8 ARCHAIC FORAGING AND THE BEGINNING OF FOOD PRODUCTION IN THE AMERICAN SOUTHWEST

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The beginning of prehistoric food production in the American Southwest is conventionally marked by the appearance of maize (*Zea mays*), squash (*Curcurbita pepo*) and the common bean (*Phaseolus vulgaris*), each domesticated in Mesoamerica sometime before 5000 bp. Currently, the corpus of directly dated domesticate specimens (primarily maize) indicates an introduction period from approximately 3500 to 3000 bp and diffusion rates of 1.0 to 2.0 km per year (table 8.1). There are at least two radiocarbon dates on maize approaching 4000 bp, as well as one or two other indirect chronometric associations of similar age, all from sites on the Colorado Plateau and adjacent Mogollon Highlands (fig. 8.1, table 8.1). These dates of circa 4000 bp are controversial and not yet widely accepted, but they still indicate that the initial use of domesticates took place at roughly the boundary between the middle and late Archaic cultural periods, or between approximately 4000 and 3500 bp (Huckell 1984).

The Southwestern Archaic is the preceramic period between the end of the Paleoindian period (ca. 10,000 bp) and the first use of ceramic technology for pottery at roughly 1800 to 1600 bp. The middle to late Archaic "transition" is indicated by a decline in the diversity of projectile point types and a widespread use of side-notched points with long blades, as well as an increase in the frequency of habitation structures, storage features, and burials. Because none of these elements, however, occurs exclusively during the late Archaic, the distinction between the two is often arbitrary and unclear.

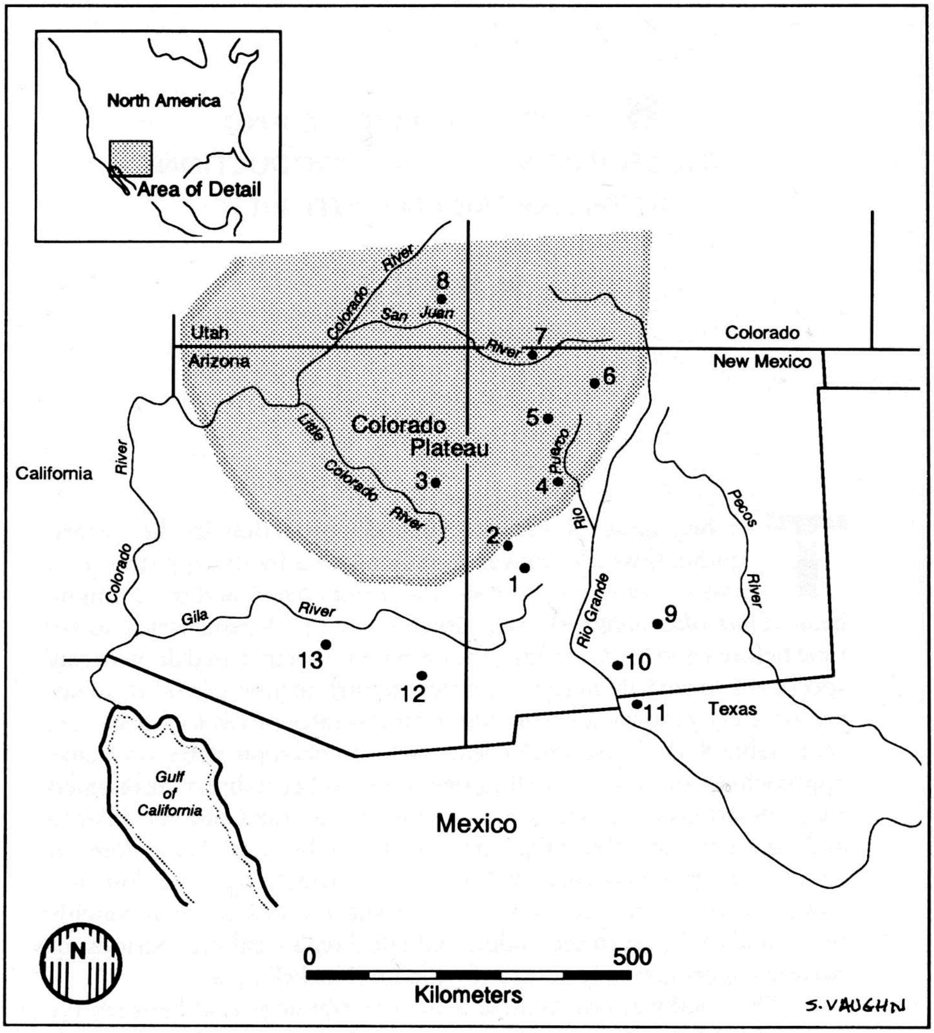


Figure 8.1. Archaeological sites mentioned in the text.

KEY:

1. Bat Cave
2. Tularosa Cave
3. AZ Q:7:35
4. Rio Puerco middle Archaic sites
5. Sheep Camp Shelter
6. OC-8
7. LA 61838
8. Cedar Mesa
9. Fresnal Shelter
10. Tornillo Rockshelter
11. Keystone Dam locality
12. Milagro, Cortaro Fan, and Fairbank sites
13. AZ AA:3:28

Not shown: Three Fir Shelter in extreme northeast Arizona

Most archaeologists view the cultural developments of the late Archaic, including the use of domesticates, as changes within indigenous hunter-gatherer populations. Recently, though, Berry (1982) and Matson (1991) argued that the material patterns that define the late Archaic were produced by a wavelike northward migration of farmers into the region. This migration model assumes that early food-producing sites in the southern Basin and Range represent the advancing edge of farming populations that eventually spread into the Colorado Plateau and other upland zones. At present, however, the oldest domesticates found in the Colorado Plateau and Mogollon Highlands pre-date the establishment of seasonally sedentary farming settlements to the south. Indeed, recently reported habitation sites containing maize in northern areas may be earlier than those in the south (Gilpin 1992). Although population movement is a plausible explanation for the appearance of maize in the Southwest, the evidence offered in support of such movement cannot so far be separated from evidence for the expected effects of increasing sedentism. In the remainder of this chapter I assume that maize, squash, and beans were incorporated into indigenous hunter-gatherer economies.

As many as 2,000 years passed between the initial use of domesticated maize around 3500 bp and evidence for the emergence of economic systems based largely on food production, generally dated between 1500 and 1000 bp. If earlier maize dates are verified, then more than two millenia passed before maize became the economic mainstay for sedentary communities. Until the early 1980s, archaeologists assumed that the "gap" between the first appearance of domesticates and the emergence of agricultural communities was even larger—on the order of 2,000 to 4,000 years (Haury 1962; Woodbury and Zubrow 1979). Researchers felt that food production prior to the appearance of villages was an unimportant or "backup" strategy that had little economic significance, because plant cultivation did not seem to stimulate shifts toward increased subsistence dependence on crops, as sedentary villages would presumably indicate (e.g., Cordell 1984). Recent research has demonstrated that these early dates were based on poor stratigraphic interpretations at Bat Cave and were in error (see Dick 1965; Ford 1981; Berry 1982; Wills 1988a, 1988b, 1990). Nonetheless, even revised downward, the interval preceding the formation of sedentary settlements remains lengthy and is still interpreted as evidence for a "casual" or supplemental economic role for plant husbandry (Minnis 1985, 1992).

In this chapter I offer tentative answers to two fundamental questions about the beginnings of early Southwestern agriculture. First, why

Table 8.1
Selected radiocarbon dates for domesticated plants in Mexico and the American Southwest

Area/Site	*Date/Lab No.*	*Calibration*	*Material*
Tehuacan, Mexico			
Cueva San Marcos	4700 ± 60 bp (AA-3305)	3616–3372 B.C.	*Zea mays*
Cueva San Marcos	4680 ± 50 bp (AA-3304)	3599–3370 B.C.	*Zea mays*
Cueva San Marcos	4600 ± 60 bp (AA-3310)	3494–3198 B.C.	*Zea mays*
Cueva Coxcatlán	4090 ± 50 bp (AA-3308)	2865–2579 B.C.	*Zea mays*
Cueva Coxcatlán	4040 ± 100 bp (AA-3312)	2865–2470 B.C.	*Zea mays*
American Southwest: Mogollon Highlands and Colorado Plateau			
Bat Cave*	3740 ± 70 bp (A-4187)	2284–2039 B.C.	*Zea mays*
Three Fir Shelter*	3610 ± 170 bp (Beta ?)	2200–1750 B.C.	*Zea mays*
Bat Cave	3120 ± 70 bp (A-4188)	1491–1320 B.C.	*Zea mays*
Bat Cave	2980 ± 120 bp (A-4186)	1377–1052 B.C.	*Cucurbita pepo*
Sheep Camp Shelter	2900 ± 230 bp (A-3388)	1430–830 B.C.	*Cucurbita pepo*
Three Fir Shelter	2880 ± 140 bp (Beta 26271)	1314–845 B.C.	*Zea mays*
Tularosa Cave	2400 ± 250 bp (A-4179)	893–233 B.C.	*Phaseolus vulgaris*
Bat Cave	2140 ± 110 bp (A-4184)	389–4 B.C.	*Phaseolus vulgaris*
American Southwest: Southern Basin and Range			
Tornillo Rockshelter	3175 ± 240 bp (GX-12720)	1733–1112 B.C.	*Zea mays*
Fairbank	2815 ± 80 bp (AA-4457)	1373–790 B.C.	*Zea mays*
Cortaro Fan	2790 ± 60 bp (AA-2782)	1009–896 B.C.	*Zea mays*
Milagro	2780 ± 90 bp (AA-1074)	1074–830 B.C.	*Zea mays*

Sources: Long et al. (1986); Simmons (1986); Wills (1988a); Huckell (1990); Smiley and Parry (1990).

* Smiley (1990) views these two dates as acceptable, whereas I currently reject the Bat Cave date as inconsistent with other chronometric evidence from the site (Wills 1988a:109). Westfall (1981:93) reported a date of 4130 ± 90 bp (UGa-3228) on charcoal recovered from a campsite hearth that contained one charred maize kernel and one charred bean. Simmons (1986) described maize pollen from an open-air hearth that produced a charcoal radiocarbon date of 3680 ± 85 bp (UGa-3621), but the same feature also had a date of 225 bp. These data may well indicate that maize cultivation began in the northern Southwest (Colorado Plateau and Mogollon Highlands) at about 2000 to 1800 B.C. (calibrated), although I believe additional dates are necessary to confirm such a conclusion, especially since the acceptance of this time range would leave a conspicuous gap between about 1800 and 1500 B.C. Historical overviews of maize chronology in the Southwest, including recent revisions of solid carbon dates obtained in the 1940s and 1950s, can be found in Glassow (1980), Ford (1981), Berry (1982), Minnis (1985, 1992), and Wills (1988a, 1988b).

were Mesoamerican domesticates introduced to the region at the beginning of the late Archaic cultural period? Second, why did more than a thousand years pass before we find evidence for agricultural economies—those in which plant cultivation contributed a majority of annual caloric requirements? In response to the first question, I argue that cultigens were introduced as a means for the intensification of local hunter-gatherer economic systems but that the roles played by these new food resources were variable in different parts of the Southwest, depending on regional ecological conditions. These initial differences help provide an answer to the second question; it seems clear that by 800 B.C., socioeconomic systems in the southern Basin and Range physiographic province and those in adjacent, cooler, northern zones had begun to diverge significantly in terms of reliance on food production, with southern desert populations developing successful maize production much earlier. As a result, by the end of the late Archaic, at approximately 200 B.C. to A.D. 200, desert peoples may have inadvertently come into economic competition with less agriculturally dependent northern groups, precipitating a rapid shift to greater crop use in those northern regions.

PRE-MAIZE FORAGER ECONOMIES: THE LATE MIDDLE ARCHAIC (CA. 5000 TO 4000 BP)

POST-ALTITHERMAL ENVIRONMENTS AND RESOURCE POTENTIAL

Several widespread environmental developments occurred at the end of the middle Archaic, all related to climatic amelioration following the mid-Holocene interval of elevated temperatures and aridity known as the Altithermal (ca. 7500 to 5000 bp). For human populations, the most important developments included (1) the establishment by 4000 bp of broad seasonal contrasts between the cool temperate environments of the Colorado Plateau and adjoining upland zones and the warmer temperate environments of the southern Basin and Range province (fig. 8.2); (2) a dramatic northward expansion of piñon-juniper woodlands from the southern Basin and Range; and (3) evidence that increased precipitation between 4000 and 3000 bp led to lake rises, grassland expansion, and increased marshlands throughout the Southwest, including its desert areas (Van Devender and Spaulding 1979; Van Devender, Betancourt, and Wimberly 1984; Hall 1985; Madsen and Rhode 1990). In general, these environmental changes meant an increase in the diversity and abundance of food resources for foragers in every part of the Southwest, but variability in the seasonality and availability of different foods.

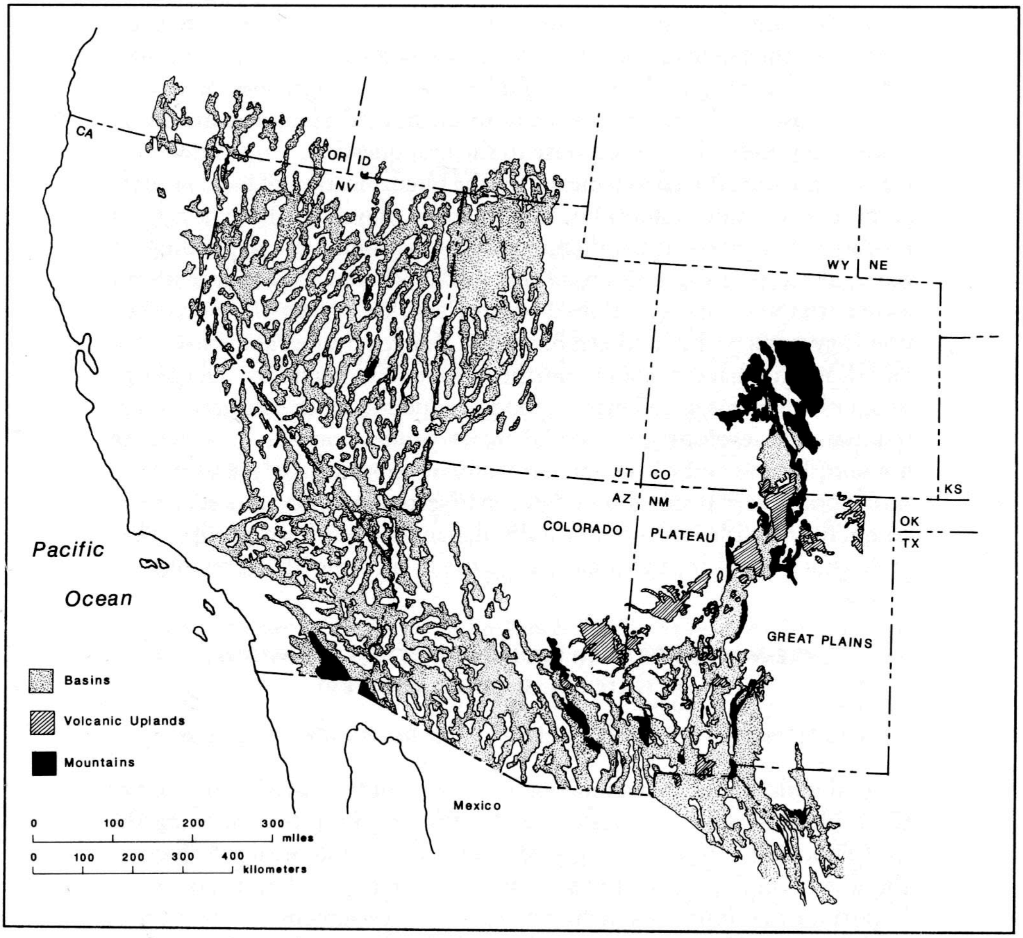


Figure 8.2. Major physiographic features of the Southwest with emphasis on basin and range topography. The Mogollon Highlands are the volcanic uplands on the southern border of the Colorado Plateau, along the Arizona–New Mexico line. Adapted from Baldridge and Olsen (1989:244).

Cool temperate woodlands, grasslands, and forests at elevations of between 1500 and 2500 m were relatively rich in large and medium-size animals, nut trees, and annual plants with large, oily seeds, such as rice grass and sunflower. The economic potential of the Upper Sonoran life zone (fig. 8.3), which is dominated by piñon-juniper woodlands, is

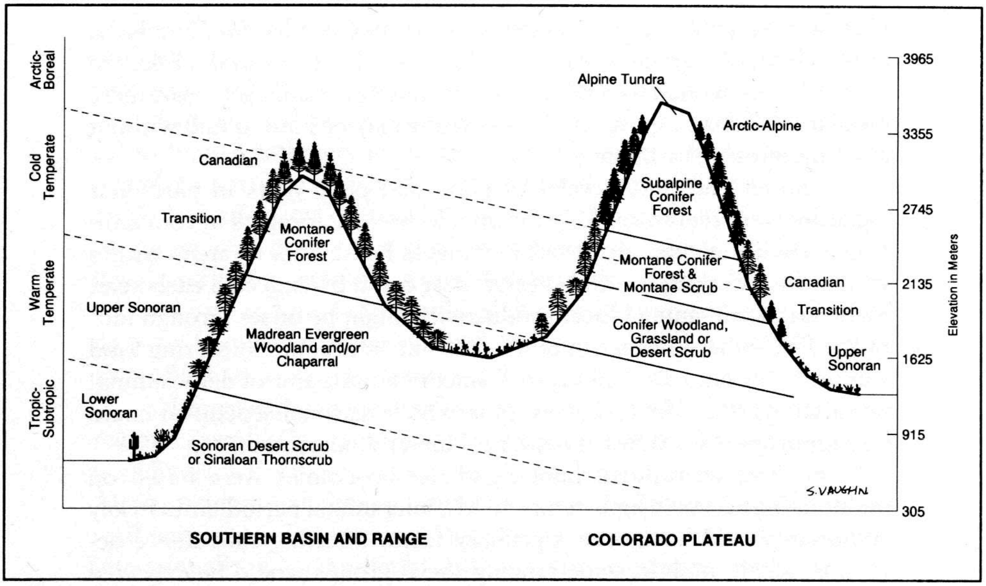


Figure 8.3. Schematic profile of topographic variability in the American Southwest, showing modern vertical climatic and biotic zonation from south to north. Adapted from Lowe and Brown (1982).

higher than that of any other life zone in the Southwest during autumn months when plants ripen and animals put on fat before the onset of winter (Hevly 1983; Hunter-Anderson 1986). All of the highest-ranked dietary items available to prehistoric foragers occur in these environments (Bayham 1982; Ackerly 1985; Hard 1986).

Food resources, however, are extremely limited at other times of the year, especially during the prolonged, cold winter months (present-day growing seasons vary between 100 and 180 days). Many of the most productive plants and animals found in cool temperate environments are available only for brief periods each year and/or exhibit annual spatial unpredictability. The piñon tree, for example, although producing nut masts capable of supporting historic hunter-gatherer groups through winter months in the Great Basin, has mast perodicities of three to seven years, depending on species, location, and climate (Madsen 1986). At large spatial scales, such as that of a mountain range, piñon nut masts can be expected every year, but it is difficult to predict their exact location—except that areas of local abundance in the previous two to three years are unlikely to experience significant cone production. Similarly, although there is certainty of finding herd animals such as elk or deer in particular areas such as a river valley or interior basin each year, these mobile and demographically shifting fauna may be hard to find without close monitoring by hunters.

"Boom and bust" cycles of good and poor years in particular localities were therefore likely for middle Archaic foragers in cool temperate environments. However, if foragers had access to areas within which, for example, a sufficient nut mast could be expected each year, high variance in annual local productivity might be offset through mobility. The ability to overwinter in cool temperate zones by storing food was probably unpredictable as well, since nut masts and/or dense animal populations were the resources upon which seasonal sedentism could be supported (e.g., Steward 1938:19; Hunter-Anderson 1986).

So long as resident hunter-gatherer economies were based on maintaining access to high-return foods, interannual periodicities in key resources would have been a primary factor affecting subsistence decisions. Small, mobile, wide-ranging social groups would be expected in order for hunter-gatherers to maintain access to high-ranked foods, and, in Binford's (1980, 1983) terms, logistical labor organization should have played an important role, with task-specific procurement groups operating out of short-term base camps.

Middle Archaic hunter-gatherers in warm temperate and subtropical environments experienced different economic opportunities and constraints. Although they had access to the same high-ranked food items as foragers in cool temperate environments, these items were confined to much smaller geographic areas and were far less abundant (see Keeley, this volume). Desert biomass is dominated instead by shrubs, annuals, and perennials such as cacti; more than 250 plants were used by historic Indian groups in the Lower Sonoran life zone (Fish and Nabhan 1991). Wildlife consists primarily of small game, such as rabbits, rodents, and reptiles. Desert foragers were therefore broader in their use of low-return foods than were contemporaneous foragers in cooler portions of the Southwest (see Goodyear 1975; Szuter and Bayham 1989).

Additionally, many of the most important economic desert plants, such as cactus, agave, and perennial legume trees, are far less sensitive to precipitation than are those of cool temperature regions, and they produce more consistently from year to year (Ackerly 1985:53). Fish, Fish, and Madsen (1990:79) argue that the middle Holocene expansion of legume tree groves along river drainages throughout the southern

Basin and Range could have supported low to moderate densities of sedentary hunter-gatherers, because although individual trees exhibit two-year production cycles, groves are reliable from year to year.

Consequently, interannual resource cycles were probably not critical to hunter-gatherers in warm temperate Basin and Range environments. In particular, spatial patterns of fall resource distribution had much less effect on overwintering tactics than they had in cool temperate regions; given the highly compressed zonation of habitats in the Basin and Range country, winter food collecting probably took place within 10 to 20 km of areas utilized during other seasons and involved daily or frequent movement between resource patches (see Goodyear 1975; Bayham 1982; Huckell 1984; Roth 1992).

Hunter-gatherer populations in warm temperate and subtropical regions were likely organized in small, mobile social groups similar, if not identical, in demographic structure to those in cooler environments. All else being equal, the key contrast was that the highest ranked foods in cool temperate diets required large foraging ranges, both annually and interannually, whereas diet breadth in warm temperate regions, though more costly in terms of processing, was more predictable temporally and spatially and thus could have supported much smaller procurement ranges.

THE MIDDLE ARCHAIC IN THE COLORADO PLATEAU AND MOGOLLON HIGHLANDS

Archaeological sites radiocarbon dated to the middle Archaic are common in the Colorado Plateau and adjacent montane zones (Berry 1982; Berry and Berry 1986; Wills 1988a; Brown 1992). The distribution and characteristics of these sites indicate that foragers moved seasonally between vertically juxtaposed vegetation zones, generally occupying intermediate or lowland areas in winter and spring, then moving into mountain ranges during summer and fall (Irwin-Williams 1973; Reher and Witter 1977; Chapman 1980; Simmons 1986; Elyea and Hogan 1983; Toll and Cully 1983; Fuller 1988; Brown 1992). For example, Vierra (1990:63) estimates that middle Archaic bands in the San Juan River drainage had annual ranges of approximately 3,000 km^2, moving linear distances of 40 to 100 km per year (fig. 8.4).

Campsites in piñon woodlands near riparian habitats are usually interpreted as fall-winter occupations. Autumn use is inferred from the seasonality of potential food resources in this zone, since middle

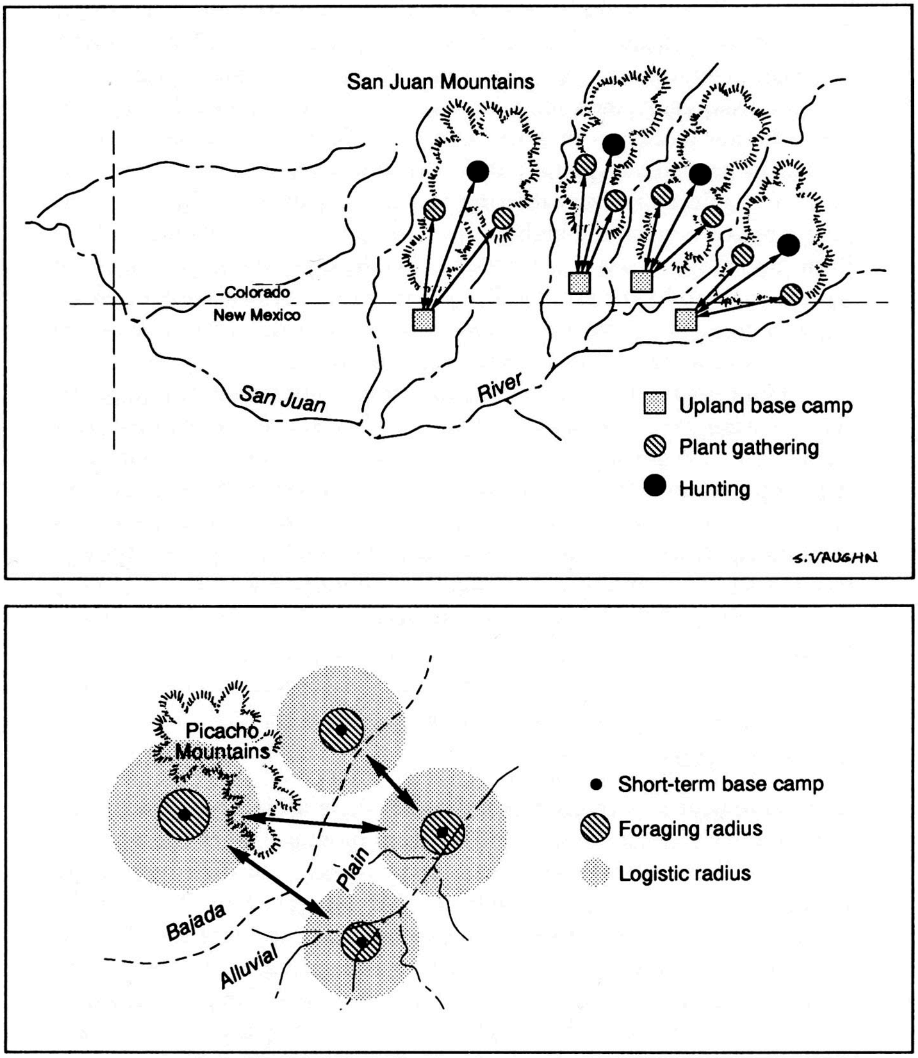


Figure 8.4. Top: Hypothetical middle Archaic seasonal mobility pattern in the San Juan River drainage of New Mexico and Colorado, with a linear distance of 40 to 100 km from river valleys to mountain hunting camps. Adapted from Fuller (1988:345). Bottom: Reconstructed annual foraging cycle for middle Archaic foragers in south-central Arizona, with a linear distance of 10 to 20 km between valley bottoms and mountain ranges. Adapted from Szuter and Bayham (1989:88).

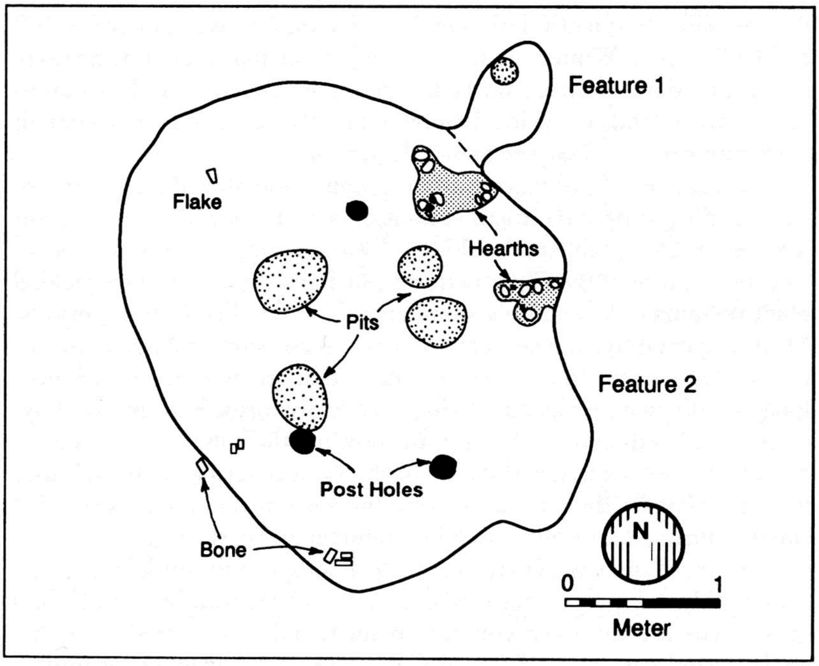
Archaic sites frequently lack subsistence remains (Westfall 1981; Toll and Cully 1983). Winter occupation tends to be interpreted by analogy to the practices of Great Basin foragers who overwintered in piñon-juniper woodlands when local piñon nut masts were productive enough to sustain small groups (see Steward 1938:19).

A number of pre-maize sites in piñon woodlands dating between 5000 and 3500 bp have small habitation structures and associated pit features (fig. 8.5, table 8.2). Although usually considered winter occupations because of the construction of shelters, these sites have yielded plant remains reflecting only summer and early fall collection periods. More importantly, faunal remains from these sites generally do not include large game animals, such as deer, that are expectable with prolonged settlement use leading to logistically organized hunting (see Bayham 1982; Speth and Scott 1989). In addition, the habitation structures are not very substantial and should probably be described as huts. Entire winter sedentism thus seems unlikely, but shelters do indicate extended site use during the resource-rich late summer and early autumn.

Ground stone is a characteristic technology of the middle Archaic, presumably for processing seeds. Charred chenopod, amaranth, and grass seeds are the most common plant remains recovered from Archaic period sites (e.g., Toll and Culley 1983). A collection of middle Archaic human coprolites from caves in southeastern Utah dating to the Desha Complex (ca. 8000 to 6000 bp) included large numbers of crushed chenopod seeds, apparently the remains of seed cakes (Reinhard, Ambler, and McGuffie 1985).

A recent bone chemistry analysis of a human burial from these same Desha Complex caves provides further substantiation for the economic importance of weedy annuals. Matson and Chisholm (1991:445) reported that a burial from Sand Dune Cave produced a $\delta^{13}C$ value of -13.9, indicating dietary contributions of approximately 40 to 70 percent from plants having a C_4 or CAM photosynthetic pathway (Tieszen 1991). Many of the primary economic plants of the Southwest, including all amaranths and many of the Chenopodiacae family, are of the C_4 variety, and consequently the findings from the Sand Dune Cave burial suggest heavy reliance on weedy annuals, grasses, and other labor-intensive plants (table 8.3; see Wills 1992:159; Wills and Huckell 1994). This conclusion is consistent with Keeley's (this volume) observation that when plants comprise 36 percent or more of hunter-gatherer diets, seeds are the predominant staple resource.

In the American Southwest, C_4 plants increase as a proportion of overall plant biomass with decreases in elevation and increases in


Feature 1
Flake
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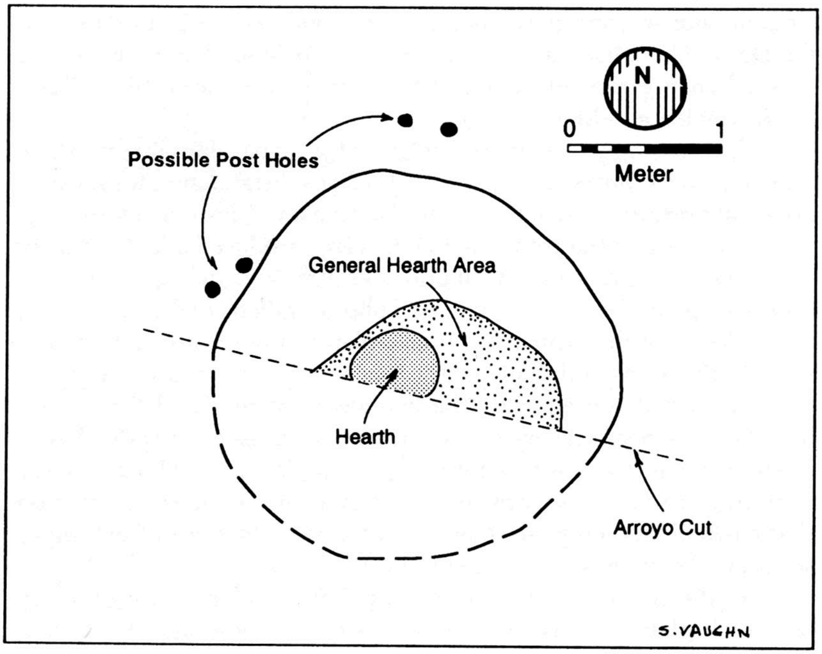
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temperature; that is, they are most abundant in warm temperate and subtropical environments (Jones 1985:51–54). A single burial should not be considered representative of all middle Archaic hunter-gatherers, but it seems reasonable to assume that elevated $\delta^{13}C$ values indicate extended foraging time at lower elevations.

Given both direct and indirect evidence that weedy annuals had an important economic role during the middle Archaic in cool temperate environments, the possibility that these plants were encouraged or cultivated seems good. Chenopodium and other annuals were cultivated historically in the Great Basin, and several researchers have suggested that pre-maize plant cultivation was likely practiced in the Southwest (Winter and Hogan 1986:137; Bohrer 1991; see Keeley, this volume). Toll and Culley (1983:386) argued that chenopodium and amaranth "have an adaptive advantage under disturbed conditions and thus might form a loose symbiotic relationship with humans at locations that were repeatedly utilized in successive years." If such a situation existed during the middle Archaic, it was probably similar to the one described by Smith (this volume) for chenopodium cultivation in the eastern United States, where campsites used annually provided anthropogenic seedbeds for plants collected in floodplain habitats. In Smith's model, settlement stability provided the basis for positive feedback processes between cultivation and domesticatory changes in chenopodium.

Radiocarbon dates from large, open-air sites typically do indicate multiple occupations, but not with the resolution required to determine the length or consistency of site use (e.g., Vierra 1980; Wills 1988a:65). In at least one locality on the Rio Puerco in central New Mexico, however, sites dating to the end of the middle Archaic are reported to have subsurface storage features and superimposed habitation structures (P. Hogan, personal communication and citation in Leonard 1992:719). Subsistence remains from middle Archaic campsites clearly reflect only a very small range of the resources that these foragers likely were using annually, especially large game. Instead, most sites are associated with foods that were available in late summer or early fall and required lengthy processing times and special grinding tools. The archaeological record may be biased toward this phase of the annual round, perhaps because

Figure 8.5. Top: A middle Archaic habitation structure at AZ Q:7:35 (4770 ± 200 bp), located in the Little Colorado River drainage in east-central Arizona. Adapted from Westfall (1981:65). Bottom: A middle Archaic habitation structure from Site 33 North (4100 ± 200 bp), Keystone Dam locality, southwest Texas. Adapted from O'Laughlin (1980:139).

Table 8.2
Pre-maize archaeological sites with habitation structures

Site	Location	Elevation	Radiocarbon Date	Reference
Colorado Plateau				
OC-8	Rio Chama	1,940 m	5240 ± 130 bp	Lang (1980:54)
AZ Q:7:35	Little Colorado River	2,000 m	4770 ± 200 bp	Westfall (1981:65)
Moquino*	Rio San Jose	1,950 m	3920 ± 155 bp	Beckett (1973); Berry and Berry (1986:290)
AZ Q:7:33	Little Colorado River	2,000 m	3310 ± 70 bp	Westfall (1981:55)
			2175 ± 100 bp	
LA 61838	San Juan River	1,840 m	3450 ± 100 bp	Brown (1991:201)
			3060 ± 90 bp	
Southern Basin and Range**				
AZ AA:3:28	Picacho Basin	450 m	4840 ± 100 bp 3920 ± 290 bp	Bayham and Morris (1986:74)
Keystone 32	Rio Grande	1,300 m		O'Laughlin (1980:48)
House 2			4100 ± 200 bp	
House 5			3800 ± 140 bp	
House 3			3640 ± 130 bp	
House 4			3300 ± 140 bp	

* Additional dates from the Moquino site include 4610 + 350 bp, 3920 + 155 bp, and 3840 + 200 bp (Berry and Berry 1986).

** Roney and Simons (1988) reported a date of ca. 4700 bp with a small structure at a site near El Paso, Texas.

these sites were reused regularly. The largest middle Archaic sites are nearly always located near streams or water sources (Chapman 1980; Wills 1988a).

THE MIDDLE ARCHAIC IN THE SOUTHERN BASIN AND RANGE

Middle Archaic sites are less common in desert settings than they are at higher latitudes, possibly owing to widespread erosion of mid-Holocene alluvium and the consequent destruction of valley bottom campsites (Waters 1986; Huckell 1990). Site density appears to be higher along the margins of desert regions at intermediate elevations (500 to 1000 m) than in the hotter, low-lying interior basins. Settlement patterns in the

Table 8.3
Selected C4 economic plants in the American Southwest

Dicotyledonae	*Monocotyledoneae*
Amaranthaceae	Gramineae
Amaranthus blitoides	*Bouteloua gracilis*
A. graecizans	*Echinochloa crusgalli*
A. hybridus	*Eragrostis orcuttiana*
A. hypochondriacus	*Helaria* sp.
A. powellii	*Muhlenbergia* sp.
A. retroflexus	*Panicum sonorum*
Chenopodiaceae	*P. capillare*
Atriplex argentea	*Setaria* sp.
A. canescens	*Sporobolus cryptandrus*
A. confertifolia	*S. wrightii*
Suaeda sp.	

Sources: Downton (1975); Jones (1985); Raghavendra and Das (1978).

southern Basin and Range (fig. 8.4) are assumed to reflect seasonal shifts between vertical resource zones, with winter campsites in valley bottoms and piedmont locations rather than in higher elevation woodlands (Whalen 1973; Huckell 1984; Carmichael 1986; Seaman 1988; MacNeish 1993).

A small number of pre-maize habitation sites are known in the southern Basin and Range; two have been reported near El Paso, Texas, and a third from central Arizona (table 8.2). The structures found at these sites are small, circular shelters similar to pre-maize dwellings in cool temperate environments (fig. 8.5). Floral remains indicate summer and fall use; winter occupation, though sometimes inferred, is not directly evident. Storage features are ambiguous at best.

Ground stone technology is very common in Archaic sites of all ages throughout the southern Basin and Range and provides a major guide to culture-historical classifications (Sayles 1983; Huckell 1984). Not surprisingly, charred weedy annuals and grass seeds are common in ethnobotanical remains, and bone chemistry studies indicate substantial dietary input from C_4 and/or CAM plants. MacNeish (1989) reported at least four Archaic burials from cave sites near Las Cruces, New Mexico, two of which pre-date the introduction of maize, with $\delta^{13}C$ levels approaching those of the Desha Complex burial (table 8.4).

Table 8.4
Chronology and carbon isotope data for burials reported from excavations by the Andover Foundation for Archaeological Research near Las Cruces, New Mexico

Site	*Burial No.*	*Location*	*Date*	*Lab No.*	*Delta 13C*
Todsen Cave	8	Zone J	1490 ± 80 B.C.	A-4563	−16.5
Todsen Cave	4	Zone J	600 ± 100 B.C.	UCR 2120?	−13.3
Todsen Cave	?	Zone C	historical?	?	−13.1
Todsen Cave	6	Zone J	850 ± 80 B.C.	UCR 2120?	−12.6
Todsen Cave	?	?	?	?	−12.2
Dry Cave	?	?	3183 ± 163 bp	?	−11.1
Mesilla Dam	?	?	A.D. 470 ± 90	Beta 20499	−9.5
Todsen Cave	7	Zone D	A.D. 1330–1420	?	−7.8
Todsen Cave	5	Zone D	A.D. 1330–1420	?	−7.5
Todsen Cave	2	Zone D	A.D. 1330–1420	?	−7.4
Todsen Cave	3	Zone D	A.D. 1330–1420	?	−7.4

Note: The information summarized here was obtained from MacNeish (1991:158–65). The original data are presented in a confusing format that contains inconsistencies in the citation of radiocarbon determinations, laboratories, burial identification, and location. For example, laboratory sample identification "UCR 2120" is associated with at least three different dates (MacNeish 1991:42, 158). Readers should consult the original report for a complete discussion of the associated archaeological record. Carbon isotope analyses are attributed to Dr. Bruno Marino. The introduction of maize in the Las Cruces area is approximately 3500 to 3000 bp, based on a single radiocarbon date reported in Upham et al. (1987).

The archaeological context for these burials is poorly documented, but considerable C4/CAM input is indicated. In this case, however, the local Lower Sonoran vegetation is well-represented by C4 and CAM species and there is no reason to infer geographically extensive mobility.

In contrast to sites in northern latitudes, many rock shelters in the southern Basin and Range have substantial pre-maize occupation sequences, and one—Ventana Cave in central Arizona (Haury 1950)—provides a rare collection of middle Archaic fauna. A recent study of these faunal remains posited a trend toward increasingly specialized hunting tactics through time, beginning in the middle Archaic and continuing through the late ceramic periods (Bayham 1982; Szuter and Bayham 1989). This trend is attributed to the evolution of regional hunter-gatherer territories and increased population stability along basin riparian zones that resulted in longer distances to highland hunting areas. As upland foraging trips became more costly, hunter-gatherers concentrated on high-ranked food items such as deer (Szuter and Bayham 1989:89). Opportunities for localized pre-maize settlement systems in the southern Basin and Range were enhanced when increased precipitation after 4000 bp extended the number and distribution of marshes and riparian habitats in desert areas (Bayham and Morris 1986, 1990; Waters 1986; Huckell 1990).

Overall, currently available data and interpretations suggest that populations in the southern Basin and Range were organized in small, mobile groups whose use of higher-elevation woodland zones was less important than resource procurement in lower-elevation habitats. Rivers were critical elements in local economies, and settlement systems appear to have been oriented toward catchments centered on riparian zones. Weedy annuals may have been cultivated in these environments, although the evidence is uncertain. As expected from what we know of their diets, hunter-gatherers in warm temperate regions were probably using smaller geographical procurement ranges and more low-return plant foods than foragers in other parts of the Southwest (see esp. Bayham 1982; Bayham and Morris 1986; cf. Keeley 1988, this volume).

EMERGENT FOOD PRODUCTION SYSTEMS: THE LATE ARCHAIC (CA. 4000 TO 1800 PB)

THE LATE ARCHAIC IN THE COLORADO PLATEAU AND MOGOLLON HIGHLANDS

Late Archaic settlement patterns in the Colorado Plateau and Mogollon Highlands suggest two temporal divisions. The first began with the initial introduction of domesticates at 3500+ bp and lasted until approximately 2200 bp. Sites with evidence for domesticates during this interval were mostly rock shelters; only a few open-air sites are currently known, although an open-air pithouse site with maize in the Lukachukai Mountains of northeastern Arizona produced radiocarbon dates of 3040 ± 90 bp (Beta 43318) and 3100 ± 90 bp (Beta 43317) on charcoal and may portend the discovery of other open-air sites from this time period (Gilpin 1992). During the second period, from 2200 to 1600 bp, there was a notable increase in the frequency of open-air habitation sites, many of which contain evidence for maize cultivation. By comparison with the pre-maize middle Archaic, the construction of subsurface storage features was the clearest change in settlement patterns likely attributable to plant cultivation.

The earliest sites with Mesoamerican cultigens include Bat Cave, Tornillo Rockshelter, Tularosa Cave, Sheep Camp Shelter, and Three Fir Shelter (fig. 8.1, table 8.1). Subsistence remains suggest that these sites were used primarily during the growing season, between late spring and late fall (Irwin-Williams and Tompkins 1968; Carmichael 1982; Long et al. 1986; Simmons 1984; Wills 1988a; Smiley 1990; Matson 1992). Some sites in this time range may have been utilized during winter months—for example, Tularosa Cave in the Mogollon Highlands and Three Fir Shelter in northeast Arizona—but the evidence is ambiguous (Martin et al. 1952; Wills 1988a; Smiley, Parry, and Gumerman 1986). After 2200 bp, however, both rock shelters and open-air sites with abundant evidence for prolonged occupation in the form of dense middens, multiple structures, burials, and storage pits are interpreted as winter occupations (e.g., Morris and Burgh 1954; Fritz 1974; F. Plog 1974; Westfall 1981; Smiley, Parry, and Gumerman 1986; Hogan 1987; Fuller 1988; O'Leary and Biella 1987; Brown 1992).

The increase in frequency of open-air habitation sites after 2200 bp covaries with evidence for local episodes of intensive occupation. Continuous local occupation sequences spanning the entire late Archaic are rare, and may not exist at all (see Carmichael 1982; Parry, Burgett, and Smiley 1985; Wills 1988a). But for the centuries after 2200 bp, especially those between about 1800 and 1600 bp, there is widespread evidence for extended, possibly multigenerational, use of local areas. For example, the late Archaic use of Black Mesa in northeastern Arizona, where Three Fir Shelter is located, is estimated to have occurred primarily between 2050 and 1750 bp, with some limited earlier occupation (Smiley 1985). Similarly, the late Archaic on Cedar Mesa in southeastern Utah is bracketed at 1800 to 1600 bp (Matson 1992). Other local occupation sequences elsewhere in the Colorado Plateau also date between about 2000 and 1600 bp (Reinhart 1968; Fritz 1974; Glassow 1980; Fuller 1988; Brown 1992). Open-air habitations and burials apparently occur for the first time in the Mogollon Highlands during this same time period (Haury 1957; Fitting 1973; Wills 1989; Oakes 1992).

Curiously, despite the assumption that maize was a major dietary item by the end of the late Archaic—made partly because greater investment in habitation structures is often attributed to seasonal sedentism associated with food production—direct evidence for plant cultivation is often absent. Late Archaic sites are now reported by archaeologists each year, but remains of maize, beans, and squash are still uncommon enough to warrant considerable attention. The inconsistent occurrence of maize is puzzling, since charred chenopodium or amaranth seeds are nearly always recovered. If maize was used as well, it seems likely that charred cobs or kernels would also be present.

It is equally puzzling that nonresidential sites—those lacking pithouses and storage pits—produce evidence for maize cultivation. On Black Mesa, for instance, 35 open-air late Archaic sites were systematically excavated and sampled, but 50 percent of all identified maize came from two sites, one of which consisted only of small hearths (Smiley 1985). Many of the Black Mesa habitation sites contained no evidence for maize, but paradoxically, all late Archaic Black Mesa open-air sites interpreted as campsites rather than as residential sites produced maize (Smiley 1990). Indeed, two of the earliest reported occurrences of maize and beans in the Southwest are from nonresidential sites consisting only of hearths (Westfall 1981; Simmons 1986).

Rock shelters continued to be consistently associated with maize and squash after 2200 bp; even in areas without evidence for contemporaneous open-air residential sites, rock shelters containing maize and storage features were common (see Anzalone 1973; Ford 1975; Carmichael 1982; Waber, Hubbell, and Wood 1982; Wills 1988a). Apparently many rock shelters in montane areas close to streams or marshes were used seasonally during summer and fall but were not occupied as winter residences. For example, faunal evidence from Fresnal Shelter in the Sacramento Mountains (Wimberly and Eidenbach 1981) and Tularosa Cave in the Mogollon Mountains (Heller 1976) indicates that deer and antelope hunting, respectively, were major fall and spring subsistence activities. Over 24,000 mule deer elements were recovered from Fresnal Shelter, mostly from late Archaic deposits that included maize and storage features. In these situations, maize cultivation appears to have been used to support not winter occupations but rather spring occupations of areas with low natural resource productivity during that season (Wills 1988a:146).

The apparent temporal and spatial stability of maize storage locations and the inconsistent association of plant cultivation with open-air residential sites suggests a system of shifting, short-term residential camps around central and/or permanent cultivation localities. Southwestern archaeologists generally assume the converse, reasoning that houses should be located on arable land (e.g., Matson 1992). Nonetheless, systematic surveys of early agricultural sites have failed to discern a consistent correlation between the apparent "best" agricultural land and habitation sites (Smiley 1985; Matson et al. 1988).

If late Archaic cultivation was essentially localized within a large area of shifting seasonal settlements, it seems likely that the overall economies remained oriented toward interannual cycles of availability in high-ranked foods such as deer, piñon, and walnuts. Any cultivation implies annual reuse of the cultivation locality during the growing season, but there is no reason why these places might not have been chosen so as to minimize the costs of plant husbandry while maintaining access to key procurement areas. A poor correlation between campsites and arable land is exactly what one might expect in such a system. Widespread localized subsistence systems after 2200 bp imply even smaller annual ranges. In other words, settlement data still reflect seasonal mobility, but probably over smaller geographical areas. The significance of smaller procurement ranges is greater dependence on annual resource cycles, a situation in which higher maize productivity was probably required to offset variance in yearly wild resource harvests.

Netting's (1990) concept of "ecological fine-tuning" seems appropriate to describe such a system, presuming that maize production was adjusted in accordance with opportunities provided by variability in other, more central economic tactics. This interpretation is also similar to O'Shea's (1989:58–59) definition of "simple, episodic" economic systems that exhibit variable interannual mixes of foraging and food production depending on the success in agriculture, except that I am suggesting that cultivation, rather than hunting and gathering, was the dependent set of tactics. If this model accurately reflects the economic role of incipient food production, then a primary selective force in the adoption of domesticates involved reducing annual variance in overall subsistence returns. Late Archaic food production can be seen as an intensification of a pre-maize economic focus on mobile and spatially variable resources, with stored cultigens serving to help establish residential control over critical fall foraging areas.

THE LATE ARCHAIC IN THE SOUTHERN BASIN AND RANGE

All current information on early food production in the southern Basin and Range comes from two areas: southeastern Arizona and the Tularosa Basin of south-central New Mexico. Most early occurrences of maize in southeast Arizona are in broad alluvial bottomlands at elevations between 1,000 and 1,200 m (but see Fish et al. 1986). Open-air sites such as Milagro and Fairbank are characterized by dense midden deposits, small pithouses, large storage pits, and multiple burials, very much like habitation sites in cool temperate zones postdating 2200 bp (fig. 8.6). Some of the larger settlements may represent extended occu-

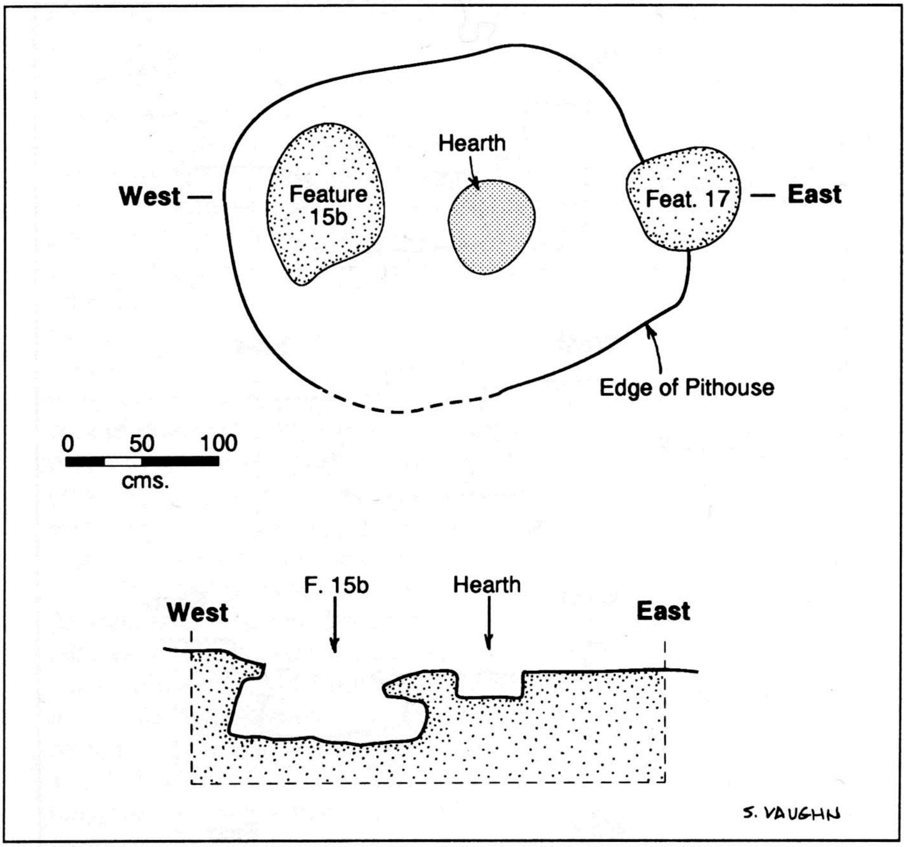

Figure 8.6. A late Archaic habitation structure at the Milagro site (BB:10:46) in southeastern Arizona. Adapted from Huckell (1990).

pations spanning several seasons within a year by large, multifamily groups (Huckell 1990).

Burials suggest group affiliation with individual sites and perhaps some degree of land tenure. Large bell-shaped storage pits (fig. 8.7) may indicate substantial food surpluses. Huckell (1990:367) argues that sites were occupied from summer through winter, then abandoned during early and middle spring, when stored food had been exhausted. Botanical data indicate an increase in the range of taxa when compared to earlier middle Archaic campsites, suggesting that the late Archaic sites played a greater logistic role, in Binford's (1980) sense, from which task groups foraged and then returned (see Bayham and Morris 1986;

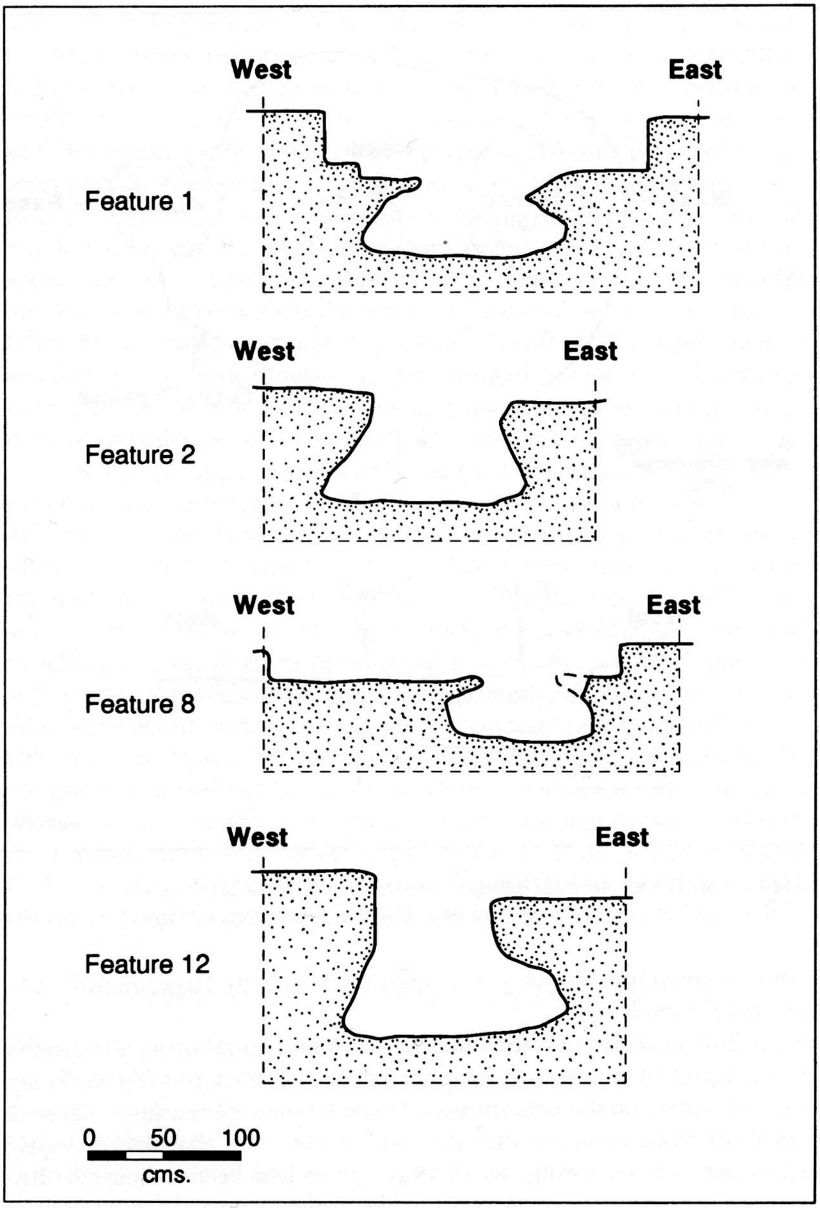

Figure 8.7. Late Archaic storage pits at the Milagro site, southeastern Arizona, associated with radiocarbon dates of around 2800 bp. Adapted from Huckell (1990:191).

Huckell 1988). Large late Archaic sites also occur on river terraces and lower piedmont slopes and may have been extended seasonal campsites, but upland forested areas lack residential localities (Roth 1989, 1992; Fish, Fish, and Madsen 1990).

Settlement location shifted during the late Archaic in response to variability in local water tables, resulting in short repositionings within the same drainage system—which suggests long-term population stability in these valleys (Huckell 1990; Halbirt and Henderson 1993). Recently reported evidence from the Vacas Muertas site in Tucson indicates that between 400 B.C. and A.D. 200, human populations along the Santa Cruz River had established a village that may have exceeded 100 people (Mabry and Clark 1994). Similar large, late Archaic sites are now being described in other portions of southeastern Arizona. The presence of these large, apparently sedentary communities at the end of the preceramic period corresponds to the observation by Roth and Huckell (1992: 362, 366) that projectile point styles at this time indicate "discrete sociocultural entities" in the broad river valleys of the northern Sonoran desert, implying the existence of bounded social territories.

Archaeologists working with late Archaic materials in southern Arizona assume that evidence for localized economies and perhaps even villages during the late Archaic was the result of surplus provided by maize cultivation (e.g., Roth 1989; Huckell 1990). Indeed, maize macrofossils are more common in late Archaic sites than in later, ceramic period villages based on irrigation agriculture (Fish, Fish, and Madsen 1990). For groups already heavily invested in a plant-oriented economy, the adoption of new plant foods similar in ecology and processing requirements to native staples was probably not very costly. Cultivation conditions for maize in southern Arizona were excellent, with long growing seasons and high water tables, and a rapid initiation of positive feedback between settlement stability and crop production is not surprising. Moreover, as Bayham (1982) suggests, successful food production may have permitted specialized long-distance hunting, thus improving access to high-ranked foods.

As in cool temperate regions, the role of early plant cultivation was to intensify middle Archaic strategies, especially with respect to reliance on plant resources. Unlike the case in the northern late Archaic, though, the effect of plant cultivation in desert environments was not to establish residential stability but to improve the productivity of existing procurement ranges. Selection processes primarily favored increased yield rather than variance reduction, thereby contributing to the promotion of positive feedback in cultivation practices and surplus production.

ECONOMIC COMPETITON AND THE "SPREAD" OF FOOD PRODUCTION

Localized economic production is the consistent element to emerge from the comparison of cool and warm temperate late Archaic settlement patterns. In the Colorado Plateau and adjoining uplands, food production allowed for smaller procurement ranges centered on areas of high natural resource productivity. In warm temperate and subtropical environments, small catchment areas apparently contributed to high crop yields and an *expansion* of effective hunting ranges. In each region, the role played by food production was consistent with the selective conditions that characterized pre-maize hunter-gatherer adaptations—in cool temperate zones, food production served to reduce variance in harvest rates; in warm subtropical zones, it created greater productivity.

The origin of Southwestern agriculture therefore seems to have been more about shifting production intervals than about new resources per se. Because the ecology and processing requirements of maize, squash, and beans were similar, if not identical, to those of native grasses, gourds, and legume trees, respectively, and because indigenous cultivation *may* have preceded the arrival of domesticates (Winter and Hogan 1986), it is not surprising that economic changes in the late Archaic reflect more intensive land-use patterns rather than new technologies or material culture. By the end of the late Archaic, populations throughout the Southwest exhibited considerable reliance on maize production and settlement longevity (Cordell 1984). Consequently, a crucial problem for archaeology is explaining why risky economic strategies (i.e., food production) became widespread in northern, cooler latitudes. Presumably the increased frequency of localized economies meant that their associated fitness values improved relative to the fitness values of subsistence economies based on larger geographic areas. In general, competition produces shifts in the relative fitness of economic strategies (Redding 1988).

It is possible that the emergence of late Archaic settlements in southeastern Arizona and the corresponding trend toward specialized hunting tactics created economic problems for populations in other regions. With the development of surpluses from food production, desert populations were able to organize and support extremely specific hunting forays into distant upland areas during autumn months, selecting only the highest return species (Bayham 1982; Shackley 1992). Similar hunting specialization by lowland populations may be evident in the faunal records from Fresnal Shelter and Tularosa Cave, which are located in montane regions adjacent to the southern Basin and Range (fig. 8.1).

For populations dependent on high-ranked faunal and flora resources, particularly during winter, the presence of hunting parties targeting those same resources during the fall would have had adverse consequences. As late Archaic populations in warm temperate environments evolved increasingly sedentary land-use systems based on successful plant cultivation, they became inadvertent agents in lowering the fitness of adaptive strategies among other populations. This scenario is essentially the same as that posited by Bettinger and Baumhoff (1982) for the displacement of Great Basin hunter-gatherers, whose low-cost strategies were based on large game, by foragers whose higher-cost tactics were oriented toward plant collection. The plant collectors are viewed as generalists who would take high-ranked foods when possible, thus depriving more specialized foragers of preferred resources.

Populations in cool temperate environments affected by competitive interaction with other populations had only three economic options: abandon the contested areas, exclude competitors, or replace lost resources with lower-ranked foods. Territoriality is not feasible without predictable and adequate resources (Dyson-Hudson and Smith 1978). In order for populations to reside year-round in upland areas—the necessary basis for territorial exclusion—they would have had to find alternatives to winter and spring foods available solely at lower elevations. Maize and other domesticates are the only logical candidates, since collection of the highest-ranked foods, such as deer and piñon nuts, could not be intensified (Hunter-Anderson 1986). Consequently, competitive exclusion from areas of critical *natural* resource availability was undoubtedly based on greater use of cultigens.

As elevation increases, however, the growing season shrinks, so that upland areas have the highest probability of losing crops to frost. Initially, at least, wild resources must have been capable of supporting year-round occupation in the event of low returns from food production (O'Shea 1989). Winterhalder (1990) makes a similar point, noting that production intervals for annual crops are large compared to returns from hunting and gathering, and cultivators need the means to sustain losses over multiple seasons. Therefore it seems likely that only localities with high natural resource productivity would have been capable of supporting shifts to *annual* reliance on crops. This likelihood implies that appropriate areas were differentially distributed within a region, and we should not envision whole regions as the context within which intensification took place. Parenthetically, yearly crop success in the upland Southwest continues to be notoriously poor even under modern agricultural regimes (Abruzzi 1989).

Although direct competition between cool and warm temperate populations would have occurred along the boundary between the Colorado Plateau and the southern Basin and Range, in areas such as the Mogollon uplift, or "rim," it is unlikely that competition between regional populations was nearly so important in the shift to localized economies as was interaction between local groups. Clinal variability in artifact styles over large areas suggests that late Archaic populations were fluid and socially dynamic. Presuming that each local group reacted to the activities and changes taking place among its neighbors, the adoption of new resources or economic tactics by even a single group could eventually have a profound effect on a much larger number of people through avalanche or cascade effects. In general, the greater the amount of interaction among local groups, the more likely that the actions of even a single group could eventually affect many others. Evolutionary biologists describe high connectivity as "coupling"; increases in coupling among the units in a population results in greater sensitivity of the entire population to small changes in any part (e.g., Kauffman and Levin 1987). The only "causal" mechanism required in such a process is that the behavior of a group, such as growing maize—or perhaps, more fundamentally, using maize to establish territories—somehow diminished the economic fitness of interacting groups (cf. Keeley, this volume).

The loss of high-ranked resources to increasingly sedentary populations is one way in which local groups might have experienced declining fitness, regardless of any internal changes in their own economies. Cascade effects would occur if some groups responded by raising investments in food production to sustain the productivity of wild resources, thereby restricting access to those resource areas for all their neighbors. Positive feedback between restricted geographic access and increased food production is obviously a prime candidate for causing the "spread" of greater reliance on domesticates in such circumstances.

The first appearance of maize and squash among cool temperate populations suggests that competition for areas containing high-ranked resources existed prior to the advent of successful maize intensification among southern Basin and Range populations. For that reason, the rise of late Archaic farming populations in desert settings and its attendant effects on neighboring populations can only partially explain the synchronous development of intensive local economies throughout the Colorado Plateau after 2200 bp.

A more complete answer might include a widespread episode of increased amounts and spatial predictability of precipitation on the Colorado Plateau between 2000 and 1750 bp (Dean et al. 1985). Increased precipitation is conventionally thought to improve conditions for food production, but since increases in precipitation covary with cooler temperatures, risk also increases at higher elevations (Abruzzi 1989). It may have been more significant for late Archaic populations that increased precipitation meant higher natural resource productivity, especially a reduction of interannual periodicities in some items, such as nut masts. Similarly, grasses and weedy annuals respond quickly to precipitation; the appearance of bison herds in the Mogollon Highlands and Rio Grande valley at the end of the late Archaic indicates extensive grasslands, standing water, and increased faunal biomass (Wills 1989).

Thus, a natural increase in the predictability and abundance of upland resources may have facilitated territoriality in highland areas under conditions of resource competition. Again, positive feedback probably played an important role, since conditions that raised natural productivity would also draw competitors to those resources. Moreover, increased precipitation in the Southwestern highlands meant greater stream flow in desert rivers such as the Salt and the Gila (fig. 8.1), perhaps supporting even more successful plant cultivation and continued specialized long-distance foraging.

Competition implies an excess of consumers over available resources, and some researchers assume that population growth primarily accounts for localized economies at the end of the late Archaic (e.g., Gumerman and Cordell 1989: 8–9). The frequency of chronometrically dated sites does increase during the late Archaic, almost exponentially, but this pattern could be explained more conservatively as resulting from increased sedentism, which led to larger, more visible sites (see Berry and Berry 1986; Wills 1988a). Clearly, demographic processes of the late Archaic were complex and may even have involved immigrant populations, as Matson (1992) speculates, but there is no unambiguous evidence for either immigration or population growth. And as Keeley (this volume) suggests, population density can be a significant factor in economic change without necessarily increasing (cf. Eldredge 1986; Robertson 1991). In the model just outlined, the only dynamic required to explain the widespread shift to localized economic systems with a food production component was competition for high-ranked natural resources.

An essential implication for this competitive process is that Archaic hunter-gatherers who initially acquired domesticates were not setting out deliberately to become farmers. Indeed, the apparent use of cultigens to intensify ongoing forager economies means that the plants were adopted in order to maintain existing subsistence strategies. The eventual replacement of land-extensive production systems by localized economies—the beginning of agriculture—can be attributed to competition between local groups, stimulated in part by the unexpected positive feedback resulting from growing maize in warm temperate environments.

Redding (1988) argued specifically, and Bettinger and Baumhoff (1982) more generally, that the basic feature of any subsistence change that requires explication is how such change conveyed a competitive advantage. I suggest that it may be profitable to consider the dynamics of economic change in the late Archaic in terms of interaction and competition between local groups for critical or high-ranked food resourcees, a situation in which successful desert farmers might have had an advantage over neighboring, more mobile upland populations. This perspective assumes substantially more economic and social complexity for the late Archaic than most archaeologists have inferred, but ultimately I think it will help account for the increasingly complicated archaeological record that is being documented by researchers throughout the Southwest for the late preceramic period. The imperative for more complex models is easily seen in the fact that whereas farming villages appear earlier in the desert regions than in cool temperate zones, it is the higher-elevation areas that continue to produce the earliest dated cultigens.