Navajo Multi-Household Social Units: Archaeology on Black Mesa, Arizona

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scale at which sites cluster or disperse. To attack this problem, I use a form of quadrat analysis using the subregions as the quadrats. Quadrat analysis compares the distribution of sites among a series of spatial blocks (quadrats) with the distribution expected under a random pattern. The resulting statistic, a ratio of the variance to the mean of quadrat site frequencies, is higher than one if sites concentrate in only a few quadrats and lower than one if sites are evenly dispersed among quadrats. This technique evaluates clustering or dispersion at a single scale—the size of the quadrats. Because the subregions are my quadrats, I can judge the degree to which clustering or dispersion occurs at the scale of the subregions, which are spatial blocks that average a bit over 20 km^2.

Unlike conventional quadrat analysis, in which quadrats are of uniform area, the subregions vary in size. This requires some modifications in the technique, and I use a "corrected variance/mean ratio" to evaluate the spatial pattern. The interpretation of this ratio in terms of interquadrat clustering or dispersion remains the same as in the usual form of the technique.[4] The ratio may be used to compare the degree to which sites cluster into subregions from time period to time period. As described in chapter 6, the quadrat analysis serves primarily as negative evidence, to show that the spatial patterns identified by the nearest neighbor technique operate at below the subregional scale.

This method does not give the same continuous information on the scale of patterning as that provided by the cluster analytic method used for the ethnographic data. It does, however, provide a check on the scale of the patterns that cause variations in the nearest neighbor statistic. The combination of the nearest neighbor and quadrat analyses gives an indication of the scale of clustering, despite the limitations imposed by the archaeological spatial data. With this suite of spatial analytic techniques, we can monitor changes in settlement patterns alongside the simultaneous changes in population, economy, and social group composition. The Black Mesa archaeological data provide a record, however imperfect, of how these variables have covaried over more than a century.

6

Measuring Change on Northern Black Mesa

Black Mesa's archaeological record offers the chance to follow long-term changes in Navajo life, but it raises methodological challenges as well. Describing changes in population, economics, and small-scale (residence-group) units is relatively straightforward. Discerning multiresidence group cooperative units is more complicated.

The Population

Shifts over time in the number of tree-ring dates, site components, or structures all track the changing population of northern Black Mesa. The level of resolution of these data can be adjusted by varying time intervals, site types, seasons, or geographic areas, but by and large the results are internally consistent.

The simplest approach is to count the number of individual tree-ring dates by period. Traditional Navajo wooden structures require frequent repair and replacement (see appendix A), so a continuous stream of architectural wood cutting accompanies life on the mesa. Figure 6.1 shows *all* tree-ring samples, including dead wood samples and noncutting dates (lacking the B, G, L, c, r, or v symbols; see chapter 5, note 1). Although dates extend to before the nineteenth century (the oldest sample falls in the twelfth century), most of these earliest specimens are isolated noncutting dates and dead wood. Small groups of dates cluster around 1775 and 1805 to 1810. These clusters, again mostly noncutting dates, may represent poorly preserved wood from sparse early occupations, but there are not enough samples to adequately demon-

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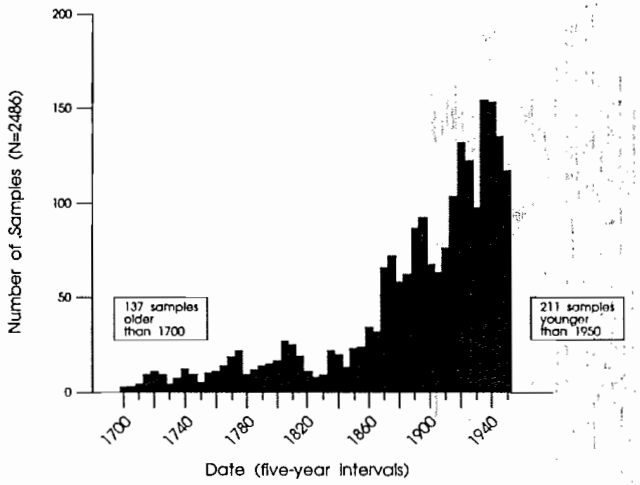

Figure 6.1. All Tree-Ring Sample Outer Dates, Including Dead Wood and Noncutting Dates.

strate this. The next group of dates falls in the 1830s and contains the earliest cutting dates clustered on individual sites. Marked growth begins after the end of Navajo captivity at Fort Sumner in the late 1860s and extends up to recent times. This large group of post-1860s dates indicates a clear increase in use of the area starting around 1870, although it may also reflect wider availability of axes for wood-cutting (Brugge, personal communication 1985). The growth trend breaks several times, around 1880, 1900, after 1920, and again after about 1940. This last decrease is due to a lack of dates from occupied sites, rather than to a population drop. Because the BMAP did not map occupied sites, very few recent tree-ring samples are available.

Counts of site components or individual structures show similar patterns (see also Rocek 1985). Figure 6.2 shows all reliably dated components (that is, it excludes components guess-dated solely on the basis of their condition; see appendix A). The pattern is similar to figure 6.1, although survey data on occupied sites (which lack tree-ring dates) add another spike around 1980. The oldest well-dated sites (based on clustered tree-ring cutting samples) are in the late 1830s. Although early sites may be underepresented due to attrition, the figure suggests that Navajo settlement in the area was light through the mid-nineteenth century. As suggested by figure 6.1, increased construction began in the late 1860s and 1870s. The number of components dipped slightly around 1880, fell again sharply during the first decade of the twentieth

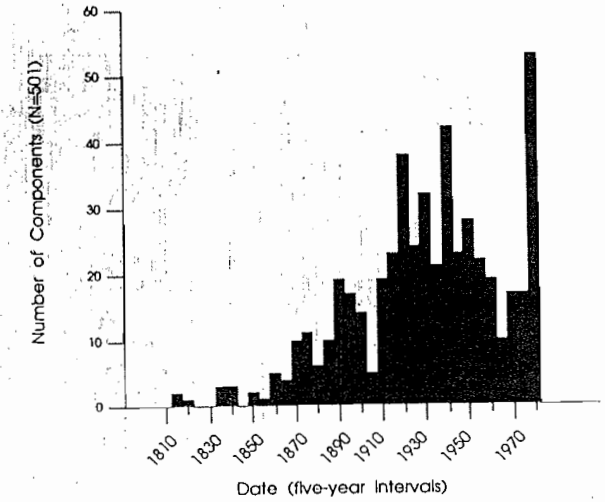

Figure 6.2. Site Component Dates by Five-year Intervals for All Site Types, Reliably Dated Components Only.

century, and leveled off and dropped again slightly after 1920. Construction rebounded in the 1940s, after which the curve falls off. Again, the gap in post-1940s components is an artifact of the lack of data on sites occupied at the time of the BMAP surveys. Occupied sites are arbitrarily dated to the year they were surveyed (primarily in the 1970s and early 1980s), and information regarding their actual construction date and use history is unavailable.

Although the tree-ring and component counts give a general indication of population trends, further refinement is possible. Breaking component counts down by subregions (fig. 5.1) gives additional details of settlement history (fig. 6.3). All subareas show increased occupation shortly after the 1860s, although subregion 3 also exhibits the greatest concentration of late pre-Fort Sumner components (late 1850s and early 1860s). Subregion 6 has the most sites from the Fort Sumner period, perhaps because of its rugged terrain and relatively high elevation, which made it an attractive refuge area. Subregion 1 is notable for its fairly steady site density in the 1880s and around 1905, in contrast to the decrease in the study area as a whole. The mid-1930s dip also varies between subregions.

A step beyond component counts, numbers of habitation site components (as defined in chapter 5 and appendix A, these are sites with both a corral and a permanent dwelling) provide still clearer population measures. Restricting

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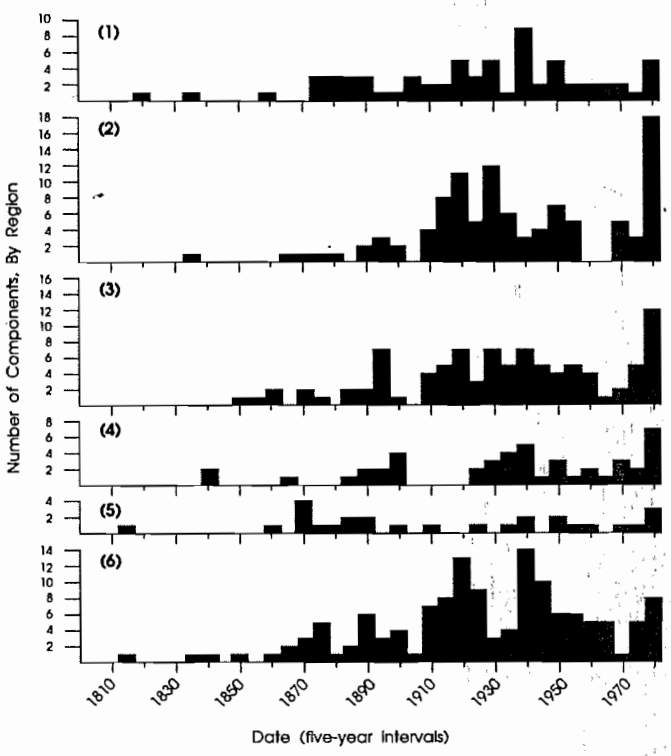

Figure 6.3. Site Component Dates by Five-year Intervals by Subregion, All Site Types, Reliably Dated Components Only.

analysis to habitation sites eliminates the variability of special activity sites such as piñon camps, travelers' camps, and isolated corrals. This makes the counts easier to interpret in terms of local population. In contrast to many special activity sites, habitation site seasonality is also relevant to residence group settlement choices and to interresidence group cooperation.

As noted in chapter 2, historical and ethnographic records suggest a shift from initial winter settlement on Black Mesa to a year-round pattern in the early twentieth century, although with considerable variation from year to year and among different areas. Archaeological and informant data are similarly mixed, but habitation site counts by season show this change. Counts by five-year intervals of winter and summer habitation components show a seasonality shift around 1920.[1] Although all seasons are represented throughout the sequence, the proportion of summer relative to winter sites increases over time.

Summer sites exceed winter in only three time intervals prior to 1920 while winter sites exceed summer sites in ten. Subsequently, summer sites dominate in nine intervals, and winter sites in only one (see also Rocek 1985, 1988). The variability of this pattern is highlighted when examining these trends by subregion. Table 6.1 shows that different areas reflect the seasonal shift to variable degrees. Subregions 4 and 6, the two highest elevation areas nearest the mesa rim, show the increase in summer habitation sites. The pattern is less clear, or even contradicted in other areas, for example subregion 2).

The seasonality data are significantly affected by differential preservation. Summer sites are in part recognized archaeologically on the basis of evidence for impermanent summer structures such as shades and tents. This evidence is more likely to be preserved on recent sites. In addition, the rugged terrain chosen for defensive purposes on early sites (Kemrer 1974) often provides sheltered locations resembling those used in later periods for winter sites. Thus, identification of early site seasonality may be biased in favor of winter, because sheltered site location is one of the bases used to identify seasonality.

Still, the subregion differences probably do reflect different seasonal settlement patterns. Winter occupation on the mesa and summer movement to the adjacent lowlands may have been more characteristic of the families living near the rim. In the mesa interior, seasonal moves were perhaps confined to the mesa itself at an earlier date (cf. Hoover 1931:327–28).

The habitation site data show that a reconstruction of population trends must take seasonality into account. Furthermore, instead of merely counting components, the number of permanent dwellings (houses and hogans) on habitation site components provides the most direct measure of relative population. Before dwelling counts can be interpreted in terms of population, however, we must control for two additional variables: the number of occupants per dwelling and the duration of component occupation.

Many archaeological studies use formulas based on site or roofed surface area rather than dwelling counts to estimate population, but I take a simpler approach based specifically on Navajo settlement practice. I assume that the average size of the smallest social unit, the household, remains constant. Outside of urbanized regions, reservation-wide data indicate a relatively steady household composition ranging from about five to seven people (mean 5.9, standard deviation .6; data from Kelley 1982b:91). Russell's investigations in the BMAP area yield similar figures: 328 people in 55 households, or 5.96 people per household (data for Eastern Lease area from Russell 1981a; data for Western Lease area derive from Russell n.d.).

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Table 6.1. Habitation Site Component Seasons by Subregion; Percentages of Reliably Dated Components, All Bases of Seasonality Assessment.[a]

	Subregion 1				Subregion 2				Subregion 3			
Decade	Total Count	Summer %	Winter %	Other/ Unk.	Total Count	Summer %	Winter %	Other/ Unk.	Total Count	Summer %	Winter %	Other/ Unk.
Pre-1840	2	...	100	...	1	100	...	...	..	...	...	...
1840–1849	..	...	...	...	..	...	...	...	..	...	...	...
1850–1859	..	...	...	...	..	...	...	...	1	100	...	...
1860–1869	..	...	...	...	..	...	...	...	..	...	...	...
1870–1879	..	...	...	...	1	100	...	...	2	...	...	100
1880–1889	2	100	...	...	..	...	...	...	..	...	...	...
1890–1899	2	...	...	100	..	...	...	...	3	...	...	100
1900–1909	1	...	100	...	..	...	...	...	..	...	...	...
1910–1919	3	...	...	100	3	33	67	...	5	60	...	40
1920–1929	3	...	67	33	5	80	20	...	2	...	50	50
1930–1939	2	100	...	...	6	...	50	50	7	43	...	57
1940–1949	5	...	20	80	4	50	25	25	9	56	...	44
1950–1959	4	50	...	50	4	50	25	25	3	...	...	100
1960–1969	..	...	...	...	..	...	...	...	..	...	...	...
Post-1969	5	60	...	40	10	30	10	60	2	50	...	50
Total	29	31	21	48	34	41	27	32	34	38	3	59

	Subregion 4				Subregion 5				Subregion 6			
Decade	Total Count	Summer %	Winter %	Other/ Unk.	Total Count	Summer %	Winter %	Other/ Unk.	Total Count	Summer %	Winter %	Other/ Unk.
Pre-1840	..	...	...	...	1	...	...	100	1	...	100	...
1840–1849	1	...	100	...	..	...	...	...	..	...	...	...
1850–1859	..	...	...	...	..	...	...	...	1	...	100	...
1860–1869	..	...	...	...	..	...	...	...	1	...	...	100
1870–1879	..	...	...	...	2	...	100	...	4	25	75	...
1880–1889	1	...	100	...	2	50	50	...	4	25	50	25
1890–1899	..	...	...	...	1	100	...	...	2	...	50	50
1900–1909	1	...	...	100	..	...	...	...	4	...	50	50
1910–1919	..	...	...	...	..	...	...	...	6	17	67	17
1920–1929	1	...	100	...	1	...	100	...	9	56	36	11
1930–1939	4	25	50	25	1	...	...	100	3	...	100	...
1940–1949	2	50	...	50	1	100	...	...	14	21	21	57
1950–1959	2	50	...	50	2	...	100	...	4	25	50	25
1960–1969	..	...	...	...	..	...	...	...	..	...	...	...
Post-1969	4	50	...	50	2	...	50	50	5	40	40	20
Total	16	31	31	38	13	23	54	23	58	24	47	29

a. Reliably dated habitation site components only. Summer category includes summer, spring-summer, summer-fall, spring-summer-fall; winter includes winter, fall-winter, winter-spring, fall-winter-spring; other/unknown includes: year-round, spring, fall, and unknown. These seasonal categories differ from those used in later analyses below, where seasonal overlap of occupation is the primary concern. There, for instance, *both* summer and winter counts include year-round sites, rather than treating them as a separate category.

Ethnoarchaeological data from the McKinley Mine area on the eastern reservation documents the number of dwellings per household on sites of various ages (Kelley 1982b:360). Kelley uses a similar definition of the household as followed here (chapter 5), but includes dependents (usually elderly relatives) living in adjacent structures. She finds a steady mean of 1.2 to 1.3 dwellings per household. Kelley (1982a:51–55) also examines the number of occupants per square meter of dwelling (hogans in particular). She finds that hogan floor area is a function of factors including the range of indoor activities carried out over the course of occupation, but dwelling size is not a good indicator of the number of occupants. This point is even clearer in a sample including Anglo-style multiroom houses along with hogans, because the use of floor space in these structures is very different.

So, a household (by Kelley's definition) occupies an average of 1.2 to 1.3 dwellings and consists of around six individuals. This suggests that each permanent dwelling on a Navajo habitation site averages slightly under five occupants. One minor correction suggested by Kelley's analysis is that hogan-like structures smaller than 3.5 meters diameter (about 9.5 m^2 floor area) typically do not serve as dwellings, but function instead as shelters for herders or for storage. Therefore, I excluded structures smaller than 9.5 m^2 in floor area from my population calculations.

Aside from variation in the number of dwelling occupants, changes in the duration of site component use would affect estimates of relative population over time. Different sites clearly vary in the number of years that they were used; the critical issue is changes over time in the average number of years families reused sites. To control for this possibility, I examine duration of occupation in several ways. Most directly, if the duration changes, then structure and feature dates of different ages should show differences in their temporal spread within components.[2] That is, changes in the difference between the latest and the earliest structure or feature dates within components should reflect changes in occupation span. But in fact there is no significant correlation between habitation site component age and the span of dates per component (Rocek 1985).

Kelley (1982b:359, 363; 1986:38, 188) offers another approach, using ethnographic estimates of occupation duration, to investigate site-use span in the McKinley Mine area. She finds a relatively constant mean length of homesite use (ten years) from 1880 up to 1950. Subsequently, average duration rises sharply to sixteen years. The most common reason for site abandonment (over 50 percent of known cases) is a death on-site. Kelley relates the 1950s

increased use span to improved roads and easier hospital access, which reduced the occurrence of deaths at the sites. Shrinking land availability and increased investment in permanent facilities may also have contributed to a reluctance to abandon sites. In any case, her data suggest that changes in occupation duration of habitation sites should not be an important factor until the most recent periods.

Finally, Blomberg (1983) uses archaeological measures of habitation sites to suggest an increase in site occupation intensity in the BMAP area through time. She shows an increase in the number of several categories of features and animal enclosures and in the distance of ash piles from hogans. These changes match her model of a shift to longer site occupations during the early twentieth century. She suggests that extended settlement should lead to increased site complexity and separation of waste disposal from dwellings.

Blomberg's findings regarding changes in site characteristics are clearly valid. For instance, the number of animal enclosures (of all types) per habitation site correlates significantly with time ($r = .16$, $n = 166$, $p < .04$), as does ash pile distance from hogans ($r = .46$, $n = 77$, $p < .01$) (though compare Kelley 1982b:307, 311 for an alternative interpretation of ash pile placement). Other measures of increased use intensity that only marginally correlate with time in Blomberg's study are more clearly significant in the present (larger) sample; for example, estimated ash pile volume correlates with time ($r = .24$, $n = 203$, $p < .01$) (cf. Kelley 1982a:66–67). Blomberg (1983:20) postulates an increase in the length of individual use events at sites (how many months a site is occupied in a particular year), as well as an increase in the overall duration of reuse (how many years a site is visited and reused). The site characteristics she investigates do not distinguish between these two aspects of site-use. In addition, some of the variables are clearly subject to taphonomic effects, such as erosion of old ash piles. Given the structure-feature date distributions on site components and Kelley's ethnographic observations described previously, at least a substantial part of the change demonstrated by Blomberg most likely relates to increasing length of annual site-use events rather than to a shift in the interannual duration of site-use.

Therefore, in my population estimates I assumed that average component occupation duration did not change markedly until after the mid-1940s. To the extent that I neglected changes that did occur in occupation span, I *overestimated* early population levels, because all lines of evidence suggest increased span. Despite this, the early site frequencies are low, indicating sparse populations in any case.

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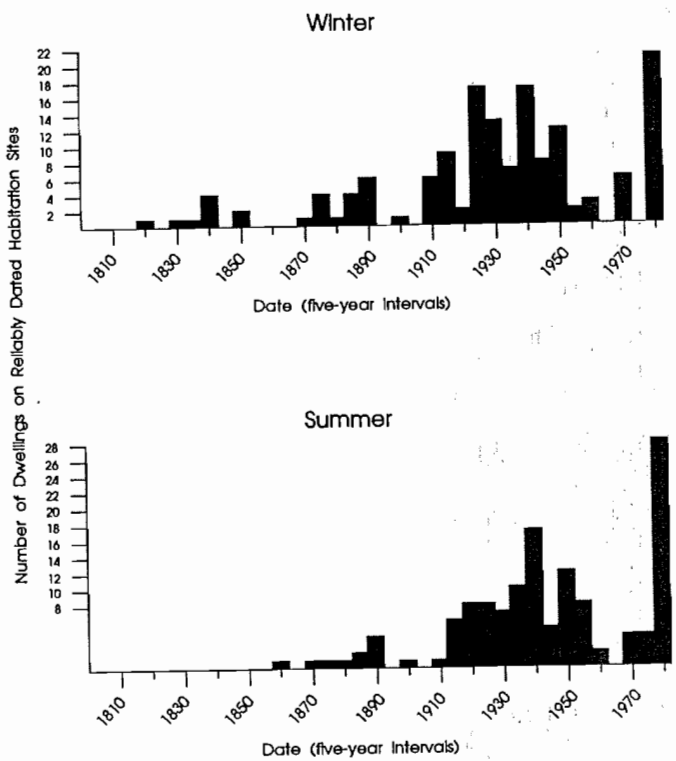

Figure 6.4. Counts of Permanent Dwellings (Hogans and Houses) on Reliably Dated Habitation Site Components, by Five-year Intervals and by Season.

With these considerations in mind, figure 6.4 shows dwelling counts by five-year intervals on reliably dated habitation components. I included only structures with an area not less than 9.5 m² (because small structures are rare, I assumed that unmeasured dwellings are larger than 9.5 m² and included them in the analysis). Components were divided into winter and summer categories on the basis of whether they were occupied in that season, regardless of whether they were also used at other times of year. For instance, the summer count includes multiseason components such as spring-summer and even year-round occupations. Some components are included in both counts, because the[illegible] used during both times of year. Due to differential preservation, the summer counts are probably somewhat less reliable than the winter, possibly underrepresenting relative population during the early periods. In

addition, the data undoubtedly miss some of the people living in temporary warm-weather structures (tents and shades). Despite these limitations, however, I used both figures, because the summer data should reflect summer population more directly than the winter counts.

The trends suggested for the two seasons are comparable, although with several specific differences. Most notably, the summer pattern lacks substantial occupation until around 1890; this may reflect the predominantly winter use of the mesa in early years. It also lacks the sharp fluctuations in dwelling counts that the winter pattern shows around 1920. Overall the dwelling data mirror the tree-ring and component counts described in figures 6.1 and 6.2. The first major growth in permanent habitation occurred around 1870, after the Fort Sumner period. A notable characteristic of both seasons is evidence of depopulation around the turn of the century (an earlier possible population drop occurs around 1880, but this is only reflected in the winter counts). This fluctuation is certainly a relatively local phenomenon, not reflected in tribal-wide population figures. That is, this was a period during which the families that normally used this area of Black Mesa used it less often; these families did not die out. Russell's (1983b:59) study of Navajo settlement just south of the BMAP area also suggests a hiatus around the turn of the century, indicating that this temporary population shift covered a substantial area of northern Black Mesa.

Climatic data suggest a possible explanation of this apparent decline. Tree-rings show declining local conditions starting from moist conditions (high tree-ring indices) around 1840 and culminating in a low about 1900 (Dean 1982:fig. 1). That low is worse than all negative tree-ring index values because the late 1700s and this late-nineteenth-century drought cycle constitutes "one of the most severe droughts of the 1600-year [Black Mesa area tree-ring index] record" (Dean 1982:6). This period corresponds to a cycle of drought years described by Left Handed, when he and his family abandoned their regular seasonal pattern in favor of long ranging migrations in search of forage (see chapter 2; Dyk 1967). Left Handed's account refers to an earlier part of this cycle in the 1870s. This drought interval also marks the beginning of the recent cycle of erosion in the study area and elsewhere in the Southwest. The tree-ring record shows that the late-nineteenth-century decline is marked by two distinct peaks of low index values—one around 1875 to 1880 and one sharper spike at 1900. These peaks may explain the two-cycle fluctuation in dwelling counts noted earlier, one around 1880 and the other more drastic one around 1900.

Three other fluctuations in the winter population data may reflect larger-

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scale changes in resident population. The dip around 1920 (not shown in the summer counts) may mark the 1918 to 1919 flu epidemic. This period (1920 and 1921 in particular) also shows a peak in windbreak construction, reflecting the temporary jump in mobility and short-term occupations immediately following the epidemic. The sharp rise in permanent dwelling construction in the succeeding period probably represents the establishment of new habitation sites by survivors who abandoned death sites.

This dip and subsequent peak in dwelling construction thus represent not only demographic fluctuations but also short-term changes in construction activity. This observation is relevant to two other dips, one in the mid-1930s and again in the 1940s. There is no reason to believe that either of these represent actual drops in Navajo population. These were, however, both periods when major national and world-scale turmoil affected the Navajo reservation (the Depression and stock reduction in the former case and World War II in the latter). In both cases an immediate impact was a major economic shift toward increased wage-labor involvement. In the 1930s, the brief boom in federally sponsored jobs (Civilian Conservation Corps and Soil Conservation Service) probably diverted the male labor force from domestic construction activities. In the 1940s, the boom in off-reservation wage jobs created by the war (as well as actual military service) physically removed a part of the labor force from the reservation for substantial periods of the year, again discouraging major construction (see also Rocek 1988). Although these interpretations cannot be demonstrated, they serve as cautionary tales regarding the interpretation of the archaeologically derived population data. Although the broad trends probably do accurately reflect patterns of population change, the short-term fluctuations are much more sensitive to the specific factors influencing the timing of activities on the local level.

For these reasons, I use a form of moving average on the dwelling counts in my subsequent consideration of local population (table 6.2). My approach is to compute the total number of dwellings by overlapping decades, for example, 1840 to 1850, 1845 to 1855, 1850 to 1860, and so on. I also perform similar analyses using fifteen-year intervals overlapping by ten years. These counts [illegible] some of the sorts of fluctuations outlined previously and perhaps lose some detail on short-term population fluctuations. They should, however, be more representative of the overall trends in locally resident population than the immediate pattern of house construction.[3] The dwelling counts derived from these longer, overlapping intervals are of course higher in their absolute values, but closely follow the trends of the five-year counts.

Table 6.2. Permanent Dwelling Counts on Habitation Sites, by Overlapping Decades and Fifteen-year Intervals.[a]

Decade			Fifteen-year		
	Dwelling Counts			Dwelling Counts	
Interval Midpoint	Winter	Summer	Interval Midpoint	Winter	Summer
pre-1835	1	0			
pre-1840	1	0	pre-1830	1	0
1830	1	0	pre-1835	2	0
1835	4	0	pre-1840	6	0
1840	5	0	1838	6	0
1845	2	0	1843	7	0
1850	2	0	1848	2	0
1855	2	1	1853	2	1
1860	0	1	1858	0	1
1865	0	0	1863	1	1
1870	1	2	1868	2	2
1875	6	2	1873	6	3
1880	5	1	1878	6	5
1885	7	3	1883	14	6
1890	10	6	1888	10	6
1895	4	5	1893	10	5
1900	1	1	1898	1	2
1905	1	0	1903	3	1
1910	11	3	1908	11	4
1915	15	10	1913	16	13
1920	10	16	1918	21	21
1925	23	16	1923	31	23
1930	27	12	1928	34	20
1935	16	16	1933	37	29
1940	25	27	1938	34	35
1945	33	25	1943	41	39
post-1969[b]	50	41	post-1965[b]	62	59

a. Only dwellings larger than 9.5 m^2 included. See text for discussion of seasonal categories and for the recent time period data.

b. Surrogate dwelling counts (see text).

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In addition, to compensate for the incomplete data on occupied sites, I adjust estimates of recent populations in two ways. First, I simply omitted the dwelling counts after the mid-1940s (when the decadal and fifteen-year interval counts began to fall off). To provide a basis for analysis of the final period (1975 for the decade analysis, 1973 for the fifteen-year intervals), however, I use a value of 1.5 times the highest previous permanent dwelling count (which occurred in the 1940s) as a surrogate estimate of relative population. This is an arbitrary value, but is intended to take into account three critical factors. First, dwelling counts on occupied sites are almost certainly underestimated, because these sites were only surveyed and not mapped. BMAP survey estimates of structure counts are almost invariably lower than the number identified during actual mapping. Second, population estimates based on dwelling counts for the final period are poorly comparable to counts from previous periods due to the proliferation of non-hogan housing. To compound the problem, the number of rooms in unmapped non-hogan dwellings is unknown. Finally, population in the study area undoubtedly continued to increase substantially from the mid-1940s onward, but permanent and temporary outmigration also increased greatly. Therefore, the factor of 1.5 times the 1940s levels is considerably lower than the known overall growth rate of the Navajo population, which more than doubled during this period (Goodman 1982:61).

The value of 1.5 times the maximum permanent dwelling count serves as a general indicator of what dwelling counts might be if housing technology had not changed and occupied sites had been investigated fully. This value permits direct comparison with dwelling counts from previous periods. Clearly this is an approximate solution to the problem, but it should roughly indicate the direction of recent trends. The values of these final period "surrogate dwelling counts" are 50 and 41 respectively for the winter and summer decadal counts. The corresponding values estimating dwelling counts over fifteen-year intervals are 62 and 59 respectively (table 6.2). Encouragingly, multiplying these figures by the roughly five- to six-person average per dwelling yields numbers fairly close to the low 300s level of recent population in the study area. Still, the intent is to use these figures for relative, not absolute population estimates.

The Economy

Like human population, the core of the domestic Navajo economy—livestock population—is open to fairly direct archaeological scrutiny. Corrals provide

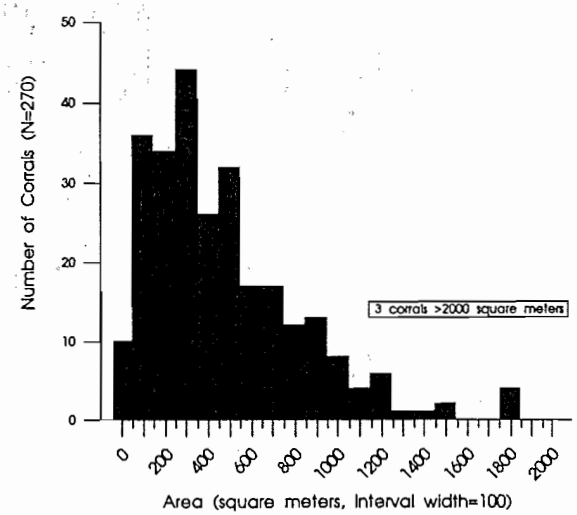

Figure 6.5. Corral Areas (m²) on Mapped Sites, Measured Corrals Only.

the most direct measure of the pastoral economy. I use estimates of corral area derived from length and width measurements of corrals on mapped sites (see Rocek 1985 for details). The distribution of corral sizes (fig. 6.5) has several large outliers, including entire canyons fenced off at their mouths as well as several large diffuse soil disturbances marking possibly corral boundaries. Both of these kinds of enclosures (or possible enclosures) reflect a different use of corral space than the majority of normal corrals and I excluded these outliers, larger than 1700 square meters, from further analyses (cf. Kelley 1982b:317–18). The remaining mapped corrals average 450 m². I substituted this value for the area of corrals that were not measured. These corral area data are the basis for two indices of livestock for each mapped site: total corral area per site, and the ratio of corral area to number of permanent dwellings (hogans and houses).[4] The former could serve as a general estimate of per-site livestock population, while the latter should more accurately reflect livestock per site inhabitant. I calculated these indices on well-dated habitation sites that have been mapped (survey estimates of corral area and dwelling counts are unreliable), and then derived medians by time intervals. The two indices produce similar results but the latter index (corral area per dwelling per site) appears to best track livestock population (see discussion that follows, and Rocek 1985). Therefore, I focused on this measure.

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