THE NUMIC SPREAD: GREAT BASIN CULTURES IN COMPETITION

Robert L. Bettinger and Martin A. Baumhoff

The rapid spread of Numic peoples into the Great Basin about 500-700 years ago is a major anomaly in the prehistory of that region because, according to current interpretations, it occurred in the absence of major adaptive change. A review of existing evidence suggests that this view is incorrect; we propose an alternative notion of important contrasts between Prenumic and Numic adaptation in terms of the relative reliance on large game and small seeds. These contrasts explain why the Numic speakers were consistently able to expand at the expense of Prenumic groups.

HAVING BARELY SETTLED into its role as establishment doctrine, the new archaeology is already under heavy fire for having failed in its most basic purpose—that of providing a viable model of culture process and cultural evolution (Dunnell 1980). At the center of this criticism is the contention that despite widespread archaeological acceptance of the idea that cultural evolution is analogous to biological evolution, the new archaeology seems to deny any such resemblance by its overriding concern with the study of subsystem interactions within individual culture units. This requires that cultural evolution be viewed as a process of internal adjustment through which culture units adapt themselves to their environment and changes in that environment. This is not the analogue of biological evolution, where the basic process is one in which the environment selects from a variety of forms the one(s) most fit. In the new archaeology, evolution is transformational; in biology it is selective (Dunnell 1980:77).

Paradoxically, the new archaeology developed partly as a conscious reaction to culture historical interpretations that explained culture change by reference to ethnic spreads, i.e., migrations, invasions, etc., which, by their implicit reliance on selective replacement, were eminently compatible with evolutionary biology.

Although new archaeologists initially professed interests in explaining the general processes underlying ethnic spreads, something seldom addressed by earlier investigators, they have almost never attacked this subject directly, dwelling instead more on the study of local system transformations, particularly where hunter-gatherers are involved. In part this is because migration theories continue to have connotations associating them with what has been called the "normative approach." Perhaps more important, however, current models of systemic transformation cannot be readily adapted to the process of ethnic spreads. Preoccupation with the ability of culture systems to change themselves has caused observed differences between various hunter-gatherers to be treated as matters of circumstance, that is, they are seen as the same system in different situations. Since two hunter-gatherer groups competing for the same resources or territory face roughly similar circumstances, and can therefore be expected to converge in form, it is difficult to see how one such group can displace another of similar kind, except in extenuating circumstances (see below).

Nevertheless, ethnic spreads do occur, and it is clear that without explaining the selective process that makes this possible, archaeological theory can lay no serious claim to being evolutionary theory. In this paper we discuss the problem of ethnic spreads among hunter-gatherers with primary reference to one in the Great Basin, the Numic spread, that has long resisted explanation.

Robert L. Bettinger and Martin A. Baumhoff, Department of Anthropology, University of California-Davis, Davis, CA 95616

0002-7316/82/030485-19$2.40/1

It is not our intent here to provide a general model of ethnic spreads, but we believe that the key elements of our explanation of the Numic spread will be central to any such model.

THE BASIS OF ETHNIC SPREADS

Linguistic distributions provide perhaps the most eloquent testimony to the movements of prehistoric hunter-gatherer populations because, in recorded history, it has usually been the case that language spread occurs through population movement. There are exceptions, as for example the transformation of Irish Celts into English speakers, but where this occurs there is almost always economic or political superordination by the speakers of the successor language. It is difficult to imagine such a situation obtaining between neighboring hunter-gatherers, and in such cases we are therefore justified in assuming that language spread implies population spread.

Historical linguistic studies make it clear that such ethnic spreads were commonplace among hunter-gatherers in many regions (e.g., Shipley 1978), yet archaeological research directed toward these phenomena has primarily concerned itself with culture historical documentation rather than with the development of a coherent approach to the study of the circumstances that precipitated these movements or the means by which they were accomplished (cf. Lathrap 1955: 1–30).

For reasons noted above, this particularistic treatment in large part derives from the assumption that all hunting and gathering groups are capable of essentially the same range of adaptive responses, from which it follows that ethnic spreads are possible only when special circumstances intervene, for instance, access to unpopulated or depopulated regions, special technical innovations, or superior sociopolitical organization in the sense of increased complexity. Tacit acceptance of this position has made the treatment of ethnic spreads a study in special pleading for such circumstances (cf. Krantz 1977), although some of these arguments are quite sophisticated (e.g., O'Connell and Hawkes 1981; O'Connell et al. 1982).

Were only such special circumstances involved, ethnic spreads would probably be rarer than appears to be the case in many regions, because unpopulated/depopulated regions and technical or organizational innovations not easily copied by competitors (cf. Gearing 1962) are themselves quite rare. The distribution of language groups in western North America, for example, points to a long succession of hunter-gatherer spreads that defies credible explanation solely with reference to such "special circumstances."

In contrast to particularistic explanations, we believe that ethnic spread is frequently an orderly process in which, without special circumstances, i.e., holding environment, organization, and technology constant, one hunter-gatherer group successfully displaces others by virtue of competitive advantages inherent in its adaptive strategy. Adaptive strategies, of course, comprise innumerable features that might afford such advantages, but the one most significant in competitive situations is likely to be cost, specifically in the form of the replacement of low-cost strategies by high-cost strategies.

This basic premise is grounded in the assumption that for hunting and gathering economies the cost per unit of return for most subsistence activities increases directly with the intensity of that activity, i.e., the law of diminishing returns (cf. Earle 1980). Because of this, as population increases with respect to resources the cost of subsistence procurement per individual also increases (cf. Glassow 1978; Christenson 1980). Accordingly, since competitive situations in which two groups vie for the same resources are by definition characterized by high population densities (Milne 1961), it follows that groups more willing or able to engage in high-cost strategies will generally displace groups less willing or able to do so.

For hunter-gatherer adaptive strategies in similar natural settings and with similar technologies, such variations in cost can perhaps best be appreciated with reference to the optimal foraging models so popular in the current archaeological literature dealing with hunter-gatherers (cf. Bettinger 1980b). In these optimal models, subsistence activities are subdivided into phases that include, usually, travel time, search time, extraction (e.g., pursuit or gathering) time, and processing time. To calculate optimal caloric gain per unit of time devoted to subsistence, potential resources are first ranked in terms of caloric output per unit of time spent extracting and preparing them for consumption. Beginning with those most highly ranked, resources are added to the diet so long as their caloric yield per unit of time spent extracting and processing them alone is greater than the average caloric return per unit of time spent extracting, processing, *and* finding all the more highly ranked resources. In this way, neither search time for high-ranked resources nor extraction or processing time for low-ranked resources is allowed to reduce subsistence efficiency (for a more detailed discussion see MacArthur and Pianka [1966], Pyke et al. [1977], and Schoener [1971]).

Change in dietary breadth occurs as a direct response to the changing availability of highly ranked resources. As these become more scarce, through depletion or increased numbers of consumers, the amount of time needed to find them (search time) increases and it may become more profitable to broaden the diet to include resources that require more time to extract and process, so long as the increase in extraction and processing time is outweighed by the reduction in search time that results from the decreased dietary selectivity. Conversely, as the abundance of high-ranked resources increases or the number of consumers decreases, lower-ranked resources are deleted from the diet when their cost of extraction and processing is no longer justified given the decreasing search time for higher-ranked resources. Thus, subsistence change occurs as a trade-off between search time for high-ranked resources and extraction and processing time for low-ranked resources. Further, subsistence cost increases as the diet is broadened to include resources with increasingly higher extraction and processing costs (although these costs are only partly responsible for the overall increase in dietary cost). From this it follows that for any particular adaptive strategy the amount of time devoted to resource extraction and processing is a direct measure of overall dietary cost.

It also follows that if both resources and technology are held constant, as we stipulate here, a high-cost strategy would be optimal only where population was relatively high with respect to resources, a low-cost strategy only where population was relatively low with respect to similar resources. This explains, in specific terms, the advantage of high-cost strategies in competitive situations. Note, however, that there is no necessary implication about absolute population size, only about the relationship between population and resources.

Because of these demographic relationships certain differences between low-cost and high-cost strategies can also be expected in terms of settlement pattern. Optimal foraging models show that as food density decreases due to increased population, consumers should spend less time travelling between resource areas (Charnov 1976; MacArthur and Pianka 1966). This occurs when diminishing returns in distant resource areas, combined with the travel time needed to reach them, finally falls below the return rate attainable in resource areas nearer at hand. Because of this, as resources are reduced in quantity, the more distant resource areas are increasingly deleted from the foraging itinerary. This results in reduced investment in travel and increased investment in actual foraging time. Since, as just noted, low-cost and high-cost strategies differ in their ratio of consumers to resources, the high-cost strategy implying relatively greater numbers than the low-cost strategy, investment in travel time should be lower in the high-cost strategy than the low-cost strategy, owing to its greater population and, hence, rate of resource depletion. That is, the low-cost strategy should allocate more time to travel than the high-cost strategy. More simply, for any particular strategy, the amount of time devoted to travel is inversely related to overall dietary cost.

In combination, the above considerations make it possible to contrast low-cost and high-cost strategies in terms specifically relevant to hunter-gatherer subsistence-settlement systems. Of the two, the low-cost strategy is the more reliant on resources of high quality, i.e., high rank, and incurs greater costs in travel time and lesser costs in extraction and processing time; we term this a *traveller* strategy. The high-cost strategy is the more reliant on resources of low quality, i.e., low rank, and incurs lesser costs in travel time and greater costs in extraction and processing time; we term this a *processor strategy*.

Diamond (1978) has drawn a distinction between "old colonist" and "tramp" strategies among animal populations in island communities that in certain respects has implications parallel to our distinction between travellers and processors. Closer to home, the contrast between "forager" and "collector" hunter-gatherer settlement systems defined by Binford (1980) is likewise similar to the traveller-processor contrast we have defined. The traveller-processor dichotomy differs from these schemes primarily in its explicit emphasis on subsistence patterns and the differential allocation of time to specific activities within subsistence-settlement systems. Because of this our *traveller* is not exactly identical to Diamond's "old colonist" or Binford's "forager," nor our *processor* to Diamond's "*tramp*" or Binford's "collector." A systematic treatment of the differences and similarities, however, is clearly beyond the scope of this discussion.

COMPETITION BETWEEN TRAVELLERS AND PROCESSORS

The traveller-processor contrast is relevant to ethnic spreads because we can predict that in competitive situations which place a processor group and traveller group at odds, the processor will be the less affected and thus more likely to prevail. This follows first because increased densities, which characterize competitive situations, raise travel and search time for both groups but should work the more extreme hardship on the travellers, who spend relatively more of their time travelling and searching, than on the processors who spend relatively more of their time processing. Perhaps more important, the processor will compete for all the resources of the traveller, while the traveller competes for only a fraction of the resources of the processor, ignoring the low-ranked ones.

Since the processor strategy is relatively higher in cost than the traveller strategy, this argument is consistent with our basic proposition that ethnic spreads can occur through the replacement of low-cost strategies by high-cost strategies and clarifies the mechanism of replacement.

It is clear, however, that such replacement would not be expected to occur unless it is also assumed that within a specific region traveller and processor strategies are specializations in the sense that a group that does one well cannot do the other equally well or quickly transform itself to do so. That is, we must assume that contemporaneous groups of hunter-gatherers in the same techno-environmental setting may be adaptively differentiated to the extent that they are not capable of the same range of behavioral responses. The necessity of this assumption is easily shown.

Consider, for example, the situation in which one group experiences resource stress, expands its diet, and then, finding the increased costs of this diet unacceptable, attempts to encroach on the territory of an adjacent group with a lower-cost restricted diet. In optimal theory, the resulting aggressor pressure would require the defender population to expand its diet to match that of the aggressor as a response to the reduction of resources brought about by the encroachment and competition, to which both would be subject. In this case, so long as both aggressor and defender were capable of similar responses, any initial discontinuities between the subsistence strategies of the two would quickly disappear, as each adjusted its diet to accommodate the competitive pressure. This would reduce the contest to a stalemate.

However, should the aggressor eventually manage to dislodge the defender and thereby establish itself in new territory, according to optimal theory it should then readjust to a low-cost, restricted diet similar to that of the group recently displaced. This would alleviate any adaptive discontinuities between these pioneer aggressors and established groups in the frontier beyond and forestall further competitive expansion.

Finally, even in the case that the aggressor initially enjoyed numerical superiority, at the expense of a high-cost diet, this would quickly play itself out through a short series of competitive encounters, since in each successive instance only the residual population, that is, the fraction causing expansion of the diet above cost levels found in the frontier beyond, would be cause for expansion. This residual would be small initially and quickly erased, unless the initial discontinuities in population density were on the order of several magnitudes, which is unlikely in the case of hunter-gatherers.

In short, so long as all hunter-gatherer groups are treated as being similar in kind or as capable of rapid adjustment to increases or decreases in population by shifting alternately between traveller and processor strategies, the competitive inequalities between these strategies would not generate successive population replacements of the scale found in ethnic spreads. Rather, for this to occur the competitive advantages of the processor over the traveller must be decisively brought into play before the traveller can counter by adopting a processor strategy. Conversely, having successfully displaced a traveller, the processor population must persist in its original strategy, rather than readjust to one lower in cost, in order to sustain continued incursion at the expense of other travellers.

That such resistance to change in fact characterizes both traveller and processor strategies, and, indeed, adaptive strategies generally, can be shown with reference to the notion of adaptive peaks.

ADAPTIVE PEAKS

However strongly influenced by subsistence, adaptive strategies incorporate systems not directly concerned with subsistence, e.g., settlement, sociopolitical organization, demography, and ideology which have, to varying degrees, subsistence effects. We can postulate that such systems will ordinarily adjust to conform to subsistence behavior, but that such adjustment occurs necessarily indicates that nonsubsistence systems can assume configurations differentially compatible with alternative subsistence strategies, being well suited to some, ill suited to others. It is further the case that despite their subsistence effects, many of these systems are capable of only slow change, regardless of changing subsistence priorities, while others are supported by subjective belief systems in which long-run subsistence considerations are not explicitly recognized or are considered in a form that runs counter to what in the long run would be adaptive as conditions change.

For this reason, although these nonsubsistence systems will in the long run change in accordance with changing subsistence patterns, in the short run they lag behind. To the extent that such behaviors are incompatible with alternative subsistence practices, this lag in the short run tends to make subsistence innovations, such as the shift from traveller to processor or processor to traveller, less efficient than traditional patterns, however ineffective or suboptimal these may become when conditions change.

Thus, adaptive strategies can be understood as economic peaks in which, for a given situation, a variety of systems, including subsistence, adjust to produce a locally optimal solution. Once this peak is established, unilateral subsistence change in the short run results in movement away from the local peak until the remaining systems change in response. This is true no matter how efficient or necessary such a change might be in the long run: such lag is guaranteed first by differences in the speed with which nonsubsistence change occurs and second by differences in how various systems regulate themselves with respect to perceived goals.

That sociopolitical organization, having subsistence effects and at the same time being generally supported by belief systems couched in nonsubsistence terms, may work to counter subsistence change seems clear (Douglas 1962). And it is the case that even within subsistence systems themselves, certain behaviors are capable of only slow change and thus foster resistance to subsistence innovations. This makes them initially inefficient by causing movement away from adaptive peaks. Indeed, if we have learned nothing else from the Tucson Garbage Project, it is that a good deal of waste—that is, lowered subsistence efficiency—stemming from errors in planning, storage, and preparation, generally accompanies subsistence innovations no matter how well informed the decisions resulting in these errors might have seemed in terms of past experience (Rathje 1978). In this respect, the implications of the Tucson project are clear: during periods of resource stress it is best to follow traditional practices, despite their diminishing returns, because the returns of nearly all innovative behaviors are initially worse under these conditions.

By the same logic, because both traveller and processor strategies are adaptive peaks, we can expect groups engaged in either one to resist abrupt changes in subsistence. Hence, when competing with processors, in the short run the travellers will maintain their low-cost subsistence strategy rather than shift to one higher in cost—even though this guarantees their competitive disadvantage—because rapid subsistence change would decrease efficiency and worsen their ability to compete with the processors. Similarly, having displaced travellers, the processors will maintain their own strategy—even though this is more costly than a traveller strategy which they are then free to adopt—because the shift from processor to traveller would in the short run decrease efficiency. This sets the stage for further competitive advance of the processors at the expense of other travellers, made likely by the relatively high population densities of the former and the incremental population growth resulting.

The preceding analysis of the processes underlying ethnic spreads is couched in broad theoretical terms because we believe explanations of this sort to be preferable to those more particularistic in nature. All the same, our inquiry was prompted by a specific problem, the well documented recent spread of Numic peoples into the Great Basin, and we now turn to show how the theoretical framework established above applies in this one case.

THE NUMIC SPREAD

The Numic language group is divided into three subbranches, Western, Central, and Southern, within each of which are two languages; Mono and Northern Paiute comprise the Western, Panamint and Shoshoni the Central, and Kawaisu and Ute the Southern (Figure 1). On the basis of extensive fieldwork conducted in the late 1920s and early 1930s, Julian Steward identified a recurrent pattern of human ecology among Numic groups throughout the Great Basin, which he attributed to adaptive limitations of environment and technology to which these peoples were subject. Archaeologists have argued that because these limitations are of long standing in the Great Basin, and therefore equally applicable to prehistoric contexts, the Numic adaptation described by Steward is capable of accounting for man-land relationships in the Great Basin during virtually the entire span of its occupancy (Jennings 1957, 1974, 1978; see also Bettinger [1978] for a summary of ideas).

Despite their role as models of long-term human adaptation in the Great Basin, the Numic folk themselves are relatively recent immigrants to the region. The Numic people apparently originated in southeast California and spread thence fanlike throughout the Great Basin, into the Snake River drainage in Idaho, and into the Rocky Mountains on the northern fringes of the Puebloan Southwest (Figure 1). The Numic spread is thought to be recent, within the last 1,000 years. Sidney Lamb (1958) was the first to outline this in detail and his ideas are supported by other Numic linguists (Miller 1966; Fowler 1972). James Goss has offered a counterproposal that appeals to some archaeologists. He indicates that Lamb is a false prophet saying that he is "less than helpful" (1977:60). Goss sees Numic as separate in the Great Basin by 2000 B.C. and, by a "fusion of the continuing fusion and fission process," attaining their ethnographic distribution by A.D. 1000. Talk about being less than helpful—Goss does not explain the ethnographic distribution at all. What he does not explain in particular is why the same Shoshone language spoken at Tonopah, Nevada was also spoken on the Snake River, Idaho, while it differed substantially from the Mono Lake Paiute language only a few miles west of Tonopah. To explain this and to explain the wedge-shaped distribution of the Numic subbranches, we must assume a rapid and recent spread of the three Numic divisions. Lamb puts this within a thousand years, but lexicostatistical estimates suggest it occurred between 700 and 500 years ago.

The puzzle for Great Basin archaeologists has always been that such sweeping displacement should occur at all given that, according to conventional wisdom, the Numic folk enjoyed no numerical, technical, or organizational superiority over their Prenumic antecessors. Indeed, it is generally held that such advantages were impossible for hunter-gatherers because the Great Basin environment made only one adaptation possible—the one described by Steward. One of us once succinctly summarized this widely held view as follows:

> One might say that Steward, in his *Basin Plateau Aboriginal Sociopolitical Groups*, proved that, given the lack of agriculture, only one form of culture is possible in the Great Basin—the kind of culture that Jennings calls the Desert Culture [Baumhoff 1958; for a similar argument regarding the Australian Desert Culture see Gould (1977)].

Figure 1. Distribution of Numic languages.

Since our earlier discussion makes it clear on theoretical grounds that the Numic spread could not have occurred were this true—that is, if only one kind of strategy were possible—theory strongly implies that there were two: a Prenumic strategy and a Numic strategy. Further, if our argument regarding the basis of ethnic spreads is correct, then these strategies should differ along the dimension of dietary cost, the Numic strategy being higher in cost and approximating that of a processor, the Prenumic strategy lower in cost and approximating that of a traveller.

The general distinctions we have drawn between travellers and processors make it possible to derive a variety of implications from this basic proposition.

First, the settlement systems of Great Basin travellers and processors should differ in terms of the distances covered in residential moves and in the distances over which resources were sought from these residences. Travellers will move residences over longer distances and from these residences seek resources over longer distances; for the processor, both residential moves and resource excursions will be shorter.

Given existing knowledge of the technology and resources at the disposal of Prenumic and

Numic groups, we can also specify certain basic differences in the range and quality of resources exploited in these low-cost and high-cost Great Basin subsistence strategies. Specifically, in optimal foraging theory, dietary cost increases through the inclusion of resources with higher so-called "handling times." This subsumes all time costs for a resource *after* it is located, including pursuit time for animals, gathering time for plants, and processing time for both—although that for plants is far higher than that for animals.

Quantitative estimates of these times are lacking for most Great Basin resources, but a variety of ethnographic evidence makes it likely that large game such as deer (*Odocoileus hemionus*), mountain sheep (*Ovis canadensis*), and antelope (*Antilocapra americana*) would be among the highest ranking, that is the least costly, Great Basin resources owing to their high caloric yield and low processing costs, both of which substantially offset whatever time is expended in their pursuit (Hawkes et al. 1982).

Large roots (e.g., Camas, *Quamasia;* epos, *Carum*), large nuts (pine nuts, *Pinus monophylla*), and berries (e.g., wolf berry, *Lycium;* chokecherry, *Prunus*), would probably rank somewhat lower, for while their returns are potentially high, so are their procurement and processing times. Small seeds, however, would probably rank lower, that is, higher in cost, than any of these because of their difficulty of procurement (cf. Bean 1972) and prolonged and intricate processing requirements (cf. O'Connell and Hawkes 1981).

Provided we are willing to generalize in terms of extremes, the low-cost Great Basin traveller strategy, which we attribute to Prenumic groups, should maximize the procurement of large game and minimize the procurement of small seeds; the high-cost Great Basin processor strategy, here attributed to Numic groups, will maximize both, and consequently, relative to a low-cost traveller strategy, will place greater reliance on small seeds and lesser reliance on large game. As we would expect, this implies that within the Great Basin increased dietary costs are levied primarily in gathering and processing; a low-cost strategy would require relatively less investment in these activities than a high-cost strategy.

In combination, the above considerations make it possible to contrast the proposed low-cost Prenumic strategy and high-cost Numic strategy in terms of first, their differential reliance on large game and small seeds and second, their differential investments in travel time and processing time. The proposed Prenumic traveller strategy is the more reliant on large game and incurs the greater cost in travel time. The proposed Numic processor strategy is the more reliant on small seeds and incurs the greater cost in gathering and, particularly, processing.

In keeping with reasoning set forth earlier, we can assume on theoretical grounds that Great Basin travellers and processors are specialists in the sense that in the short run both would be unable to alter their adaptive strategies fundamentally to accommodate variations in competitive pressure. The specific distinctions we have drawn between Great Basin travellers and processors, however, lead us to propose that in this particular instance the potential for resistance to subsistence change is especially likely to be expressed in terms of something as straightforward as sex ratios.

Again, compared to processors, it is clear that travellers are required to maximize the procurement of large game, a highly ranked resource, and to gather information about the density and distribution of high-ranked plant resources over a fairly large area. Because such tasks generally fall to males and because processing tasks, which generally fall to females, are minimized, it follows that travellers should adopt practices that produce high male/female ratios, i.e., a male-rich society.

Conversely, in processing strategies, there is increased emphasis on the intensive use in more restricted areas of resources requiring extensive processing. Accordingly, the need to monitor large areas decreases, and the need to process resources becomes more acute. In processing societies, therefore, the sex ratio should strike a more even balance between males and females or produce female-rich societies.

If we apply this logic to the Numic expansion, where travellers and processors are in competition, it is clear that no matter how desirable it might be for the Prenumic travellers to adopt a processing strategy, and thereby blunt the competitive advantage of the advancing Numic processors, the time lag required to make the necessary adjustment in sex ratios would militate against this solution; for the travellers, any move toward a processing strategy is hindered by an excess of males and a shortage of females. This lag would be relatively prolonged given the low reproductive capacity of such "female-poor" societies in comparison to "female-rich," societies. (Parenthetically, it might be noted that this condition would, in the absence of competition, tend to maintain these low-cost strategies at optimal population/resource levels.) In addition, this lag might also be prolonged if the value placed on male offspring was weighed in nonsubsistence terms or if, as is likely, high value continued to be placed on the acquisition by males of prestige resources such as large game. Whatever the exact circumstances, it is likely that the Prenumic groups were "male-rich" and that this at least partly explains why they failed to make the necessary adaptive shift to a processing strategy: despite the long-run benefits of such a shift, in the short run it would have lowered their efficiency and thus their ability to resist Numic encroachment.

On the other hand, the Numic groups, who were processors, faced the same problem. If we suppose balanced male/female ratios, in the short run it would have been uneconomical to revert to a lower-cost traveller strategy owing to the excess of males and shortage of females this strategy entails. Thus, once successful in dislodging their traveller predecessors in the Great Basin, they failed to adopt an optimal strategy despite their freedom to do so. Their continued incursion at the expense of other travellers, on the other hand, is made likely by the relatively high fertility conferred on them by their balanced sex ratios.

PRENUMIC-NUMIC ADAPTIVE CONTRASTS

A survey of the published archaeological evidence tends to support our proposed contrast between Prenumic travellers and Numic processors and underscores the differences, rather than similarities, between these two adaptations. Since a complete treatment of these data is now in preparation (Bettinger and Baumhoff 1981), we confine ourselves here to summary presentation of three lines of evidence: rock art, projectile point distributions, and seed harvesting technology. In the following discussion, we accept the traditional assumption that Numic components can be roughly distinguished from Prenumic components by the presence in the former of small triangular (Desert Side-Notched and Cottonwood) projectile points and crude, coil-scrape pottery (e.g., Owens Valley Brownware). We do not argue, however, that these items are ethnically Numic, which they are demonstrably not; both the pottery and point types are found among non-Numic groups and the pottery is absent among many Numic groups. It is simply argued that these traits mark the time period (A.D. 1300–A.D. 1860) during which the Numic peoples first appeared in the Great Basin.

Rock Art

It has been long held that Prenumic, rather than Numic, groups were chiefly responsible for the elaborate rock art that is so widespread in the Great Basin (Heizer and Baumhoff 1962:14–15, 226–230, 293; Heizer and Clewlow 1973:25; Thomas and Thomas 1972), there being no evidence of its production, or even an oral tradition explaining its origins, among Numic speakers (see below). The precise function of this artistic expression is not understood fully, but its consistent association with game trails and depiction of ungulates, especially mountain sheep, and hunting weaponry leaves little doubt of its use in magico-religious rituals performed at habitual hunting locations (Heizer and Baumhoff 1962:5–15, 210–225; Grant et al. 1968:29–42). The obvious care and effort devoted to this form of hunting ritual, along with the absence of contemporaneous occupation sites at locations where it is found, suggest that the procurement of large game was a major aspect of Prenumic subsistence and of sufficient importance to warrant the reservation of specific areas exclusively for this activity, either because the act of hunting was itself sacred or because other activities such as camping or gathering in the same area would disturb game.

Given the importance of hunting that is implied by Prenumic rock art, the absence of a similar ritual tradition among Numic peoples is significant and suggests lesser reliance on game as a subsistence resource. Although Great Basin rock art resists accurate dating, it is relatively certain that Numic groups made almost none, and that the little which they made differed from the Prenumic art just described (see below).

During the ethnographic surveys of Steward (1941, 1943) and others (Stewart 1941, 1942), historic Numic peoples throughout the Great Basin uniformly denied authorship, and often even knowledge, of rock art and attributed it to either mythical beings or former occupants of the region (Stewart 1941:418, 1942:321). This was in contrast to their Uto-Aztecan- and Hokan-speaking neighbors in California, who acknowledged having made both petroglyphs and pictographs, chiefly in connection with initiation and fertility rituals (DuBois 1908:96; Kroeber 1908:174–176; Gayton 1948:113; Heizer 1953). This may only represent native reticence to impart sacred knowledge to whites, yet in view of the other kinds of information willingly forwarded by knowledgeable native hunters (cf. Steward 1934:425–432), it is unlikely that a secret of such importance would have been so thoroughly kept by so many across an area the size of the Great Basin, and thus escape anthropological detection.

Steward, the ethnographer who knew Numic culture best, saw a basic incongruity between Great Basin rock art and Numic adaptation as he described it (Steward 1963:977, 1968:viii-x), partly because these groups were insufficiently reliant on large game to account for such a practice, and partly because they were incapable of maintaining male groups of sufficient size in sufficiently continuous association to sustain hunting cults of the sort likely to have been responsible for Great Basin rock art. Steward saw the absence of Numic rock art as evidence of a fundamental contrast between Numic and Prenumic adaptations, particularly with respect to reliance on large game, and, based on this, questioned the notion of long-term adaptive continuity in the Great Basin specified in the Desert Culture concept (Steward 1968:x). This view is similar to our own and consistent with our portrayal of Prenumic groups as more dependent on large game than Numic groups.

Turning to a different line of evidence, that the early Numic occupants of the Great Basin may have been less preoccupied with complicated hunting magic than with other, more pressing matters is also suggested by the character of what little rock art is recent enough to be safely ascribed to Numic authorship. These designs lack the elaboration and attention to detail found in Prenumic rock art, the bulk of them being quite simple and crudely executed in a style that requires little effort. The style has been termed Great Basin Scratched (Heizer and Baumhoff 1962: 232–234; Werlhof 1965:3–5; Nissen 1974:54). These often occur as unpatterned scrawls, frequently superimposed over earlier Prenumic elements, in many instances apparently with the deliberate intention of obliterating them (cf. Werlhof 1965:Figures 26d, i, j, 27d, f, g). This, in combination with the offhand quality of the Great Basin Scratched style, would suggest that Numic rock art was concerned less with hunting magic than with the defacement of Prenumic rock art. Similar observations may apply to the red pictographs that apparently date to Numic, rather than Prenumic, occupation (Heizer and Baumhoff 1962:234). Conceivably, such defacement might be explained as attempts either to neutralize or purify potentially malevolent magic thought to be associated with Prenumic designs (cf. Steward 1933:335; Gifford 1940:154), thus permitting safe site use or, alternatively, to disrupt the activities of Prenumic groups still using them as hunting locations when Numic groups entered the Great Basin. By either explanation, Numic rock art would derive primarily from the initial phase of the spread and have been neglected thereafter, which would explain why the historic groups had no knowledge of them at contact.

Aside from changes in the number and kind of petroglyphs and pictographs produced, the reduced importance of hunting in Numic times appears documented by changes in site use at several Great Basin rock art localities. These show evidence of occupancy as residential locations (e.g., Heizer and Baumhoff 1962:232–233, 43; Werlhof 1965:14, 15, 27) or as seed gathering and processing stations (e.g., Heizer and Baumhoff 1962:45, 52; Werlhof 1965:19, 20, 23); either use would have disturbed game and therefore must have occurred when the sites were not in use as hunting stations. Although it is difficult to establish the temporal relationship between hunting and such competing activities, where this is possible it is apparent that hunting is replaced by residential occupation and seed processing. This is most easily shown in the case of seed processing since in both Nevada and eastern California, bedrock seed milling features (metates) are often found superimposed over Prenumic petroglyphs (Heizer and Baumhoff 1962:52; Richard Weaver, personal communication, 1981; Alan Garfinkel, personal communication, 1981), while the reverse—petroglyphs over milling surfaces—is not known to occur. The residential use of rock art sites is less securely dated, but what little evidence is available, in the form of stratigraphy (Werlhof 1965:14), time sensitive artifacts (Heizer and Baumhoff 1962:54–55; Werlhof 1965:7, 15, 26–27; Hillebrand 1974), and ethnographic accounts (e.g., Steward 1933:334), places such occupation either specifically in Numic times or, where only relative dating is possible, subsequent to use as hunting stations. This pattern is especially well illustrated in Owens Valley, where several major petroglyph complexes occur in an area known to have been used primarily for seed collecting in late prehistoric (Numic) times (cf. Werlhof 1965:25–27, 29–36; Steward 1933:244).

In sum, the evidence from Great Basin rock art sites appears to support the proposal that large game procurement was of substantially greater importance to Prenumic groups than Numic groups as shown first by the presence of elaborate hunting ritual among Prenumic groups and its absence among Numic groups; second, by the segregation of hunting from other potentially disrupting activities in Prenumic times, and third, by the use of favorable hunting locations as residences and seed gathering stations in Numic times. From the chronometric data provided by rock art sites it cannot be established unequivocally that the inception of this subsistence change was in early Numic, as opposed to late Prenumic, times, but contrasts between Prenumic and Numic hunting patterns documented by projectile point distributions make this likely.

Projectile Points

Although regional data regarding the occurrence of Numic and presumably Prenumic projectile points at specific settlement categories (i.e., base camps, hunting stations, etc.), are unavailable for much of the Great Basin, those that have been reported, primarily from surveys in eastern California, show an abrupt shift in hunting patterns at the outset of Numic times which implies decreased reliance on large game relative to plants and certain related changes in settlement patterns. Excavations at several localities support the interpretation that these changes are not confined to eastern California but apply to the Great Basin as a whole.

Both surveys (Bettinger 1975, 1977, 1980a; Hall 1980; Clewlow and Pastron 1972) and excavations (Layton and Thomas 1979; Bard et al. 1979; Pastron 1972) document the regular occurrences of Prenumic points at small hunting stations far removed from base camps, as well as at the base camps themselves. These hunting stations are found in a broad range of upland and lowland settings that suggest procurement of ungulates took place virtually year-round except, perhaps, in the dead of winter, when snow would have made travel difficult. This tends to support the notion, previously suggested on the basis of evidence from rock art sites, that Prenumic groups were heavily dependent on large game. It further suggests they were willing to travel long distances away from base camps to procure them.

It makes sense, moreover, that in addition to the taking of ungulates, an important part of these long hunting forays would have been the collection of useful information regarding the density and distribution of plant resources (cf. Bean and Saubel 1961). Such observations would have been used as a basis for guiding group movements to resource areas that were large or especially productive of high-ranked resources, that is, those easy to gather and process. If this inference is correct, then it might be proposed that entire Prenumic bands, as well as smaller hunting parties, covered broad areas in the course of the foraging round, chiefly directing their attention to high-ranked resources, and pursuing a travelling strategy.

Numic projectile points, on the other hand, are more restricted in distribution, occurring only at sites that contain either milling equipment or dwellings, or both—that is, base camps (cf. Bettinger 1975; Hall 1980; Pastron 1972; Clewlow and Pastron 1972); they are either rare or absent at specialized hunting camps (Bard et al. 1979; Layton and Thomas 1979; Pastron 1972). From this it would appear that Numic hunters were unwilling to invest the travel time needed to establish separate hunting camps in advantageous locations and, since the migratory habits of most ungulates would place them seasonally beyond reach of hunters working exclusively out of base camps (cf. Bettinger 1975:323–324), this necessarily implies reduced importance of large game relative to plants in the Numic diet. This pattern is fully in accord with ethnographic descriptions of Numic subsistence-settlement patterns in which the direction and frequency of seasonal movement was dictated by the distribution and availability of plant resources with less regard to advantages for hunting (Steward 1938:254).

These more restricted Numic hunting patterns would limit the area over which plant resources could be monitored and may imply more intensive use of a broader range of resources, including lower ranking plants, in the area immediately surrounding base camps. In comparison to Prenumic groups, then, the Numic folk spent less time in travel and in the procurement of certain high-ranked resources, particularly ungulates, and relatively more time in the intensive use of resources in restricted areas—hence, pursuing a processing strategy. More detailed evidence regarding the nature of this intensive collecting with respect to plants is provided by a comparative analysis of Prenumic and Numic seed harvesting technology.

Seed Harvesting and Processing Technology

Since the Numic processors are argued here to contrast most sharply with Prenumic travellers in their intensive use of small seed resources, this should be evident in their plant harvesting technology—and such is indeed the case. The twined, paddle-shaped seed beater and deep, twined, triangular winnowing tray that together are the hallmarks of the Numic seed harvesting complex (Steward 1941:238–239; Stewart 1941:386–387, 1942:270) are entirely absent in the Prenumic basketry complex, which evidently lacked seed beaters altogether (although sticks may have been used) and relied principally on the horn sickle and coiled flat winnowing-parching trays, as did Southwestern Basketmakers (Loud and Harrington 1929:Plates 16d, 30a; Heizer and Krieger 1956:Plates 9, 18; Adovasio 1970:Figure 105; Kidder and Guernsey 1919:Plates 46Ac, 76h). Archaeological examples of seed beaters are quite rare, all having been found in very late contexts in eastern California, including Death Valley (Wallace and Taylor 1955:Figure 105), the Coso Range (Panlaqui 1974:Figure 10), and the Mohave Desert (Campbell 1931:Plates 36e, f, g). Twined, triangular trays are even more scarce and are well documented only in the vicinity of Colville rockshelter near Death Valley (Meighan 1953:177–178; Baumhoff 1953:193–194; Lathap and Meighan 1951).

Ethnographically, the paddle-shaped seed beater is found throughout California and into the Great Basin, where it is almost precisely coterminous with Numic-speaking peoples (Driver and Massey 1957, Map 31). Although Driver and Massey do not give the distribution of the triangular twined winnowing tray, the culture element distribution surveys indicate that it too is found in all Numic groups ethnographically (Steward 1941, 1943; Stewart 1941, 1942). The two implements are similar in construction and appearance and in fact seem to comprise a complex, being shown together frequently in pictures of Paiute or Shoshone houses. This complex replaces the earlier horn sickle and coiled tray mentioned above.

It is remarkable that this change of seed gathering equipment and its significance was not noted earlier. It has long been recognized that the ethnographic basketry of the Numics differed from that of their predecessors, particularly in the Humboldt Nevada region where the distinctive Lovelock Wicker was unknown ethnographically (Steward 1941:433). Heizer and Krieger recognized the basketry differences and published a photograph (1956:Plates 33a, 34b) to illustrate it. Although an ethnographic seed beater is shown, the absence of this form in the Lovelock and Humboldt cave deposits is not commented on in the discussion (1956:87). Evidently, everyone working on basketry over the last few decades (including one of the present authors) has been so bemused by the quite technical aspects of basketry technology as to overlook its more important aspect, namely function.

The absence of the seed beater and triangular winnowing tray in Prenumic basketry collections cannot be dismissed, as might be contended, through a supposed scarcity of plant harvesting and processing tools in archaeological contexts where they would be preserved, because it is the case that digging sticks, conical harvesting baskets, and coiled parching trays are all well represented in cave deposits in the Great Basin. It is notable in this regard that either the seed beater or the triangular winnowing tray, or both, are depicted in nearly every ethnographic photograph where Numic basketry appears (cf. Fowler et al. 1969:Figures 1, 5; Heizer and Krieger 1956:Plates 33a, 34b). If Prenumic groups used either of these tools with anything like the degree of frequency implied by these photographic records, it is almost certain that they would have by now been found archaeologically.

We are uncertain regarding the specific advantages of the paddle seed beater over the horn sickle, stick beater, or hand picking, or of the deep triangular winnowing-parching tray over the shallow, flat coiled tray. We suspect, however, that the seed paddle is more effective than any of these alternative harvesting methods in extracting seeds from plants with many small dispersed seeds, e.g., bunchgrasses, plants with extremely fragile inflorescences (as would be the case with grasses at the peak of maturity), or plants with few seeds per individual. The deep tray, on the other hand, appears better suited to the collection, winnowing and parching of small seeds that might roll or blow off the shallower coiled tray. Regardless of the exact circumstances, that Numic and Prenumic seed harvesting and processing technologies differ so dramatically, and that Numic seed harvesting and processing technology is the more elaborate of the two, is substantial evidence in support of the idea that these two strategies differed in their degree of reliance on small seeds.

Bringing these disparate lines of evidence together then, in simple terms, Prenumic hunter-gatherers can be thought of as following a travelling strategy in which a good deal of time was spent finding and capturing large game and monitoring large resource areas for productive stands of high-ranked plant resources. This strategy is low in cost because it minimizes use of low-ranked resources. On the other hand, Numic hunter-gatherers followed a processing strategy in which relatively less time was spent in travel and relatively more time in the collection and processing of grasses and other hard seeds within more restricted areas. This strategy is high in cost because it is reliant on low-ranked resources, i.e., those requiring extensive processing.

That Numic groups, who as processors followed a high-cost strategy, were successful in replacing Prenumic groups, who as travellers followed a low-cost strategy, is explained by optimal models which indicate that, owing to increased population densities, the most deleterious effects of traveller/processor competition would have fallen on the travellers, i.e., Prenumic groups. This competition certainly lacked the character of military conquest but no doubt led to frequent conflict and local disruption, a point seemingly borne out by Numic rock art.

This hypothesis explains why the Numic spread originated in central-eastern California, most probably within Owens Valley or areas nearby. As indicated elsewhere, this locality is noteworthy for its extreme environmental contrasts (Bettinger 1980a). Owens Valley is especially attractive to hunter-gatherers, being both warm wintered and well watered, while nearby valleys are substantially less suitable in these respects, being either warm but extremely dry (e.g., Death Valley) or wet but extremely cold (e.g., Bridgeport Valley). This contrast worked against solution of local population/resource imbalances through emigration. In response, the archaeological record in Owens Valley points to a succession of subsistence-settlement shifts toward more intensive use of local resources, particularly pinenuts and low-ranked plants including grasses, along with more spatially restricted hunting patterns. As a direct consequence of this, there is by 2000 B.P., evidence of increasingly circumscribed population movement within core subsistence areas having well fixed territorial boundaries.

By about 1000 B.P. a well developed processing strategy, marked by attenuated travel, reduced dependence on large game, and increased dependence on a broad range of seed plants, was probably fully established in Owens Valley (Bettinger 1977, 1978). Not long after this, probably between 500 and 700 years B.P. judging from lexicostatistical estimates for the time depth of language splits within each of the three Numic subbranches, the Numic groups began their rapid spread across the Great Basin.

It may be that the timing of the Numic spread merely reflects the point at which processors in central-eastern California had become sufficiently differentiated from travellers in the rest of the Great Basin that they had the necessary competitive advantages mentioned earlier. The speed with which the spread actually took place, however, suggests that it may have been accelerated by circumstances that enhanced the advantages of the processor strategy over the traveller strategy.

In theory, any condition that resulted in an overall reduction in resources, such as a deterioration in climate, would cause such acceleration given that the processor strategy is better suited than a traveller strategy to such conditions for the same reasons it is better suited to competition.

Alternatively, any condition that differentially reduced the availability of high-ranked resources, especially large game, would have meant even more pronounced advantages for Numic processors by working greater relative hardships on Prenumic travellers, who were the more dependent on these resources. The overexploitation of ungulates following the introduction of the bow and arrow around A.D. 600 (Grant et al. 1968) and the decimation of native gamestocks by epizootics contracted from European expeditions beginning as early as A.D. 1540 are two suggestions worthy of consideration in this regard.

These possibilities should be regarded not as explanations of the Numic spread but as potentially contributing historical elements—possibly acting as trigger mechanisms. Even in this limited role, none of them would have had effect unless the Prenumic and Numic strategies differed as we have described so that deteriorating conditions would favor one (i.e., Numic) over the other.

CONCLUSIONS AND IMPLICATIONS

We divide our concluding remarks into two parts, the first dealing with the specific implications of our model of the Numic spread for the Great Basin, the second with its broader implications for understanding culture evolution.

For the Great Basin, the point of greatest significance is the proposed discontinuity between Numic and Prenumic adaptive strategies. The more or less standard view of Great Basin adaptation was derived from Julian Steward's (1938) landmark work, "Basin-Plateau Aboriginal Sociopolitical Groups." What this seemed to show was that, "the harshness of the Great Basin environment imposed restrictions so severe that, to live there at all (with a hunting-gathering economy), the Indians were forced into a rather narrowly proscribed set of subsistence and social customs" (Heizer and Baumhoff 1962:7). This, and perhaps other reasoning, led to the notion of the Desert Culture (Jennings 1957), conceived as an adaptation which, although exhibiting minor stylistic variations, remained essentially unchanged for 10,000 years. The Desert Culture is no longer a widely accepted concept, but its central tenet, that of continuity in basic adaptation, particularly between Numic and Prenumic hunter-gatherers, remains intact (cf. Jennings 1978:15, 235, 246).

In the broadest sense, this position is no doubt correct: the Great Basin never did, aside from brief Puebloan and Fremont episodes, undergo changes of the order perceived between, say, the Paleolithic and Bronze Age cultures of the Mediterranean. At the same time, although the Numic-Prenumic adaptive contrasts are minor by comparison, they are significant in terms of a shifting balance between hunting and gathering, differences in hunting techniques, and differences in gathering techniques. Significant enough, that is, to yield archaeological evidence of perceptible change between Numic and Prenumic adaptations that has heretofore gone almost entirely unrecognized, the Numic adaptation being commonly regarded as the ethnographic analogue of the Desert Archaic adaptation. Only Butler, in reviewing the evidence for Numic entry into Idaho, seems to have taken a position similar to ours by arguing that the Numic peoples were less well adapted to the environment of that region than their Prenumic predecessors (Butler 1981:15), i.e., that their adaptation was different. Since the Numic strategy ultimately prevailed in Idaho, however, it seems unlikely that it was less well adapted in an evolutionary sense. More likely, Butler is referring to the high cost of the Numic strategy in comparison to the Prenumic strategy.

Once having granted the possibility of discontinuity between Prenumic and Numic adaptations, it is likely that a thorough review of archaeological evidence in the Great Basin will reveal numerous examples better explained by this interpretation than by one that assumes continuity in basic adaptation through time. For example, the traveller/processor contrast would seem to explain why, despite abundant evidence of both Prenumic and Numic occupation at lakeside sites in the Lahontan Basin, only Prenumic groups regularly used nearby caves to cache specialized gear for lacustrine exploitation; Numic groups used these caves very little for this or any other purpose. The Prenumic caches imply long-distance movement between dissimilar environments and within these environments exploitative patterns directed toward a limited set of high return resources—both features being consistent with a traveller strategy. Lack of similar use in Numic times implies either more confined movements or the development of a more generalized technology, or both, and thus, in turn, suggests reliance on a range of resources which was broadened to include items of lower quality—features consistent with a processor strategy.

Certainly, the Prenumic folk are not suitably characterized as mobile hunters, nor the Numic folk as sedentary gatherers. Both Numic and Prenumic peoples had base camps, hunted large game, and used a wide variety of plant resources, including small seeds. But of the two, the Prenumic strategy was lower in cost, sustained lower population densities, made greater use of large animals—these being procured over long distances, and less use of small seeds. In these terms, this strategy bears great resemblance to Early and Middle Archaic adaptations in the East and Midwest, with which we believe it can be suitably placed. Further, it is worth noting here that recent summaries of the agricultural Fremont adaptation have likewise stressed its dependence on large game—also, evidently, taken by far-ranging hunting parties (cf. Jennings 1978:234). As much as the supposed failure of Fremont agriculture, this may explain why Numic groups, with their competitive advantages over groups more heavily reliant on large game, were able to dislodge Fremont peoples as easily as they had Prenumic hunter-gatherers.

In contrast to the Prenumic strategy, the Numic strategy was higher in cost, sustained higher population densities, made less use of large animals—these being procured over shorter distances—and more use of small seeds. In these respects, the Numic adaptation seems to resemble more closely the one found in California in ethnographic times, notwithstanding the obvious sociocultural differences between the two. The adaptive similarity in terms of reliance on high-cost plant resources is evident in the nearly universal use of the woven seed beater in both regions despite its near neglect elsewhere in North America. Further, in California this dependence on high-cost resources extends to the major dietary staple, the acorn (*Quercus* spp., *Lithocarpus densiflora*). Although the abundance and reliability of this crop has drawn much attention regarding the stability and affluence it afforded the native California economy (Baumhoff 1963; Krober 1925:523–526; Heizer 1958), it probably ranks among the most costly wild plant resources regularly exploited in North America, primarily because of the processing—drying, cracking, pounding, and, especially, leaching—needed to make it palatable (cf. DuBois 1935; Reidhead 1980). That California adaptive strategies were high in cost and processorlike follows from the nearly unbiquitous reliance on the acorn in California, especially where, as we would expect, population densities were high. And it seems probable that, as in the Great Basin, the competitive advantages of these high-cost strategies facilitated many of the ethnic spreads documented by ethnographic language distributions in California (Shipley 1978).

To take this a step further, it can be argued that the historic adaptations noted in both California and the Great Basin represent a distinct type, or stage, of hunting and gathering set apart from the Archaic. Archaeologists, of course, have long objected to the classification of the California groups as Archaic (cf. Heizer 1958) but have also expressed dissatisfaction with attempts to classify them in developmental categories, such as the Formative (cf. Willey and Phillips 1958), that were obviously intended for early agricultural stages preceding civilization (cf. Baumhoff 1963). The Numic adaptation has caused little trouble in this respect, yet, if we are correct, it should have, for there is every indication that it parallels the late prehistoric adaptation in California in its intensive use of high-cost resources, particularly those with heavy demands in processing, even though many of the species were different. Reliance on such resources is in contrast to the Archaic, which we believe to have been characterized by primary reliance on lower-cost resources. We reserve more detailed discussion of this stage, which we term *protestant foraging*, in view of its work emphasis, for another time.

Leaving aside its specific meaning for Great Basin and California prehistory, the model of the Numic spread proposed here is also of significance for understanding the respective roles of transformation and selection in cultural evolution and process. Transformation models are especially appropriate for explaining how and why specific innovative behaviors may become established in response to locally changing conditions experienced by specific groups, i.e., changes of small scale. Thus, in the Great Basin the initial development of processing strategies can be viewed as a gradual adjustment to population/resource imbalances in at least one restricted area, the southwestern Great Basin, where this was required by the absence of more suitable alternatives. Transformations may also occur on a broader scale to accommodate conditions changing over much larger areas. Models of this process are therefore also useful for understanding the evolution of the broader cultural landscape, i.e., the culture histories of entire regions. Nevertheless, it would be wrong to assume that all adaptive change within local or regional culture systems is a response to problems originating within these systems. And it would be equally wrong to conclude that all culture systems can successfully cope with the full range of internal and external challenges to which they are potentially subject. Outside the southwestern Great Basin the transition from Prenumic traveller to Numic processor cannot be understood as a transformation precipitated by either local or regional conditions; throughout this larger area, it must be seen as deriving from a chain of events and circumstances set in motion elsewhere that resulted in the extinction of one kind of system and the establishment of another. The Numic spread was a selective, not transformational, process, and this would seem to be the case with most ethnic spreads.

In a larger sense, we can also conclude that adaptive strategies tend to be conservative because they reflect adaptive peaks achieved by distinctive combinations of subsistence, settlement, sociopolitical, and demographic patterns. Unilateral change in any one of these systems in response to changing conditions is likely to result in the short run in lowered efficiency and output due to lag in the others, either because they are slow to change or because they are supported by subjective belief systems not understood in long-run subsistence terms. This property furnishes the adaptive diversity needed in order for selective replacement of the kind found in ethnic spreads to occur.

Finally, owing to differences in the way they allocate time and use resources, it should generally be the case that processors will replace travellers, and because processing strategies have the quality of being an adaptive peak, when this occurs such a strategy will tend to remain fixed in a region long after one would be led to expect return to a lower-cost travelling strategy. Hence, we can expect, in any given area, a general directional change toward processing strategies through time. This expectation is consistent with other models, including optimal foraging, which have been used to address density-dependent cultural phenomena, such as the broad spectrum and agricultural revolution models. Its advantage is that it relieves us from having to postulate intrinsic population growth as the proximate cause for these phenomena.

Acknowledgments. Our ideas about the recency of seed beaters in the archaeological record were prompted by the research of Phillip Wilke. We thank the editor and several reviewers for their comments and suggestions.

REFERENCES CITED

Adovasio, J. M.

1970 Textiles. In Hogup cave, by C. Melvin Aikens, pp. 133–153. *University of Utah Anthropological Papers* 93. Salt Lake City.

Bard, J. C., C. I. Busby, and L. S. Kobori

1979 Ezra's retreat: a rockshelter/cave occupation site in the north central Great Basin. *Center for Archaeological Research at Davis, Publication* 6.

Baumhoff, M. A.

1953 Minor sites excavated. In Coville Rockshelter, by C. W. Meighan, Appendix A. *University of California Anthropological Records* 12(5). Berkeley.

1958 History of Great Basin ethnography. *University of California Archaeological Survey Reports* 421-6. Berkeley.

1963 Ecological determinants of aboriginal California populations. *University of California Publications in American Archaeology and Ethnology* 40(2). Berkeley.

Bean, L. J.
1972 *Mukat's people.* University of California Press, Berkeley.
Bean, L. J., and K. Saubel
1961 Cahuilla ethnobotanical notes: aboriginal uses of oak. *University of California Archaeological Survey Annual Report* 3:237-245. Los Angeles.
Bettinger, R. L.
1975 *The surface archaeology of Owens Valley, eastern California: prehistoric man-land relationships in the Great Basin.* Unpublished Ph.D. dissertation, Department of Anthropology, University of California, Riverside.
1977 Aboriginal human ecology in Owens Valley: prehistoric change in the Great Basin. *American Antiquity* 42:3-17.
1978 Alternative adaptive strategies in the Great Basin. *Journal of Anthropological Research* 34:27-46.
1980a Archaeology east of the Range of Light: aboriginal human ecology of the Inyo-Mono region of California. Ms. on file, Department of Anthropology, University of California, Davis.
1980b Explanatory/predictive models of hunter-gatherer adaptation. In *Advances in Archaeological Method and Theory* 3:189-256. Academic Press, New York.
Bettinger, R. L., and M. A. Baumhoff
1981 Seed beaters and petroglyphs: Numic culture history. Ms. in possession of the authors.
Binford, L. R.
1980 Willow smoke and dog's tails: hunter-gatherer settlement systems and archaeological site formation. *American Antiquity* 45:4-20.
Butler, B.
1981 Little Lost River Cave No. 1, the Birch Creek Project and the antiquity of the Northern Shoshoni. *Occasional Papers of the Idaho Museum of Natural History* 32:4-27. Pocatello.
Campbell, E. W. C.
1931 An archaeological survey of the Twenty Nine Palms region. *Southwest Museum Papers* 7. Los Angeles.
Charnov, E. L.
1976 Optimal foraging, the marginal value theorem. *Theoretical Population Biology* 9:129-136.
Christenson, A. L.
1980 Change in the human niche in response to population growth. In *Modeling change in prehistoric subsistence economics,* edited by Timothy K. Earle and Andrew L. Christenson, pp. 31-72. Academic Press, New York.
Clewlow, C. W., and A. G. Pastron
1972 Preliminary investigations. In Grass Valley Archaeological Project: collected papers, edited by C. W. Clewlow and M. Rusco, pp. 11-32. *Nevada Archaeological Survey Research Paper* 3. Reno.
Diamond, J.
1978 Colonization cycles in man and beast. *World Archaeology* 8:249-261.
Douglas, M.
1962 The Lele: resistance to change. In *Markets in Africa,* edited by P. Bohannan and G. Dalton, pp. 211-233. Northwestern University Press, Evanston.
Driver, H. E., and W. C. Massey
1957 Comparative studies of North American Indians. *Transactions of American Philosophical Society* 47(2). Philadelphia.
DuBois, C. G.
1908 The religion of the Luiseno Indians of southern California. *University of California Publications in American Archaeology and Ethnology* 8(3). Berkeley.
DuBois, C. A.
1935 Wintu ethnography. *University of California Publications in American Archaeology and Ethnology* 36:1-148. Berkeley.
Dunnell, R. C.
1980 Evolutionary theory and archaeology. In *Advances in archaeological method and theory* 3:35-99. Academic Press, New York.
Earle, T. K.
1980 A model of subsistence change. In *Modeling change in prehistoric subsistence economies,* edited by Timothy K. Earle and Andrew L. Christenson, pp. 1-29. Academic Press, New York.
Fowler, C. S.
1972 Some ecological clues to Proto-Numic homelands. *Desert Research Institute Publications in the Social Sciences* 8:105-122. Reno.
Fowler, D. D., R. C. Euler, and C. S. Fowler
1969 John Wesley Powell and the anthropology of the canyon country. *Geological Survey Professional Paper* 670.
Gayton, A. H.
1948 Yokuts and Western Mono ethnography. *University of California Anthropological Records* 10. Berkeley.
Gearing, F.
1962 Priests and warriors. *American Anthropological Association Memoir* 93.

Gifford, E. W.
1940 Culture element distributions: XII, Apache-Pueblo. *University of California Anthropological Records* 4(1). Berkeley.
Glassow, M. A.
1978 The concept of carrying capacity in the study of culture process. *Advances in Archaeological Method and Theory* 1:31-48. Academic Press, New York.
Goss, J. A.
1977 Linguistic tools for the Great Basin prehistorian. *Desert Research Institute Publications in the Social Sciences* 12:49-70. Reno.
Gould, R. A.
1977 Puntutjarpa rockshelter and the Australian Desert culture. *Anthropological Papers of the American Museum of Natural History* 54(1). New York.
Grant, C., J. W. Baird, and J. K. Pringle
1968 Rock drawings of the Coso Range. *Maturango Museum Publication* 4. China Lake, California.
Hall, M. C.
1980 *Surface archaeology of the Bodie Hills geothermal area, Mono County, California.* Ms. on file at the Bureau of Land Management District Office, Bakersfield, Calif.
Hawkes, K., K. Hill, and J. F. O'Connell
1982 Why hunters gather: optimal foraging and the Ache of eastern Paraguay. *American Ethnologist* 9(2):379-398.
Heizer, R. F.
1953 Sacred rain rocks of northern California. *University of California Archaeological Survey Reports* 20:33-38. Berkeley.
1958 Prehistoric California: a problem in historical-developmental classification. *University of California Archaeological Survey Reports* 41:19-26. Berkeley.
Heizer, R. F., and M. A. Baumhoff
1962 *Prehistoric rock art of Nevada and eastern California.* University of California Press, Berkeley.
Heizer, R. F., and C. W. Clewlow, Jr.
1973 Prehistoric rock art of California (Vols. 1, 2). *Ballena Press Publications in Anthropology.* Ramona.
Heizer, R. F., and A. D. Krieger
1956 The archaeology of Humboldt Cave, Churchill County, Nevada. *University of California Publications in American Archaeology and Ethnology* 47(1). Berkeley.
Hillebrand, T. S.
1974 The Baird site. *Maturango Museum Monographs* 1:63-86. China Lake, California.
Jennings, J. D.
1957 Danger Cave. *Society for American Archaeology Memoir* 14.
1974 *Prehistory of North America* (second ed.). McGraw-Hill, New York.
1978 Prehistory of the eastern Great Basin. *University of Utah Anthropological Papers* 98. Salt Lake City.
Kidder, A. V., and S. J. Guernsey
1919 Archaeological explorations in northeastern Arizona. *Bureau of American Ethnology Bulletin* 65. Washington, D.C.
Krantz, G. S.
1977 The populating of western North America. *Society for California Archaeology Occasional Papers in Method and Theory in California Archaeology* 1:1-63.
Kroeber, A. L.
1908 Notes on the Luisenos. In Religion of the Luiseno Indians of southern California, by C. G. DuBois, pp. 174-186. *University of California Publications in American Archaeology and Ethnology* 8(3). Berkeley.
1925 Handbook of the Indians of California. *Bureau of American Ethnology* Bulletin 78. Washington, D.C.
Lamb, S.
1958 Linguistic prehistory of the Great Basin. *International Journal of American Linguistics* 25:95-100.
Lathrap, D. W. (editor)
1955 An archaeological classification of culture contact situations. In Seminars in archaeology: 1955, edited by Robert W. Wauchope, pp. 1-30. *Memoirs of the Society for American Archaeology* 11.
Lathrap, D. W., and C. W. Meighan
1951 An archaeological reconnaissance in the Panamint Mountains. *University of California Archaeological Survey Reports* 11:11-32. Berkeley.
Layton, T. N., and D. H. Thomas
1979 The archaeology of Silent Snake Springs, Humboldt County, Nevada. *Anthropological Papers of the American Museum of Natural History* 55(3). New York.
Loud, L. L., and M. R. Harrington
1929 Lovelock Cave. *University of California Publications in American Archaeology and Ethnology* 25(1). Berkeley.
MacArthur, R. H., and E. R. Pianka
1966 On optimal use of a patchy environment. *American Naturalist* 100:603-609.
Meighan, C. W.
1953 The Coville rockshelter, Inyo County, California. *University of California Anthropological Records* 12(5). Berkeley.

Miller, W. R.
1966 Anthropological linguistics in the Great Basin. *Desert Research Institute Social Sciences and Humanities Publications* 1:75–112. Reno.
Milne, A.
1961 Definition of competition among animals. In *Symposia of the Society for Experimental Biology 15: Mechanisms of Biological Competition*, edited by F. Milthorp, pp. 40–61. Academic Press, New York.
Nissen, K. M.
1974 The record of a hunting practice at petroglyph site NV-Ly-1. *University of California Archaeological Research Facility Contributions* 20:53–82. Berkeley.
O'Connell, J. F., and K. Hawkes
1981 Alywara plant use and optimal foraging theory. In *Hunter-gatherer foraging strategies: ethnographic and archaeological analyses*, edited by B. Winterhalder and E. Smith, pp. 99–125. University of Chicago Press, Chicago.
O'Connell, J. F., K. T. Jones, and S. R. Simms
1981 Some thoughts on prehistoric archaeology in the Great Basin. In Man and environment in the Great Basin, edited by D. B. Madsen and J. F. O'Connell, *SAA Papers No. 2*, in press.
Panlaqui, C.
1974 The Ray Cave site. *Maturango Museum Monograph* 1:1–62. China Lake, California.
Pastron, A. G.
1972 Excavation of two rockshelters. In Grass Valley archaeological project: collected papers, edited by C. W. Clewlow and M. Rusco, pp. 33–68. *Nevada Archaeological Survey Research Paper* 3. Reno.
Pyke, G. H., H. R. Pulliam, and E. L. Charnov
1977 Optimal foraging: a selective review of theory and tests. *Quarterly Review of Biology* 52:137–154.
Rathje, W. L.
1978 Le projet du garbàge 1975: historic trade-offs. In *Social archaeology: beyond subsistence and dating*, edited by C. L. Redman, M. J. Berman, E. V. Curtin, W. T. Langhorne, Jr., N. M. Versaggi, and J. C. Wanser, pp. 373–379. Academic Press, N.Y.
Reidhead, V. A.
1980 The economics of subsistence change: an optimization model. In *Modeling change in prehistoric subsistence economies*, edited by Timothy K. Earle and A. Christenson, pp. 141–186. Academic Press, New York.
Schoener, T. W.
1971 Theory of feeding strategies. *Annual Review of Ecology and Systematics* 2:369–404.
Shipley, W. F.
1978 Native languages of California. In *Handbook of North American Indians* (Vol. 8): California, edited by Robert F. Heizer, pp. 80–90. Smithsonian Institution, Washington, D.C.
Steward, J. H.
1933 Ethnography of the Owens Valley Paiute. *University of California Publications in American Archaeology and Ethnology* 33(3). Berkeley.
1934 Two Paiute autobiographies. *University of California Publications in American Archaeology and Ethnology* 33:423–438. Berkeley.
1938 Basin-Plateau aboriginal sociopolitical groups. *Bureau of American Ethnology Bulletin* 120. Washington, D.C.
1941 Culture element distributions: XIII, Nevada Shoshone. *University of California Anthropological Records* 4(2). Berkeley.
1943 Culture element distributions: XXIII, Northern and Gosiute Shoshoni. *University of California Anthropological Records* 8(3). Berkeley.
1963 Review of Prehistoric rock art of Nevada and eastern California. *American Anthropologist* 65: 976–977.
1968 Preface. In Rock drawings of the Coso Range, by C. Grant, J. W. Baird, and J. K. Pringle, pp. vii–x. *Maturango Museum Publication* 4. China Lake, California.
Stewart, O. C.
1941 Culture element distributions: XIV, Northern Paiute. *University of California Anthropological Records* 4(3). Berkeley.
1942 Culture element distributions: XVIII, Ute-Southern Paiute. *University of California Anthropological Records* 6(2). Berkeley.
Thomas, David Hurst, and T. C. Thomas
1972 New data on rock art chronology in the central Great Basin. *Tebiwa* 15:64–71.
Wallace, W. J., and E. S. Taylor
1955 Archaeology of Wildrose Canyon, Death Valley National Monument. *American Antiquity* 20: 355–367.
Werlhof, J. C., von
1965 Rock art of Owens Valley California. *University of California Archaeological Survey Reports* 65: 1–128. Berkeley.
Willey, G. R., and P. Phillips
1958 *Method and theory in American archaeology*. University of Chicago Press, Chicago.