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INTRODUCTION

THE DISCIPLINE OF anthropology, now more than a century old, has never been quite sure what its view of history is. In its early years, to be sure, it was almost boundlessly confident that the principles of evolution could be used in describing any aspect of culture or history, but by the beginning of the twentieth century grave doubts began to grow about the soundness of this position. Through the first decades of the century the doubts were dominant. In the past ten or twenty years, some anthropologists, especially archaeologists, have come full cycle. Again they apply avowedly evolutionary analysis to the data of culture history—though with much more caution.

Latter-day evolutionary analyses present series of developmental stages to which are assigned the data of archaeology and ethnology. Agreement is widespread that the stages should be so defined that they make a true progression, logically as well as chronologically. Beyond this, defining criteria for the stages have not been agreed upon. In most proposed schemes, subsistence occupies a prominent position. The reason is not its importance per se but that subsistence efficiency has important effects on population size, density, and aggregation, each of which has important social correlates. It is clear that the three factors, subsistence, demography, and society, and their relationships are basic to evolutionary analysis. Until now, however, the culture historian interested in this aspect of culture growth has been handicapped by a lack of subsistence-demographic-sociological analyses on the ethnographic level. If one attempts to learn, for example, what population densities are to be expected among hunters as against fishermen, both theory and data are entirely inadequate for even a tentative conclusion (cf., for example, Braidwood and Reed, 1957).

It is felt that a proper beginning on this problem is possible on the subsistence-demographic level with only minimal attention to social factors. It is true, of course, that a society with a given technology in a given environment will have a population that varies according to its social organization. It may be hoped, though, that the investigation of groups with similar social organization will reveal some pertinent subsistence-demographic relationships. Intensive work on such relationships has been done for the food-producing stages of culture growth, though even for these levels the pictures are very far from clear. The greatest lack, however, is found at the hunting-gathering stage. In dealing with agricultural levels we may expect that pertinent economic information will be available because of agriculture's great importance to modern society. For a preagricultural economy, however, we have only the scantiest information, almost none of it quantitative. I propose, therefore, to take the people of aboriginal California as an example of a hunting-gathering-fishing people and to try to establish some relationships between population size and environment. More specifically, the proposal is to establish the degree to which population size and density were dependent on the amounts of certain food products available before the introduction of Euro-American technology and agriculture.

As noted above, social factors must be held constant while the relation of subsistence to population is investigated. It is hoped that this can be done by holding culture constant. In other words, the aim is to compare the effects of subsistence on population within areas of substantially similar culture. For the delimitation of such areas we consult Kroeber, whose work on the subject is definitive. Kroeber (1939) divided North America into six major culture areas; the state of California includes portions of three of these—the Intermediate and Intermountain area, the Northwest Coast area, and the Southwest area.

1) Intermediate and Intermountain Area. The California province (I use the term "province" to designate a subarea of a larger culture area) of this culture area is entirely within the boundaries of modern California and includes most of the groups discussed herein. For present purposes we shall ignore two other provinces of the Intermediate and Intermountain culture area—the Great Basin province, east of the Sierra Nevada, and the Klamath Lakes–Pit River province, in northeastern California—for both are largely outside California.

2) Northwest Coast Area. Most of the Lower Klamath province of this culture area is in California. Since population and subsistence data are relatively complete for the province, it is conveniently included in the present study.

3) Southwest Area. A part of the Southwest culture area, Southern California, is within the present California boundary. The Southern California province includes coastal groups north to and including the Chumash, of Santa Barbara County, and interior groups as far north as the Tehachapi Mountains. The native culture of the province was dissipated early, and ethnographic materials are correspondingly scarce. More to the point in the present study is the fact that population data for the province are the least studied of any in California. Doubtless there are historical records that will ultimately yield valuable information, but these have yet to be systematically studied. Thus, it is best to exclude the Southern California province from the present work. We can scarcely hope to establish relationships between subsistence and demography when we have no acceptable population estimates.

We have, then, two culture provinces to work with—the Lower Klamath province of the Northwest Coast culture area and the California province of the Intermediate and Intermountain culture area. The question is, are we justified in considering the culture as substantially uniform in each province? Some uniformity over each area is certain (most will agree that the Yokuts of the San Joaquin Valley resemble the Pomo more than they do the Aztecs), but it is also certain that differences were considerable (some Pomo were predominantly matrilineal; the Miwok were patrilineal, etc.).

What we need is a typology of societies based only on factors that are demographically relevant. The relevant factors may be classified initially according to whether they affect mortality or fertility. In aboriginal California one finds very few social factors seeming to increase mortality rates. Warfare, for example, was so little developed that it can scarcely have taken many lives. Again, the complete lack of urbanism must have made for a public health situation as satisfactory as possible under primitive conditions. The only possible major social factor that one can see as affecting the mortality rate is the practice of infanticide. Nearly all tribes practiced infanticide (see Driver, 1937, p. 96; 1939, p. 350; Voeglin, 1942, p. 121; Essene, 1942, p. 33; Aginsky, 1943, p. 436), but usually only on bastard children. It is impossible to estimate the frequency of infanticide in aboriginal times, but it was presumably not great: girls married young and had little opportunity to produce illegitimate offspring. By and large, then, social factors tending to increase mortality rates were unimportant or absent in aboriginal California.

For social factors affecting fertility we may turn to the systematic typology of Davis and Blake (1956; see also Davis, 1955; Dorjahn, 1958; Lorimer, 1954). Those authors presented a series of "intermediate variables," mechanisms with direct effect on fertility, pro and con, and including such things as contraception, voluntary abstinence, and widowed celibacy. They then showed how some types of social organization are related to the intermediate variables and thus affect the over-all fertility of the society. It must be noted that we do not have adequate data on aboriginal California to assess the strength of each of the intermediate variables. As far as gross social structure is concerned, Davis and Blake found that family organization was most important: that societies with large corporate kin groups have both motive and mechanism for sustaining a high fertility rate whereas groups with independent nuclear families tend to have a lower fertility rate. We find that societies of the Lower Klamath culture province had an independent nuclear family organization whereas societies in the California province were based on loose forms of the clan or extended family. There was some variation within each of the provinces, but they can be considered substantially uniform.

As far as we know, then, if we assume that the societies found in each of the two culture provinces were substantially uniform we shall not be far wrong. This being so, we can go on to assess the effect of subsistence differences without having them obscured by social differences.

POPULATION

A TROUBLESOME ASPECT of the present study is the question of size and density of the native populations of California. Estimates of these populations now have a rather long history. The earliest were made by Powers (1877), who calculated that there had been an aboriginal population of 705,000 in the state of California. His total figure is probably wide of the mark,[1] but his method of estimation shows considerable sophistication and is worth quoting here (pp. 415–416):

[1] Powers' figure was questioned at the time by John Wesley Powell, who expressed his view that it was overestimated in a letter of transmittal accompanying Powers' *Tribes of California*. Powers' reply to Powell's request for modification is also included and reads in part: "... I have waded too many rivers and climbed too many mountains to abate one jot of my opinions or beliefs for any carpet-knight who wields a compiling pen.... If any critic, sitting in his comfortable parlor in New York,... can overthrow any of my conclusions with a dash of his pen, what is the use of the book at all?"

In Chapter V it was shown that there were sixty-seven and a half Indians to the square mile for forty miles along the Lower Klamath in 1870. Before the whites came doubtless there were one hundred, but we will take the former figure. Let us suppose there were six thousand miles of streams in the State yielding salmon; that would give a population of four hundred and five thousand. In the early stages of my investigation I was led to believe that wild oats furnished a very large source of supply, but have abandoned that idea as erroneous [just as well, too; wild oat is not native to California]. In all oak-forests, acorns yielded at least four-sevenths of their subsistence, fish perhaps two-sevenths; on the treeless plains the proportion of fish was considerably larger, and various seeds contributed say one-seventh. There are far more acorns in the Sierra and the Coast Range than on the Klamath, and all the interior rivers yielded salmon nearly as abundantly as that river. I think three hundred thousand might be added to the above figure in consideration of the greater fertility of Central and Southern California; this would give seven hundred and five thousand Indians in the State.

Powers' method had merit, but his measurement of resources was faulty. Salmon streams of California probably total something like 2,000 miles rather than the 6,000 he supposed. On this basis the total population estimate would be 235,000, close to some present estimates.

Whatever its merits, Powers' estimate has been consistently ignored since the turn of the century. In 1905, C. Hart Merriam proposed a different estimate, based not on a consideration of natural resources but on an extrapolation from figures derived from mission baptismal records. His basic calculations were made on the mission strip, from Sonoma, just north of San Francisco Bay, south to San Diego, near the Mexican border. Merriam asserted that the Christianized population of this area was 30,000 in 1834, but gave no source for the information. He assumed that the ratio of neophyte Christians to gentiles at that time was 3:1, and therefore that total population of the area was 40,000. He then raised the esimate to 50,000 on the assumption that disease had caused a considerable decrease in the decades preceding 1834.

As to the remainder of the state, Merriam assumed that population density was no less in the nondesert areas than in the mission strip. He defined the mission strip to include only the tribes which had missions within their tribal boundaries. On this basis it constitutes a fifth of the nondesert area of the state, and therefore the total population of the nondesert area was at least 250,000. Add to this 10,000 persons in the desert areas and the final estimate for the whole state is 260,000 persons.

A. L. Kroeber (1925, p. 881) disagreed with Merriam's estimate. He accepted the assumptions regarding population losses as well as the ratio of neophyte Christians to gentiles, but he questioned other aspects of the Merriam estimate. Doubting the "vague report of 30,000 [Christianized Indians] in 1834," he preferred to accept the 24,634 given for 1830. Further, he maintained that the area drawn on for missionization included many inland groups rather than the coastal tribes only, which Merriam had used as the basis for his estimates. Kroeber therefore concluded that the mission strip constituted a third of the state's nondesert lands rather than a fifth. Kroeber's figures adjusted in several respects yield a population of 150,000 persons for the state, or just over half the Merriam estimate.

Kroeber's own population figures (1925) were based not on gross extrapolation but on detailed figures calculated separately for each tribe. The tribal calculations themselves were based on ethnographic data combined with whatever historical information was available to him. The accuracy and reliability of Kroeber's several estimates vary considerably. Among the Yurok, for example, nearly all villages are known and, for most of them, the exact number of houses is known. Furthermore, a census of the Yurok taken in 1852 enabled Kroeber to determine the average number of persons per house at that time. These factors together allow a fairly solid estimate of the total population. His population figures for some of the little-known groups, in contrast, were little better than pure guesses, usually on the conservative side. The figures obtained by these methods came to 133,000 persons for the whole state (1925, Table 11).

In 1939 Kroeber still adhered to his 1925 figure, or one even slightly less, but by then difficulty had arisen in another quarter. In 1935 Meigs calculated the population of parts of Baja California, using Spanish documents, and arrived at a population density greater than Kroeber's population density for Alta California. Kroeber outlined the difficulty in 1939 (p. 179).

> If Meigs's figures are right, mine are too low, and Merriam's 260,000 is more in order. The whole problem of California population needs to be reopened. Only, if we accept 260,000, one-quarter of all United States Indians were in California; and this seems unlikely enough. Shall we, then, assume that Mooney and practically all American anthropologists compute far too low?
>
> Whoever uses Spanish figures seems almost always to reach higher populations than modern ethnologists. The kernel of the problem lies here. Shall we pin more faith on contemporary Spanish opinions, or on those of professional ethnologists who often have not seen an Indian of the tribes they deal with?

The reopening of the problem of California Indian population suggested by Kroeber in 1939 was undertaken by S. F. Cook, who began an investigation in 1943 in order to re-evaluate Kroeber's data in connection with a study of the effects on the Indians of the Spanish and American invasions. Cook's efforts at that time increased Kroeber's estimates by only about 10 per cent, but the reanalysis has continued and he has published intensive investigations of the aboriginal population of the San Joaquin Valley (1955*a*), the north coast of California (1956), and the East Bay area (1957). In these later papers, Cook radically revised the Kroeber estimates; in fact, if the pattern continues throughout the state, the final figure is likely to be near Merriam's 260,000, as Kroeber predicted.

Cook's revisions were so radical that a brief outline of his census methods is in order. These he stipulated in 1943 (p. 162) and has used ever since, though with some alteration, as we shall see. They are:

1) Direct enumeration. This method simply employs the head counts, official or unofficial, of early observers. Cook (1943) said of this: "These are usually unreliable in detail and suffer from a universal tendency toward exaggeration." But he has since changed his mind about that (see below).

2) The village-house method. With this method one calculates the total number of houses in an area from ethnographic or archaeological data. If the data are complete, they yield quite adequate population estimates.

3) The area method. Here one assumes that a census taken over a portion of an area will be representative of the area as a whole. The method was employed by Powers (1877) in his original attempt to estimate California population.

4) The baptism method. This simply uses mission baptismal records to estimate population around a given mission. Merriam (1905) used this, together with the area method, in his calculations.

Cook's 1943 enumeration, as I have said, raised Kroeber's estimates by only about 10 per cent. The change was small for two reasons: (1) the data used were hardly better than the information available to Kroeber in 1925, and (2) Cook used them very conservatively. By 1955 the situation had changed considerably. For one thing, Cook had accumulated a large quantity of useful census data from early historic sources as well as a new increment of ethnographic information in the unpublished village lists of C. Hart Merriam. Furthermore, he had begun to shake off his earlier conservatism. A statement in his paper on the population of the north coast makes this clear (1956, p. 81).

> To maintain explicitly or by implication that every observer without exception who reported on the size of Indian villages or numbers of Indians seen was guilty of inflating the values is no more justifiable than to accuse every man who makes a tax return of having cheated the government.... Evidence of falsehood should be looked for and, if found, the account should be discounted or discredited. Otherwise it should be admitted at face value.

Cook also maintained that the testimony of informants should not be relied on to the exclusion of historical evidence. It is his contention that an informant describing a culture from memory will probably be reasonably accurate as to qualitative facts, but highly suspect in his quantitative judgment.

Having altered his position and acquired new data, Cook has gone on to reestimate population. For the groups he has treated, his estimates have turned out to be from two to three times as large as the earlier Kroeber estimates. How accurate are Cook's figures? Are they to be preferred to Kroeber's? In my judgment they are much better, and I therefore use them herein. I justify my position as follows:

1) The most important reason for preferring Cook's figures is that Kroeber's are, for the most part, based on quite unacceptable evidence. For example, Kroeber said (1925, p. 308) that the Achomawi population in 1910 was 1,000. Their territory was remote from white contact "so that, instead of a tenth or a fiftieth, we may reckon their present numbers as constituting perhaps a third or more of the original population. This may be set roughly at 3,000 for the Achomawi and Atsugewi combined." Again, Kroeber said of the Wintun (*ibid.*, p. 356), "If the Pomo aggregated 8,000 and the Maidu 9,000, the former Wintun population may be set around 12,000." The majority of Kroeber's figures are obtained in the same fashion, making it impossible to judge their reliability.

2) I agree with Cook that the testimony of historical accounts was discounted much too readily by the ethnographers, and, what is more important, was often not used at all. Much historical documentation, unfortunately, was not available to the earlier ethnographers. Cook had the advantage of the work of a whole generation of California historians, and has himself contributed a good deal of historiography.

3) I also agree with Cook that some informant testimony should be discounted. That is particularly true for the Central Valley, where the malaria epidemic of 1832–33 (Cook, 1955*b*) reduced population enormously. An informant in 1900

would have to have been well over seventy to have had firsthand quantitative data predating the epidemic. No evidence suggests that quantitative information was obtained from such informants by the ethnographers.

4) Finally, I have myself subjected Cook's estimates to independent test and have found that they hold up very well. In 1956 Cook published his population figures for the north coast. At about the same time I had occasion to calculate population for the California Athabascans, who occupied a part of the north coast area (Baumhoff, 1958). It happened that my information included much more detail on villages and houses than was available to Cook, but my population estimate (18,779) was close to his (17,447). The similar estimates from different evidence gives confidence in Cook's estimates for other tribes.

If Cook's population figures are used, Kroeber's must be excluded; the two series differ so widely that they are not at all comparable. This fact immediately restricts the scope of the present paper to the areas where population has been re-evaluated by Cook—the north coast, San Joaquin Valley, and the East Bay region. Even within these areas not all tribes will be used to reconstruct aboriginal ecology. Only where the population is derived from detailed village lists or from early censuses will the figures be accepted. Where such detailed information was not available, Cook fell back on the area method—extrapolation of population densities from areas of known population to areas of unknown population. Such a method, however, would not be at all suitable for my present purposes, for the intent here is to relate population to features of the natural environment. Magnitude of area is itself very much a part of the natural environment, so it would be meaningless to base a population estimate on area and then proceed to ask what effect area has on population.

RESOURCES

THE FOOD RESOURCES of the California Indians are characterized by great variety. Barrett and Gifford (1933), for example, mentioned eight species of mammals, four species of birds, three species of fish, and some eighty-five species of plants used as food by the Miwok Indians, and even this list is far from complete. To assess the economic value of all the many products is clearly impossible, so it will be necessary to concentrate on a few. Products selected for study should be those composing the staple foods of the people, important by reason of sheer bulk. Beyond this it is desirable to choose foods that can be stored. The lean time of the year for most aboriginal Californians was the early spring, before plant growth began and before the start of the spring salmon run. It was then that the threat of starvation was most serious. Thus the quantity of stored food that could be carried over the winter would have been a crucial factor in determining population size.

The foods that best meet those requirements are acorns, large game mammals, and fish. There is no doubt that each of these products was available and taken in large quantities; the ethnographers are unanimous on that point. Each of these products also satisfies the criterion of storability. The acorn may be kept without treatment; fish and game may be stored if they are dried or smoked.

Presumably, then, if we can establish the relative quantity of each of these products available to a tribe we will be in a good position to evaluate total economy. In the following pages the nature of each resource—acorns, game, and fish—is outlined and the methods of evaluation will then be specified.

Acorn Resources

The main staple of the California Indians was the acorn. Even among the peoples of the Lower Klamath province, acorns are sometimes said to have been the main staple in spite of a greater reliance on salmon there than in other areas. The Yurok, for example, "ate very largely of the acorn, the staple food of most Californians; but fish, that is, salmon, constituted a greater proportion of their food than was usual elsewhere" (Kroeber, 1925, p. 84). Throughout the remainder of California (excepting the desert areas) the reliance on acorns was even greater. Acorns were gathered in the fall before they fell from trees. The men usually climbed the trees and knocked the limbs so the acorns could be picked up by the women. The acorn harvest lasted many days, perhaps as long as a month (Gayton, 1948, p. 178), until enough nuts had been picked up to last over the winter, when food was scarce. Periods of starvation are mentioned for some groups. In the California culture province these must have been caused by failure of the acorn crop.

There are nearly twenty species of oak in California, but only nine species in two genera were of economic importance, and some of these were marginal. The nine species are the tan oak (*Lithocarpus densiflora*), valley oak (*Quercus lobata*), Oregon oak (*Q. garryana*), blue oak (*Q. douglasii*), scrub oak (*Q. dumosa*), maul oak (*Q. chrysolepis*), coast live oak (*Q. agrifolia*), interior live oak (*Q. wislizenii*), and black oak (*Q. kelloggii*). Our interest is in four characteristics of these species: (1) nutritive value of the acorns, (2) preference of the natives for each species, (3) range and abundance of each species, and (4) crop size and regularity for each species.

NUTRITIVE VALUE

There have been several analyses of the food value of California acorns (see, for example, Woods and Merrill, 1900; Jaffa, 1908; Merriam, 1918), but for present

TABLE 1
Chemical Composition of Hulled Acorns

Species	Chemical Composition (in per cent)						
	Water[a]	Protein	Fats	Fiber	Carbohydrates	Ash	Total proteins, fats, carbohydrates
Lithocarpus densiflora	9.0	2.9	12.1	20.1	54.4	1.4	69
Quercus lobata	9.0	4.9	5.5	9.5	69.0	2.1	79
Q. garryana	9.0	3.9	4.5	12.0	68.9	1.8	77
Q. douglasii	9.0	5.5	8.1	9.8	65.5	2.1	79
Q. chrysolepis	9.0	4.1	8.7	12.7	63.5	2.0	76
Q. agrifolia	9.0	6.3	16.8	11.6	54.6	1.8	78
Q. kelloggii	9.0	4.6	18.0	11.4	55.5	1.6	78
Barley	10.1	8.7	1.9	5.7	71.0	2.6	82
Wheat	12.5	12.3	1.8	2.3	69.4	1.7	84

Source: Modified from Wolf (1945, Table 1) and Spencer (1956, Table 156).
[a] Water content of acorns was assumed to be 9 per cent on the basis of other analyses (Wolf, 1945, Table 2).

purposes it is best to rely on the work of Wolf (1945), whose analyses of acorns of seven different species were made under uniform conditions so they would be directly comparable (he also gave an analysis of barley as a base for comparison). Wolf's data are given in table 1, together with comparable data for wheat as given by Spencer (1956, p. 187). The table shows that California acorns as a whole are inferior to barley and wheat in protein and carbohydrates but superior in fat and somewhat inferior in terms of total food content. The high fat content, however, makes the acorn superior to most grains in caloric value: 2,265 calories per pound, according to Woods and Merrill (1900), compared to 1,497 for wheat (Spencer, 1956, p. 187).

Table 1 also shows that there is some interspecific variation in the food value of acorns. The tan oak (*L. densiflora*) acorn has the lowest total food content and lowest protein content, but the protein deficiency is not serious because the tan oak is common only where abundant salmon assures an adequate supply. The coast live oak (*Q. agrifolia*) is the only species with a markedly high protein content. The black oak (*Q. kelloggii*), the coast live oak (*Q. agrifolia*), and tan oak acorns have high fat content, so they doubtless have high caloric value as well.

Generally speaking, the data in table 1 show that the acorn compares favorably with the grains in nutritive value. They also show that there were some differences among the species, though probably not enough to have had noticeable economic effect.

NATIVE PREFERENCE

A partial search of the literature has revealed the data in table 2, on preferences of the California Indians as to the various species. Preference, however, was not necessarily the factor that dictated which species was the principal staple in a given area. Often the question of abundance was more crucial. A preferred species is rated 1, a commonly used species is rated 2, and an undesirable species is rated 3.

Species	*Average Rating*
Tan oak (*L. densiflora*)	1.0
Valley oak (*Q. lobata*)	1.9
Oregon oak (*Q. garryana*)	2.0
Blue oak (*Q. douglasii*)	1.5
Scrub oak (*Q. dumosa*)	2.5
Maul oak (*Q. chrysolepis*)	2.2
Coast live oak (*Q. agrifolia*)	2.0
Interior live oak (*Q. wislizenii*)	2.3
Black oak (*Q. kelloggii*)	1.5

The indications are that tan oak acorns were preferred wherever known. Acorns of the valley oak were a great staple but were usually not preferred, probably because they were difficult to hull (Barrett and Gifford, 1933, p. 142). Other species were preferred in some areas. For example, the blue oak was preferred in the Northern Sacramento Valley, and the black oak in the Sierra foothills. These preferences may relate to relative abundance of the trees, or perhaps simply to custom without rational basis. Oregon oak acorns are in the same class as those of the valley oak—they were a great staple but were always thought to be less desirable than the acorns of the tan oak, with which the Oregon oak is always associated.

TABLE 2

PREFERENCE RATINGS OF ACORNS OF VARIOUS OAKS

(1 = preferred species; 2 = commonly used; 3 = not used or used only when other species fail)

Tribe	Species[a]									Reference
	L. densiflora	*Q. lobata*	*Q. garryana*	*Q. douglasii*	*Q. dumosa*	*Q. chrysolepis*	*Q. agrifolia*	*Q. wislizenii*	*Q. kelloggii*	
Yurok	1	–	–	–	–	–	–	–	–	(Ring, 1930)
Hupa	1	–	2	–	–	2	–	–	2	(Goddard, 1903, p. 27. *Q. californica* given for *Q. kelloggii*)
Shasta	1	–	2	–	–	3	–	–	2	(Dixon, 1907, p. 423. Nuts of *L. densiflora* had to be imported)
Yuki[b]	1	1	2	2	3	3	–	–	2	(Chestnut, 1902, pp. 342–344)
Wintun	–	2	–	1	2	–	–	3	1	(Du Bois, 1935, pp. 19–20)
River Patwin	–	1	–	1	–	–	–	3	–	(Kroeber, 1932, p. 275)
Hill Patwin	–	2	–	1	–	–	–	3	2	(Kroeber, 1932, p. 295)[c]
Pomo	1	2	2	–	–	2	2	–	2	(Kniffen, 1939, p. 379)
N. Maidu	–	–	–	–	–	1	–	1	1	(Dixon, 1905, p. 181)
S. Maidu	–	3	–	2	–	–	–	2	1	(Beals, 1933, pp. 351–352)
Miwok	–	2	–	2	–	–	–	2	1	(Barrett and Gifford, 1933, p. 142)
Yokuts	–	2	–	–	–	–	–	–	1	(Gayton, 1948, p. 77)

[a] Most sources give common names for the species. Identification has been made by means of Jepson's (1910) extensive common-name synonymy, together with geographical location.

[b] Foster (1944, p. 165) gave a different scaling for Yuki. If I interpret him correctly, he gives rating of 1 to *Q. lobata* and *Q. kelloggii*, 2 to *Q. garryana* and *L. densiflora*, and 3 to *Q. dumosa*. There is a 2 rating for the "Mush-oak" and a "Scrubby-mush-oak," which I cannot identify.

[c] Patwin *sai* can scarcely have been *Q. dumosa*, as Kroeber suggested. *Sai* are said to have produced favored acorns, whereas those of *Q. dumosa* are small and bitter. *Sai* must have been *Q. douglasii*.

Acorns of the scrub oak, the maul oak, and the interior live oak seem not to have been preferred and were not much used. Acorns of the coast live oak are not often mentioned, but they may have had considerable use in areas where our ethnographic knowledge is scant.

OAK RANGE AND ACORN CROP

The other variables are perhaps the most important of the lot. They are therefore discussed for each species.

1) *Lithocarpus densiflora* (tan oak). The tan oak, for many years regarded as a species of the genus *Quercus* but now assigned to a separate genus, is the least typical of the California oaks but is similar enough to be grouped with them for our purposes. The tan oak is found throughout the Coast Ranges from the Umpqua River of Oregon south to Santa Barbara. It usually grows around the redwood belt and hence is most abundant in Mendocino and Humboldt counties, of the North Coast Range. There it mingles with the redwood trees where they are not too dense, grows in a fringe along the inland side of the redwood belt, and is found also in clear areas or on the bald hills within the redwood belt.

The tan oak forms a major part of the flora in its range, hence it produces an important crop. According to Smith (1929, p. 130) the tan oak seed crop is about 125 pounds per tree in a good year, varying from 30 to 300 pounds with size and situation. Wolf (1945, p. 51), with less information, thinks that the tan oak will produce about as well as the black oak, or over 200 pounds in a good year. I am inclined to accept Wolf's figure because of his greater knowledge of other California oaks and their crops. The size of the crop varies, but there is said to be at least a partial crop every year.

2) *Q. lobata* (valley oak). The valley oak is mainly confined to the Central Valley of California, although it is occasionally found as far north as the Trinity River and as far south as the San Fernando Valley. The floor of the Central Valley formerly had great numbers of these trees along stream courses and other well-watered places. It is also found in the foothills of the Sierra up to elevations of about 1,500 feet, and throughout the Coast Ranges in hot, well-watered valleys away from the sea.

Since the valley oak does not grow in dense stands, it is less abundant than some other species. Because of its large size and abundant crops, however, its total production is probably as large as that of any oak. In 1943, Wolf (1945, p. 27) collected 500 pounds from beneath a single tree and felt that this was less than half the production of some of the other trees in the vicinity. Smith's (1929) data for the same species suggest that an average crop is about 175 pounds. In view of the undoubted accuracy of Wolf's information it is likely that Smith's crop yield figures should be doubled here (and in other instances also). According to Smith there is a good crop one year out of three, with partial crops in the other years.

3) *Q. garryana* (Oregon oak). According to Jepson (1910, p. 210), the Oregon oak "is abundant and the most common oak on the highest slopes and ridges of the North Coast Ranges at a distance of twenty to forty miles from the ocean in a region inside the redwood belt known as the 'Bald Hills' of Mendocino and Humboldt Counties." The species is therefore of fair abundance where there are tan oaks. Smith's data suggest that the crop of the Oregon oak varies between 100 and 600 pounds per tree. It probably averages 200 pounds or more. In acorn yield, then, it is like the tan oak except that it frequently fails—having a good crop only once in three or four years.

4) *Q. douglasii* (blue oak). The blue oak is common on dry, rocky hillsides in the Sierra foothills between 500 and 2,000 feet elevation. It is found throughout the south Coast Ranges, and in the inner ranges of the north Coast Range as far west as Round Valley. There are probably more individuals of this species than of any other oak in California. Some nearly pure stands are found in the Sierra foothills and in the south Coast Ranges as well, especially in Monterey County. Trees of the blue oak are not so large as some other species, and the crops are correspondingly smaller. An average tree with a rather heavy crop produced 160 pounds in 1944 (Wolf, 1945, p. 23). Moreover it appears that this species fails rather frequently—there are no concrete data on this question, but it appears that a good crop is produced no oftener than one year in three.

5) *Q. dumosa* (scrub oak). Scrub oak forms a part of the chaparral in the Coast Ranges, especially south of San Francisco Bay. The acorns of the scrub oak are said to have been used by the Wintu (Du Bois, 1935, p. 19), but one can scarcely believe that they were plentiful enough to have been important. Many of the

references to scrub oak in the literature may refer to dwarf individuals of other species rather than to trees of the species *Q. dumosa.*

6) *Q. chrysolepis* (maul oak). The maul oak is found in a variety of places throughout the state. In the Sierra, it occurs chiefly between 1,500 and 5,000 feet elevation, and in the Coast Ranges is scattered through most river valleys. Maul oaks occasionally attain great size in the north Coast Ranges, and may accordingly have been individually important, but they are usually few and scattered, and their aggregate effect can scarcely have been great. Crop size for an individual tree of this species may run up to 400 or 500 pounds but mostly would run considerably less—150 to 200 pounds, perhaps. The acorn crop of the species is quite irregular—probably not more than one good crop in three years.

7) *Q. agrifolia* (coast live oak). The coast live oak is abundant in the south Coast Ranges and in the north Coast Ranges in Marin and Sonoma counties. These trees and their acorns are both rather small, so the yields are not large, probably a hundred pounds or less on the average. In addition to being small, the crops are variable, no more than one good one occurring in two years.

This species is not mentioned often in the ethnographic literature, which probably reflects our lack of knowledge of the Indians of the south Coast Range.

8) *Q. wislizenii* (interior live oak). The interior live oak occurs throughout the Sierra foothills up to about 2,000 feet in the north and about 4,000 feet in the south. It is abundant on the western side of the Sacramento Valley, where it penetrates the inner Coast Ranges as far south as Ukiah Valley. Observations on twelve trees indicate a maximum crop in excess of 100 pounds per tree (Smith, 1929, p. 130). There is a good crop about one year in two.

9) *Q. kelloggii* (black oak). The black oak is found in the Sierra and the Coast Ranges. In the Sierra it occurs in or just below the yellow pine belt (1,500 to 4,500 feet in the north and 3,500 to 6,500 feet in the south). In the Coast Ranges it is found with the tan oak and the Oregon oak, but never with the redwood, and is therefore especially abundant in the north Coast Ranges, although it is common as far south as San Luis Obispo County.

The black oak produces large crops of acorns, between 200 and 300 pounds in a good year. This species appears to be a regular producer, averaging more than one good crop in two years.

TECHNOLOGY

The necessary technology of the acorn industry is a simple matter. The steps involved are harvesting, transport, storage, and preparation. Harvesting is the simplest step. One needs only a long pole to knock the nuts off the tree so they can be picked up off the ground. The nuts must then be transported to their storage place, a matter that would have presented some difficulty if the oaks had been far away from the villages. The areas of local autonomy, tribelet areas, within which acorns were harvested were usually very small, however, so transport needed only a large container. One wonders, in fact, whether the economic necessities of acorn transport may not have been largely responsible for determining the minute tribelet areas. In any case, the container was easily come by through basket-making techniques, a craft probably known to the earliest inhabitants of

California, for it is undoubtedly thousands of years old, as indicated by archaeological evidence from Nevada caves.

Storage of acorns presents few technical difficulties. All that is needed is protection from rodents (Merriam, 1918). Storage by the Indians was either in large baskets kept inside the dwelling or in large wattle granaries on platforms several feet above the ground.

The crucial technical process in the acorn industry is preparation of the nut for food. The bitter tannic acid in all acorns—in substantial quantities in some—must be removed before the nut is palatable. It can be removed without grinding the nut, but the process is so slow and difficult as to be uneconomic in supporting a large population. Suitable grinding methods have always been available to the acorn industry of California. They were undoubtedly known to the earliest Indians: the *mano* and *metate,* and perhaps the mortar and pestle, are found in contexts many thousands of years old in California and adjoining areas (the earliest cultures known from the Santa Barbara Coast, the Cochise Cultures of southern Arizona, and the oldest Nevada archaeological sites).

The important technical invention, then, was the process for removing tannic acid from the acorn meal. Extraction, a leaching process, was accomplished by placing the meal in a basket or, more often, in a sand-lined depression in the ground and pouring hot water over the meal until it was sweet (Gifford, 1936). This was the process that had to be developed before the acorn could assume the economic importance it is known to have had. How long it has been known we do not know. It must have been in use in Central California by Middle Horizon times (i.e., before Christ) at least. The quantity of mortars and pestles found in Middle Horizon archaeological sites indicates a heavy reliance on vegetal food, and no plant food other than the acorn was present in the Central Valley in sufficient quantity to merit such reliance. Similarly, the quantity of *metates* and *manos* found in "Oak Grove" sites of coastal Santa Barbara indicates that these people, too, were eating largely of the acorn. The age of the "Oak Grove" culture is not definitely known, but one may be confident that it dates from at least four to five thousand years ago. Presumably, then, the leaching process has a respectably antiquity in California.

Game Resources

Land mammals—deer, elk, and antelope—composed a second major source of subsistence to aboriginal Californians. They were everywhere of lesser importance than acorns, but ranked higher than fish in areas without good salmon streams. Among the Wintu, for example, with adequate fish resources at hand, the main source of flesh food was salmon, steelhead, and suckers (Du Bois, 1935, p. 15). Among the Wappo, in contrast, "Fish were regularly caught, but were apparently a less important food than land mammals..." (Driver, 1936, p. 184).

The California natives seem to have been on a par regarding hunting techniques and devices (Driver and Massey, 1957, pp. 189–201). The bow and arrow were ubiquitous, and so was some method of snaring. A surround technique was used through most of the Central Valley, the only area in which it could be economically employed, and other kinds of communal drive were known elsewhere. Pitfalls were used only in the northern part of the state, but that trick can scarcely have been of crucial importance. We may therefore conclude that one group was about as able to take game as another, so that the important variable must have been local supply.

Land mammals of considerable economic importance in native California include two races of deer (California mule deer and Columbian black-tailed deer), two species of elk (Roosevelt elk and tule elk), and the prong-horn antelope. We consider each of these animals in turn.

Odocoileus hemionus (black-tailed deer).—Altogether, six subspecies or races of black-tailed deer are represented in California, but the area of present interest had only two—the California mule deer (*O. h californicus*) and the Columbian black-tailed deer (*O. h. columbianus*). The California mule deer is found throughout the south Coast Ranges, the Transverse Ranges, and the Sierra as far north as Lake Tahoe. The Columbian black-tailed deer has a complementary distribution through the north Coast Range, north of the Central Valley to the Cascades and south through the Sierra to Lake Tahoe. The California mule deer is slightly the larger of the two races—bucks average about 145 pounds, as against an average of 130 pounds for the Columbian black-tailed deer (Sheldon, 1933).

The habitat of the two races is about the same, given the difference in range. The best statement on deer environment is given by Longhurst, Leopold, and Dasmann (1952, p. 11):

> From these accounts we gain the impression that deer originally were numerous in the coastal mountains from San Diego to the Klamath River and in the foothills bordering the Central Valley. Populations were moderate or only locally abundant in the high Sierra, the Great Basin area and the Central Valley. They were scarce in the desert and the heavily timbered northwest.
> In terms of vegetation types, the areas of deer abundance were predominantly chaparral and oak woodland. Frequent burning doubtless helped maintain a high carrying capacity in these areas for game. Presumably lightning started most fires at higher elevations, but from all accounts the Indians set numerous fires in the coast ranges and foothills.... The mechanism of Indian fires, tending to set back plant successions to sub-climax levels favorable to deer, undoubtedly contributed to the high numbers found originally in coastal and foothill areas. It was only after the heavy timber was broken up that deer attained high density in the California mountains.

Cervus canadensis roosevelti (Roosevelt elk).—In aboriginal times the Roosevelt elk was abundant in the north Coast Ranges as far south as San Francisco Bay. It was most common in cool, humid regions along the coast, but in the north was known as far east as Mount Shasta (Grinnell, 1933, p. 205).

The Roosevelt elk is a very large animal. No accurate records are available, but it is even larger than the Rocky Mountain elk, adult males of which species average about 630 pounds.

The carrying capacity of a given area for Roosevelt elk appears to depend on the quantity and quality of winter range. In winter that elk lives mostly on browse, so one expects to find more animals where there is extensive chaparral and oak woodland. In spring they eat considerable grass, so grassland is also of some importance. The relative density of elk in the various vegetation zones, then, is about the same as that of the Columbian black-tailed deer except that the elk did not extend into the Sierra or so far east into the inner coast ranges.

Cervus nannodes (tule elk).—The tule elk formerly inhabited the entire Central

Valley, from Redding to Bakersfield. Grinnell (1933, p. 206) had record of them only as far north as Butte Creek, but in 1832 John Work's party (Maloney, 1945, p. 18) began to kill elk in great numbers as soon as they entered the valley, at Cow Creek. The usual range of the tule elk is below 2,500 feet, and their "metropolis was below 500 feet and within the Lower Sonoran life-zone, from which more or less seasonal wanderings carried herds up into hill country, especially that west of Tulare and Buena Vista Lake regions. Inhabited mostly marshes and open plains of valley floors" (Grinnell, 1933, p. 206).

The tule elk is sometimes known as the dwarf elk. It is a smaller animal than the Roosevelt elk but much larger than deer or antelope. Recorded weights of some of these animals are: four young adult males—328, 383.5, 434, and 441 pounds; two old adult males—493 and 522.5 pounds (Murie, 1951, p. 72).

Antilocapra americana (prong-horn antelope).—The prong-horn antelope today is found only in the desert regions of northeastern California, but in prehistoric times the greatest numbers were found in the Central Valley (McLean, 1944). The original habitat of the antelope in the Central Valley appears to have been about the same as that of the tule elk except that the antelope, a smaller animal, did not penetrate the tule marshes as deeply or as often. In any case the early accounts always speak of elk and antelope together. Thus, Manly (1929, p. 302) wrote of the San Joaquin River in 1850: "On our way droves of antelope could be seen frolicking over the broad plains, while in the distance were herds of elk winding their way from the mountains towards the river for water."

The prong-horn antelope is much smaller than elk or even deer. Reported average weight in an Oregon herd was 114 pounds for bucks and 92 pounds for does (Einarsen, 1948, p. 41). Herds of antelope would have to be very large to compare favorably with even a moderate elk herd, but an offsetting fact is that antelope are very curious animals, and correspondingly easy to surround or otherwise trap.

FISHERY

Fish undoubtedly constituted a very important part of the diet of aboriginal Californians. In Northwestern California it equalled or surpassed the acorn in importance; in the rest of the state its significance varied—fishery was of great importance on streams with a substantial fish population, especially the Sacramento, the San Joaquin, and their important tributaries. Rostlund (1952), who has gone into the question very thoroughly, accords five ranks to the several tribes on the following plan:

1) Tribes for which fish was the most important staple in the annual food economy.

2) Tribes having fish as a staple but no more important than game or plants.

3) Tribes for which fish was a common, but only supplementary, part of the diet, not a staple food of great importance.

4) Tribes with very little fish in the yearly diet, either from scarcity, as in the arid basins of the high mountains, or because fish, though present, were sought only as an emergency food when other supplies failed.

5) Tribes reported as never using fish.

According to these criteria a rating of 1 is assigned to the entire Lower Klamath province (NW California) with the exception of the Sinkyone and the Shasta, which are rated 2. In the California Province all groups are rated 2 but the following (rated 3): Wappo; Maidu and Nisenan of the foothills and mountains; Tubatalabal; and Costanoans.

These ratings provide additional justification for the present separation of native California into two cultural provinces—the Lower Klamath and the Californian.

The fish species of interest here are the king salmon (*Oncorhynchus tschawytscha*), the silver salmon (*Oncorhynchus kisutch*), and the steelhead trout (*Salmo gairdnerii*). Other anadromous and freshwater fish are neither abundant nor of high quality in California (pelagic fish were of importance only to the peoples of the south coast, the only native Californians with deep-water gear). Possible exceptions are the sea lamprey, the sturgeon, and the smelt, but they were of local importance at best and we have no way of evaluating their productivity. Pacific salmon and the steelhead trout are born in fresh water, and soon after birth swim out to sea, where they grow to maturity. After four to six years they return to fresh water to spawn. The Pacific salmon, genus *Oncorhynchus,* almost always dies after spawning. The steelhead usually returns to sea and spawns annually for several years.

The most important quality of salmon, from the standpoint of aboriginal economics, is that its annual or semiannual spawning run carries it upstream in great numbers for a limited period so that a brief, concentrated effort gave a comparatively great return. The economic value of a given stretch of stream, therefore, depends on the quantity and condition of the spawning beds above that stretch. The spawning female salmon prepares her nest on gravel bottoms of streams with shallow, cold, clear water—these are usually found near the headwaters of larger tributary streams. Accordingly, several factors must be taken into consideration in evaluating the fish resources of a group, the main ones being distance from headwaters and the number of runs per year (in some streams there is no spring run of king salmon). These as well as other local factors are considered in the discussion of individual groups.

Another factor of particular relevance here is the irregularity of salmon yields. Skinner (1958, pp. 1–2) reported on the situation in the Sacramento–San Joaquin drainage.

> Between 1870 and 1910 the commercial salmon catch in the Sacramento–San Joaquin system varied from two to more than ten million pounds a year. Few records are available to indicate the magnitude of catches before 1870, but, apparently, very good catches were made during the late 1850's and early 1860's. Toward the end of the latter decade the runs decreased.
>
> The State Legislature created the State Board of Fish Commissioners in 1870, and the decreasing salmon runs were their most immediate concern. The Commissioner immediately set out to obtain legislation to provide for fishways and screens at dams and diversions and to prohibit the pollution of streams by sawdust in particular. The U.S. Fish Commission had established a king salmon egg collecting station on the McCloud River in 1872 in an attempt to establish king salmon in other parts of the country. The California commissioners were instrumental in obtaining the aid of the U.S. Fish Commission in the rearing and release of king salmon fry in the Sacramento River. This program of artificial propagation resulted in much rejoicing about 1880 as the landing soared toward ten million pounds. Present knowledge, however, indicated the runs most likely recovered on their own.

Another decline immediately occurred, which by 1891 reached the low of two million pounds. By 1910, however, another peak year of more than ten million pounds was recorded. The mean annual catch for the period 1874–1910 (27 years data) was over six million pounds.

Data from the north Coast Ranges indicate a similar cyclical yield, but with less severe fluctuations. Fish counts of the South Fork of the Eel River, for example, show that the minimum counts are nearly half the maximum counts (table 3), and the situation is evidently much the same on the Klamath River (table 4).

TABLE 3

Fish Counts on South Fork of the Eel River

Year	No. of fish (1000's)
1938	26
1939	27
1940	44
1941	52
1942	51
1943	44
1944	52
1945	43
1946	49
1947	57
1948	43
1949	25
1950	42
1951	38
1952	30
1953	26
1954	26
1955	21
1956	20

Source: Data from the State of California, Department of Fish and Game. The numeration includes king salmon, silver salmon, and steelhead trout. Most of the variation is in the numbers of salmon; steelhead are relatively constant.

TABLE 4

Klamath River Salmon Catch

Year	Catch (1000's of lbs.)
1915	1,232
1916	801
1917	266
1918	672
1919	535
1920	872
1921	614
1922	1,040
1923	824
1924	815
1925	956
1926	812
1927	408
1928	308

Source: Adapted from Snyder, 1931, Table 49.

The greater reliability of the fish runs in Northwestern California may be responsible in part for the greater emphasis on fishery there. At the same time, reliance on the fish resource put the natives more squarely at the mercy of its fluctuations. Kroeber (1925, p. 524) maintained that periods of actual starvation were rather scarce among most Indians of California: "The only definite cases that have come to cognizance, other than for a few truly desert hordes whose slender subsistence permanently hung by a thread, are among the Mohave, an agricultural community in an oasis, and among the Indians of the lower Klamath, whose habits, in their primal dependence on the salmon, approximated those of the tribes of the coasts north of California."

A broad view of fishery includes all products of ocean and stream, not just members of the superclass *Pisces*. The most important nonfish products are shellfish and sea mammals. Such resources, though used in large quantities by peoples living on the seacoast, could not compare with salmon as an assured and abundant food supply. For these reasons I include coast waters in the computation of total resources available to a people but have weighted them less heavily than most salmon streams.

TECHNOLOGY

Fishery technology involves both catching and preserving. Certain devices, particularly for catching fish, permit a much more efficient exploitation of the fish resources than is otherwise possible, so it is necessary to evaluate the position of the California Indians in this respect. Information on this subject is taken mostly from Rostlund (1952).

Among the more important devices in mass-production fishery are nets, but native Californians were generally rather poor net fishermen as compared, for example, with the Indians of the eastern seaboard. A variety of nets were known by the tribes in fishing territory, and many were used skillfully, especially dip nets; yet really efficient nets, like seins or set gill nets, were scarcely used at all. Rostlund said these people failed to attain maximum production of their fishery because of failure to make full use of these instruments. His conclusion may not be correct, since it appears that their use of weirs (see below) made excessive net fishing unnecessary, at least for the inland fishery.

Probably the most important fishing device of the California Indians was the fish weir, an object built across a stream so as to impede the progress of the fish and aid in their capture. A weir is really useful only for catching fish on a spawning run, for only then are the fish impelled to pass the obstacle. Fish weirs were known and used throughout California wherever there were salmon runs. Evidently they were extremely successful. The Yurok, for example, annually built a barrier of poles and logs across the Klamath River (Waterman and Kroeber, 1938). Small openings in the barrier let the fish go upstream into small enclosures or traps, where they could easily be caught and killed. The weir is said to have been built so well that only an occasional fish escaped. It was allowed to stay up only ten days during the salmon run lasting several weeks. Waterman did not know the reason for this but thought that neighboring peoples upstream would have descended and destroyed the weir had the Yurok not torn it down themselves.

Weirs like this were known up and down the state, and it seems clear that they were as efficient as any net fishing in capturing the salmon run. Since salmon and steelhead were the really important anadromous or freshwater fish in California waters, it follows that the native fish technology must have been producing nearly an optimum yield. It does not seem likely that technological innovations, such as greater use of large seine nets, could have increased exploitation of the anadromous fishes.

Ocean fishing was a different matter. The Californians (except those of Santa Barbara and south) were poor sailors and had little deep-water gear, so they failed utterly to exploit the pelagic fishery. There is no doubt that most coastal groups could have exploited deep-sea resources much more effectively with an improved technology.

As to minor gear, the California Indians used fishhooks, fish spears, harpoons, fish poison, and fish clubs. Among these devices, probably only fish spears were of economic importance. Spears probably increased yields in the anadromous fishery on rapids where weirs could not be built. Rostlund (1952, Map 35) showed that spears were used by all tribes on salmon streams.

Large catches would have had only ephemeral effect and little economic importance without proper preservation. The California Indians preserved fish by drying or smoking them, or both. Dried fish were split and exposed to the sun for four or five days; smoked fish were dried in a rack over a fire (see, for example, Barrett and Gifford, 1933, p. 140).

Evaluation of Resources

Evaluation of resources has turned out to be somewhat arbitrary. What we want to know, obviously, is the total harvestable yield of acorns, game, and fish in a tribal territory. We want to know average production and how variable it might be. Our information is most precise for fish resources. Rostlund calculated that the annual aboriginal fish production in the region of Pacific anadromous fishes averaged about 800 pounds per square mile of tribal territory. Since Yurok territory must have been somewhat above average, we may assume that they produced about 1,000 pounds per square mile of territory. Since they held about 740 square miles of territory, their production would have been about 740,000 pounds or 740,000,000 calories (salmon run about 1,000 calories to the pound). If we assume an average daily intake of 2,500 calories per person, or 912,550 calories per person per year, fish production in the Yurok territory would support about 810 people if they ate nothing but fish, 1,620 if 50 per cent of their diet was fish, or 3,240 people if 25 per cent of their diet was fish. The actual population of the Yurok is estimated at 3,100 (see p. 180). Thus, if our assumptions are correct, fish must have made up about a quarter of their diet.

But Rostlund's figures are too crude for our use: they do not differentiate between the small areas under present consideration. In addition to Rostlund's calculations we have some figures on the commercial catch on the Sacramento–San Joaquin and also on the Klamath (tables 3 and 4). Those figures, however, cannot be compared with the size of the aboriginal catch. We do not know the efficiency of aboriginal fishery as compared with modern fishery, and also we do not know how much the modern fish resource has been reduced by the damming of streams. Thus, for the most part we are unable to calculate the caloric value of the annual product of fish, and we have even less certainty about game and acorns. Other means of evaluation are therefore employed.

For fishery the primary datum is the list of anadromous fish streams of California issued by the Department of Fish and Game and reproduced here as table 5. The rivers on the list are ranked as follows:

Primary salmon streams.—These are the lower courses of large rivers having either one or both of the following: (*a*) spawning runs of all three species (king salmon, silver salmon, and steelhead trout) or (*b*) both a spring and fall spawning run of the king salmon.

Secondary salmon streams.—These are the higher courses of the primary streams and the entire courses of lesser streams, except the very smallest.

TABLE 5

ANADROMOUS FISH STREAMS OF CALIFORNIA

Stream	Fall-run King salmon	Spring-run King salmon	Silver salmon	Steelhead trout
Smith River	×	×	×	×
Smith River, South Fork	×	×	×	×
Smith River, North Fork	×	×	×	×
Klamath River	×	×	×	×
Trinity River	×	×	×	×
Trinity River, South Fork	×	..	×	×
Salmon River	×	..	×	×
Salmon River, South Fork	×	..	×	×
Salmon River, North Fork	×	..	×	×
Scott River	×	..	×	×
Shasta River	×	..	×	×
Redwood Creek	×	..	×	×
Little River	×	..	×	×
Mad River	×	..	×	×
Elk River	×	..	×	×
Eel River	×	..	×	×
Van Duzen River	×	..	×	×
Eel River, South Fork	×	..	?	×
Eel River, North Fork	×	..	×	×
Bear River	×	..	×	×
Mattole River	×	..	×	×
Ten Mile River	..	..	×	×
Ten Mile River, North Fork	..	..	×	×
Ten Mile River, South Fork	..	..	×	×
Noyo River	×	..	×	×
Big River	..	..	×	×
Albion River	..	..	×	×
Navarro River	..	..	×	×
Elk Creek	..	..	×	×
Alder Creek	..	..	..	×
Brush Creek	..	..	..	×
Greenwood Creek	..	..	..	×
Garcia River	×	..	×	×
Gualala River	..	..	×	×
Russian River	..	..	×	×
Russian River, East Branch	..	..	×	×
Salmon Creek	..	..	×	×
Lagunitas Creek	..	..	×	×
Corte Madera Creek	..	..	×	×
Napa River	..	..	..	×
Sacramento River	×	×	..	×
Mokelumne River	×	..	..	..
Cosumnes River	×	..	..	..
American River	×	×	..	×
San Joaquin River	×	×	..	..
Stanislaus	×	..	..	..
Tuolumne	×	..	..	..
Merced	×	×	..	..
Fresno	×	..	..	..
Kings	?	..	..	..

SOURCE: California Department of Fish and Game.

Tertiary salmon streams.—These are the very smallest streams, draining less than 100 square miles.

For our purposes the unit of productivity on such streams is the fish-mile, defined to be a linear mile of the course of a salmon stream. The total fish-miles have been found for each tribe by totaling the miles of salmon stream in their territories (with the aid of U.S. Geological Survey maps). To calculate the total productivity of a tribal territory, fish-miles on primary salmon streams are doubled, fish-miles on secondary streams are retained as they are, and fish-miles on tertiary streams are halved. It is rather difficult to assess the productivity of coastline in terms comparable to the productivity of salmon streams. It seems certain that coastline was less valuable than the best salmon streams, but conclusions beyond this must be less definite. I tentatively accord coastline the same value as tertiary salmon streams, but some of it—on bays and lagoons, for example, where shellfish were collected in abundance and there was no need for deep-water gear—may have had more nearly the value of secondary salmon streams. An index of the total fish resource, then, is given by twice the number of primary fish-miles plus the number of secondary fish-miles plus half the number of tertiary fish-miles and coastline. The fish resource index is ten times this total—to be of the same order of magnitude as the acorn and game indexes.

Admittedly the method of calculation here is more arbitrary than is desirable—we do not know that primary streams have twice the productivity of the secondary streams. The ranking of the streams is presumably correct, but the actual weight assigned is subject to revision when further data are available.

The basic data used to compute acorn and game resources are derived from the map of vegetation types of California (Wieslander and Jensen, 1945). This large-scale map (1:1,000,000) shows in detail the occurrence of some 22 vegetation types (for example pine forest, grassland, juniper woodland, etc.). Geographical distribution of the vegetation types, shown as it is thought to have been before the landscape was altered by modern American civilization, was determined by field surveys, aerial photography, and detailed soil maps. No attempt was made to determine the original vegetation of areas now devoted to agriculture or urban development; such areas are mapped simply as "cultivated, urban, or industrial." In dealing with such areas, including nearly the whole of the Central Valley, I have had to fall back on other sources to classify vegetation types. The sources used include historical accounts in which the authors note local vegetation, the California soil surveys (the authors of those publications often attempt some reconstruction of original vegetation), and particularly useful, Burcham's *California Range Land* (1957), which includes a state-wide reconstruction of vegetation types at the opening of the historic period. By such means an adequate picture of aboriginal vegetation has been developed.

The vegetation types of interest here are redwood forest, pine-fir forest, oak woodland (including both the woodland and woodland-grass categories of Wieslander and Jensen), chaparral, and grassland. These types are rated for acorn and game production on the following scales:

Primary acorn land

Oak woodland

Secondary acorn land

Pine-fir forest at low elevations

Redwood forest on the inland side of the redwood belt

In both these forest areas there are significant numbers of oaks, but they are scarcer and smaller than in pure oak stands.

Tertiary acorn land

Pine-fir forest at high elevations

Redwood forest on the seaward side of the redwood belt

Chaparral

Grassland

Insignificant numbers of oaks are found in such areas, but there will usually be a few, despite imperfect mapping.

Primary game land

Chaparral

Grassland (north Coast Ranges and Central Valley)

Oak woodland

Chaparral and oak woodland provide the main support for game. Grassland is included for the north Coast Ranges because the Roosevelt elk lives on grass during part of the year. The Central Valley grassland was heavily populated with antelope and tule elk.

Secondary game land

Pine-fir forest at low elevations

Redwood forest on the inland side of the redwood belt

These forests supported a moderate game population. They were relatively open and had some browse, and the acorns produced by the oaks were eaten by the deer.

Tertiary game land

Pine-fir forest at high elevations

Redwood forest on the seaward side of the redwood belt

To calculate acorn and game resources I determined, tribe by tribe, the total area of each of these vegetation types available (by means of a polar planimeter used on a Wieslander and Jensen vegetation map). I then multiplied the area of primary lands by 2, left the area of secondary lands as is, and halved the area of the tertiary lands. The total of the three is an area-like figure weighted according to productivity.

Again it is impossible to justify the specific weighting procedure, but until more is known about the actual productivity of the lands it is necessary to rely on simplistic assumptions.

It should also be emphasized here that the measures refer not to the quantity of food resources actually used but to the quantity of resources available in a given area.

PRESENTATION AND ANALYSIS—LOWER KLAMATH PROVINCE

In presentation and analysis of the ecological data, the first groups dealt with are those of the Lower Klamath province of the Northwest Coast culture area.

The culture of the Lower Klamath province shows clear-cut affiliations with wider Northwest Coast culture, but there are important differences between, say, the Yurok and the Kwakiutl. The participation of Lower Klamath tribes in Northwest Coast culture, as well as their variation from it, is illustrated in two important aspects of the people's lives—an emphasis on wealth pervading many of their activities and an economic and general outlook focusing on water transport and produce.

Like all Northwest Coast people those of the Lower Klamath province had as a primary concern the heightening of prestige through the acquisition of wealth. They differed from the more northerly groups, however, in making wealth a purely individual and personal matter rather than a concern of large corporate kin groups. The difference was important because it resulted in societies, among the Lower Klamath peoples, whose basic units were conjugal families rather than larger kin groups. Therefore, social relations could not crystallize and formalize as between clan and clan or moiety and moiety but were always in a state of flux, with small, unpredictable social movements occurring more or less constantly. This social organization, with main emphasis on the conjugal family, was in many ways similar to that of modern America (cf. Goldschmidt, 1951).

The outlook of the people of the Lower Klamath province was centered on rivers—they lived and traveled on rivers, got their livelihood from rivers, and even conceived their cosmography in terms of rivers. In this they differed from their northern congeners, whose lives were adapted to the ocean as well as to the rivers. Kroeber considered that the Lower Klamath culture represents an earlier stage in the evolution of the Northwest Coast maritime adaptation, but this was denied by others, especially Drucker, who concluded that the northern Northwest Coast peoples have been maritime since they first came to their homes. Regardless of the historical basis of the difference, the focus on rivers and immediate coastal waters was so economically restrictive that the size of Lower Klamath populations must have been limited thereby.

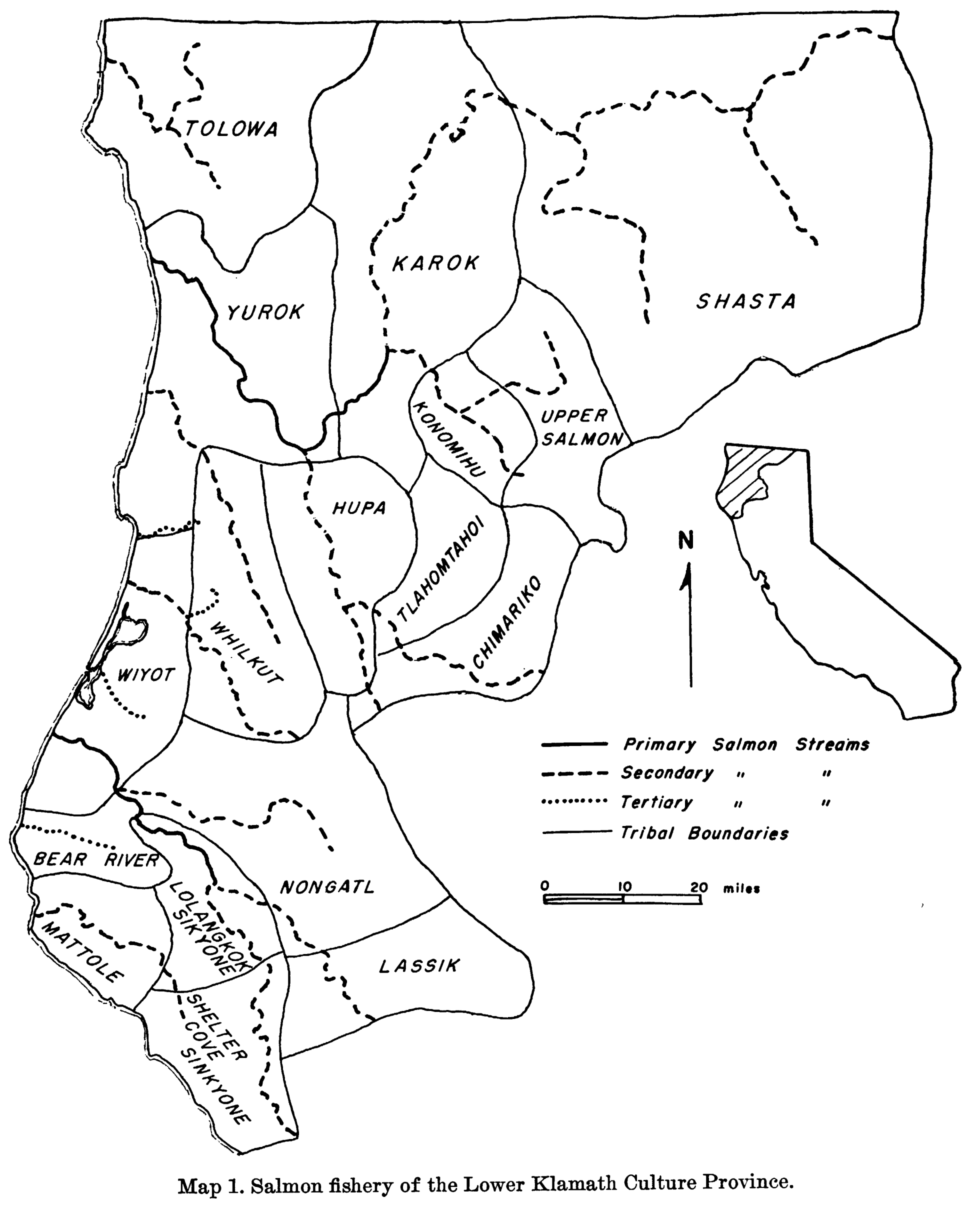
The divisions of the Lower Klamath province, here designated tribes, are basically linguistic units but also have political connotations. All members of a tribe had free access within tribal territory to resources not privately owned, and foreigners could be denied such access, especially in difficult times. There were seventeen such tribes in Lower Klamath province. Of these, only eight have adequate population data—derived from detailed village lists or reliable historic accounts.

Tribes of the Lower Klamath province are listed below.

Population Known		*Population Unknown*	
Tolowa	Hupa	Shasta	Bear River
Yurok	Whilkut	Konomihu	Nongatl
Karok	Lolangkok Sinkyone	Upper Salmon	Shelter Cove Sinkyone
Wiyot	Mattole	Tiahomtahoi	Lassik
		Chimariko	

TRIBAL RESOURCES

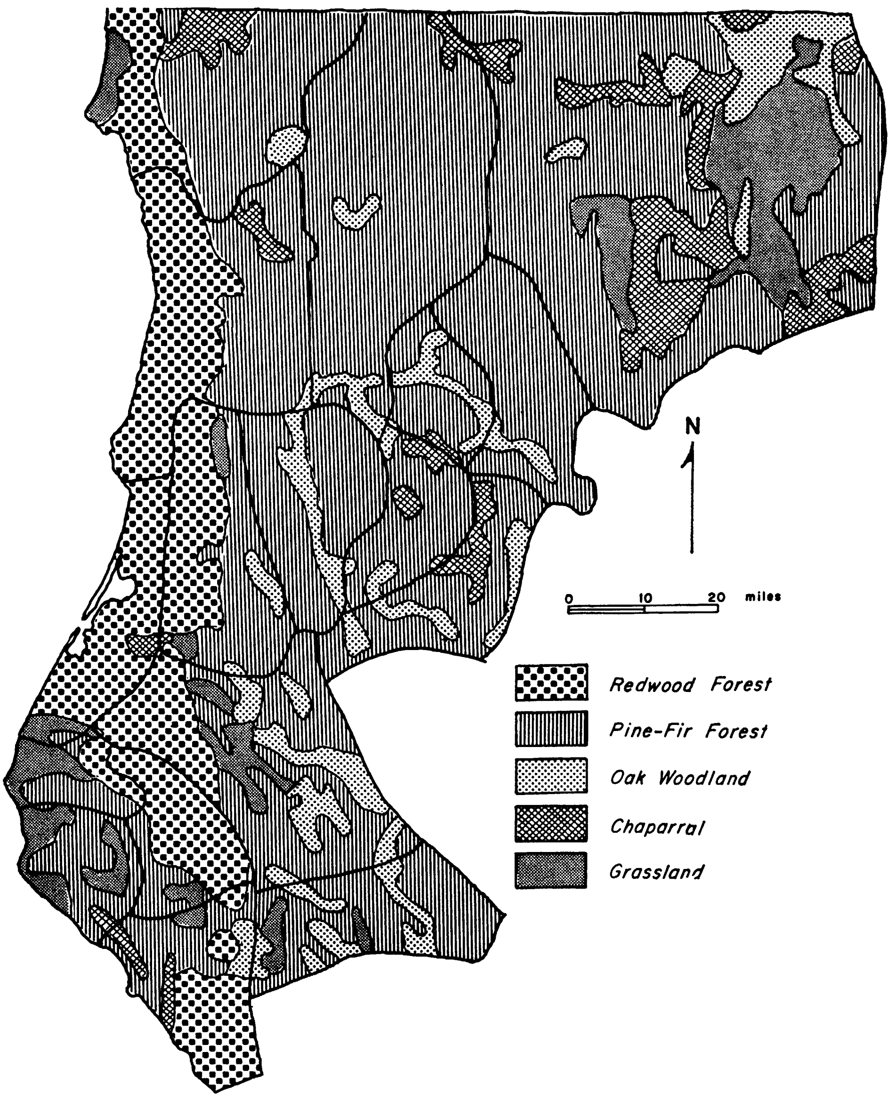
Most of the essential data for evaluating the resources are taken from maps specifying salmon streams and vegetation types. These data are given in simplified form in maps 1 and 2. Detailed information for tribes with adequate population estimates, on the pages following, is evaluated with the criteria presented previously.



Map 1. Salmon fishery of the Lower Klamath Culture Province.

TOLOWA

The Tolowa lived on the Smith River, a rather small stream draining only a little more than 600 square miles but nevertheless having spawning runs of silver salmon, king salmon, and steelhead. The redwood forest was only a thin coastal strip there, and evidently not productive of either game or acorns. About half the pine-fir forest was in pure stands of knob-cone pine and was very nearly oakless. The other half was Douglas fir or mixed pine-fir-Douglas fir and had fair numbers of oaks. Half the pine-fir forest is therefore classed as tertiary acorn and gameland, and half as secondary for those products.



Map 2. Vegetation types of the Lower Klamath Culture Province.

RESOURCE INDEX FOR TOLOWA

(Area: 955.1 square miles. Population: 2,400, Cook 1956, p. 101)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
Ocean............	32	½ × 10	..	..	160.0	....	....
River (secondary)	35	1 × 10	..	..	350.0	....	....
Vegetation	(sq. mi.)						
Redwood forest..	128.5	....	½	½	....	64.3	64.3
Pine-fir forest....	698.0	....	¾	¾	....	523.5	523.5
Oak woodland....	22.7	....	2	2	....	45.4	45.4
Chaparral........	60.5	....	½	2	....	30.2	121.0
Grassland........	45.4	....	½	2	....	22.7	90.8
Total resource index					510.0	686.1	845.0

YUROK

The Yurok had 43 miles of ocean; 44 miles on the Klamath River, the best salmon fishery in the north Coast Ranges; and 17 miles on Redwood Creek, large enough to have been of secondary value in fish production. The redwood forest is assigned a coefficient of ⅝ for both acorns and game because only about a quarter of the redwood belt held by the Yurok is interior, the remainder being coastal. The pine-fir forest here was at low altitudes; hence there were fair quantities of tan oak, Oregon oak, and black oak. The oak woodland was rich in both acorns and deer whereas the chaparral supported many deer but few oaks.

RESOURCE INDEX FOR YUROK

(Area: 740.9 square miles. Population: 3,100, Cook 1956, p. 84)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
Ocean............	43	½ × 10	..	..	215	....	....
River (primary)..	44	2 × 10	..	..	880	....	....
River (secondary)	17	1 × 10	..	..	170	....	....
Vegetation	(sq. mi.)						
Redwood forest..	378.0	....	⅝	⅝	....	236.3	236.3
Pine-fir forest....	312.5	....	1	1	....	312.5	312.5
Oak woodland....	5.0	....	2	2	....	10.0	10.0
Chaparral........	45.4	....	½	2	....	22.7	90.8
Total resource index					1,265	581.5	649.6

KAROK

The Karok held 70 miles of the Klamath River and 8 miles of the Salmon River. I have rated the Klamath as primary salmon stream as far as the mouth of the

Salmon, and secondary above that. This would seem to be indicated by the fact that Karok settlements were clustered at and below the mouth of the Salmon, with very few above (see Kroeber, 1936). A large portion of the spawning fish evidently went up the Salmon River. The pine-fir forest in Karok country is mostly Douglas fir, sometimes in pure stands but often mixed with tan oak—it is here divided half into secondary acorn land and half into tertiary acorn land. The same applies to the game potential of the pine-fir forest. Other vegetation types are classified as usual.

Resource Index for Karok

(Area: 1,053.4 square miles. Population: 2,700, Cook 1956, p. 98)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
River (primary)..	10	2 × 10	..	..	200	....	....
River (secondary)	68	1 × 10	..	..	680	....	....
Vegetation	(sq. mi.)						
Pine-fir forest....	992.9	....	¾	¾	....	744.7	744.7
Oak woodland....	45.4	....	½	½	....	22.7	22.7
Chaparral........	15.1	....	½	2	....	7.5	30.2
Total resource index....................................					880	774.9	797.6

WIYOT

The Wiyot, with their long waterfront in Humboldt Bay, held 80 miles of ocean front, and also held 12 miles of primary salmon stream on the lower Eel River, 12 miles of secondary stream on the Mad River, and 21 miles of tertiary stream on Little River and Elk River. The redwood forest in Wiyot country was coastal,

Resource Index for Wiyot

(Area: 297.4 square miles. Population: 3,200, Cook 1956, p. 93)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
Ocean............	80	½ × 10	..	..	400	....	....
River (primary)..	12	2 × 10	..	..	240	....	....
River (secondary)	12	1 × 10	..	..	120	....	....
River (tertiary)..	21	½ × 10	..	..	105	....	....
Vegetation	(sq. mi.)						
Redwood forest..	254.5	....	½	¾	....	127.3	190.9
Pine-fir forest....	7.6	....	½	1	....	3.8	7.6
Chaparral........	12.6	....	½	2	....	6.3	25.2
Grassland........	22.7	....	½	2	....	11.3	45.4
Total resource index....................................					868	148.7	269.1

and therefore poor in oaks—Loud (1918, p. 232) did not even include oak on the list of Wiyot trees, a very unusual circumstance for California. On the other hand there seems to have been an abundance of elk around Humboldt Bay, elk bone being the most common of the mammal bones recovered in archaeological investigations there (Loud, 1918, p. 235). The redwood forest is therefore rated tertiary for acorns, but for game is rated half tertiary and half secondary.

HUPA

The Hupa held 39 miles along the Trinity River and the South Fork of the Trinity. The Trinity is a better-than-average salmon stream—with both fall and spring runs of King salmon, for example—but, being distinctly inferior to the Klamath, is classed as secondary. Hupa pine-fir forest is almost all Douglas fir forest, with a substantial amount of tan oak mixed with the evergreens (Sudworth, 1908, p. 321), hence it is classed as secondary for both acorns and game.

Resource Index for Hupa
(Area: 428.4 square miles. Population: 1,475, Baumhoff 1958, Table 8)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
River (secondary)	39	1 × 10	..	..	390	....	....
Vegetation	(sq. mi.)						
Pine-fir forest....	360.4	....	1	1	....	360.4	360.4
Oak woodland....	68.0	....	2	2	....	136.0	136.0
Total resource index					390	496.4	496.4

WHILKUT

The Whilkut held 55 miles of salmon stream on Redwood Creek and Mad River. These are both middling streams and are classified as secondary. They also held 6 miles on North Fork Mad River, so small that it must be classed as tertiary. The redwood forest in Whilkut territory is mostly on the inland side of the redwood belt. For both game and acorns, three fourths is classed as secondary and only one fourth as tertiary.

MATTOLE

The salmon stream of the Mattole is the Mattole River, a fair stream but not large. It is classed as secondary. The Mattole obtained all other fish resources from 17 miles of ocean front. The tan oak is said to have been fairly abundant in the Douglas fir forest there (Jepson, 1911), which therefore is all classed as secondary for acorn production. Presence of the tan oak indicates a rather open type of forest, good for deer and elk, hence it is classed as secondary in game production also.

RESOURCE INDEX FOR WHILKUT

(Area: 463.7 square miles. Population: 2,588, Baumhoff 1958, Table 8)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
River (secondary)	55	1 × 10	..	..	550	....	....
River (tertiary)..	6	½ × 10	..	..	30	....	....
Vegetation	(sq. mi.)						
Redwood forest..	204.1	....	⅞	⅞	....	178.6	178.6
Pine-fir forest....	216.7	....	1	1	....	216.7	216.7
Oak woodland....	20.2	....	2	2	....	40.4	40.4
Chaparral........	2.5	....	½	2	....	1.2	5.0
Grassland........	20.2	....	½	2	....	10.1	40.4
Total resource index					580	447.0	481.1

RESOURCE INDEX FOR MATTOLE

(Area: 219.2 square miles. Population: 1,200, Baumhoff 1958, Table 8)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
River (secondary)	25	1 × 10	..	..	250	....	....
Ocean...........	17	½ × 10	..	..	85	....	....
Vegetation	(sq. mi.)						
Pine-fir forest....	123.5	....	1	1	....	123.5	123.5
Chaparral........	7.5	....	½	2	....	3.8	15.0
Grassland........	88.2	....	½	2	....	44.1	176.4
Total resource index					335	171.4	314.9

LOLANGKOK SINKYONE

The Lolangkok Sinkyone held 17 miles of primary fishery, on the Eel up to the mouth of South Fork, and 26 miles of secondary fishery, on the South Fork itself and on the Eel above South Fork. The Eel may be slightly overrated here, but two minor salmon streams (Bull Creek and Salmon Creek) are omitted, so the total resource should average out. The southern half of the redwood forest in Lolangkok territory, as well as their entire pine-fir forest, is classed as secondary for acorns and game because it is open and contains a fair abundance of tan oak. Farther north on the Eel, the redwood forest is very dense, producing little of either acorns or game.

ANALYSIS OF LOWER KLAMATH PROVINCE

The resources of the tribes of the Lower Klamath culture province, calculated in the preceding pages, are summarized in tables 6 and 7, which also show tribal area, population, and population densities according to area and resources. Initial inspection of these data was surprising. When this study was originally conceived, I had thought that if population showed a close relationship to resources it would be best expressed by a function of the form

$$\text{population} = f\ (\text{fish resource, acorn resource, game resource}) \pm \text{error}$$

I had expected that f would be an increasing function of each of the three variables; that is, a larger amount of any resource would be associated with a larger population if the other resources were held constant. But such is definitely not the case. The Wiyot, for example, with no greater fish resources than the Yurok or the Karok and with minimal acorn and game resources, actually had the largest population of any group.

Resource Index for Lolangkok Sinkyone

(Area: 254.5 square miles. Population: 2,076, Baumhoff 1958, Table 8)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
River (primary)..	17	2 × 10	..	..	340	....	....
River (secondary)	26	1 × 10	..	..	260	....	....
Vegetation	(sq. mi.)						
Redwood forest..	176.4	....	¾	¾	....	132.3	132.3
Pine-fir forest....	65.5	....	1	1	....	65.5	65.5
Grassland........	12.6	....	½	2	....	6.3	25.2
Total resource index					600	204.1	223.0

TABLE 6

Summary of Resources of Lower Klamath Culture Province

Tribe	Population	Area	Resource		
			Acorn	Fish	Game
Tolowa	2,400	955.1	686.1	510	845.0
Yurok	3,100	740.9	581.5	1,265	649.6
Karok	2,700	1,053.4	774.9	880	797.6
Wiyot	3,200	297.4	148.7	865	269.1
Hupa	1,475	428.4	496.4	390	496.4
Whilkut	2,588	463.7	447.0	580	481.1
Mattole	1,200	219.2	171.4	335	314.9
Lolangkok Sinkyone	2,076	254.5	204.1	600	223.0
Total	18,739	4,412.6	3,510.1	5,425	4,076.7

Figures shown are calculated as follows:
Population—number of persons.
Area—square miles.
Acorn resource—square miles adjusted according to yield
Fish resource—tens of linear stream miles adjusted according to yield.
Game resource—square miles adjusted according to yield.

Inspection of the data, however, does reveal that though population seems to have almost a random scatter when plotted against acorn or game resources, it is a remarkably stable reflection of fish resources. If we look at the standard deviations of population densities relative to each resource (table 7), we see only a small variability in density relative to fish resources and larger variability in densities relative to the other resources.

TABLE 7

POPULATION DENSITIES OF THE LOWER KLAMATH CULTURE PROVINCE

Tribe	Density[a] according to			
	Area	Acorns	Fish	Game
Tolowa	2.51	3.50	4.71	2.84
Yurok	4.18	5.33	2.45	4.77
Karok	2.56	3.48	3.07	3.39
Wiyot	10.76	21.52	3.70	11.89
Hupa	3.44	2.97	3.78	2.97
Whilkut	5.58	5.79	4.46	5.38
Mattole	5.47	7.00	3.58	3.81
Lolangkok Sinkyone	8.16	10.17	3.46	9.31
Average	5.33	7.47	3.65	5.55
Standard deviation	2.88	6.14	.68	3.30
Grand density	4.25	5.34	3.45	4.60

[a] The densities here are calculated from the quantities shown in table 6.

The same fact is demonstrated even more conspicuously by scatter diagrams of population plotted against each resource (fig. 1). The points appear to be thrown almost broadcast on the acorn and game resource diagrams but on the fish resource diagram describe a neat curve. There is no need of further statistical analysis, I think, to show that the limiting factor on population in the Lower Klamath culture province is the fish resource.

Although the acorn and game resources show little or no general effect on population, we might ask whether they have some marginal effect at least. Among tribes with very small fish resources, will those with greater acorn resources have greater populations? The sample of Lower Klamath tribes is too small to answer this question conclusively, but an answer is at least suggested. The best results are obtained by dividing the eight tribes of our sample into four groups:

1) Tribes low in acorn resources and low in fish resources
2) Tribes low in acorn resources but high in fish resources
3) Tribes high in acorn resources but low in fish resources
4) Tribes high in acorn resources and high in fish resources

The scatter diagrams (fig. 1) show that there are natural clusterings of the tribes with respect to both these resources so that we may define "low" and "high" as follows:

Low acorn resources: index less than 400
High acorn resources: index more than 400
Low fish resources: index less than 700
High fish resources: index more than 700

If we then plot these in a 2-by-2 table we obtain:

	Low acorn resources		*High acorn resources*	
	Tribe	Population	Tribe	Population
Low fish resources	Mattole	1,200	Tolowa	2,400
			Hupa	1,475
	Lolangkok Sinkyone	2,076	Whilkut	2,588
High fish resources	Wiyot	3,200	Yurok	3,100
			Karok	2,700

If we average the populations in each of the four cells we obtain:

	Low acorn resources (av. pop.)	*High acorn resources* (av. pop.)
Low fish resources	1,638	2,154
High fish resources	3,200	2,900

These data suggest that an increase in the acorn resources has some effect at a low level of fish resources but not at a high level of fish resources. At that level an increase in acorn production has, if anything, a depressing effect (I doubt that the effect is actually depressing; the sample size is so small for the tribes with a high fish resource that peculiar responses are expectable). In any case, the data indicate that acorns must have been of considerable importance to the fish-poor peoples since a reduction of their acorn supply would evidently have caused population to drop by several hundred.

It is easy to show that the same facts are also true for the game resource. In the Lower Klamath culture province, though, this fact probably has no significance; the magnitude of the game supply is inextricably confounded with the magnitude of the acorn resource because the oaks and the game thrive in pretty much the same country. In other words, a tribe will have a large acorn resource if, and only if, it has a large game resource, so we cannot tell which is the controlling factor.

We see then that the significant determinant of population in the Lower Klamath province is fish resources. That this is true is not surprising—fish were known to have been important there—though the extent of dependence certainly seems greater than expected. The scatter diagram of population plotted against fish resources (fig. 1) describes a curve that is very close to logarithmic. This is very convenient for transforming the data to linear form but poses the problem of

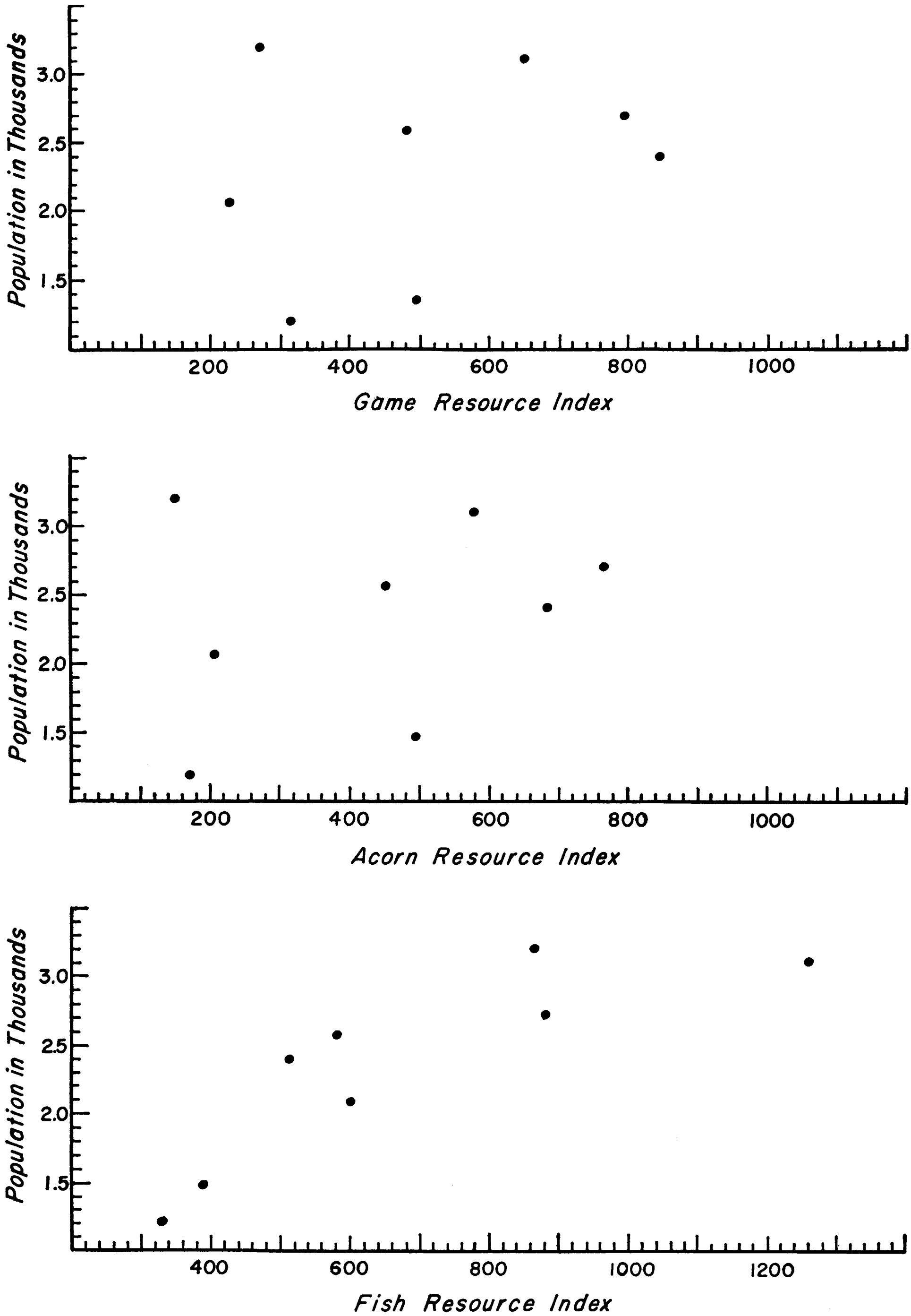


Fig. 1. Scatter diagrams of population-resource data in table 6.

why the data take that curve. What happens is that an added increment of the fish resource fails to make as much impression at the upper levels as it does in the lower levels.

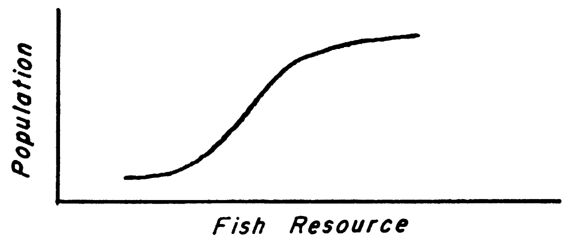
At least two possible explanations suggest themselves. The first is that population among tribes with high fish resources was being held down in spite of an excess of food, perhaps because of health factors or social organization. Thus, increased population density among these tribes may have increased transmission of some contagious diseases to the extent that population would again be reduced. It seems more likely, however, that the structure of the society itself might have restrained population after it reached a certain density. One thinks, for example, of the effect that slavery might have had. Kroeber (1925, p. 32) reported that only about a twentieth of the Yurok were slaves and that people became slaves through debt arising "from legal rather than economic vicissitudes." It seems entirely possible that an increase in population density might have led to an increase in the proportion of slaves—increased population would bring increased competition for the limited wealth, in the form of wealth objects such as white deer skins, which in turn would lead to an increase in the emotional outbreaks and physical violence that got people into trouble. An increase in slavery in turn would very likely lead to a decrease in birthrate since a slave could marry only if his master was willing to buy a wife for him. This aspect of the social structure could have produced a dynamic equilibrium in population size.

The second possible explanation for the logarithmic form of the data may lie in the way that fish resources were calculated. It will be remembered that stream miles on primary salmon streams were assigned double weight in the computations. If the primary salmon streams are reduced in our calculation to secondary streams, the fish resources of the Yurok, Karok, Wiyot, and Lolangkok Sinkyone are reduced and the data assume approximately linear form. To calculate the fish resource on such a basis, however, would be equivalent to saying that the Klamath River fishery is no better than the Mattole River fishery. At least one bit of evidence suggests that this might indeed be true despite its apparent ridiculousness. In describing fish technology above (p. 172) I cited a passage by Waterman and Kroeber (1938) indicating that the Klamath River Yurok let the Kepel fish weir remain in operation for only ten days of a possible two months. In other words, they exploited only a modest fraction of the potential fish resource of the Klamath. Thus, even though the Yurok stretch of the Klamath was exceedingly valuable, limited use made it in effect no better than a smaller river. If the use was limited by the threat of intervention by upstream tribes, as Waterman suggested, and if such threats were universal, a sort of intertribal balance of power kept primary salmon streams from attaining greater importance than secondary streams.

It is not now possible to say which of these or other factors caused population to level off when the fish resource increased beyond a certain point, but that is the phenomenon mainly responsible for giving the data the form of a logarithmic curve. Further consideration, however, indicates that a logarithmic function cannot describe the behavior of data such as these when the fish resource is at a low level. We may show this by means of an example. If the data were actually described by a logarithmic function, we could transform them on a logarithmic scale and, by the method of least squares, find the straight line of best fit. The equation of the line is

population (thousands) = (ln [logarithm to the base *e*] fish resource) – 7.15

Now we apply this equation to a tribe of unknown population. The Tlahomtahoi was a small group living just east of the Hupa. They held only 8 miles of secondary salmon stream, giving them a fish resource of 80 according to present calculations. If we substitute 80 in the equation above, we obtain an impossible result: a negative population for the Tlahomtahoi. Tribes with very low fish resources evidently did not depend on fish for their livelihood, so a decrease in fish resource in this range will not show a commensurate decrease in population. Essentially, the function that will best describe the data has a curve shaped like that of a cumulative normal probability distribution function:



The upper part of the curve, the part including the data in table 6, has a shape somewhat like that of a logarithmic curve, as it should, but the left hand tail swings back asymptotically at some point before it reaches zero population.

The curve described here is simply the logistic curve. The logistic has often been used on data of population growth. A country (France, for example) will remain with a relatively constant population for many years, perhaps centuries, and suddenly, because of technical or social change, begin a rapid increase that after a time levels off again (cf. Taylor, 1950). One conceives of such plateaus as the carrying capacities of the country under different sets of social and economic conditions. Similar considerations may apply in the present situation. In the given social and technological conditions, a low resource will hold the population at a low plateau, with only small variability perhaps associated with varying acorn and/or game resources. A very large fish resource will sustain people under the same condition at a higher plateau, its height probably being determined by social conditions. In between the two levels, population rises sharply with each increment of fish resource.

PRESENTATION AND ANALYSIS—CALIFORNIA PROVINCE, NORTH COAST RANGE

We come now to tribes of the California province, where adaptation is obviously quite different from that in the Lower Klamath province. The differences between the groups may be approached in terms of a fundamental dichotomy among preagricultural peoples—economic specialization as opposed to a generalized economy. Specialized peoples—for historical reasons (continuance of an already established pattern) or for environmental reasons (availability of a single produce overwhelmingly superior to all others)—concentrate on a single aspect of the environment, exploiting it with great skill and efficiency. Such specialization is found, for example, among the bison hunters of the Great Plains (after the introduction of the horse), among the Upper Paleolithic hunters of the Old World, and among the fishermen of the Northwest Coast culture area of North America, of which the Lower Klamath province is a part.

The opposite adaptation, a generalized economy, was known ethnographically in North America only in the Intermediate and Intermountain culture areas, where subsistence practices were directed equally toward all available aspects of the environment; in extreme cases (the Great Basin for example), nearly everything edible was used. It is likely that the earliest inhabitants of the California culture province existed in a diffuse economic context similar to that of the Great Basin peoples. At some point in the development of the culture province, undoubtedly more than 2,000 years ago, the Californians discovered or acquired a technology enabling them to concentrate on the magnificent acorn crops. One of the questions to be asked is how far the aboriginal Californians had become specialized acorn gatherers by the historic period. Was the acorn overwhelmingly important or merely the first among many important crops? We hope to acquire evidence on this point in the sections on the California province.

The first group of tribes concerning us in the California culture province is that of the north Coast Range from San Francisco Bay north to the Yuki and Wailaki, on the Eel River, and from the Pacific Ocean east to but not including the Wintun, of the Sacramento Valley. Included are fifteen tribes, of which ten have population data reliable enough for our purposes.

Tribes of the California province, north Coast Range are listed below.

Population Known	*Population Unknown*
Wailaki	Kato
Coast Yuki	Huchnom
Yuki	Salt Pomo
Northern Pomo	Southern Pomo
Eastern Pomo	Coast Miwok
Central Pomo	
Southeastern Pomo	
Southwestern Pomo	
Wappo	
Lake Miwok	

Tribal Resources

The main body of data on the resources of the north Coast Range of the California province is again derived from the Wieslander and Jensen vegetation map. The vegetation types of the north Coast Range area are given in simplified form in map 4. Salmon fishery of the north Coast Range is calculated from the salmon streams and coastline shown in map 3. As before, the salmon streams and vegetation types are weighted according to productivity.

WAILAKI

The pine-fir forest of the Wailaki is mostly Douglas fir, at only moderate altitudes and therefore containing quantities of tan oak and Oregon oak. The chaparral and oak woodland there made excellent deer range, but Wailaki country was outside the Roosevelt elk range so the grassland was not much used. Wailaki fishery was on the Eel River, a secondary salmon stream.

RESOURCE INDEX FOR WAILAKI
(Area: 415.8 square miles. Population: 2,760, Baumhoff 1958, p. 223)

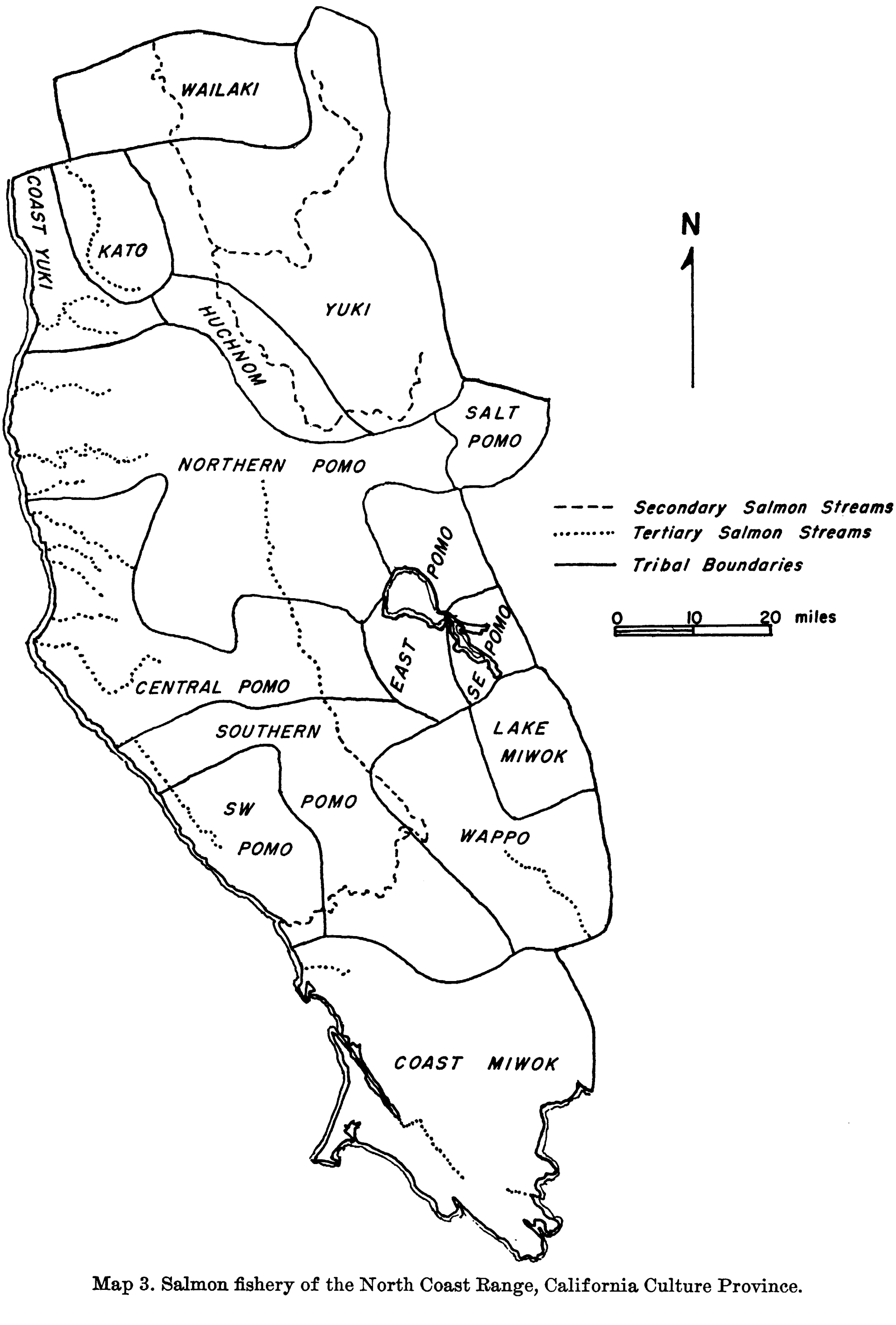
Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
River (secondary)	16	1 × 10	..	..	160	....	....
Vegetation	(sq. mi.)						
Pine-fir forest....	186.5	....	1	1	....	186.5	186.5
Oak woodland....	206.6	....	2	2	....	413.2	413.2
Chaparral........	15.1	....	½	2	....	7.6	30.2
Grassland........	7.6	....	½	½	....	3.8	3.8
Total resource index....................................					160	611.1	633.7

COAST YUKI

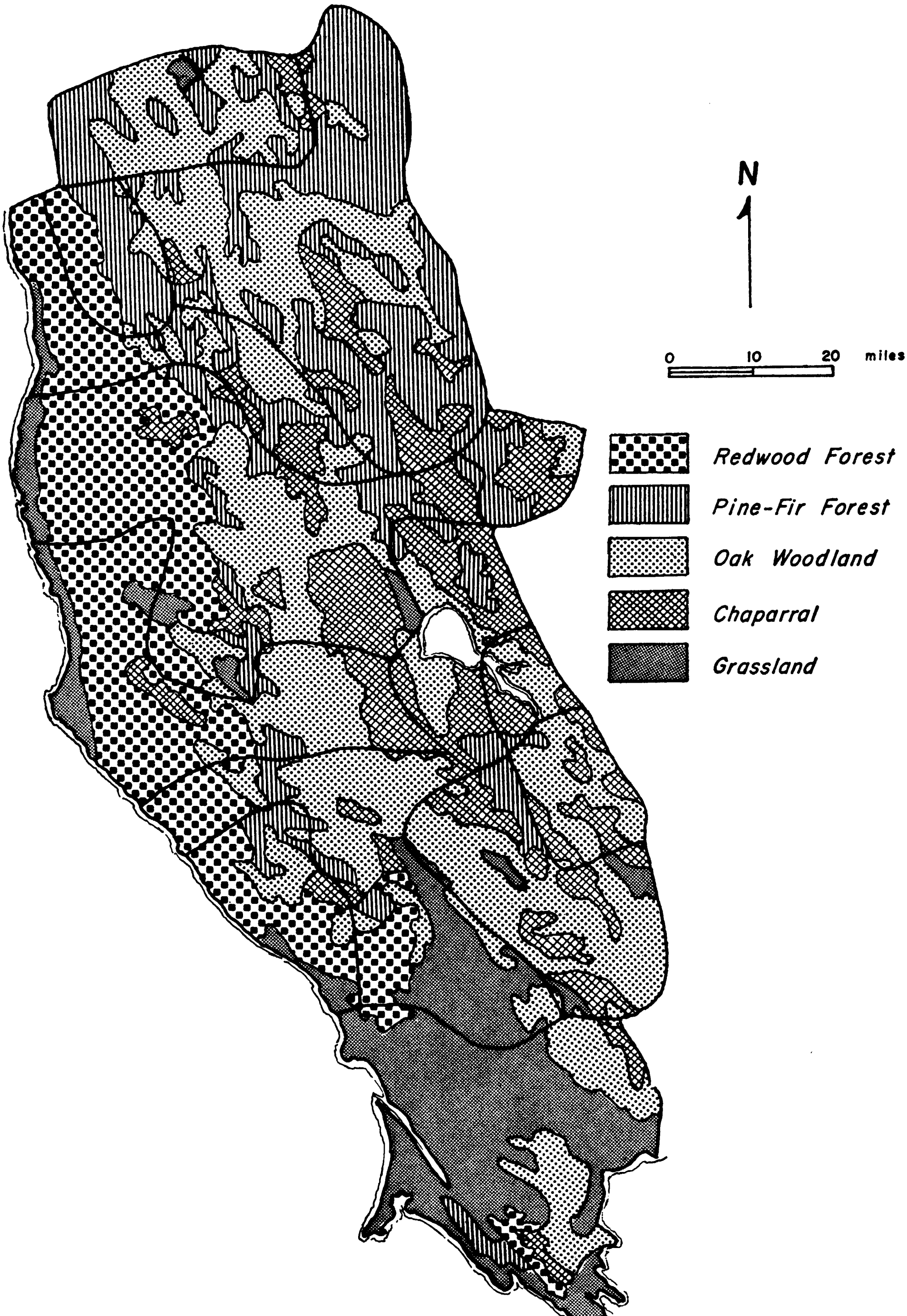
The Coast Yuki, in addition to their 22 miles of ocean front, held only the two forks of the Tenmile River. Most of the Coast Yuki redwood forest lies in the dense coastal strip, only about a quarter of it being far enough inland to have fair acorn and game production, hence it is given a coefficient of ⅝ for both products. The grassland there, unlike that of the Wailaki, was in elk range, and therefore is rated as primary gameland.

RESOURCE INDEX FOR COAST YUKI
(Area: 178.9 square miles. Population: 750, Cook 1956, p. 106)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
Ocean............	22	½ × 10	..	..	110	....	....
River (tertiary)..	12	½ × 10	..	..	60	....	....
Vegetation	(sq. mi.)						
Redwood forest..	156.2	....	⅝	⅝	....	97.6	97.6
Pine-fir forest....	2.5	....	1	1	....	2.5	2.5
Oak woodland....	7.6	....	2	2	....	15.2	15.2
Grassland........	12.6	....	½	2	....	6.3	25.2
Total resource index....................................					170	121.6	140.5



Map 3. Salmon fishery of the North Coast Range, California Culture Province.



Map. 4. Vegetation types of the California Province, North Coast Range.

YUKI

Yuki fishery was all on the Eel River—21 miles of the Eel proper, 45 miles on the Middle Fork of the Eel, and 17 miles on the Eel above and just below modern Lake Pillsbury (referred to as South Eel River).

The small portion of Yuki territory in Round Valley is unclassified by Wieslander and Jensen because it is now cultivated. It is assigned herein to oak woodland (it was probably parkland) because (*a*) there is woodland all around the margins of the valley and (*b*) a few isolated oaks remain in spite of intensive agriculture there. The rest of the area is classified as usual except for the pine-fir forest, which is assigned one fourth to secondary oak and gameland and three fourths to tertiary oak and gameland (this at higher altitudes). Thus the over-all coefficient for the pine-fir forest is ⅝.

RESOURCE INDEX FOR YUKI
(Area: 1,169.2 square miles. Population: 6,880)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
River (secondary)	83	1 × 10	..	..	830	....	....
Vegetation	(sq. mi.)						
Pine-fir forest....	640.1	....	⅝	⅝	....	400.1	400.1
Oak woodland....	395.6	....	2	2	....	791.2	791.2
Chaparral........	156.2	....	½	2	....	78.1	312.4
Total resource index......					830	1,269.4	1,503.7

NORTHERN POMO

The fishery of the Northern Pomo was concentrated on 23 miles of coast line, 3 miles of lake front, and 68 miles of tertiary salmon stream on the Noyo River (20 miles), Big River (24 miles), Albion River (10 miles), and headwaters of the Russian River (14 miles). The lake front is on Clear Lake, the only sizeable body of fresh water in the area. For the most part, fresh-water fish in California seem to have been of less importance than anadromous fish, but the produce of Clear Lake is definitely an exception. Kniffen's study of Pomo geography (1939, p. 356, pp. 363 ff.) leaves little doubt that fish were important to the lake people and that much time was spent in fishing. I therefore class this lake front as equivalent to secondary salmon stream.

The population of the Northern Pomo is given by Cook (1956, p. 116) as 5,040. My definition of the tribal boundary, however, includes groups that are in Cook's Central Pomo and Lake Pomo, so the population here is increased to 7,010.

The settled or cultivated sections of Northern Pomo territory in Willits Valley and Ukiah Valley were not classified by Wieslander and Jensen. Burcham (1957) included these sections in his oak woodland type. His gross mapping makes interpretation uncertain, but his judgment is confirmed by soil surveys (Dean, 1920; Gowans, 1958), so the presently cultivated and urban areas of the Northern Pomo are herein counted as oak woodland.

RESOURCE INDEX FOR NORTHERN POMO
(Area: 1,194.4 square miles. Population: 7,010)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
Ocean	23	½ × 10	..	..	115	....	....
River (tertiary)	68	½ × 10	..	..	340	....	....
Lake	3	1 × 10	..	..	30	....	....
Vegetation	(sq. mi.)						
Redwood forest	473.8	....	¾	¾	....	355.4	355.4
Pine-fir forest	141.1	....	1	1	....	141.1	141.1
Oak woodland	304.9	....	2	2	....	609.8	609.8
Chaparral	244.4	....	½	2	....	122.2	488.8
Grassland	30.2	....	½	2	....	15.1	60.4
Total resource index					485	1,243.6	1,655.5

EASTERN POMO

Wieslander and Jensen classify 42.8 square miles around Clear Lake as urban or agricultural. Burcham (1957) assigns that land to chaparral, corresponding to most of the surrounding territory. But the most abundant soil types there—Aiken Loam, Rincon Loam, and Hugo Clay Loam—support parkland vegetation (Carpenter, Storie, and Cosby, 1927). I therefore classify the area as oak woodland. Eastern Pomo fishery was concentrated entirely on Clear Lake, which, in accordance with the principles set forth above for the Northern Pomo, is classed as equivalent to secondary salmon stream.

RESOURCE INDEX FOR EASTERN POMO
(Area: 284.7 square miles. Population: 1,410)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
Lake	27	1 × 10	..	..	270	....	....
Vegetation	(sq. mi.)						
Pine-fir forest	55.4	....	1	1	....	55.4	55.4
Oak woodland	85.7	....	2	2	....	171.4	171.4
Chaparral	143.6	....	½	2	....	71.8	287.2
Total resource index					270	298.6	514.0

The population figures for the Eastern Pomo are taken from Cook (1956, p. 112). The groups designated Clear Lake Pomo by Cook include some Northern Pomo, the Eastern Pomo, and the Southeastern Pomo. The Eastern Pomo as herein defined include Cook's areas 3, 4, 5, 6, and 7.

CENTRAL POMO

Twenty square miles of Central Pomo country around Hopland are classified as urban or agricultural by Wieslander and Jensen. I include this area as oak woodland because it is completely surrounded by woodland and because Burcham also includes it as woodland. Three fourths of Central Pomo redwood forest has been counted as secondary, and one fourth as tertiary for both acorns and game—toward the southern end of the redwood belt the forest becomes less dense, and hence more suited to game and oaks. The grassland is classed as secondary for game because it is elk country.

Besides their 42 miles of coast line the Central Pomo held rights to 59 miles of tertiary fishing stream—on the Russian River (12 miles), the Navarro River (19 miles), Greenwood Creek (6 miles), Elk Creek (3 miles), Alder Creek (4 miles), and Garcia River (15 miles).

The population figure is from Cook (1956, pp. 116, 117) but differs slightly because different boundaries were used.

RESOURCE INDEX FOR CENTRAL POMO
(Area: 693.0 square miles. Population: 3,440)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
Ocean	42	½ × 10	..	..	210	....	....
River (tertiary)	59	½ × 10	..	..	295	....	....
Vegetation	(sq. mi.)						
Redwood forest	355.3	....	⅞	⅞	....	310.9	310.9
Pine-fir forest	35.3	....	1	1	....	35.3	35.3
Oak woodland	176.4	....	2	2	....	352.8	352.8
Chaparral	88.2	....	½	2	....	44.1	176.4
Grassland	37.8	....	½	1	....	18.9	37.8
Total resource index					505	762.0	913.2

SOUTHEASTERN POMO

The vegetation types in the country of the Southeastern Pomo are weighted as usual, with the pine-fir forest given a coefficient of 1 because it was at low elevations and hence was not barren of either game or oak. The lake shore there, on Clear Lake, is classed as secondary fishery, like that of the Northern and Eastern Pomo (see discussion under Northern Pomo above). The population figures are from Cook (1956, p. 112), who gives populations of 500, 230, and 340 for the three groups of the Southeastern Pomo.

RESOURCE INDEX FOR SOUTHEASTERN POMO
(Area: 206.6 square miles. Population: 1,070)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
Lake shore.......	27	1 × 10	..	..	270	....	....
Vegetation	(sq. mi.)						
Pine-fir forest....	5.0	....	1	1	....	5.0	5.0
Oak woodland....	148.7	....	2	2	....	297.4	297.4
Chaparral........	52.9	....	½	2	....	26.5	105.8
Total resource index..........					270	328.9	408.2

SOUTHWESTERN POMO

The redwood forest in Southwestern Pomo territory is near the southern end of the redwood belt and is therefore open rather than dense forest, hence it is weighted as secondary game and acorn land. In addition to their coastline the Southwestern Pomo held fishing rights to 8 miles of secondary stream on the Russian River and 12 miles of tertiary stream on the Gualala River.

RESOURCE INDEX FOR SOUTHWESTERN POMO
(Area: 274.6 square miles. Population: 1,480, Cook 1956, p. 117)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
Ocean............	27	½ ×10	..	..	135	....	....
River (secondary)	8	1 × 10	..	..	80	....	....
River (tertiary)..	12	½ × 10	..	..	60	....	....
Vegetation	(sq. mi.)						
Redwood forest..	156.2	....	1	1	....	156.2	156.2
Pine-fir forest....	30.2	....	1	1	....	30.2	30.2
Oak woodland....	52.9	....	2	2	....	105.8	105.8
Chaparral........	10.1	....	½	2	....	5.1	20.2
Grassland........	25.2	....	½	1	....	12.6	25.2
Total resource index..........					275	309.9	337.6

WAPPO

There are 68 square miles of Wappo territory, partly in Napa Valley and partly in the Russian River Valley, classified as urban or agricultural by Wieslander and Jensen. Burcham indicated that these areas were formerly in oak woodland, and I have followed him in this. Wappo secondary fishery was on the Russian River, and its tertiary fishery on the Napa River.

Cook (1956, p. 126) calculated a population of 8,000 for a group that includes the Wappo, the Lake Miwok, and the Napa Valley Wintun. Of the 8,000 persons, 900 are attributable to the Lake Miwok and 2,500 to the Napa Valley Wintun, leaving 4,600 to the Wappo.

RESOURCE INDEX FOR THE WAPPO
(Area: 519.2 square miles. Population: 4,600)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
River (secondary)	20	1 × 10	..	..	200	....	....
River (tertiary)..	10	½ × 10	..	..	50	....	....
Vegetation	(sq. mi.)						
Pine-fir forest....	32.8	....	1	1	....	32.8	32.8
Oak woodland....	322.6	....	2	2	....	645.2	645.2
Chaparral........	136.1	....	½	2	....	68.1	272.2
Grassland........	27.7	....	½	½	....	13.9	13.9
Total resource index....................................					250	760.0	964.1

LAKE MIWOK

The population figure for the Lake Miwok is from Cook (1956, p. 126), as indicated under Wappo above. Cook included the Lake Miwok in his calculation of Wappo population and found that the Northern Wappo and Lake Miwok together had a population of 1,800. Most of the people of these two groups were in four large villages. It is probable, though not certain, that two of the villages were Lake Miwok and two were Northern Wappo. I assume a split of about half and half, and divide the populations on that basis.

RESOURCE INDEX FOR LAKE MIWOK
(Area: 93.2 square miles. Population: 900)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
None............	.....	....	..	..	....	....	....
Vegetation	(sq. mi.)						
Pine-fir forest....	5.0	....	1	1	....	5.0	5.0
Oak woodland....	40.3	....	2	2	....	80.6	80.6
Chaparral........	47.9	....	½	2	....	24.0	95.8
Total resource index..						109.6	181.4

ANALYSIS OF CALIFORNIA PROVINCE, NORTH COAST RANGE

The resource and population data for the north Coast Range of the California province are summarized in tables 8 and 9. The same data are shown in figure 2 as scatter diagrams of population plotted against resource indexes. The most notable feature of these compilations is that they reflect a situation opposite from that encountered for the Lower Klamath culture province. It is noted above that size of population on the Klamath River and in adjoining regions bore little relation to the acorn or game resource but was closely related to the size of the fish resource. In the north Coast Range of the California province, in contrast, population size bears little or no relationship to the fish resource but, when plotted

TABLE 8

SUMMARY OF RESOURCES OF CALIFORNIA PROVINCE, NORTH COAST RANGE

Tribe	Population	Area	Resource Index[a]		
			Acorn	Fish	Game
Wailaki	2,760	415.8	611.1	160	633.7
Coast Yuki	750	178.9	121.7	170	140.5
Yuki	6,880	1,169.2	1,269.4	830	1,503.7
Northern Pomo	7,010	1,194.4	1,243.6	485	1,655.5
Eastern Pomo	1,410	284.7	298.6	270	514.0
Central Pomo	3,440	693.0	762.0	505	913.2
Southeastern Pomo	1,070	206.6	328.9	270	408.2
Southwestern Pomo	1,480	274.6	309.9	275	337.6
Wappo	4,600	519.2	760.0	250	964.1
Lake Miwok	900	93.2	109.6	...	181.4
Total	30,300	5,029.6	5,814.8	3,215	7,251.9

[a] Resource indexes are calculated as follows:
Acorn resources—square miles of territory adjusted according to yield.
Fish resources—tens of linear miles along fishing streams and coastline adjusted according to yield.
Game resources—square miles of territory adjusted according to yield.

TABLE 9

POPULATION DENSITIES OF THE CALIFORNIA PROVINCE, NORTH COAST RANGE

Tribe	Density[a] according to			
	Area	Acorns	Fish	Game
Wailaki	6.64	4.52	17.25	4.36
Coast Yuki	4.19	6.16	4.41	5.34
Yuki	5.88	5.42	8.29	4.58
Northern Pomo	5.87	5.64	14.45	4.23
Eastern Pomo	4.95	4.72	5.22	2.74
Central Pomo	4.96	4.51	6.81	3.77
Southeastern Pomo	5.18	3.25	3.96	2.62
Southwestern Pomo	5.39	4.78	5.38	4.39
Wappo	8.86	6.05	18.40	4.77
Lake Miwok	9.66	8.21	....	4.97
Average	6.158	5.326	9.352	4.177
Standard deviation	1.77	1.33	5.75	.85
Grand density	6.02	5.21	9.42	4.18

[a] Averages shown are computed from the figures in table 8.

against the acorn or game index, gives points that very nearly describe straight lines. This indicates a heavy reliance on acorns and game, and little if any on fish.

We may therefore express population in terms of a linear combination of acorn and game resources:

$$\text{population} = a + b_1 \text{ (acorn resource)} + b_2 \text{ (game resource)}$$

in which a, b_1, and b_2 are constants to be determined. Rounding off the figures in table 8 to simplify computation gives the figures in table 10. The least-squares estimates of a, b_1, and b_2 may be obtained by solving the following system of linear equations:

$$10a + b_1\Sigma A_i + b_2\Sigma G_i = \Sigma p_i$$
$$a\Sigma A_i + b_1\Sigma A_i^2 + b_2\Sigma A_iG_i = \Sigma A_ip_i$$
$$a\Sigma G_i + b_1\Sigma A_iG_i + b_2\Sigma G_i^2 = \Sigma G_ip_i$$

in which p_i, A_i, and G_i are respectively the population, acorn resource index, and game resource index of each of the tribes of the north Coast Range. Substituting the figures at the bottom of table 10 gives the following,

$$10(a) + 58.1(b_1) + 72.4(b_2) = 30.4$$
$$58.1(a) + 499.93(b_1) + 619.92(b_2) = 266.74$$
$$72.4(a) + 619.92(b_1) + 774.80(b_2) = 331.93$$

the solution to which are $a = -.21$, $b_1 = .30$, $b_2 = .20$. In terms of the scale of table 10, the resulting regression equation is

$$p_i = .30(A_i) + .20(G_i) - .21$$

or, if we return to the original scale,

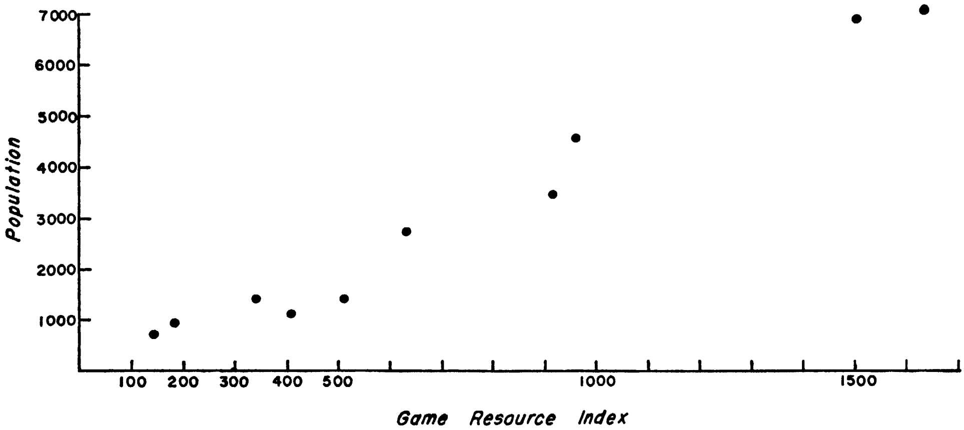
$$\text{population} = 3 \text{ (acorn resource)} + 2 \text{ (game resource)} - 210.$$

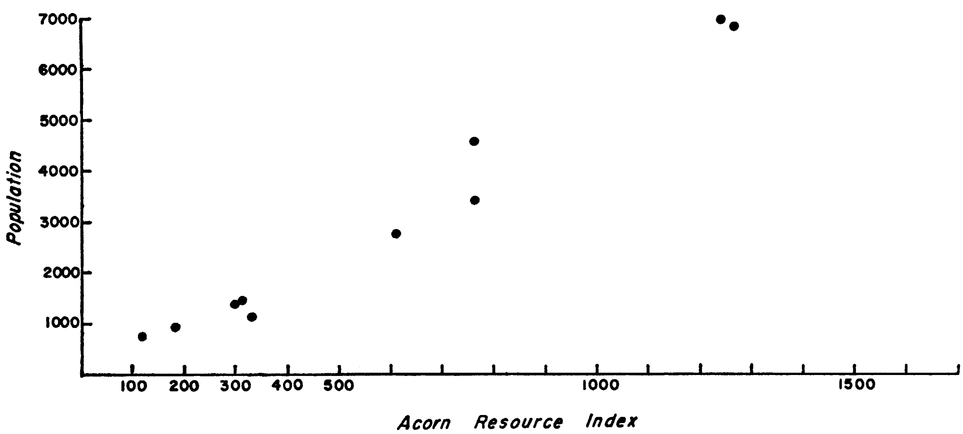
TABLE 10

TRANSFORMATION OF DATA IN TABLE 8

Tribe	Population in thousands (p_i)	Acorn resource in hundreds (A_i)	Game resource in hundreds (G_i)
Wailaki	2.8	6.1	6.3
Coast Yuki	0.8	1.2	1.4
Yuki	6.9	12.7	15.0
Northern Pomo	7.0	12.4	16.6
Eastern Pomo	1.4	3.0	5.1
Central Pomo	3.4	7.6	9.1
Southeastern Pomo	1.1	3.3	4.1
Southwestern Pomo	1.5	3.1	3.4
Wappo	4.6	7.6	9.6
Lake Miwok	0.9	1.1	1.8

$\Sigma p_i = 30.4$; $\Sigma A_i = 58.1$; $\Sigma G_i = 72.4$
$\Sigma A_i^2 = 499.93$; $\Sigma G_i^2 = 774.8$; $\Sigma A_ip_i = 266.74$; $\Sigma G_ip_i = 331.93$
$\Sigma A_iG_i = 619.92$





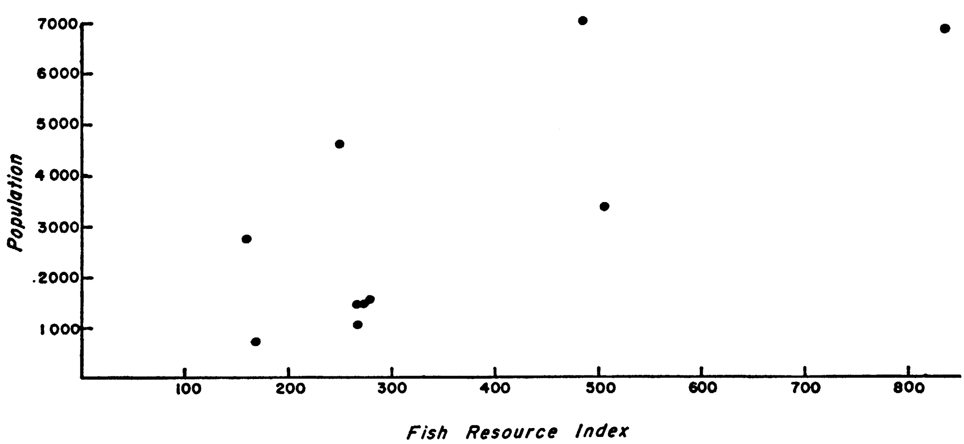


Fig. 2. Scatter diagrams of population-resource data in table 9.

The resulting descriptive relationship between population and resources for the tribes of the north Coast Range is perhaps the best that can be obtained in the present circumstances. Figure 3 graphs the line determined by the points established. The fit seems very good indeed. The equation indicates that the acorn resource has more influence on population than the game resource. It must be emphasized, though, that the scale used is quite arbitrary—a square mile of "primary" game land has weight equal to a square mile of "primary" acorn land, although one might produce from 2 to 10 times as much caloric value as the other.

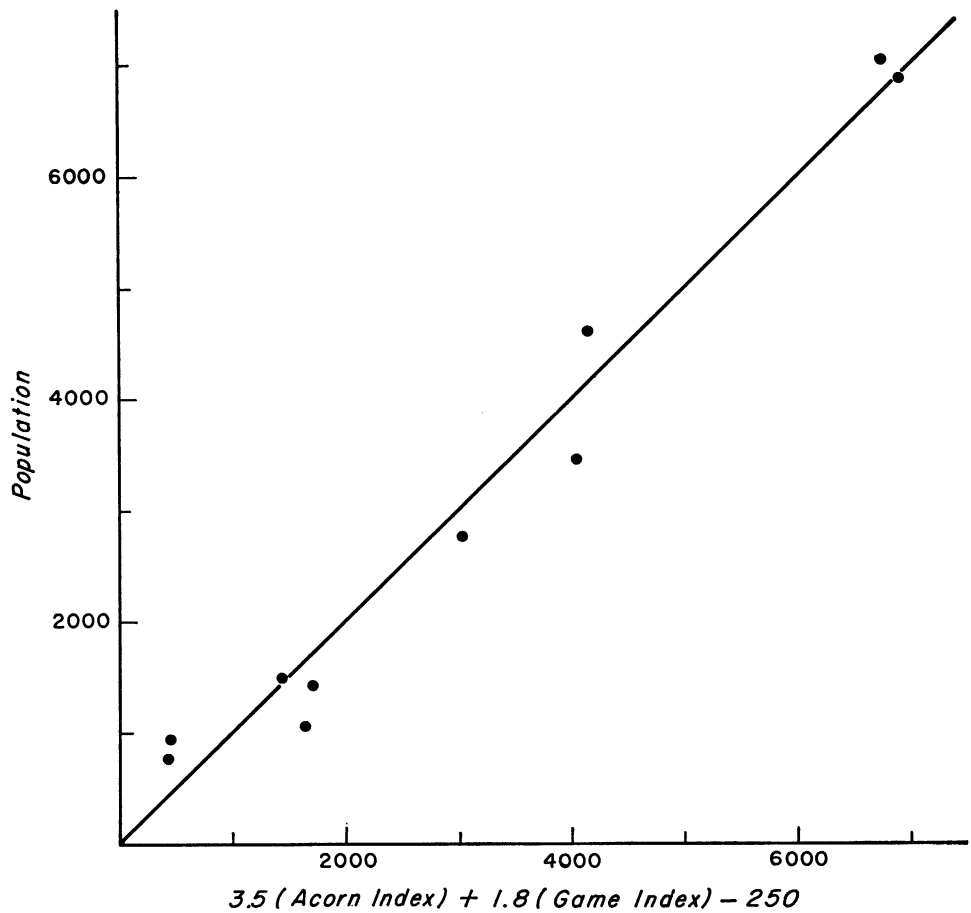


Fig. 3. Relation between population and resources of North Coast Range tribes.

More realistic measurement would certainly produce a different equation. Since, however, it is not now possible to measure the produce in a more realistic way the equation will have to be accepted as being descriptively good but not susceptible to further interpretation in terms of the relative importance of the two products.

Now we must ask whether the available fish resource, even though it has no primary effect on population size, may have a residual effect. To test this question the figures in table 11 are compiled. They show population as predicted (by the regression equation above) on the basis of acorn and game resources only. One would suppose that populations greater than those so predicted might be the tribes with the greatest fish resource, and that populations less than those so predicted would have the least fish resource. We find the following:

	Number of tribes	*Average population difference*	*Average fish resource*
Population less than predicted	4	355	301
Population greater than predicted	6	−312	335

Thus, tribes "underpopulated" with respect to acorn and game resources have a smaller average fish resource than the "overpopulated" tribes, but the difference is very slight. A t-test applied to the hypothesis that the difference is statistically significant (i.e., that the fish resource figures for the "overpopulated" tribes constitute a sample from a universe with a mean value different from that represented by the figures for the "underpopulated" tribes) gives the value $t = .128$, which is not significant even at a .9 significance level. Thus, there is no reason to believe that the "overpopulated" tribes have significantly greater fish resources than the "underpopulated" tribes.

TABLE 11

PREDICTED AND ACTUAL POPULATIONS OF TRIBES OF CALIFORNIA PROVINCE, NORTH COAST RANGE

Tribe	Predicted Population[a]	Actual Population	Difference
Wailaki	2,891	2,760	131
Coast Yuki	436	750	−314
Yuki	6,606	6,880	−274
Northern Pomo	6,832	7,010	−178
Eastern Pomo	1,712	1,410	302
Central Pomo	3,902	3,440	462
Southeastern Pomo	1,593	1,070	523
Southwestern Pomo	1,395	1,480	− 85
Wappo	3,998	4,600	−602
Lake Miwok	482	900	−418

[a] Predicted populations are those derived from formula: population = 3 (acorn resource) + 2 (game resource) − 210.

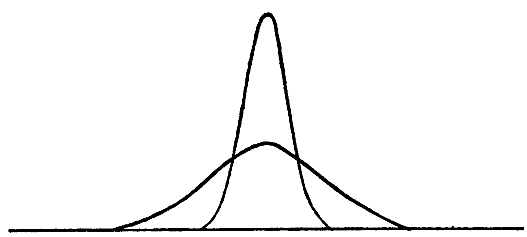
Now let us turn to a slightly different line of inquiry and analyze some of the density figures set forth thus far. For comparison let us recapitulate the over-all population densities of the Lower Klamath province and of the California province, north Coast Range.

	Population density according to:			
	Area	*Acorns*	*Fish*	*Game*
Lower Klamath Province	4.25	5.34	3.45	4.60
California Province, North Coast Range	6.02	5.21	9.42	4.18

We see that population density per unit of fish productivity is almost three times as great in the north Coast Range as in the Lower Klamath province. This is not surprising—fish production was not the determining factor in population in the north Coast Range, so the density could easily be quite high (the same would be true in the fishless Mojave Desert).

We note that the population density per square mile is significantly higher in the north Coast Range than in the Lower Klamath, but this also should occasion no surprise—there were two economic systems and two environments, and the densities cannot be expected to be the same. One cannot even say that the north Coast Range peoples had greater efficiency in exploiting their environment. The north Coast Range (given a preagricultural situation) may be, and probably is, inherently richer in natural products than the Lower Klamath region.

What is surprising is the virtual identity between the Lower Klamath and the north Coast Range in number of people per unit of acorn and game productivity. Game and acorn resources are an important determinant of population in the north Coast Range, but not on the Lower Klamath. Why, then, should over-all density with respect to game and acorns be the same in both areas? What the figures actually suggest is that each group is a sample from a universe of tribes, and that each universe of tribes has the same mean density but different standard deviation. The situation is analogous to the two normal probability distribution functions with a common mean and different standard deviation, graphs of which are shown below.



This in turn suggests that acorn and game production have in both regions the same central tendency, a tendency to hold populations at the same level per unit of productivity, but that the tendency had a great deal more force in the north Coast Range than on the Lower Klamath. It was presumably owing to the fishing specialization on the Lower Klamath that the central tendency of the acorn and game resource had less force there—the effect of the acorn and game resource was often swamped by an excess or deficiency in the fish resource.

The central tendency and the small scatter in the figures for the north Coast Range suggest that the mean density represents some sort of optimum density or point of Malthusian equilibrium. If Malthusian checks were not operative, or at least immanent, we would expect different behavior from the data. Thus, if acorn and game resources had little or nothing to do with population size we would expect a vague and shadowy relationship, at best, between population and those resources. Or, if acorn and game resources had a definite effect on population size but the ultimate checks were other than Malthusian, we would expect the relationship to show up in other than linear form. We might, for example, find a logarithmic form, like that between fish resources and population on the Lower Klamath, where resource loses its effect at a certain level. But where the magnitude of resource comes in as a purely linear factor, as in the north Coast Range, the effect can only be interpreted as a Malthusian response. That is not to say, of course, that the populations were necessarily held at observed levels simply because excess people were always eliminated by starvation. It may be that a long and delicate adjustment, involving birth rates as well as death rates, was responsible for the equilibrium. It has been observed that infanticide was practiced in central California, and it may be that this and other population controls provided the immediate check on numbers of people. But whatever the direct mechanism of population control, the data suggest very strongly that an increase in population would necessarily have invoked Malthusian checks directly. If that were not the case we would expect at least some of the low-resource tribes to have large populations. Since they do not, the resources themselves must have been the ultimate limiting factor.

PRESENTATION AND ANALYSIS—CALIFORNIA PROVINCE, SAN JOAQUIN VALLEY

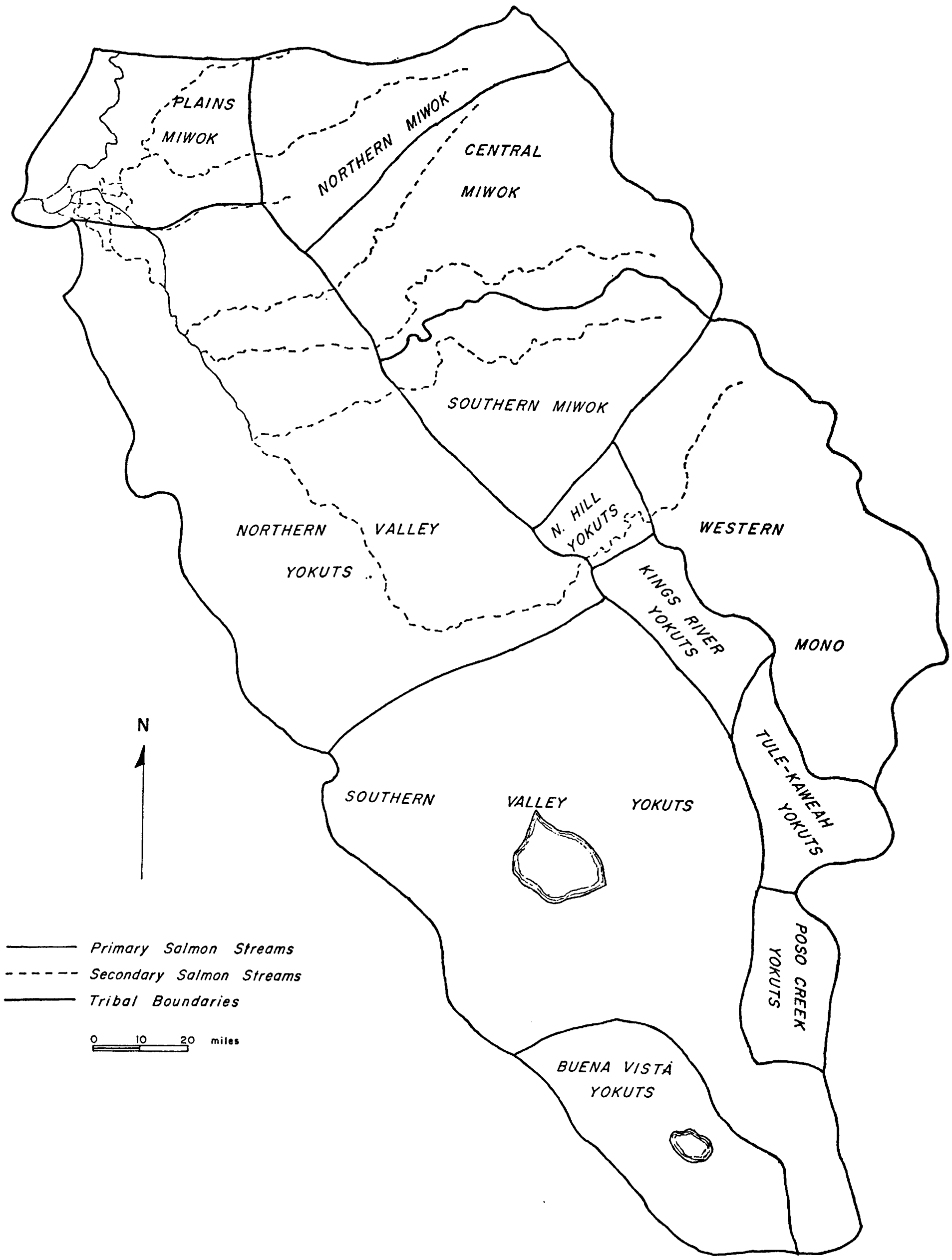
THE FINAL GROUP of tribes to be considered in the present paper comprises those of the San Joaquin Valley, those of the foothills and mountains bordering the San Joaquin in the east, and the Plains Miwok, who occupied the Sacramento–San Joaquin Delta and adjacent valley lands (map 5). The lands occupied by these tribes are the most difficult to assess economically because they have been greatly altered by recent agricultural enterprise. The San Joaquin Valley itself is virtually all under cultivation so that the Wieslander and Jensen vegetation map can give us little idea of its native condition. The alteration has been effected here in three ways: (1) large areas of overflow bordering the rivers, given over to a marshland vegetation, have since been drained and put under cultivation; (2) former grassy plains have been put into crops; and (3) former areas of oak woodland have been deforested and are now under cultivation. To reconstruct the original vegetation I have relied mainly on two sources. For the marsh areas I have used a map of the Sacramento–San Joaquin valleys showing the areas of lakes and marshes in 1887, prepared by William Ham. Hall for the California State Legislature in that year (a copy of this map was kindly made available to me by Professor Tracy I. Storer of the University of California, Davis). For other reconstruction I used the work of Burcham. Burcham's reconstruction is supplemented by the abundant soil surveys available for the San Joaquin Valley.

I have accepted virtually all the detail of the William Ham. Hall map—it agrees very convincingly with the data of the soil surveys and also with the data of topographic maps, on which former marshes can often be deduced from present drainage canals. The Hall map also agrees with Kroeber's map of the central and southern Yokuts (1925, Plate 47), which indicates (but does not label) the marsh areas. Since Kroeber may also have had access to the Hall map, the concurrence need not constitute additional confirmation.

Burcham's (1957) reconstruction of native vegetation types has been valuable to me in deciding what parts of the former dry lands now under cultivation were originally grassland and what parts were in oak woodland. Burcham's main conclusions, reached on the basis of historical information, are that the rivers running from the Sierra into the Valley were formerly bordered by considerable zones of oak woodland and that the Valley elsewhere was given over to grassland.

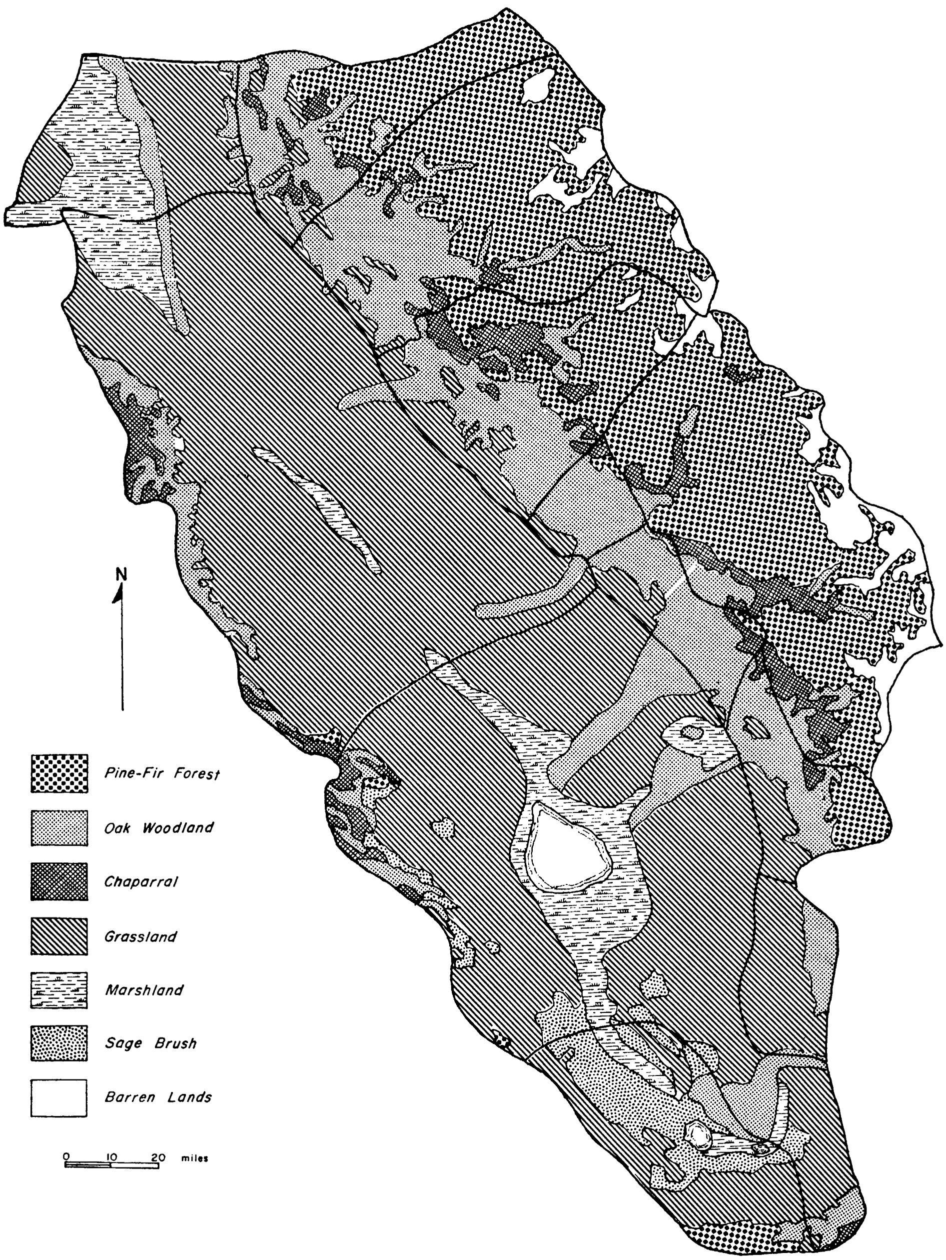
That position seems unassailable, and I have therefore followed Burcham except for minor changes made in accordance with information on the soil surveys. My decisions on aboriginal vegetation distribution are shown on map 6.

The economy of the San Joaquin area generally resembled that of the north Coast Range area, but with some difference in the environment-population rela-



Map. 5. Salmon fishery of the San Joaquin Valley, California Culture Province

tionships. At this point the data raise serious questions about the weighting factors that so far have been successful in evaluating vegetation types. Preparatory to dealing with these questions, I nevertheless proceed as before, assigning the same weighting factors and computing the total resource indexes. With these in hand we can judge whether (*a*) the weighting factors may legitimately be



Map 6. Vegetation types of the San Joaquin Valley, California Culture Province.

changed to bring the San Joaquin data into line with data for the north Coast Range, or (*b*) the San Joaquin situation differs fundamentally from that of the north Coast Range and therefore requires distinct treatment.

Population data for ten of the twelve tribes in the San Joaquin area are adequate. Resource evaluation is presented for the Northern Valley Yokuts too, since their population data are nearly adequate. The population data for the San Joaquin tribes were more difficult to deal with than those of the Lower Klamath and the north Coast Range. The reason is that Cook (1955*a*) analyzed the demography of the San Joaquin in terms not of tribal areas but of physiographic areas. The Cook figures have been reapportioned to correspond with tribal affiliation. It has been possible to determine tribal numbers with relatively little ambiguity in terms of the tribal boundaries shown on map 5. At the same time, most totals are made up of portions of two or more of Cook's area totals. Thus, a specific citation cannot be given for each tribal figure.

Tribes of the California province, San Joaquin Valley, are listed below.

Population known	*Population unknown*
Plains Miwok	Northern Miwok
Central Miwok	Northern Valley Yokuts
Southern Miwok	
Northern Hill Yokuts	
Kings River Yokuts	
Tule-Kaweah Yokuts	
Poso Creek Yokuts	
Southern Valley Yokuts	
Buena Vista Yokuts	
Western Mono	

Tribal Resources

Presentation of tribal resources follows the plan used in the previous sections:

PLAINS MIWOK

The fish resources of the Plains Miwok are primary along 55 miles of the Sacramento River and 27 miles of the San Joaquin River, and secondary along 92 miles of the sloughs in the Delta region, 44 miles of the Mokelumne River, and 34 miles of the Cosumnes River. Evaluation of the sloughs is not entirely certain. They were presumably less valuable than the main rivers, but midden analysis of archaeological sites makes it clear that many fish were taken from them (Cook and Heizer, 1951).

CENTRAL MIWOK

The fish resources of the Central Miwok are on the Stanislaus (40 miles) and Tuolumne (48 miles) rivers. The pine-fir forest there is given a coefficient of $5/8$ because one fourth is at low elevations, mixed with oak and brush, and the rest is at high elevations and correspondingly less valuable for acorns and game.

RESOURCE INDEX FOR THE PLAINS MIWOK
(Area: 1,290.2 square miles. Population: 14,350)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
River (primary)	82	2 × 10	..	..	1,640	....	......
River (secondary)	170	1 × 10	..	..	1,700	....	......
Vegetation	(sq. mi.)						
Oak woodland	151.2	....	2	2	....	302.4	302.4
Grassland	632.5	....	½	2	....	316.3	1,265.0
Marshland	506.5	....	½	2	....	253.3	1,013.0
Total resource index					3,340	872.0	2,580.4

RESOURCE INDEX FOR CENTRAL MIWOK
(Area: 2,870.3 square miles. Population: 2,130)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
River (secondary)	88	1 × 10	..	..	880	......	......
Vegetation	(sq. mi.)						
Pine-fir forest	1,733.6	....	⅝	⅝	....	1,083.5	1,083.5
Oak woodland	728.3	....	2	2	....	1,456.6	1,456.6
Chaparral	75.6	....	½	2	....	37.8	151.2
Grassland	95.7	....	½	2	....	47.9	191.4
Barren lands	236.9	....	..	..	....	......	......
Total resource index					880	2,625.8	2,882.7

SOUTHERN MIWOK

One third of the pine-fir forest in Southern Miwok country, being below 5,000 feet elevation, has oak mixed with pine and has been given a coefficient of 1. The rest, pure coniferous forest, is given a coefficient of ½. The fish resource there is 60 miles of the Merced River.

NORTHERN VALLEY YOKUTS

The population figures for the Northern Valley Yokuts are not reliable. Of the 25,100 estimated by Cook (1955*a*), about half (12,000) is based not on historic or ethnographic sources but on a persons-per-river-mile extrapolation from known populations on the Merced and Kings rivers. In addition the population of the semidesert region west of the San Joaquin River, if there was any, is not counted at all. The population figures for the Northern Valley Yokuts are therefore not to be used as primary data but may be useful as a check.

The primary fish stream of the Northern Valley Yokuts was the San Joaquin River to the mouth of the Tuolumne (36 miles). The secondary fish streams are the San Joaquin River above the Tuolumne (79 miles), the sloughs in the Delta (146 miles), the Calaveras River (6 miles), the Tuolumne River (34 miles), the Stanislaus River (39 miles), the Merced River (40 miles), and the Fresno River (15 miles).

RESOURCE INDEX FOR SOUTHERN MIWOK

(Area: 1,905.1 square miles. Population: 2,725)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
River (secondary)	60	1 × 10	..	..	600	......	......
Vegetation	(sq. mi.)						
Pine-fir forest....	682.9	....	⅔	⅔	....	455.2	455.2
Oak woodland....	657.7	....	2	2	....	1,315.4	1,315.4
Chaparral........	221.8	....	½	2	....	110.9	443.6
Grassland........	287.3	....	½	2	....	143.7	574.6
Barren lands.....	55.4	....	..	..	....	......	......
Total resource index..................................					600	2,025.2	2,788.8

RESOURCE INDEX FOR NORTHERN VALLEY YOKUTS

(Area: 362.9 square miles. Population: 3,900)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
River (primary)..	36	2 × 10	..	..	720	......	......
River (secondary)	359	1 × 10	..	..	3,590	......	......
Vegetation	(sq. mi.)						
Pine-fir forest....	10.1	....	1	1	....	10.1	10.1
Oak woodland....	587.2	....	2	2	....	1,174.4	1,174.4
Chaparral........	123.5	....	½	2	....	61.8	247.0
Grassland........	5,360.0	....	½	2	....	2,680.0	10,720.0
Sagebrush........	80.6	....	½	1	....	40.3	80.6
Marshland.......	347.8	....	½	2	....	173.9	695.6
Total resource index..................................					4,310	4,140.5	12,927.7

NORTHERN HILL YOKUTS

Following Burcham (1957), I have shown oak woodland bordering the San Joaquin River from the edge of the foothills some 30 miles out into the San Joaquin Valley. This increases the woodland area of the Northern Hill Yokuts over that shown by Wieslander and Jensen, and correspondingly decreases their grassland. The fish resources of the Northern Hill Yokuts are found in the San Joaquin River.

RESOURCE INDEX FOR NORTHERN HILL YOKUTS
(Area: 362.9 square miles. Population: 3,900)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
River (secondary)	30	1 × 10	..	..	300	....	....
Vegetation	(sq. mi.)						
Pine-fir forest....	12.6	....	1	1	....	12.6	12.6
Oak woodland....	302.4	....	2	2	....	604.8	604.8
Chaparral........	7.6	....	½	2	....	3.8	15.2
Grassland........	40.3	....	½	2	....	20.2	80.6
Total resource index......					300	641.4	713.2

KINGS RIVER YOKUTS

Burcham (1957) showed a wide patch of oak woodland extending from the foothills out into the Valley along and south of the Kings River. I have followed him in this, showing for the Kings River Yokuts a slightly larger area of oak woodland than is shown by Wieslander and Jensen.

RESOURCE INDEX FOR KINGS RIVER YOKUTS
(Area: 612.3 square miles. Population: 4,750)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
None............	.....	....	..	..	....	....	....
Vegetation	(sq. mi.)						
Pine-fir forest....	15.1	....	1	1	....	15.1	15.1
Oak woodland....	473.8	....	2	2	....	947.6	947.6
Chaparral........	42.8	....	½	2	....	21.4	85.6
Grassland........	80.6	....	½	2	....	40.3	161.2
Total resource index......					....	1,024.4	1,209.5

TULE-KAWEAH YOKUTS

In the territory of the Tule-Kaweah Yokuts the vegetation types of Wieslander and Jensen can be accepted, with a slight addition of oak woodland near the delta of the Kaweah River.

RESOURCE INDEX FOR TULE-KAWEAH YOKUTS
(Area: 748.4 square miles. Population: 4,200)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
None	.....	....	..	..	....	....	....
Vegetation	(sq. mi.)						
Pine-fir forest	98.3	....	1	1	....	98.3	98.3
Oak woodland	418.3	....	2	2	....	836.6	836.6
Chaparral	60.5	....	½	2	....	30.3	121.0
Grassland	171.3	....	½	2	....	85.7	342.6
Total resource index					....	1,050.9	1,398.5

POSO CREEK YOKUTS

The northern part of Poso Creek Yokuts territory, now under cultivation, must have been grassland since it is on the valley floor. A strip of oak woodland at the southern end of the territory has been deforested and is now grassland.

RESOURCE INDEX FOR POSO CREEK YOKUTS
(Area: 604.8 square miles. Population: 1,500)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
None	.....	....	..	..	....	....	....
Vegetation	(sq. mi.)						
Oak woodland	126.0	....	2	2	....	252.0	252.0
Grassland	478.8	....	½	2	....	239.4	957.6
Total resource index					....	491.4	1,209.6

SOUTHERN VALLEY YOKUTS

On the Wieslander and Jensen map, the Southern Valley Yokuts territory shows almost no unmodified areas. The figures shown are based on the reconstruction in map 6, which is derived from the William Ham. Hall map of swamplands and the Burcham (1957) map of vegetation types (see discussion on pp. 205–208).

BUENA VISTA YOKUTS

The pine-fir forest in the territory of the Buena Vista Lake Yokuts was actually piñon pine. This country could therefore have been little suited to either acorn or game production and is given a minimal coefficient. The same applies with even greater force to the sagebrush land.

RESOURCE INDEX FOR SOUTHERN VALLEY YOKUTS
(Area: 6,572.2 square miles. Population: 15,380)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
None............	.....	....	..	..	....	......	......
Vegetation	(sq. mi.)						
Oak woodland....	864.4	....	2	2	....	1,728.8	1,728.8
Chaparral........	128.5	....	½	2	....	64.3	257.0
Grassland........	4,432.7	....	½	2	....	2,216.4	8,865.4
Sagebrush........	241.9	....	½	½	....	121.0	121.0
Marshland.......	904.7	....	½	2	....	452.4	1,809.4
Total resource index.................................					....	4,582.9	12,781.6

RESOURCE INDEX FOR BUENA VISTA YOKUTS
(Area: 1,461.5 square miles. Population: 1,340)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
None............	.....	....	..	..	....	....	......
Vegetation	(sq. mi.)						
Pine-fir forest....	118.4	....	½	½	....	59.2	59.2
Oak woodland....	103.3	....	2	2	....	206.6	206.6
Grassland........	546.8	....	½	2	....	273.4	1,093.6
Sagebrush........	567.0	....	½	½	....	283.5	283.5
Marshland.......	126.0	....	½	2	....	63.0	252.0
Total resource index.................................					....	885.7	1,894.9

WESTERN MONO

One eighth of the pine-fir forest in Western Mono territory is at low elevations and thus has pine and oak mixed. Accordingly, it is given a coefficient of 1 for both acorns and game. The remainder, at high elevations, is given a coefficient of only ½. The fish resources of the Western Mono are 35 miles of the San Joaquin River.

ANALYSIS OF CALIFORNIA PROVINCE, SAN JOAQUIN VALLEY

The resource and population data as computed above are summarized in tables 12 and 13. The first point of interest is to determine how well these data conform to the relationships observed in the data for the north Coast Range. The figures in table 14 were therefore compiled to show populations predicted from the equation

$$\text{population} = 3 \text{ (acorn index)} + 2 \text{ (game index)} - 210.$$

RESOURCE INDEX FOR WESTERN MONO
(Area: 3,417.1 square miles. Population: 3,640)

Type	Extent	Coefficients			Indices		
		Fish	Acorn	Game	Fish	Acorn	Game
Fishery	(fish-miles)						
River (secondary)	35	1 × 10	..	..	350	......	......
Vegetation	(sq. mi.)						
Pine-fir forest....	2,341.1	....	9/16	9/16	....	1,316.9	1,316.9
Oak woodland....	241.9	....	2	2	....	483.8	483.8
Chaparral........	340.2	....	½	2	....	170.1	680.4
Barren lands.....	493.9	....	..	..	....	......	....
Total resource index					350	1,970.8	2,481.1

Actual population figures are also shown, together with absolute and relative differences between predicted and actual population. The table shows that differences between predicted and actual populations are usually enormous, both absolutely and relatively. In other words the relationships observed in the north Coast Range simply do not hold for the San Joaquin data as computed here. Two alternative explanations are considered: (1) the relationship observed in the north Coast Range is fortuitous or, at best, is a purely local relation inapplicable to other areas, or (2) the relationship does in fact hold true over the entire California culture province but a substantial error in evaluating resources became clear in the San Joaquin region that did not evidence itself in the north Coast Range. The

TABLE 12
SUMMARY OF RESOURCES OF CALIFORNIA PROVINCE, SAN JOAQUIN AREA

Tribe	Population	Area	Resource index		
			Acorn	Fish	Game
Plains Miwok	14,350	1,290.2	872.0	3,340	2,580.4
Central Miwok	2,130	2,870.3	2,625.8	880	2,882.7
Southern Miwok	2,725	1,905.1	2,025.2	600	2,788.8
Northern Hill Yokuts	3,900	362.9	641.4	300	713.1
Kings River Yokuts	4,750	612.3	1,024.4	...	1,209.5
Tule-Kaweah Yokuts	4,200	748.4	1,050.9	...	1,398.5
Poso Creek Yokuts	1,500	604.8	491.4	...	1,209.6
Southern Valley Yokuts	15,380	6,572.2	4,582.9	...	12,781.6
Buena Vista Yokuts	1,340	1,461.5	885.7	...	1,894.9
Western Mono	3,640	3,417.1	1,970.7	350	2,481.1
Total	53,915	19,844.8	16,170.4	5,470	29,940.2

Figures shown are calculated as follows:
Population—number of persons.
Area—square miles.
Acorn resources—square miles adjusted according to yield.
Fish resources—tens of linear stream miles adjusted according to yield.
Game resources—square miles adjusted according to yield.

TABLE 13

POPULATION DENSITIES OF THE CALIFORNIA PROVINCE, SAN JOAQUIN AREA

Tribe	Density[a] according to			
	Area	Acorns	Fish	Game
Plains Miwok	11.12	16.46	4.30	5.56
Central Miwok	.74	.81	2.42	.74
Southern Miwok	1.43	1.35	4.54	.98
Northern Hill Yokuts	10.75	6.08	13.00	5.47
Kings River Yokuts	7.76	4.64	....	3.93
Tule-Kaweah Yokuts	5.61	4.00	....	3.00
Poso Creek Yokuts	2.48	3.05	....	1.24
Southern Valley Yokuts	2.34	3.36	....	1.20
Buena Vista Yokuts	.92	1.51	....	.71
Western Mono	1.07	1.85	10.40	1.47
Average	4.42	4.30	6.93	2.41
Standard deviation	4.10	4.57	4.42	1.92
Grand density	2.72	3.33	9.86	1.80

[a] The densities here are calculated from the quantities shown in table 12.

first alternative, the conclusion that the two areas simply do not have similar subsistence-demographic relationships, cannot be accepted because of one circumstance. The exceptional circumstance is that predicted populations are closest to actual populations in the foothill areas (the Northern Hill Yokuts, the Kings River Yokuts, and the Tule-Kaweah Yokuts), precisely the region where the vegetation types are most like those of the north Coast Range. The relationship holds true where the landscape is similar to that of the north Coast Range and fails elsewhere.

TABLE 14

PREDICTED AND ACTUAL POPULATIONS OF THE CALIFORNIA PROVINCE, SAN JOAQUIN VALLEY

Tribe	Predicted population[a]	Actual population	Difference	Difference ÷ actual population
Plains Miwok	7,567	14,350	−6,783	−0.47
Central Miwok	13,433	2,130	11,303	5.31
Southern Miwok	11,443	2,725	8,718	3.20
Northern Hill Yokuts	3,140	3,900	− 760	−0.19
Kings River Yokuts	5,282	4,750	532	0.11
Tule-Kaweah Yokuts	5,740	4,200	1,540	0.37
Poso Creek Yokuts	3,683	1,500	2,183	1.46
Southern Valley Yokuts	39,102	15,380	23,722	1.54
Buena Vista Yokuts	6,237	1,340	4,897	3.65
Western Mono	10,664	3,640	7,024	1.93
Total	106,291	53,915	52,376	0.97

[a] Predicted populations are those derived from the formula: population = 3 (acorn index) + 2 (game index) − 210.

Thus, the valuation of resources appears faulty. If the differences were due to cultural factors, the relationship would predict poorly in all cases. If the valuation is faulty, the difficulty must be in the grassland and pine-fir forest, for the error is greatest where these vegetation types are preponderant. Reducing the valuations of these two vegetation types brings predicted populations into line with actual populations.

How would such reductions affect the accepted relationship in the north Coast Range? We observe that any change in the valuation of grassland figures would have negligible effect in the north Coast Range because grassland is a very small factor in the tribal territories considered there. The only large areas were in the territories of the Coast Miwok and the Southern Pomo, both of which were omitted because of faulty population data. If they had been included, the accuracy of the grassland valuation would presumably have come into question earlier.

As to the pine-fir forest, a reduced valuation can be justified in the Sierra east of the San Joaquin Valley while the previous valuation is retained in the north Coast Range. In the Sierra there are pure stands of conifers covering large, continuous areas at high average elevations (5,000 to 14,000 feet above sea level). The value of such land for game or acorns would be minimal. In the north Coast Range, in contrast, the pine-fir forest is at lower average elevation and occurs in small patches interspersed with oak woodland and chaparral. Such pine-fir forest produces moderate quantities of game and acorns.

I am, of course, acutely aware of the methodological difficulties of the approach implied by the proposed revaluation. It is possible to take an arbitrary set of data and, if unlimited juggling is permitted, arrive at any desired conclusion. The revaluation is justified, however, by the fact that the data for the foothill Yokuts partially confirmed the north Coast Range relationship and that the valuations originally proposed were admittedly somewhat arbitrary and therefore subject to revision. The San Joaquin data suggest the changes, and they are made accordingly.

The original valuations proposed that the tribal areas be weighted with coefficients 2, 1, or $\frac{1}{2}$, respectively good, fair, or poor in acorn and game production. The San Joaquin data suggest that $\frac{1}{2}$ is too great a weight for some of the "poor" lands, that some lands are poorer than others. This appears especially true when "poor" lands occur in large tracts. Thus, even if pine-fir forests everywhere had a moderate amount of game that would be used if it were near at hand, it would not be of great economic value if spread thinly over great distances from the centers of use. The same situation applies to acorns. I am therefore reducing the weighting factor for the Sierra pine-fir forest to $\frac{1}{10}$. For grasslands, a different order of reduction is indicated. Grassland was originally weighted 2 for game and $\frac{1}{2}$ for acorns. The 2 for game was based on the large herds of elk and antelope observed in the Central Valley before 1850 (cf. Maloney, 1945). But those grasslands were dry through the summer and fall, so it is likely that they were less productive of game fodder than the plants of the chaparral, which retain their foliage through most of the year. The game rating is therefore reduced to 1. The acorn rating for the grasslands is reduced from $\frac{1}{2}$ to 0 on the grounds that the acorn resource must have been negligible in the plains.

Before presenting the revalued data, I would first like to approach another difficulty in the San Joaquin data. It concerns Cook's (1955*a*) population figures for the Central Miwok, Southern Miwok, and Western Mono. Those population data differ from others in the sample in being derived in whole or in part from ethnographic (post-1900) rather than historic (1800–1860) information. Since the ethnographic data were obtained in the present century, Cook thought the aboriginal population was probably underestimated. The population losses of the San Joaquin Valley, he asserted, were due to Spanish contact, in connection with missionization. Since the Central Miwok, Southern Miwok, and Western Mono were hill tribes, relatively remote from the Spanish, he supposed that their losses were relatively small—amounting to only about 30 per cent. Cook is undoubtedly correct that the hill tribes lost only a few people as a direct result of Spanish contact, but I feel that he has greatly underestimated losses due indirectly to contact, especially losses through disease.[2] I refer particularly to the malaria epidemic of 1833. Evidence (Cook, 1955*b*) is abundant that the epidemic took a fearful toll up and down the Central Valley. Reflection indicates that the three tribes could scarcely have been so isolated as to remain untouched. The ethnographic census data were obtained from informant memories that could scarcely have predated 1833, so these data are probably an underestimate of aboriginal population. Mortality in the Central Valley from the 1833 epidemic, Cook estimated (1955*b*), must have been about 75 per cent. It must have been almost as high in the foothill region, so the population figures, being derived from post-1833 data, should have been increased by at least a factor of 3 to approximate the situation as of 1800. Accordingly I recalculate the figures as follows: the Central Miwok had 1,470 persons in 1850 (Cook, 1955*a*, p. 69), giving them an aboriginal total of 4,410; there were 1,922 Southern Miwok in 1850 (*ibid.*, pp. 48, 53), giving them 5,766 people in 1800; finally, we have for the Western Mono two groups, those on the lower Kaweah who numbered 600 before the epidemic (*ibid.*, p. 48) and those living elsewhere, numbering 2,144 in 1850 (*ibid.*, pp. 37, 50), so that altogether the Western Mono must have numbered 7,032 before the epidemic.

With these resource and population changes I present in tables 15 and 16 a revised summary of the data on the San Joaquin area, and also table 17, a comparison of predicted and actual population analogous to table 14 (the same data are shown graphically on fig. 4). We see that on the whole the comparison comes out very much better. In fact, if we look at the totals we see that the predicted population is quite close to actual population, the discrepancy amounting to only 5 per cent. Individual tribal comparisons, however, show less accuracy. It is worth while to consider the possible reasons for the discrepancies at the tribal level.

For the two southernmost tribes, the Southern Valley Yokuts and the Buena Vista Yokuts, the formula overestimates population rather seriously. The overestimate there is probably due to an overvaluation of resources—over much of the

[2] This is borne out by Cook's own statement (1962). Cook adds a note to an excerpt from Pico's diary on his expedition to the San Joaquin and Kings rivers, 1825–26, in which Pico says, "Now the guides . . . were holding in their possession the Christians who were at the river because they were sick." Cook's note reads:

This is an enlightening observation and refers to the frequent tendency of missionized interior natives to return to their old homes when they became seriously ill. It was apparently a semi-instinctive attempt to escape the disease-ridden mission environment. Needless to say, the effect was substantially useless and in fact did more harm than good, since the still intact villages of the interior became themselves infected.

territory of those two tribes there is desert climate with rainfall averaging no more than 5 inches per year, so that a given vegetation type would be much less productive there than its classificatory counterpart in more northerly parts. A further reduction in valuation could be justified, but its magnitude would be difficult to estimate with only two tribes represented.

The mountain tribes (Central Miwok, Southern Miwok, and Western Mono) also show considerable variance between predicted and actual population, even after adjustment of both resource and population figures. I am inclined to believe

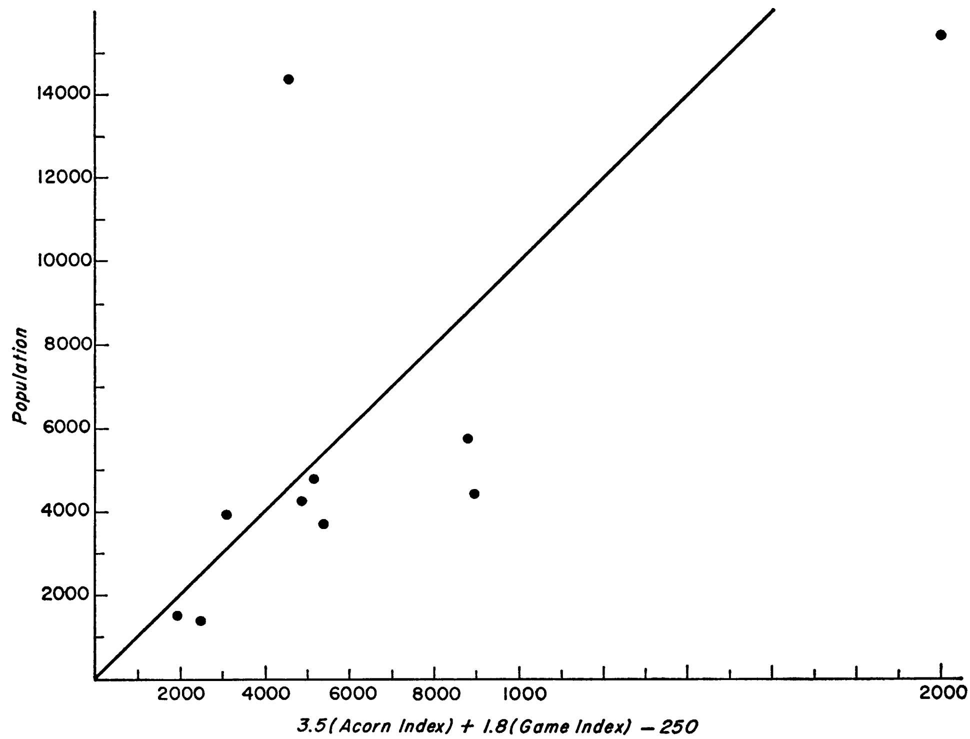


Fig. 4. Relation between population and resources of San Joaquin Valley tribes.

there is something basically wrong here—either the population figures are quite incorrect or else the north Coast Range relationship fits only very loosely for the Sierra tribes. The discrepancies would be easier to deal with if they were all in the same direction, but they are not. For two tribes the formula overestimates, and for one tribe (Western Mono) it underestimates. The variation in the estimates is evidently due to variation in the quantity of oak woodland available. For the Central Miwok there were 728 square miles of woodland and population is overestimated by 4,137 persons; for the Southern Miwok there were 658 square miles of oak woodland and population is overestimated by 2,737. For the Western Mono there were 242 square miles of oak woodland and population is underestimated by 1,781. Population density of these tribes per square mile of oak woodland is 6.1 for the Central Miwok, 8.8 for the Southern Miwok, and 29.1 for the Western Mono. I am unable to believe that Western Mono territory was so much

TABLE 15

REVISED SUMMARY OF RESOURCES OF CALIFORNIA PROVINCE, SAN JOAQUIN AREA

Tribe	Population	Area	Resource index		
			Acorn	Fish	Game
Plains Miwok	14,350	1,290.2	302.4	3,340	1,947.9
Central Miwok	4,410	2,870.3	1,667.8	880	1,876.9
Southern Miwok	5,766	1,905.1	1,494.6	600	2,114.7
Northern Hill Yokuts	3,900	362.9	609.9	300	661.6
Kings River Yokuts	4,750	612.3	970.5	...	1,115.3
Tule-Kaweah Yokuts	4,200	748.4	876.7	...	1,138.7
Poso Creek Yokuts	1,500	604.8	252.0	...	730.8
Southern Valley Yokuts	15,380	6,572.2	1,793.1	...	8,252.1
Buena Vista Yokuts	1,340	1,461.5	218.4	...	1,073.9
Western Mono	7,032	3,417.1	888.0	350	1,398.3
Total	62,628	19,844.8	9,073.4	5,470	20,310.2

Figures shown are calculated as follows:
Population—number of persons.
Area—square miles.
Acorn resources—square miles adjusted according to yield.
Fish resources—tens of linear stream miles adjusted according to yield.
Game resources—square miles adjusted according to yield.

superior to Miwok territory that it could have supported more than three times as many people per square mile of oak woodland. Nor is there any sociological explanation for the greater population of the Western Mono. The basic element of Mono social organization was the nuclear family, whereas among the Miwok

TABLE 16

REVISED POPULATION DENSITIES OF THE CALIFORNIA PROVINCE, SAN JOAQUIN AREA

Tribe	Density[a] according to			
	Area	Acorns	Fish	Game
Plains Miwok	11.12	47.45	4.30	7.37
Central Miwok	1.54	2.64	5.01	2.34
Southern Miwok	3.03	3.86	9.61	2.73
Northern Hill Yokuts	10.75	6.39	13.00	5.89
Kings River Yokuts	7.76	4.89	....	4.26
Tule-Kaweah Yokuts	5.61	4.79	....	3.69
Poso Creek Yokuts	2.48	5.95	....	2.05
Southern Valley Yokuts	2.34	8.58	....	1.86
Buena Vista Yokuts	0.92	6.14	....	1.25
Western Mono	2.06	7.92	20.09	5.03
Average	4.76	9.86	10.40	3.65
Standard deviation	3.84	13.33	6.47	1.98
Grand density	3.16	6.90	11.45	3.08

[a] The densities here are calculated from the quantities shown in table 15.

TABLE 17

REVISED COMPARISON OF PREDICTED AND ACTUAL POPULATIONS OF THE CALIFORNIA PROVINCE, SAN JOAQUIN AREA

Tribe	Predicted population[a]	Actual population	Difference	Difference ÷ actual population
Plains Miwok	4,593	14,350	−9,757	−.68
Central Miwok	8,547	4,410	4,137	.94
Southern Miwok	8,503	5,766	2,737	.47
Northern Hill Yokuts	2,943	3,900	− 957	−.25
Kings River Yokuts	4,932	4,750	182	.04
Tule-Kaweah Yokuts	4,698	4,200	498	.12
Poso Creek Yokuts	2,008	1,500	508	.34
Southern Valley Yokuts	21,674	15,380	6,294	.41
Buena Vista Yokuts	2,593	1,340	1,253	.94
Western Mono	5,251	7,032	−1,781	−.25
Total	65,742	62,628	3,114	.05

[a] Predicted populations are those derived from formula: population = 3 (acorn index) + 2 (game index) − 210.

there was a fairly strong lineage organization. Such social organization would lead us to expect, if anything, a greater population density among the Miwok than among the Mono (see p. 157). In these circumstances we must simply conclude that the environmental-demography relationships are less sure for Sierra tribes than for other tribes.

The final discrepancy between predicted and actual population to be considered is that observed for the Plains Miwok. In this tribe, the relative disagreement is only about 48 per cent but the absolute error is very large, 9,757. Since the formula, based only on the acorn and game indexes, underestimates to this extent we may suggest that the excess Plains Miwok population was due to the great quantity of fish available in the tribal territory. The delta of the Sacramento–San Joaquin was undoubtedly one of the prime fishing areas of native California, and full exploitation could easily account for a dense population there. But if excess population there is due to the fish resource, we must conclude that the demography of the California culture province cannot be accounted for in terms of the acorn and game factors alone, as the north Coast Range data suggest. We shall have to conclude that the economy was flexible and capable of concentration on any one of several possible dominant resources.

Fortunately, we may test the question to some extent by referring to data on the Northern Valley Yokuts. Part of the territory of this tribe was similar to that of the Plains Miwok and therefore should show a comparably high population density if its fish resource was utilized to the same extent. It will be remembered that the Northern Valley Yokuts were excluded from previous consideration because of low-grade population data. Cook (1955*a*) concluded that the aboriginal population of this group was 25,100. There was solid historical evidence for 13,100 of these, but the remaining 12,000 were estimated on the basis of stream-mileage density. In those computations Cook did not consider at all the population in

Northern Valley Yokuts territory west of the San Joaquin River, about half the total area. Therefore, even if the stream-mileage estimates are to be distrusted, when we consider the area west of the river we must conclude that the total population cannot have been less than 25,000 and may have been more. If we estimate Northern Valley Yokuts population with the formula

$$\text{population} = 3\ (\text{acorn resource}) + 2\ (\text{game resource}) - 210$$

we obtain a figure of 18,474 (the acorn and game resources are respectively calculated at 1237.2 and 7486.1), an underestimate of about the same order as we obtained for the Plains Miwok. The Northern Valley Yokuts data, then, bear out the suggestion that the great fish resource of the Delta region was responsible for a substantially greater population there than would otherwise have been possible.

As a matter of fact, if we look at table 17 we observe that the three tribes whose population is underestimated by the acorn-game formula—the Plains Miwok, the Northern Hill Yokuts, and the Western Mono—all are on the course of the San Joaquin River. It is possible that this river carried a salmon run much greater than any of its tributaries and was a significant economic factor all along its course, although the tributaries were not. The Plains Miwok data suggest that the fish resource index should be brought in with about a factor of 3. That is, we should revise the formula to read

$$\text{population} = 3\ (\text{acorn index}) + 2\ (\text{game index}) + 3\ (\text{fish index}) - 210.$$

If we use this formula and restrict our attention to tribes along the San Joaquin and Sacramento rivers, we obtain the following:

Tribe	*Predicted Population*	*Actual Population*
Plains Miwok	14,613	14,350
Northern Valley Yokuts	31,404	25,000+
Northern Hill Yokuts	3,843	3,900
Western Mono	6,301	7,032

The figures seem quite convincing, but we are not in a position to say offhand whether the San Joaquin was that much more productive than its tributaries or, if it was, whether the resource would have been automatically used by tribes along its course. Presumably we will ultimately be able to determine this through archaeological analysis. At any rate, the figures suggest that the tribes of the Central Valley, unlike those of the north Coast Range, were influenced by the magnitude of the fish resource.

CONCLUSIONS

THE POPULATION DATA given in the preceding sections suggest that there were three distinct adaptations made by the various groups of the Lower Klamath and California culture provinces: (1) a fishing adaptation in the Lower Klamath province, (2) an acorn-game adaptation throughout the California province except along the Sacramento and San Joaquin rivers, where there was (3) an acorn-game-fish adaptation. These are considered in turn.

1) *Lower Klamath fish adaptation.*—It was found that, for the most part, the Lower Klamath population could be accounted for in terms of fish alone, though the acorn harvest was of importance to tribes with a poor fish resource. The relationship between fish resources and population in this adaptation was

$$\text{population (thousands)} = 1.45 \text{ (in fish resource index)} - 7.15$$

where fish resources are more than minimal. With minimal fish resources the relationship does not hold; in such cases the fishing specialization evidently loses its force. There is reason to believe that tribes with minimal fish resources—the Tlahomtahoi and Chimariko, on the eastern margin of the Lower Klamath province—are more properly assigned to the California province (Kroeber, 1925, pp. 109–110). If so, the relationship described by the equation given above would hold for the entire province so far as is known. The fact that population is a linear function of the logarithm of the fish resource suggests that population was not in a Malthusian equilibrium. If the controls had been purely Malthusian we would expect the Yurok, for example, with their great fish resource, to have had a much greater population than in fact they did. Some other factor evidently holds down population, though it is not now possible to identify it.

The nature of the fishing adaptation on the Lower Klamath probably accounts for the failure of its generalized Northwest Coast culture type to spread farther into California. As I pointed out earlier, the entire ethos and outlook of Lower Klamath culture was directed toward rivers and seacoast and was economically dependent on the annual or semiannual salmon run. It is just on the borders of the Lower Klamath province that the salmon run becomes poor or nonexistent, and not until one reaches the Sacramento River does the salmon run again attain a level comparable to that of the Lower Klamath province. On the southern border we find the Athabascan Kato and Wailaki, presumably northern in origin, who must once have had a Lower Klamath adaptation but who had, by the opening of the historic period, become Californian in adaptation. They simply could not depend heavily on fishing in an area of poor fish resources, and accordingly were forced to adopt a Californian mode of subsistence like their neighbors to the south. Similarly the Wintu, bordering the Lower Klamath province on the east (and possibly the Tlahomtahoi and Chimariko as well), are in a zone intermediate between the good fishing areas of the Lower Klamath province and the Sacramento River, so they too were unable to accept the Lower Klamath culture with its heavy dependence on fishing. Thus the Lower Klamath adaptation was blocked from further expansion.

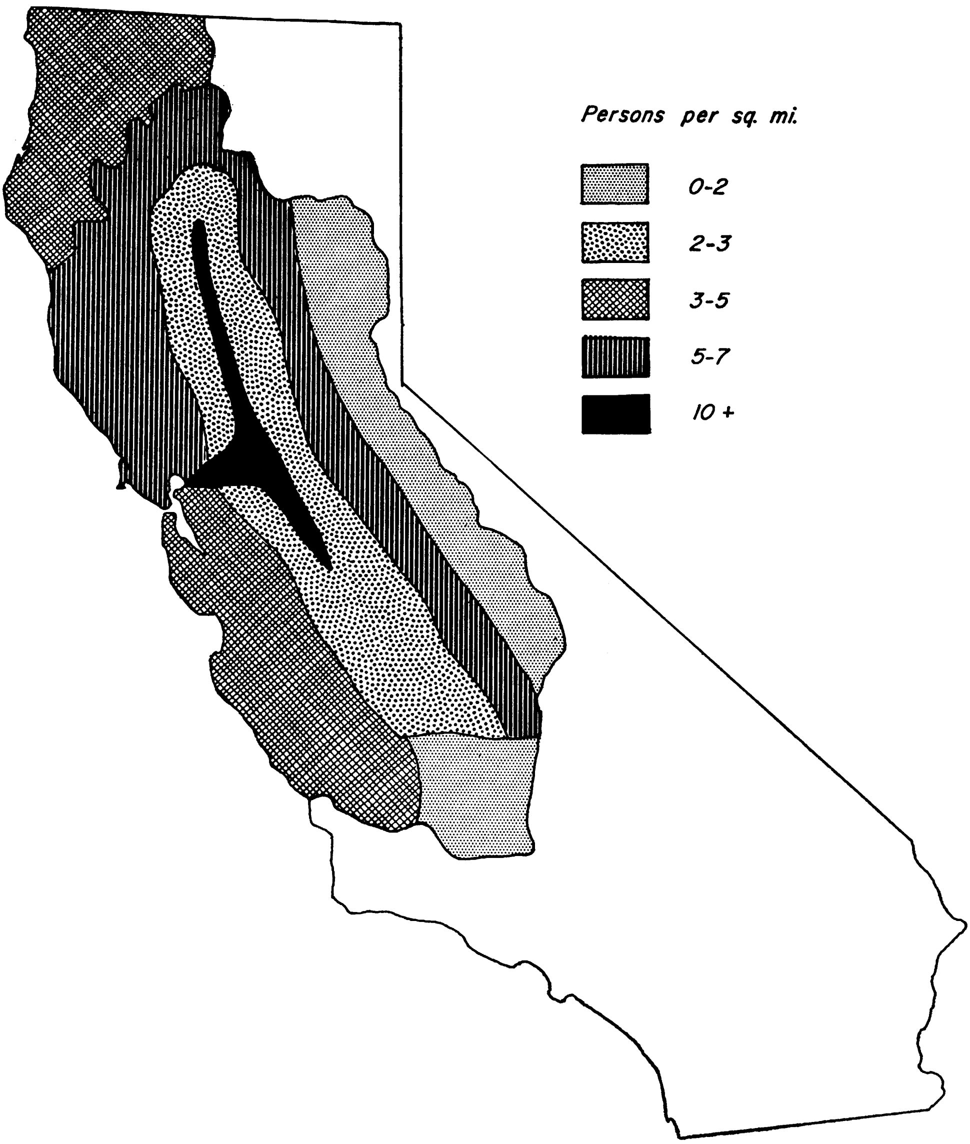
The population densities of the tribes of the Lower Klamath province varied from 2.5 to 10.8 persons per square mile, but most of them run 3, 4, or 5 per square mile. On map 7 they are shown as 3–5. The over-all density of the tribes with known population is 4.25 persons per square mile, but the tribes without known population were mostly inland ones and therefore were probably more sparsely settled. This being so we are not justified in assuming an over-all density of more than 3 persons per square mile. On this basis the entire province, with an area of 9,600 square miles, would have had a population of 28,700.

2) *California acorn-game adaptation.*—The acorn-game adaptation, as far as

can be judged from present data, was to be found throughout the California culture province except along the Sacramento and San Joaquin rivers. In groups with the acorn-game adaptation it was found that the population could usually be accounted for by the equation

$$\text{population} = 3\ (\text{acorn index}) + 2\ (\text{game index}) - 210.$$

The equation was not entirely satisfactory for Sierra tribes but worked out neatly elsewhere. To the extent that the equation describes the relationship adequately we may conclude that the population was in Malthusian equilibrium. We do not



Map 7. Population densities of the Lower Klamath and California Culture Provinces.

find here a situation like that of the Lower Klamath province, where an added increment of resource has less effect at a high resource level than at a low resource level. In the California province a given increment of resource seems to have the same effect at both high and low resource levels, hence we must conclude that the populations were about maximum with respect to the carrying capacity of the territories.

Since populations were dependent on the quantity of resources available we find that population per square mile varies with the local landscape. The entire region can be divided into five environmental zones, each with a relatively uniform population density. These zones are the north Coast Range–Sierra foothill zone, the Central Valley zone, the south Coast Range zone, the High Sierra zone, and the Buena Vista zone.

The north Coast Range and the Sierra foothills have very similar landscape, and the response of aboriginal populations appears similar in both areas. Densities for individual tribes range from 4.2 to 10.8 per square mile, but the over-all average for the tribes of known population is about 6 per square mile. In map 7 the entire area is shown as having a density of 5–7 persons per square mile. The environmental zone, as I have mapped it, has a total area of about 22,300 square miles. On the basis of 5 persons per square mile the population of the zone would have been 111,550.

The Central Valley zone, which does not include lands bordering the Sacramento and San Joaquin rivers, had a population distinctly sparser than that of the north Coast Range and Sierra foothills. The zone, being characterized by vast areas of grassy plains, could not be expected to have had a population density as high as that of the oak-covered hills. The only tribes who inhabited the Central Valley zone whose population is adequately known were the Poso Creek Yokuts and part of the Southern Valley Yokuts, with respective population densities of 2.5 and 2.3 persons per square mile. The territory of the Northern Valley Yokuts was partially in the Central Valley zone, too, but their heavy population on the San Joaquin River biases their total density. On the assumption that the Southern Valley tribes are representative I have attributed a density of 2–3 persons per square mile to this zone. The area of the zone is about 17,000 square miles, so that its total population, on the basis of 2 persons per square mile, would have been 34,000.

The south Coast Range zone is similar to the north Coast Range but generally poorer. Rainfall is less than 20 inches per year over most of the area, in contrast with generally more than 40 inches in the north Coast Range. Hence the south coast vegetation is less luxuriant than that of the north Coast Range. In the south Coast Range one finds a preponderance of chaparral and grassland, whereas much of the north Coast Range is given over to oak woodland. For these reasons we would expect to find the south Coast Range less densely populated than the area north of San Francisco Bay. Unfortunately, population data on the south Coast Range are scarce; we have only Cook's (1957) study of the East Bay district. From the number of baptisms of Indians of the East Bay listed in the mission records Cook concluded that the native population of the area must have been between 3,000 and 4,000. These peoples occupied an area of about 1,150 square miles, so the density indicated is 2.6 to 3.5 persons per square mile. If we assume that the lower density is the more accurate and apply it to the entire south Coast Range that zone would be on a par with the Central Valley zone. But, since the south Coast Range was certainly richer than the grassy plains of the Valley, I choose the larger figure and assign the south Coast Range zone a density of 3–5 persons per square mile. The area is about 12,500 square miles, so the population, at 3 persons per square mile, would have been 37,500.

The High Sierra zone is also an area of low density, with barren lands above the timber line and vast tracts of coniferous forest below. There are no population figures for groups living exclusively in the High Sierra zone, but it is clear that the density must have been very low. Thus, if there were 1,200 North Fork Mono inhabiting about 1,500 square miles of territory, density would have been 0.8 persons per square mile even if the high population estimate on p. 217 is accepted. But even in this instance, most of the population was probably in the north Coast Range–Sierra foothill zone. Thus there cannot have been more than 0.5 persons per square mile, and very likely it was closer to 0.25. On this latter basis the 10,400 square miles of the High Sierra zone would have had a population of about 2,600.

Finally there is the Buena Vista zone, occupied at the southern end of the San Joaquin Valley by the Buena Vista Yokuts and part of the Southern Valley Yokuts. This zone is technically desert, and its vegetation, with large areas of sagebrush, reflects the fact. Population density, as one would expect, is quite low. The Buena Vista Yokuts had about 0.9 persons per square mile, and the Southern Valley Yokuts within the zone cannot have been much denser. On map 7 I have shown this zone as carrying 0–2 persons per square mile. There are about 4,000 square miles of land there, so its aboriginal population at 1 person per square mile would have been 4,000.

3) *California acorn-fish-game adaptation.*—The final adaptation we have to consider is that found on the Sacramento and San Joaquin rivers, where the fish resource, as well as the acorn and game resource, was of importance. It is difficult to generalize about this zone because data are scarce, but those available suggest that the population-resource relationship can be stated by the equation

$$\text{population} = 3\ (\text{acorn index}) + 2\ (\text{game index}) + 3\ (\text{fish index}) - 210.$$

The equation is simply the California acorn-game relationship with the fish resource brought in as an additional linear factor. Here, it is worth while to note the demographic distinction between the Lower Klamath fishermen and these Californian semifishermen. Table 16 indicates that the Plains Miwok had a density of 4.3 persons per unit of fish productivity, and a total fish resource index of 3,340. If the Plains Miwok had been a Lower Klamath people with a fish resource index of that magnitude, we would have expected them to have had a much lower density with respect to fish resources. Thus, the Yurok, with the largest fish resource index of any Lower Klamath tribe (1,265), have the lowest density (2.5 persons per unit of fish productivity), and it is generally true in the Lower Klamath province that high resource indexes are associated with low densities. This situation is, of course, only a reflection of the fact that the fish resource effect comes in logarithmically in the Lower Klamath province. The data on the Sacramento–San Joaquin riparian zone, however, indicate that the fish resource there comes in as a linear factor, that no factors there damp populations of tribes with high resources, that the controls are purely Malthusian.

Thus it is quite clear that the Sacramento–San Joaquin economy was distinctly Californian and unlike that of the Lower Klamath; retention of the acorn-game formula by merely adding a factor for fish resources serves to emphasize this fact. One other point of interest is also brought out by the Sacramento–San Joaquin riparian data. The north Coast Range data indicated that fishing had no significant part in the economy of that region, and suggested that the traditional economy of California had specialized away from fishing. We see now that such is not the case. In the California economy fishing was not ignored when fish resources were very large but fishing was minimized when they were scanty. It may be that the California economy was in the process of differentiating into two distinct economies—a full-blown riparian economy along the large rivers and a pure acorn-game economy elsewhere. If so, it is clear that the differentiation had not got very far by the opening of the historic period.

The population density of the Sacramento–San Joaquin river area is the highest of any zone in either the Lower Klamath or the California province. The Plains Miwok had a density of 11.1 persons per square mile, and data for the Northern Valley Yokuts indicate that the zone was about that densely settled elsewhere. It is not certain how far north the acorn-game-fish zone extended. There was surely a dense population on the Sacramento far north of the Plains Miwok (cf. description of villages by Work in 1832 [Maloney, 1945]), and I feel that it must have extended at least as far north as Red Bluff. On this basis there were about 3,000 square miles of territory in the Sacramento–San Joaquin river area, giving it, at a density of 10 persons per square mile, a population of 30,000.

The foregoing population figures are recapitulated in table 18, and relative densities are shown on map 7. If we compare these figures to those of Kroeber (1939) we find not only that population densities are everywhere much higher than his but also that some of the relative densities differ. The areas of highest density, as given by Kroeber, are the Pomo, the foothill Yokuts, and the foothill Maidu. The present data indicate that the Sacramento–San Joaquin river zone surpasses all others in the state. The difference here simply reflects the fact that historical information either was used less or was valued less by Kroeber than by Cook. Other differences in relative densities between Kroeber's formulation and the present one are minor.

As to absolute numbers, the present estimates vastly exceed those of Kroeber. I estimate that the native population of the Lower Klamath province and the California province combined was 248,300. If these figures are correct I do not see how the total aboriginal population of the State of California can have been less than 350,000. The south coast (southeast of Point Conception) is known to have been heavily populated, perhaps as heavily populated as the Sacramento–San Joaquin fishing area. The south coast alone, not to mention the Achomawi-Atsugewi, the Colorado River, and the desert areas, would likely have brought the total up to 350,000. If there were 350,000 aboriginal Californians, then, according to Kroeber's figures (1939), almost a third of the Indians of the United States were in California. This seems ridiculous on the face of it and suggests that populations of other areas are underestimated if the California figures are correct. In the Southwest, for example, according to Kroeber's figures, the Rio Grande Pueblos had the highest population density, a density of 7.2 persons per square mile, or substantially less than that of the Sacramento–San Joaquin river area. Perhaps the most striking example of this nonconformity is to be observed in the southeastern United States, where the Natchez, with a civilization almost

TABLE 18

NATIVE POPULATION OF THE LOWER KLAMATH CULTURE PROVINCE AND THE CALIFORNIA CULTURE PROVINCE

Province	Area (sq. mi.)	Density (persons per sq. mi.)	Population
Lower Klamath Province	9,600	3.00	28,700
California Province	(69,200)[a]	(3.20)	(219,600)
Acorn-game adaptation	(66,200)	(2.90)	(189,600)
North Coast Range–Sierra Foothill Zone	22,300	5.00	111,500
Central Valley Zone	17,000	2.00	34,000
South Coast Range Zone	12,500	3.00	37,500
High Sierra Zone	10,400	0.25	2,600
Buena Vista Zone	4,000	1.00	4,000
Acorn-game-fish adaptation			
Sacramento–San Joaquin Zone	3,000	10.00	30,000
Total	78,800	3.20	248,300

[a] Figures in parentheses are subtotals.

on a par with that of Mexico, had, according to Kroeber's figures, a population density of only ½ person per square mile. That a civilization based on a well-developed agricultural economy would have been more sparsely populated than the poorest hunters-gatherers of California is improbable, to say the least. If the California figures are right the figures for the Southeast must be wrong.

But even if the comparative figures for other parts of North America are wrong and some upward revision is necessary, the fact remains that, if present figures are correct, the population density of parts of California was very high. This, together with the conclusion that the population was in a Malthusian equilibrium, suggests the reason that southwestern agriculture was never accepted in native California. It is widely held that Californians had ample opportunity to learn about agriculture but there is disagreement as to the reasons why they failed to accept it. C. O. Sauer (1936) maintained that environment was the determining factor, that the winter rain regime of California was unsuitable for southwestern plants, which depend on summer rain. Heizer (1958) disagreed with Sauer, stating his belief that the California acorn economy was sufficiently well developed to negate the appeal of an agricultural economy. The present population figures suggest that we may go even further than Heizer. They suggest that an agricultural economy would have been less productive than the native economy in the initial stages of introduction, before its techniques were well known, and therefore would have produced widespread starvation and hardship. The reasoning here depends on two facts—the relative density and state of equilibrium of the California population. If a hunting-gathering population had been sparse, as it must have been in the Southwest in preagricultural times, then even a relatively inefficient agriculture might have been more productive than the native economy. The state of Malthusian equilibrium means there was no slack, so that any diversion of manpower from the more productive native economy to the less productive incipient agriculture would result in a net loss of productivity. It is in fact possible that isolated individuals tried agriculture from time to time but were forced to give it up because of its lower productivity. Looked at in these terms it is clear that possible environmental barriers are irrelevant. Even if the food plants of the Southwest had been ideally suited to the California environment, the natives could not have taken up their cultivation without great hardship. All of this supposes, of course, that there was no massive invasion, such as that which occurred during the Spanish period, which might have forced a change of economy regardless of hardships.

The extremely dense populations of Central California also bring up another point worth mentioning here. Some years ago, Goldschmidt (1948) called attention to the fact that certain of the tribes in Central California had acquired rather well-developed unilineal kin groups, some almost approaching full-fledged clans. His data indicated that the unilineal organization was most strongly developed among the Nomlaki, the Patwin, and the Miwok, and less developed among the Yokuts, Mono, and Pomo. One cause of the development, he maintained, was the high population densities in Central California. In areas of dense populations one could not have intimate knowledge of everyone with whom one came into frequent contact. Therefore it was necessary to formalize relationships between people, and this was most easily done along family lines. Goldschmidt's hypothesis is substantially supported by the present population data: the tribes with strongest lineage organization are in the most densely populated areas—the north Coast Range–Sierra foothills zone and the Sacramento–San Joaquin river zone. I suspect that more adequate ethnographic data would yield even stronger support for the hypothesis. Thus the Yokuts data suggest a relatively weak development of unilineal organization, but none of the information on the Yokuts comes from the Delta area, where population was densest. The only group from the Sacramento–San Joaquin zone whose social organization is well known is the Patwin, and among these people the unilineal organization was as well developed as anywhere in California (McKern, 1922).

On the whole I feel that Goldschmidt is substantially correct in proposing a significant correlation between the development of unilineal kin groups and high population density.

This being so we may consider the California situation from the standpoint of cultural evolution. Let us take as an example the scheme that Willey and Phillips (1955) adopted as an organizational framework for the culture history of the New World. They recognized six stages (they called them historical-developmental stages): Early Lithic, Archaic, Preformative, Formative, Classic, and Postclassic. The stages are defined as follows:

Early Lithic.—The Early Lithic stage refers to small nomadic groups of big-game hunters who lived several thousand years ago. It is difficult to infer anything about their social organization. Those peoples are presumed to have been sparsely distributed and widely roaming, but even that conclusion is purely deductive, though probably correct.

Archaic.—The economy of the Archaic stage replaced dependence on hunting with a mixed subsistence pattern of hunting, fishing, and gathering. The main consequence of the change is found in the evolution of year-round or seasonally fixed settlement patterns and slightly larger populations. There are obviously many variations of this stage, for it includes both the sparsely settled Great Basin gatherers and the densely populated Northwest Coast fishermen.

Preformative.—The Preformative stage grows out of the Archaic. It differs from the Archaic only in that agriculture now forms a small part of the economy.

Formative.—Preformative peoples that have fully adapted to agriculture are designated Formative. The increased quantity and reliability of the food supply provide a basis for greater population density, sedentary settlement pattern (and architectural developments possibly associated with it), craft specialization, and increased ceremonialism.

Classic.—Change to the Classic stage seems to involve little change in the social organization. Ceremonialism and craft specialization are further emphasized, however, and these lead to an intense artistic development and perhaps also to the monumental architecture so noticeable in archaeological remains of the stage.

Postclassic.—In this stage of New World culture development, we find the beginnings of what would have been some truly momentous changes if they had been allowed to develop unaltered by European contact. In this stage true cities develop, cities with tens of thousands of people, having important political, economic, and religious functions and depending for food supply on a large territory. In this period also we find increased militarism, imperial dominance, and the beginnings of secular political control. The changes in this stage are comparable to those of the Mediterranean civilizations of 3000 to 1000 B.C., and later developments might also have been parallel.

The stages proposed are clearly a set of subsistence-demography-society relationships. Thus the Early Lithic subsistence pattern could not support many people; Archaic subsistence methods did support more people and allow them to develop fixed settlement patterns; the Formative, through its efficient agriculture, supported larger settlements as well as craft specialization and other social results.

The question is where to fit the California cultures into this scheme. Willey and Phillips (1955) put them into the Archaic but Heizer (1958) argued that if the scheme is to be used, California fits more properly in the Formative than the Archaic stage. In a revised version of their earlier work (1958), Willey and Phillips have included the Central California cultures in the Formative.

Now, it is quite true, as Heizer argued, that the abundant and assured food supply of the Central Californians (and of the Northwest Coast peoples as well) created a demographic and, therefore, a social situation that was in many ways comparable to that of the Puebloans, to take an example of a Formative culture.

But one essential thing was lacking. The Puebloans, with their agricultural economy, could, through technical innovations, increase their food production and in turn their population so that they could ultimately achieve a more developed cultural level, perhaps comparable to that of the Valley of Mexico. In other words, an agricultural economy is expandable—not, perhaps, indefinitely, but certainly beyond what is now foreseeable. The Central Californians, on the other hand, had evidently reached about the limit of productivity, given a nonagricultural economy, and therefore could have progressed no further unless they abandoned their economy and started on a new tack. It therefore seems to me to be a mistake to class the Californians with agriculturalists, especially under the term Formative, since their economy was blocked from "forming" a subsequent stage.

What seems a desirable solution is a more elaborate classification of the preagriculturalists. I would suggest a two-dimensional classification—one dimension concerned with the traditional subsistence patterns of the people in question and the other depending on the environment in which they found themselves. For example, one group might be marine fishermen who would occupy territory with good, fair, or poor marine fish resources. The two dimensions would undoubtedly not be entirely independent—one would not expect to find marine fishermen in territory of poor marine fish resources—but they would not be entirely dependent either, since it is a fact that marine fishermen do occupy territories of variable resources. I will not propose at this time a complete classification of this sort, but only suggest some divisions that seem applicable to the California situation.

1) *River and Coastal Fishermen.*—This is the economic type of the Lower Klamath province in California. The fish resources available in the province were quite rich and a moderately high population was therefore attained. If the people had also been marine fishermen they would have had much greater resources available and would presumably have had even greater population. As it was, their density of 3–5 persons per square mile was not great enough to encourage the elaborate social forms found farther north on the Northwest Coast.

2) *Gatherers-Hunters.*—This economic type was found throughout most of the California province. One may postulate four subtypes within this group, depending on the richness of the environment. They correspond to the various environmental zones discussed earlier, and have population densities of 0–2, 2–3, 3–5, and 5–7. Only in the subtype of greatest density do we find the more elaborate social forms characteristic of higher cultures.

3) *Gatherers-Hunters-Fishermen.*—This is the economic type found along the Sacramento and San Joaquin rivers. The environment there is extremely rich so that population density was very high, and the formal social organization was accordingly well developed.

Another possible economic type in the California province is the coastal shellfish collectors. Unfortunately, the present data touch on these people only marginally, so it is not possible to make any statements about them.

One hopes that a series of well-defined categories such as these could, together with accurate data on their demography and geography, provide an adequate framework for interpreting preagricultural society.

APPENDIX

Summary Table for California Tribes with Known Population

Tribe	Population	Area[a]	Density[b]
Lower Klamath Province	18,739	4,412.6	5.33
Tolowa	2,400	955.1	2.51
Yurok	3,100	740.9	4.18
Karok	2,700	1,053.4	2.56
Wiyot	3,200	297.4	10.76
Hupa	1,475	428.4	3.44
Whilkut	2,588	463.7	5.58
Mattole	1,200	219.2	5.47
Lolangkok Sinkyone	2,076	254.5	8.16
California Province, North Coast Range	30,300	5,029.6	6.02
Wailaki	2,760	415.8	6.64
Coast Yuki	750	178.9	4.19
Yuki	6,880	1,169.2	5.88
Northern Pomo	7,010	1,194.4	5.87
Eastern Pomo	1,410	284.7	4.95
Central Pomo	3,440	693.0	4.96
Southeastern Pomo	1,070	206.6	5.18
Southwestern Pomo	1,480	274.6	5.39
Wappo	4,600	519.2	8.86
Lake Miwok	900	93.2	9.66
California Province, San Joaquin Valley	62,628	19,844.8	3.16
Plains Miwok	14,350	1,290.2	11.12
Central Miwok	4,410	2,870.3	1.54
Southern Miwok	5,766	1,905.1	3.03
Northern Hill Yokuts	3,900	362.9	10.75
Kings River Yokuts	4,750	612.3	7.76
Tule-Kaweah Yokuts	4,200	748.4	5.61
Poso Creek Yokuts	1,500	604.8	2.48
Southern Valley Yokuts	15,380	6,572.2	2.34
Buena Vista Yokuts	1,340	1,461.5	.92
Western Mono	7,032	3,417.1	2.06

[a] Square miles.
[b] Persons per square mile.

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ABBREVIATIONS

AA	American Anthropologist, Menasha, Wisconsin
AMNH–B	American Museum of Natural History Bulletin, New York
BAE–B	Bureau of American Ethnology Bulletin, Washington
UC	University of California Publications, Berkeley and Los Angeles
–AR	Anthropological Records
–IA	Ibero-Americana
–PAAE	American Archaeology and Ethnology
UCAS–R	University of California Archaeological Survey Reports, Berkeley

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