

The exciting recent discoveries on Cyprus provide a special perspective on this long period of low-level food production (sensu Smith 2001) in the mainland Fertile Crescent. This work has produced solid evidence for the early importation of morphologically domesticated cereals (einkorn, emmer, and barley) and morphologically wild but managed animals (goats and cattle) to Cyprus by 10,500 cal BP, with managed pigs possibly brought to the island even earlier (Vigne, Carrère, and Guilaine 2003; Vigne et al. 2011; Willcox 2003). This means that at the same time that the earliest morphologically domesticated einkorn and emmer is found in the Upper Euphrates valley (and even earlier than there is solid evidence for morphologically altered domestic barley) and when we see the first indications of animal management in the mainland Fertile Crescent, people were loading these managed plants and animals into boats and carrying them, along with the knowledge of how to successfully care for them, to an island 160 km off the Levantine coast. The importation and successful exploitation of these nascent domesticates on Cyprus, where none of these plants and animals occur naturally, suggests that human control over these budding domesticates was more established than is apparent on the mainland, where the likely continued utilization of free-living populations of these species makes it hard to determine the degree of human investment in plant and animal management.

What is perhaps even more interesting about the Cyprus data is that people also imported fallow deer and foxes to the island, as well as other elements of the mainland biotic community that do not appear to have been subjected to the same degree of human control. People who colonized Cyprus in the eleventh millennium did not selectively choose to import only those plants and animals with which they had a developing domestic partnership. Instead, they seem to have transported from the mainland their entire ecological niche, made up of a wide range of economically important species exploited with a diverse array of more and less intensive strategies. It is unlikely that these early pioneers drew strict classificatory boundaries between resources collected from free-living populations, resources that required a higher degree of encouragement and protection from competition or predation, and resources that had begun to show physiological, behavioral, or morphological responses to human management. They simply took with them the world that they knew. The apparent relaxation of management strategies over time that Vigne, Carrère, and Guilaine (2003) have proposed for goats (perhaps because of the lack of major predators and a reduced threat from human poaching on this sparsely inhabited island) underscores the fluidity of exploitation strategies and the blurring of distinctions between degrees of engagement in the management of important resources that existed at that time.

This backward look at the mainland from Cyprus provides us with new insight into the initial context of plant and animal domestication in the Near East. It suggests that domestication and agriculture arose in the context of broad-based systematic human efforts at modifying local environments and biotic communities to encourage plant and animal resources of economic interest, a practice that has been characterized as human niche construction or ecosystem engineering (Smith 2007*a*, 2007*b*, 2011). The data emerging over the past 15 years clearly indicate that active human engagement in ecological niche construction was taking place across the entire Fertile Crescent during a period of dramatic post-Pleistocene climate and environmental change (Bar-Yosef 2011), with considerable regional variation in the scope and intensity of these activities as well as in the range of resources being manipulated. In certain instances, this context of human niche construction gave rise to coevolutionary relationships between humans and certain species that eventually resulted in a full-fledged domestic partnership, as it did with einkorn, emmer, and pulses in southeastern Anatolia, with barley in both the southern Levant and the Zagros, and with the four major livestock species in different parts of the broad territory between Anatolia to southern Iran. In others instances, the relationship never developed beyond the first tentative steps toward domestication. Failure to move beyond these initial stages of the domestication process may have been due to either behavioral or biological barriers on the part of the plant or animal species, as perhaps in the case of gazelle in the southern Levant that are behaviorally unsuited to domestication or with rye that could not survive conditions of increasing heat and aridity in the northern Levant. Or it might simply be due to a lack of follow-through by humans, as may have happened with wild oats that were likely cultivated in the southern Levant during the PPNA but were not domesticated until much later.

This broad middle ground between wild and domestic, foraging and farming, hunting and herding makes it hard to draw clean lines of demarcation between any of these states. Perhaps this is the greatest change in our understanding of agricultural origins since 1995. The finer-resolution picture we are now able to draw of this process in the Near East (and, as seen in the other contributions to this volume, in other world areas) not only makes it impossible to identify any threshold moments when wild became domestic or hunting and gathering became agriculture but also shows that drawing such distinctions actually impedes rather than improves our understanding of this process. Instead of continuing to try to pigeonhole these concepts into tidy definitional categories, a more productive approach would be to embrace the ambiguity of this middle ground and continue to develop tools that allow us to watch unfolding developments within this neither-nor territory.

In the Near East, this means looking more closely at the relationships between humans and plants and animals, especially within the natural habitats of future domesticates.

Continuing to develop archaeobiological and archaeological tools for examining these evolving relationships will be key, as will the development of new genetic approaches, including, one hopes, the analysis of ancient DNA of plant and animal remains from Near Eastern archaeological contexts. In 2011, we are clearly on the cusp of a new understanding of agricultural origins in the Near East and elsewhere. One can only imagine what the picture will look like in 2025.

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