Population Pressure and Agriculture in Owens Valley

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THE origins of agriculture has been an important topic of research among archaeologists for many years. Generally, research into the development of agriculture has focused on those regions of the world in which agriculture was practiced on a major scale and associated with dramatic sociocultural changes. In areas where agriculture was practiced less intensively, little research has been done, and it has been of a limited scope. Owens Valley, in eastern California, is an area where aboriginal agriculture was not intensive, and, consequently, it has attracted very little interest from the anthropological community.

In this paper, an attempt will be made to draw additional attention to Owens Valley agriculture. Following a brief review of research conducted in Owens Valley, attention will be directed toward an explanation of *why* agriculture developed in that region. This evaluation will use as a research orientation Mark N. Cohen's (1977) population-growth hypothesis for the development of agriculture, and it will test this hypothesis against archaeological data published by Robert L. Bettinger (1975, 1976, 1977, 1978).

PREVIOUS RESEARCH

The first published efforts dealing with aboriginal agriculture in Owens Valley were by Julian H. Steward (1930, 1933, 1938). These reports evaluated the ethnographic information concerning the practice of irrigation in the northern portion of the valley, and concluded that the Owens Valley Paiute did not actually practice agriculture—tilling the soil, planting, or cultivating—but had "intensified by irrigation what nature had already provided" (Steward 1930:150). Steward proposed three hypotheses as possible explanations for the existence of irrigation in Owens Valley: (1) it was a survival of an early practice which preceded cultivated plants in the Southwest; (2) it was a differential borrowing from a horticultural complex, taking the irrigation practices but not the cultivation of traditionally grown plants; or (3) it was a local and independent invention. Steward favored the third hypothesis as the most probable explanation.

Following Steward's work, the topic of agriculture in Owens Valley received little attention until the recent publication of Lawton *et al.* (1976). In this paper, the authors carefully surveyed the ethnographic and historical literature pertinent to the area, first discussing Steward's work and then introducing new information from several sources.

After surveying these sources and relevant botanical literature, the authors concluded that the Owens Valley Paiute did in fact practice agriculture, contrary to Steward's appraisal. They noted that the Paiute did till the soil, using digging sticks to turn up the soil when harvesting the underground plant

parts. In addition, they probably planted by reburying those corms and tubers which were too small to be of much food value; and they did cultivate, in the sense of nurturing plants, with the alternate irrigation of the field plots. Lawton *et al.* (1976:37) concluded that the Paiute "had developed a complex farming system on an agronomic scale that required substantial communal labor."

In an attempt to explain the origins of agriculture in Owens Valley, Lawton *et al.* (1976) proposed three hypotheses in addition to those of Steward. After a summary evaluation, they, like Steward, supported the local and independent origins of agriculture in Owens Valley. Acknowledging that the aboriginal population in this area occupied permanent villages and that this valley possessed one of the highest aboriginal population densities in the Great Basin, the authors suggested that these factors may have played a causal role in the development of agriculture in Owens Valley.

This short review of the literature concerning the origins and development of aboriginal agriculture in Owens Valley demonstrates both the general paucity of work done on this topic and the absence of any work treating this problem with archaeological information. The intent of the remainder of this paper is to evaluate Owens Valley archaeological data in light of Cohen's (1977) population-growth hypothesis. This will be done in response to the conclusion of Lawton *et al.* (1976) that the Owens Valley Paiute did practice agriculture, and to their proposition, along with Cohen's, that population density (pressure) was a causative factor in the development of agriculture.

COHEN'S HYPOTHESIS

Cohen's hypothesis, one of many on the origins of agriculture, is derived from a population pressure model and attempts to account for the relatively simultaneous inception of agriculture on a worldwide scale as a response to an inadequate food supply. As the cause of that pressure, he proposed the phenomenon of population growth.

Cohen (1977) presented a detailed and comprehensive line of argument which led to his hypothesis correlating population growth with the development of agriculture. He initiated his discussion by describing agriculture not as a single unified concept or behavior but as a combination of behaviors which may be either inadvertent or purposeful. Subscribing to the school of thought that accepts the concept that a knowledge of the mechanics of seed germination is universal, the need, in his view, is to understand the processes which led to the use of growth-enhancing techniques, techniques which had always been self-evident and available to mankind. An opposing school of thought considers agriculture a conceptual leap in cultural development and would attempt to seek to explain the widespread availability of the new knowledge.

Assuming that hunters and gatherers have a basic knowledge of plant growth, Cohen compared the costs and benefits of both hunter-gatherer and agricultural subsistence techniques. He considered the labor requirements of each subsistence technique, the group's subjective impression of each, and the temporal differences for each group in labor rewards (immediate for hunters and gatherers and delayed for agriculturalists). His conclusion was that the hunting and gathering mode of subsistence was indeed more beneficial.

Why, then, was agriculture ever begun? Cohen answered this question by pointing out one obvious advantage of agriculture:

> . . . agriculture permits denser food growth supporting denser populations and larger social units but at the cost of reduced dietary quality, reduced reliability of harvest, and equal or probably greater

> labor per unit of food. If it is true then that agriculture is not a difficult concept but something readily available to hunting and gathering groups, and if it is true that its only advantage lies in the greater density of food produced, it follows that agriculture will occur only in situations where greater productivity per unit of space is required [Cohen 1977:39-40].

After considering various explanations, Cohen chose population growth as the only satisfactory explanation of a phenomenon which would make agriculture a worldwide requirement. He argued (1977:42) that human populations have tended to grow almost continuously and as a result have had to constantly redefine their "adaptive equilibria with their environment." Under most conditions, he recognized, growth rates are dampened by cultural mechanisms, but he insisted that such mechanisms are rarely 100% effective. In addition, he maintained that not all populations have necessarily grown throughout history.

Throughout the development of growing populations, however, various forms of stress (pressure) would cause such populations to devise new methods of adaptation. This pressure Cohen defined as

> . . . the imbalance between a population, its choice of foods, and its work standards, which forces the population either to change its eating habits or to work harder (or which, if no adjustment is made, can lead to the exhaustion of certain resources). By this definition, population pressure can be seen to motivate technological change in the food quest without ever threatening carrying capacity in the absolute sense, without ever reducing the human population to starvation, and without threatening to break down the ecosystem [Cohen 1977:50].

The different methods of adaptive responses which have been used through time have been classified by Cohen (1977) into two categories: expansion and intensification. Expansion consists of a group lengthening the radius of the area it exploits, dispersing daughter groups into adjacent areas, or increasing its fluidity with other groups—marriage exchange, family movements, etc.—all of which act as strong pressure-equalizing forces. The process of intensification—working harder, using less desirable foods, storage, etc.—would increase rapidly as the capacity for territorial expansion became more difficult. Each of these techniques requires increased labor and would only be undertaken when such labor would be less costly to a group than retaining the old techniques.

After expansion was no longer feasible and hunter-gatherer intensification provided fewer alternatives, those growing groups eventually had to artificially increase the density of desirable crops; they had to initiate the practice of agriculture.

In sum, Cohen's hypothesis suggests that population growth creates a pressure on human populations which continuously forces them to readapt to their environment. Agriculture is just another step in the whole process of adaptation.

In order to deal with population pressure archaeologically, Cohen (1977) proposed fourteen criteria (test implications) with which to test for the phenomenon. These criteria deal with changes in subsistence patterning which appear to be toward the exploitation of more calorically dense yet less desirable resources and which are not the result of those resources being newly available.

To demonstrate that this pressure was the result of population growth, all other alternative explanations (climatic change, migration, etc.) would have to be ruled out, or the subsistence change would have to be shown to be so widespread in both time and space that only a general explanation such as population growth could adequately account for it.

The specific criteria to be applied to

Bettinger's archaeological data will be discussed in a later section of this report.

BETTINGER'S DATA

The data for testing Cohen's hypothesis have been taken from Bettinger's (1975) dissertation, which was the result of a survey of the surface archaeology of an east-west running transect of Owens Valley. The object of this research was to determine if the archaeology of Owens Valley supported the Desert Culture view—ten thousand years of consistent unspecialized settlement-subsistence patterns and consistent climatic and environmental conditions—or the Variation view—regional subsistence diversity, resource specialization, and climatological diversity through time. Bettinger carried out this examination by constructing a model of the ethnographic settlement-subsistence patterns and comparing it to a model derived from the archaeological data.

The results of Bettinger's survey indicated that the settlement patterns of the prehistoric and ethnographic periods were similar in that they both focused on the use of permanent villages on the valley floor as base camps. The subsistence patterns were also similar, since they were both fundamentally based on the exploitation of lowland roots and seeds.

Bettinger (1975:268), however, did find four differences between the prehistoric and ethnographic settlement-subsistence patterns:

1. The use of the riverine community as a location for permanent villages and temporary hunting camps in prehistoric times, but not in historic times;
2. More intensive prehistoric hunting in the upper sage [brush] zone, and relatively less in the desert scrub zone, than observed among the historic Paiute;
3. More frequent prehistoric use of temporary hunting camps in the desert scrub, and less frequent use of temporary camps in the pinyon community, than found ethnographically; and tentatively
4. The prehistoric pattern of hunting in the pinyon zone apparently was seasonally limited to coincide with the fall pinyon harvest, compared with the summer-early fall hunting pattern suggested in the ethnographic accounts.

Attempting to integrate this information into a discussion of human ecology in Owens Valley, Bettinger encountered some unforeseen shortcomings in his data. There were no specific dates for these changes, and the various patterns that occurred did not account for all the differences between the ethnographic and prehistoric systems of settlement and subsistence (the four patterns account for less than 25% of all rejected predictions).

Bettinger then reclassified his data according to site types based on the knowledge of site activities, the season of use, and the chronological phase of occupation. The chronological phases were established by the use of time-sensitive projectile points (see Table 1).

Table 1

CULTURAL PHASES

(From Bettinger and Taylor 1975)

Phase	Date	Projectile Point Types
Clyde/Cowhorn	4500 B.C. - A.D. 600	Silver Lake, Lake Mohave, Little Lake, Pinto Basin, Elko, Gypsum Cave
Baker	A.D. 600 - A.D. 1300	Rose Spring, Eastgate Expanding Stem
Klondike	A.D. 1300 - A.D. 1850	Cottonwood, Desert Side-notched

This reclassification produced five categories of sites: (1) lowland occupation sites (riverine and desert scrub); (2) pinyon camps; (3) riverine temporary camps; (4) desert scrub temporary camps; and (5) upland temporary camps. With this new information, Bettinger was able to reconstruct the settlement-subsistence pattern for each cultural phase. The patterns in each phase were then compared with each other and with the ethnographic patterns.

The data from this portion of the study showed a relative consistency among the prehistoric and historic periods in the habitation of lowland occupation sites, in a heavy dependence on lowland plant resources, and in the minor role played by animal foods in the diet. Three major inconsistencies, however, were also found:

I. There was a shift in the plant resource exploitation from the riparian to the dryland plants sometime between 1500 B.C. and A.D. 600. This change simply represented a shift in the emphasis of the resources exploited. This was demonstrated archaeologically by a shift in the location of lowland occupation sites from the riverine area to the desert scrub area.

II. The archaeological record demonstrated that pinyon camps appeared sometime between A.D. 600 and A.D. 1000, indicating the inception of pinyon gathering. This was not accompanied by a decrease in the exploitation of other resources; rather, it was a broadening of the resource base.

III. A decrease in large game hunting became evident sometime between A.D. 1000 and A.D. 1300. This was shown by the lack of temporary hunting camps in the upland and desert scrub areas during this cultural phase.

Bettinger offered tentative explanations for these inconsistencies.

For the first change (I), he considered three possible alternatives. He first proposed a reduction in available moisture as an explanation, but rejected this because there would have been a more devastating effect on the desert scrub than on the riverine resources. He next considered an increase in the available moisture as a possible explanation. Since the desert scrub area is about thirty times larger than the riverine area, any increase in resource productivity would be greatly magnified in the desert scrub zone. Bettinger recognized that the riparian resources would also increase, but there would be concurrently increasing erosional activity which would decrease the total area of the riparian communities. This postulated decrease in the riparian communities may have been large enough to have forced the population into using the desert scrub zone. Citing climatological evidence of such an increase in moisture, he supported this explanation as the causative factor of this change. His third proposal was that either by intrinsic growth or by immigration, population pressure increased beyond the capacity of the riverine resources; this proposal, however, lacked supporting evidence.

The second change (II) was evaluated from four possible perspectives. Bettinger first proposed a decrease in moisture and indicated that there were some data to support such a climatological change. He considered this proposal plausible but not, however, conclusive. The second proposal was an increase in available moisture. Bettinger rejected this explanation because, since this would have also increased the output of the lowland resources, the population could have remained in the lowland area. The third proposal involved a population increase and the use of the pinyon resource as a means of broadening the subsistence base to regain equilibrium. Bettinger was aware of the lack of good archaeological data on this problem, but cited linguistic data which could be used as evidence of the population increase. At about A.D. 1000, there was an emigration out of southeastern California and into Owens Valley associated with the existing drier climatic conditions. For these emigrations to

have disrupted the equilibrium in Owens Valley, two conditions would have had to exist: (1) the bulk of the Owens Valley population would have to have remained behind, and (2) there would have to have been sufficient numbers of immigrants remaining long enough to upset the equilibrium. Bettinger felt this explanation was also plausible, as the Owens Valley has more abundant resources than surrounding regions. In later publications, Bettinger (1976, 1977, 1978) included intrinsic population growth as a fourth possible explanation for population increase.

Bettinger offered three possible explanations for the third change (III). The first explanation considered was a deterioration of the plant forage, which in turn reduced the animal population. There is evidence of this period being hotter and drier than the previous period, but not any more so than during the Clyde phase (4500 B.C. - 1500 B.C.) in which animals were a major resource. Another possibility was a conflict in scheduling food-getting activity, the result of which precluded hunting. The only known scheduling change around this time would have been the inception of irrigation. This irrigation would have required the labor of a group of men during the spring, summer, and fall—contrary to Steward's evidence that one man ran the project after group effort only in the spring. Bettinger supported this scheduling conflict as the causative factor for the decrease in large game hunting, although he did not suggest why irrigation became important. The third possible explanation concerned a reduction in the size of projectile points around A.D. 600. This reduction implies the use of the bow and arrow, which some consider to be a revolutionary event in hunting technology. Bettinger saw two possible consequences of this technological change. The first possibility was that hunting became so efficient that all the meat was obtained within the catchment of lowland occupation sites, eliminating the need for more distant temporary hunting camps. He considered this an unsound argument because deer and mountain sheep are not in the lowlands during the summer and early fall, and antelope are not susceptible to hunting with the bow and arrow. Thus, large game could not have been significant to the diet from late spring to the early fall after A.D. 1000. A second possibility was that more efficient hunting led to the depletion of the animal population. Bettinger considered this explanation unacceptable because weapons technology is seldom a limiting factor in terms of hunting efficiency. In this argument, he noted that the number of animals that must be killed in order to deplete the game population would probably have been beyond the capabilities of Owens Valley hunters.

Some of Bettinger's evaluations of the causal explanations are either not well-substantiated and/or not totally logical, perhaps because little conclusive evidence exists in any of these areas. No attempt will be made here to re-evaluate them. His conclusions will be used to test Cohen's hypothesis and can be used as guidelines for future research.

To summarize the salient points of this section, Bettinger recognized three major shifts in the settlement-subsistence patterns in Owens Valley and gave *tentative* explanations for each, only one of which involves population growth.

The cause of the first shift was best explained by climatic change, the second by climatic change and/or immigration (and possibly population growth), and the third by irrigation.

The significance of the first two explanations is that each would result in the alteration of the population size/carrying capacity ratio of any environment. The implication of this statement, which Bettinger did not recognize, is that population pressure would increase because the carrying capacity of the environment and cultural preference would no longer

be sufficient to support the population.

Although Bettinger speculated about the existence of population pressure, he did not deal with that specific problem in his dissertation. In one of his subsequent discussions, however, he (1978) suggested that this trend of shifts toward increasing diversification and intensification of subsistence (broad spectrum) was a response to the long-term increase/growth in the population size. The climatic fluctuations, he proposed, were the possible triggering mechanisms for these shifts. Here, too, he did not attempt to substantiate the significance of population pressure.

COHEN'S TEST CRITERIA

Cohen's (1977) criteria will now be used to test the hypothesis that population pressure was the significant factor causing the development of agriculture in Owens Valley. Although these criteria measure population pressure regardless of the cause, Cohen stressed population growth as the causative factor. In order to determine if growth was, in fact, the causative factor, alternative explanations (climate, immigration, etc.) would have to be ruled out.

Of the fourteen criteria employed by Cohen for this type of analysis, only those with supporting evidence in Owens Valley will be considered. He emphasized that a group of supported criteria would be a more significant indicator of population pressure than just a single supported criterion.

Following Cohen, the first indicator of population pressure is evidence of a given population increasing the distance it travels to collect food. This occurred during the first two examples of change in the settlement-subsistence pattern of Owens Valley noted by Bettinger (1975). In each case, the area covered by the gatherers increased considerably as they began to exploit new resources in addition to old. It is inferred from this that the group was finding it increasingly difficult to obtain enough food to support itself from the area near the home base.

The second indicator is the occurrence of group expansion into a new ecological zone or territory to obtain new resources while continuing to exploit the old. Again, as noted by Bettinger, the Owens Valley population was entering into and exploiting the resources of new zones which previously had held little attraction. Such a change may indicate increasing difficulty in obtaining preferred resources in a particular season. Cohen noted that this change is especially significant when it involves a group which adopts a scheduled transhumance pattern after it has been inhabiting only a single zone. A similar condition occurred when the Owens Valley population began to utilize the pinyon crop.

Indicator three is demonstrated when a population becomes more eclectic in the exploitation of microniches which previously have been ignored while continuing the exploitation of old niches. This occurred in Owens Valley when the inhabitants began to systematically exploit pinyon. This increased eclecticism would indicate that the population could no longer support itself by the old pattern of resource exploitation. The first pattern change was a switch in emphasis from riparian to desert scrub resources; no new resources were involved.

The fourth indicator is when a population switches to more eclectic food-gathering patterns with reduced selectivity in the foods eaten. This is demonstrated by the same evidence that supports the third indicator.

The fifth indicator of population pressure is considered by Cohen to be a shift in emphasis by a population from the hunting of large mammals to the hunting of small mammals for reasons other than the extinction of the large mammals. Such a situation may have occurred in the third change noted by Bettinger, where evidence indicates that large

mammals were no longer hunted. Cohen noted that large animals are a more desirable resource, but they make up a relatively small portion of the animal biomass in any region. A switch in emphasis from large to small mammals might indicate an inability to support the population with the meat of large animals. If Bettinger was correct in suggesting that the practice of irrigation posed a scheduling conflict in Owens Valley, it could serve the same purpose as the substitution of small for large mammals in the diet. The hunting of large mammals was replaced by another subsistence pattern.

The final indicator appropriate to use with these data from Owens Valley is the disappearance of an exploited species from the archaeological and fossil record. This would indicate that this species was exploited beyond its carrying capacity. The third change in Owens Valley could possibly support this indicator.

It is obvious that the fifth and sixth indicators could be directly related to each other if the switch to irrigation was a result of the killing off of the large mammals.

The first four indicators are also closely associated with each other; one can distinguish between them only by some minor details.

With this evidence, potentially six of Cohen's fourteen criteria for population pressure are supported. From this group of supported criteria, one might say with an undetermined degree of confidence that population pressure was a significant factor influencing the various settlement-subsistence patterns in Owens Valley, particularly the development of agriculture. This information offers positive support to the suggestion of Lawton, *et al.* (1976) and Bettinger (1978) that population pressure was an important causative factor in the development of Owens Valley aboriginal agriculture. The exact cause of the pressure, however, remains to be determined.

CONCLUSION

Before attempting to draw any conclusions from this analysis, a few points must be mentioned concerning the use of Bettinger's data in conjunction with Cohen's hypothesis.

Bettinger's (1975) dissertation was not written to deal with the problem of population pressure, and for this reason, his data are far from complete in relating to this problem. The solution to this inadequacy lies in the following: more extensive research—much more than surface survey; the expansion of the project to a regional scope to determine which pressures are important on the large scale; and, in addition to the three subsistence changes noted by Bettinger, the inclusion of two more research problems: the replacement of the atlatl by the bow and arrow; and the inception of agriculture.

Despite these gaps in the record, Bettinger's data do contain significant information. They show that population pressure was probably the most important variable in determining the direction of change in Owens Valley settlement-subsistence patterns. They also supply evidence for the conclusion that climatic change and immigration were probably the causes of the population pressure. The Owens Valley data do not, however, support population growth as a cause of population pressure. The implication of the data is that while population pressure is probably the impetus for the development of agriculture, population growth is not always the stimulus for population pressure.

This should not be seen as an attempt to detract from the importance of the concept of population growth. Cohen's study has shown that, indeed, population growth is an extremely important phenomenon throughout the course of human development, not merely as a goad to the inception of agriculture. It is only through the growth of human populations that climatic changes and immigrations could have had the effects they did in Owens

Valley and in other regions of the world. Climatic changes and migrations have occurred throughout time, but never before had they created enough pressure in and of themselves to necessitate the development of agriculture. Through growth, populations increased in size to a threshold at which a slight alteration (climatic change, immigration, etc.) changed the population size/carrying capacity ratio to the point where a new subsistence mode (e.g., manipulation of the environment) became a necessity. In the study of the specific process of the development of agriculture throughout the world, one should view agriculture not only as possibly indirectly related to population growth but as probably directly related to some form of population pressure.

Cohen's study of agriculture has drawn attention to population growth as an important archaeological problem. It is a problem that, so far, has not been dealt with adequately. It remains for archaeology in the immediate future to evaluate more thoroughly the possibility of population growth as a contributory factor to the development of the culture groups being studied.

In Owens Valley, we have seen how population growth may not be the direct cause of the development of agriculture, but it is potentially an important contributory factor. In order to evaluate these problems in this area, much more archaeological work remains to be done. Once such work has been completed, archaeologists will be better able to accept or reject any of the hypotheses proposed to explain the development of agriculture in this region.

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