Comparative Traditional Economics and Ecological Adaptations

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Environment (biological and nonbiological) has been an extremely important general factor in the explanations and counter-explanations offered by ethnologists and archeologists to account for economic, kinship, and ritual organization among Pueblo cultures in the American Southwest. Beginning, perhaps, with Bryan (1929) and Steward (1937), anthropologists and geographers have sought to correlate variations in Pueblo environment with variations in Pueblo social and ritual organization (see Dozier 1970; Eggan 1950, 1966; Longacre 1970; and Ortiz 1972 for a sampling of this extensive literature). Pueblos have been central in these discussions; other Southwestern peoples have not had their social and religious organizations probed and explained in reference to environment on nearly so large a scale. Because of the unusually wide variation of cultures, languages, and, for want of a better term, microenvironments in the Southwest, there existed the need for all Southwestern tribes to be analyzed for cultural and environmental similarities and differences. In this fashion the explanations of Pueblo culture can be controlled through comparisons with non-Pueblo culture, and vice versa. Such comparisons are controlled here by working with 37 tribes or culture units representing all the language groups in the Southwest. (The term tribe is used here, even though some of these units do not correspond to the usual definitions of tribe.) The topic analyzed is restricted to economics and ecological adaptations: not ecology, kinship, or ritual. Whereas kinship and ritual are distinguished from economy for analytical purposes, "traditional economy" is deeply embedded in kinship and ritual organization. Examples for analysis are: whether or not land-owning and land-inheriting groups are organizations of kinsmen; whether or not producers of crops share their products, and if so with whom (kinsmen or others); whether or not ritual is a part of the sharing, reciprocity, redistribution, or gifting of economic resources; and the like. This is to say that whereas kinship and ritual, as such, are not the central topics of concern, they are critical to the following analysis nevertheless. Thus, in comparing traditional economics among Southwestern peoples it was necessary to define and measure information about (1) technology and material culture—tools and their uses, techniques of food extraction and production, and other products and techniques by which people articulated with their environments; (2) subsistence economy—the contributions of various types of foods to the local diet, the manner and places in which the foods were procured, the ways in which economic goods were transported, and the manner and duration of food storage; and (3) economic organization—the organization of extraction and production including the division of labor by sex, age, task groups, and specialization; the reciprocity, distribution, gifting, and sharing of access to resources; the ownership and the inheritance of property. It was also deemed important to compare Southwestern tribes for demographic information on the sizes of local community populations and the population densities in their approximate tribal territories. For information about how and what information was selected, collected, and analyzed see the explanation of methodology at the end of this chapter.

In order to analyze the ecological adaptations and to measure the relations between ecology and economy, ecological areas are defined as physical contexts, including physiography and climate, and the animals and plants that occupy those contexts. The measures of ecology are, of course, selected from an indefinitely large amount of information about biological and nonbiological environments and the relations that obtain within these environments. It is important to stress that within environments, no matter how environmental space is circumscribed (that is, as some definite or indefinite form), the phenomena and the relations among phenomena are infinite. For instance, indefinitely many surface phenomena can be intercorrelated, as can subsurface phenomena, and these two sets can, in turn, be intercorrelated.

"Ecological adaptations" has come to convey the meaning in some quarters of anthropology that human, other animal, and plant populations interact in physical space in such ways that the human population—usually unwittingly, but not necessarily so—has optimized its viability. It has, in brief, enhanced its survival probabilities by "adapting" to other aspects of a nonrational (human intentions, or reasons, or dispositions for causing them to act as they do are not required), self-reg-

ulating system. This chapter does not make such claims for ecological adaptation. Because all Southwestern tribes were practicing customs of one sort or another and occupying definable spaces at contact, it is a trivial truth to say that all were ecologically adapted. Ultimately an adaptation is anything that works. It is quite another thing to allege that "whatever is" (the nature of the tribes' economic organization), "had to be" (the tribe's economy is organized as it is because it had to be so organized). The lawlike explanation is a nonsequitur.

This chapter assesses the relations between environment and economy to learn whether scholars can postdict why economies of particular constellations of resource production and management features correlate with constellations of environmental features. It tests several hypotheses about environment-economy relations through nonmetric, multivariate techniques, or through a method of explicitly controlled and formally measured comparisons. This is not a review of the various ecological explanations that have been advanced to account for Pueblo society. The methodology employed in making these comparisons is described in the final section so as not to detract from the discussion in the text. Yet at a few points some relatively technical information must be introduced.

The sample used here of 37 Southwestern culture units (fig. 1) was drawn from a larger study of 172 culture units in Western North America (Jorgensen 1980). The culture units follow, organized by language family and subfamily membership. Elsewhere in this chapter they are referred to by means of partially overlapping classifications. For example, sometimes the Tewa are referred to separately, and sometimes the term Eastern Pueblos is used to include the Tewa (represented by Santa Clara, Nambe, San Juan, and San Ildefonso) and Taos. This use of the term Eastern Pueblos is different from that in "Pueblos: Introduction" (vol. 9). The term River Yuman is used as a cultural label to include both the River branch and the California-Delta branch of this linguistic classification.

All these groups are also treated elsewhere in *Handbook* volumes 9 and 10, except for the Tipai, who are described in volume 8, and the Lipan, in volume 13.

Yuman
- Upland Yuman—Havasupai, Walapai, Yavepe Yavapai (Verde Valley), Kewevkapaya Yavapai
- River Yuman—Mohave, Quechan, Maricopa
- Delta-California Yuman—Cocopa, eastern Tipai

Uto-Aztecan
- Pima, Papago; Hopi

Apachean (Athapaskan)—Western Apache: Northern Tonto, Southern Tonto, San Carlos, Cibecue, White Mountain; Chiricahua Apache: Warm Spring, Huachuca; Mescalero Apache; Lipan Apache; Jicarilla Apache; eastern Navajo, western Navajo

Zuni

Keresan—Acoma, Zia, Santa Ana, Santo Domingo, Cochiti

Tanoan (Kiowa-Tanoan)
- Tewa—San Juan, San Ildefonso, Santa Clara, Nambe
- Tiwa—Taos, Isleta
- Towa—Jemez

The 37 culture units in the sample are not the total universe of Southwest culture units. Because the ethnographic information was meager, it was necessary to eliminate some River Yumans, such as Halchidhoma and Kavelchadom; Tolkapaya Yavapai; some Tanoan Pueblos, such as Pecos and the doubtfully classified Piro; some Pima and Papago (especially the Salt River, Santa Cruz River, and San Pedro River Pimas, and the Río de la Concepción Papagos); and most of the Mexican groups. Nevertheless, the sample is extremely large relative to the total number of sixteenth-, seventeenth-, and eighteenth-century culture units in the Southwest.

An Overview of Southwest Environment and Culture

It will be helpful to know whether the measures employed to evaluate the relations among the environments of the 37 tribal territories in these comparisons reproduce a distribution of environments that is consonant with traditional expectations. That is, will the mountainous regions of central and southeastern Arizona occupied by Apaches be distinguished from the Colorado Plateau occupied by western Navajos and Western Pueblos, and the river plains occupied by the Yuman speakers? and so forth. Figure 2 is a two-dimensional mapping of the relations among the environments of the 37 tribes. The shorter the distance between any pair of tribal territories represented by points, the more similar the environments of the tribes.

The ordering of the environments is based on 134 separate variables for each tribal territory covering 334 different items of information about, among other things, the altitude range in each territory, the annual average precipitation, the range of average temperatures in January and July, the latitude and longitude ranges, and the numbers of species and the intensities of distributions of oaks, pines, cacti, mesquite, screw bean, mescal, yucca, sotol, berries, roots, grasses, ferns, lilies, mammals, fishes, and birds.

It is apparent that the Papago of the Sonoran Desert occupied an environmental niche most different from all other groups, and that the Tewa Pueblos (San Juan, San Ildefonso, Nambe, Santa Clara) and the Eastern Keresan Pueblos (Zia, Santa Ana, Santo Domingo,

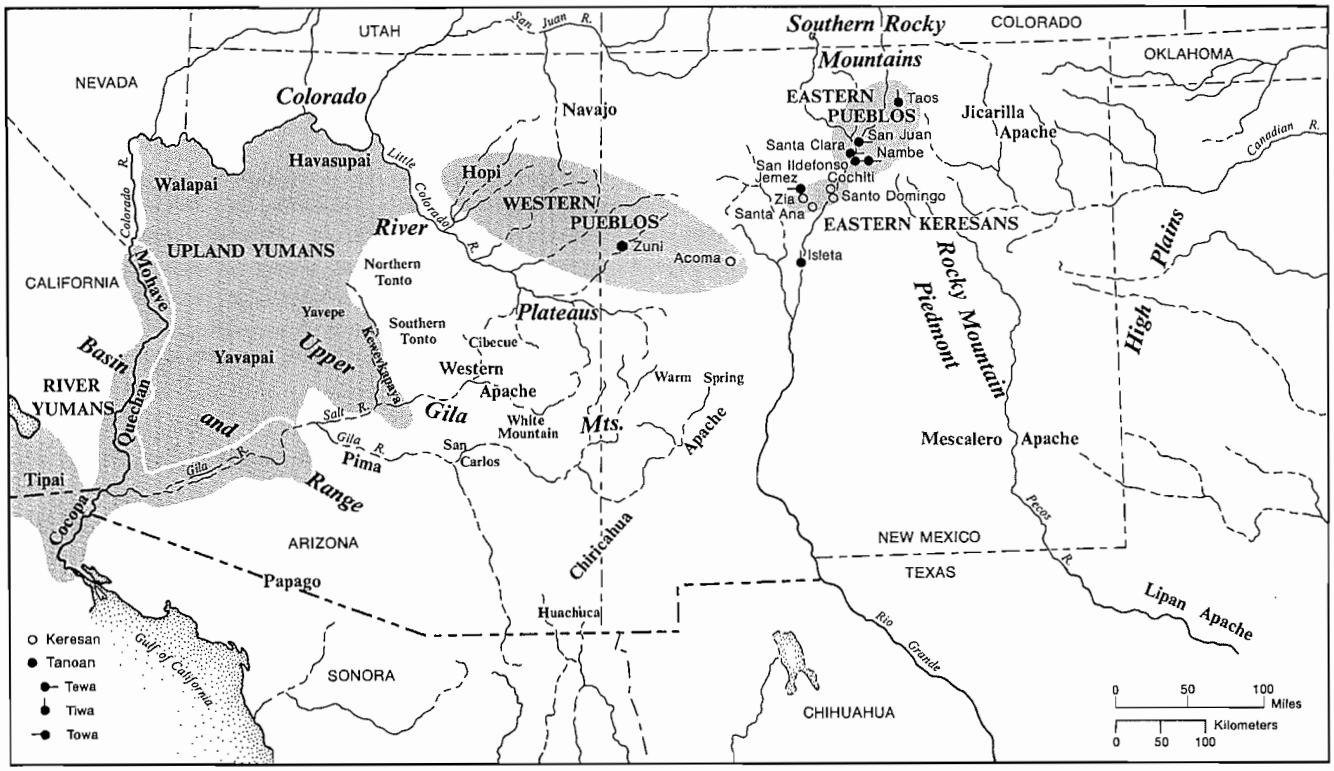


Fig. 1 Major physiographic regions of the Southwest (after U.S. Geological Survey 1970:61) and tribes evaluated in this chapter.

Cochiti) occupied the most similar micro-environmental niches. Indeed, the Pueblos in general, plus the Navajos and the Jicarilla Apache of the Colorado Plateau and the northern New Mexico Rocky Mountain and Rio Grande region shared a relatively similar environment overall. On the other hand, internally the Pueblo groups were much more similar to each other in their articulations with the environment and their economies generally than they were to their Athapaskan-speaking neighbors.

The western and eastern Navajos occupied territories that covered predominantly steppe and mountain life zones and that generally had meager precipitation (7 to 11 inches, although up to 26 inches in the mountain regions above 7,500 feet). Most of the precipitation came from summer storms, although winter storms helped account for the precipitation at higher elevations. The growing seasons varied from 170 days in the lowest elevations to 95 days in the mountain zones. Except for the relatively inaccessible Colorado River, and the somewhat more accessible San Juan River, most Navajos relied upon intermittent springs, seeps, streams, and small lakes for water. Furthermore, in this high (3,500–10,000 feet), arid (high evaporation rates), diverse area, high winds occurred periodically.

It is possible that for perhaps 700 years prior to A.D. 1000 the area in question received more precipitation than after A.D. 1000. Furthermore, the greatest amount of annual precipitation appears to have occurred during the winter periods (see R.G. Vivian 1970:75–78 for a review of the literature on this topic). After 1000 the pattern seems to emphasize a dwindling precipitation rate and a focus on summer accumulation. The recession of far-flung Pueblo occupations from the length and breadth of the entire area between about 1000 and 1300 is well documented (Longacre 1970). People who once farmed maize, beans, and squashes in scattered homesites located almost wherever it was practicable to farm—and to hunt deer, rabbits, antelope, sage hens, Rocky Mountain bighorn sheep, and to collect sundry wild plant products—evacuated the vast majority of territory. By the time the Athapaskan-speaking Navajos and Apaches entered and began to spread across the area, perhaps no earlier than the sixteenth century (Gunnerson and Gunnerson 1971:7–22), Puebloans were using it only for hunting, gathering, and religious and trade excursions. The question has not been answered about whether Navajos and other Athapaskans who took up farming initially learned the techniques from Pueblo Indians (Hester 1962:51; Opler 1971:32), or from Plains village farmers (Driver 1966), or both; that is to say, some Athapaskan speakers learned farming and pottery-making from Plains farmers whereas others learned it from Pueblo farmers (Gunnerson and Gunnerson 1971:7–22). The question is not trivial as it has become part of a larger question about the origin

of matrilocal residence, matrilineal descent, and parent-in-law and children-in-law avoidances among Navajos and Western Apaches (Driver 1966; Kaut 1974; Dyen and Aberle 1974).

Sidestepping the question about the origin of matri-centered kinship organization (the Western Pueblos and the Eastern Keresan Pueblos are predominantly matricentered) and the origin of in-law avoidance customs among Navajos and most Apaches (no Pueblo group practiced these customs, whereas most Plains farmers did), it is not too daring to speculate that prior to about 1550 the Southern Athapaskans were, for the most part, scattered along the western Plains. They were predominantly hunters of bison, although some Athapaskan groups—the proto-Navajo in particular—might well have gained some sustenance from horticulture. The proto-Navajos moved into some unoccupied niches and contested for other niches with Pueblos, hunting large game (deer) as well as small (rabbits and prairie dogs), collecting plants, and, where there was sufficient water on alluvial plains, washes, or near springs, also farming. The diversity of the environment, no matter how meager the resources, tolerated a wide range of simple extractive pursuits, as well as farming. In preceding centuries Pueblo Indians had proved that farming could be done on river plains at 3,500 feet and on foothills and mesas at 7,500 feet.

The Pueblo groups occupied environments much like parts of the Navajo environment. The Hopi and Zuni lived on arid mesas, or steppe life zones. The Hopi did not have permanently flowing streams and, whereas the Zuni had a stream, it was not used for farming. Indeed, Hopi, Zuni, and Acoma (the Western Pueblos), lived in environments more similar to the western Navajos than to the Eastern Pueblos. Similar to the western Navajos, the Acoma, Zuni, and Hopi relied on rainfall, seeps, springs, and wash-offs for their farming.

The Eastern Pueblos, on the other hand (represented by Taos, Santa Clara, Nambe, San Juan, and San Ildefonso in figure 2), located their villages and farm sites on the banks of the Rio Grande and its tributaries. Not only did the Eastern Pueblo villages get greater precipitation from storms attracted by the mountains, as in the mountainous regions occupied by some Navajos, but also they had regular sources of water from the river system. Furthermore, Eastern Pueblo groups positioned their farmland at elevations lower than the river, thus availing themselves of a longer growing season than was enjoyed in the steppe areas, yet also placing themselves to draw water from the river by gravity flow.

As was pointed out by Eggan (1950) and others, Eastern Keresans and the Jemez Towa were situated on tributaries of the Rio Grande that were not nearly so conducive to farming as were the areas occupied by the Eastern Pueblos. The tributaries ran only intermittently, the rainfall was more sparse (about 10 inches) than in the adjacent Eastern Pueblo areas, and although they hunted and gathered, their hunting range was restricted by Navajos.

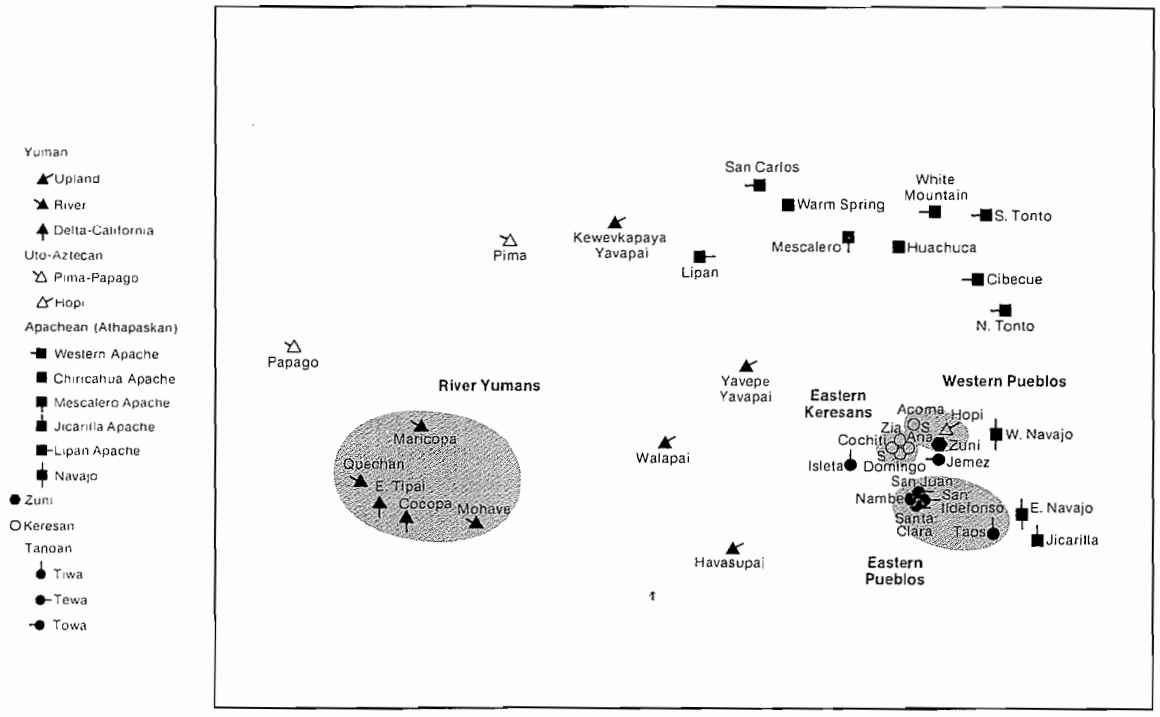


Fig. 2. Total environment in aboriginal Southwest. MINISSA smallest space analysis in 2 dimensions. Ranked G-coefficients based on 134 variables (334 attributes). K = .10 in 24 iterations.

Whereas the Eastern Pueblos did practically no dry farming, the Eastern Keresans did some dry farming and some irrigation farming, and the Western Pueblos relied almost wholly on rainfall and wash-offs.

South and west of the Pueblo-Navajo area the Western Apaches (Northern Tonto, Southern Tonto, Cibecue, White Mountain, San Carlos) occupied the desert, steppe, and mountainous areas of central and eastern Arizona. Both the desert areas and the steppe areas were at lower elevations (2,000 to 5,000 feet) than were the comparable areas farther north. Concomitantly, the growing seasons were somewhat longer (116 to 295 days) in the Western Apache territory. The annual precipitation was somewhat greater (10 to 30 inches) than in the north; and there was definitely a greater variety of edible plants, including cacti, mescal, and mesquite, in the more southerly area. The Salt and Gila rivers and their tributaries traversed Western Apache territory, and whereas some local groups farmed on the river bottoms, others farmed near seeps and springs at the higher elevations in the transitional biotic zones of the steppe (see Goodwin 1942; Griffin, Leone, and Basso 1971).

The Chiricahua (Huachuca, Warm Spring) and Mescalero Apache occupied environments that were more similar to those of their Western Apache congeners than to any other groups in the Southwest, and this is demonstrated in figure 2. Furthermore, except that the Mescalero, who were located east of the Rio Grande in what is now New Mexico, had access to bison on the southern Plains, the Chiricahua and Mescalero exploited contiguous territories that were very large—ranging throughout deserts, steppe, and mountains from the Pueblo villages in the north through the northern states of Mexico in the south (Castetter and Opler 1936). The Mescalero and Chiricahua were mountain dwellers who regularly exploited the mescal, mesquite, cacti, oak, piñon, grasses, large and small mammals, and other food resources throughout their ranges. Castetter and Opler (1936:3–63) analyze over 100 plants used by these people for food, drink, and narcotics, and they do not pretend to present a complete inventory of all plants used.

Unlike their Western Apache and Navajo counterparts, Mescalero and Chiricahua Apache did very little farming, although they did some. Castetter and Opler (1936:27) are of the opinion that these mobile hunters and gatherers did practically no farming in the aboriginal period, presumably extending back to the sixteenth century. They do not consider whether these Apaches began to rely less upon horticulture either with their acquisition of the horse and the greater range horses provided for hunting and gathering, or with their movement from the western plains to the less salubrious, for horticultural purposes, mountains, steppe, and deserts of southeastern Arizona and New Mexico during the competitive equestrian hunting period. It is known, for instance, that Cheyenne and, perhaps, Crow Indians gave up most or all of their horticultural pursuits during the equestrian hunting period. The Mescalero and Chiricahua could have done likewise.

Several mountain ranges and high basins, as well as steep canyons and low flatlands are distributed in the area. The low, desert areas had extremely meager water supplies, and the highest mountains had springs and heavy snow packs. To the east the Pecos River and Rio Grande cut through some of the valley floors and provided nearly constant water, but for the most part streams in the Chiricahua and Mescalero areas ran intermittently. The Apaches are said to have been masters of their huge territories, moving with the seasonal changes and pursuing the wild food harvests, plant and animal, as they occurred (Castetter and Opler 1936:10–15).

In figure 2 the crescent-shaped distribution of Apache environments and the ball-like distribution of Pueblo-Navajo environments are separated from the River Yuman environments (Maricopa, Quechan, eastern Tipai, Cocopa, Mohave) by a string of steppe-desert dwellers, the Upland Yumans (Havasupai, Walapai, Yavapai).

The Havasupai once occupied the territory as far east as Moenkopi near what is now Tuba City, Arizona. But according to Spier (1928) the Havasupai were displaced by Navajos and from the early nineteenth century occupied Supai canyon (3,200 feet) in the Grand Canyon from March through September. During these months they farmed, yet in October they split into small groups of families and returned to the Coconino Plateau, a semiarid limestone plateau 6,000 to 7,000 feet above sea level, staying there until the following spring. Whereas Supai was much warmer during the late fall and winter months, the Havasupai scaled the plateau in order to hunt bighorn sheep, and to collect yucca, grasses, mesquite, and mescal on the way up, and juniper berries, piñon, and seeds on top. The winter snow accumulation provided water and also made it easier to track rabbits, deer, and antelope on the plateau.

The Walapai, near neighbors of the Havasupai, did not have rich canyon farmland. Rather, they were strung out along the bases of several cliffs and mountains, occupying dry transitional steppe areas between desert and mountains. Cacti and mescal were available, as were some acorns, walnuts, and piñons at the highest elevations. Yet the Walapai territory was primarily washes and undissected plains, basins, or valleys. The rains were in the late summer and early winter and the precipitation was very sparse, averaging about six inches a year.

The Walapai convened winter camps of several families and hunted bighorn sheep, antelopes, and rats but split into even smaller hunting and gathering groups

during spring through fall as they sought edible plants, small game, and water. Thus, they convened and dispersed in a pattern completely opposite to the Havasupai. According to Kroeber (1935) these mobile people claimed to have tried farming in only two locales in the territory they occupied in the nineteenth century.

The Yavepe (Northeastern Yavapai) occupied upper Verde Valley in central Arizona and were separated from the Walapai and Havasupai to the north by uninhabited land that was used periodically by the Northern Tonto Western Apache. The Yavepe hunted antelope in Lonesome Valley and deer, rabbits, and rats wherever available. Mescal was the most important single wild food in their diet, but they also relied on the giant saguaro cactus, sunflower seeds, and many more wild plants. The Yavepe farmed maize and tobacco at contact, but not beans and squashes, nor did they plant panic grasses and other wild grasses used by their River Yuman congeners.

The Kewevkapaya (Southeastern Yavapai) were located in the desert canyon country south and west of the Yavepe and bordered on the south and east by the San Carlos Apache. They farmed even less than their northeast counterparts in the period when they were adjacent to Western Apache. Whereas the Yavapai had access to waters of the Gila and Salt rivers and their environment was as similar to the Gila River Pima as it was to the San Carlos Apache, by the nineteenth century they primarily supported themselves by collecting mescal, mesquite, acorns, cacti, seeds, berries, roots, and bulbs, and by hunting deer and bighorn sheep. The growing season was long (290 days), and the precipitation was meager (3 to 10 inches per year), but the Salt and Gila provided water—even two floods a year in some locales.

It is interesting that the Kewevkapaya did not farm more, and that they did not rely more upon domesticates in their diet. Of course, the same can be said for the Western Apaches and the River Yumans.

The River Yumans are set off from all other groups. The Mohave, Quechan, eastern Tipai, and Cocopa occupied the floodplains of the Colorado River and the hot deserts above (rainfall about four inches a year, mean temperature about 70° F., growing season 300 days). A flood of the Colorado deposited silt on the river plain at least once each year, yet the plain remained moist all year through subsurface capillary action, and it supported mesophytic vegetation. The rocky, arid mesas above the plain supported only xerophytic plants (Castetter and Bell 1951).

Bottomlands supported mesquite and screw beans in considerable numbers, as well as many wild grasses (which they planted), roots, nuts, cacti, and yucca (Castetter and Bell 1951:187–188, 200–201, 204, 205). The desert environment did not provide either abundance or variety of animals. Small groups of deer, mountain sheep, and antelope browsed in the mountains at some distance and were not especially important. Rather, rats (*Dipodomys* spp.), rabbit (*Sylvilagus audubonii*), jackrabbit (*Lepus californicus*), migratory ducks, and freshwater fish were the most important of all. The Cocopa even fished for ocean fishes and shellfishes. Other small animals eaten occasionally included lizards (*Sceloporus clarkii, S. magister*), ground squirrels, beavers, and coyotes. The humpback sucker, the Colorado squawfish (*Ptychocheilus lucius,* a three-foot-long minnow), the bonytail (*Gila elegans*), and the mullet were the most important fishes.

The Maricopa were located on the Gila River, upriver from its confluence with the Colorado. The Gila had more fertile land than the Colorado and regularly flooded twice a year. Two floods on the Colorado were much less predictable but did occur from time to time. In general the Maricopa had access to practically all the types and quantities of subsistence resources that were available to their Colorado River congeners, but in addition they had land and water that made farming a more stable source of food products than was the same pursuit on the Colorado. Two floods, even when the farmer relies upon capillary action of subsurface water to irrigate the crops, allows for two plantings and two yields a year. Nevertheless, the Maricopa culled less of their diet from farm products than some of the Colorado River groups, and substantially less than their neighbors on the Gila, the Uto-Aztecan-speaking Pima. The Pima and Papago spoke the same language and shared many culture traits but occupied different environments. The Papago had considerably fewer water resources and therefore possessed a very different subsistence economy.

The Pima, situated on the fertile plains of the Gila with an annual growing season of 295 days, not only utilized the two floods a year for two plantings but also developed a canal system of irrigation with dams and ditches. Not even the Maricopa developed canals until very late (about 1850 according to Castetter and Bell 1942). Nevertheless, the Pima and their desert-dwelling relatives, the Papago—who had an "impoverished marginal version of the Gila Pima irrigation system" (Castetter and Bell 1951:239)—exploited the mescal, mesquite, screw bean, cacti, grasses, and small game in their areas. The major differences were that the Pima used wild food sources much less, and the Papago used wild food sources much more than any of the Yuman-speaking farmers.

It is apparent from these generalizations about tribal environments in the Southwest that four major types of environments prevail. Most Apacheans reside in territories that encompass mountains, steppe, and deserts. The Western Apache have access to more water than most other Apachean speakers, whereas Mescalero and Chiricahua had a wider range of wild foods available

to them spread over a much wider and more diverse desert terrain than did their Western Apache neighbors.

The Pueblos and Navajo and Jicarilla reside on the high Colorado Plateau and Rocky Mountain zones of the northern Southwest. Only the Eastern Pueblos of these groups have regular, year-round sources of water, as well as abundant fish. The growing seasons were much shorter in the north than in the south, and the cacti, mescal, mesquite, screw bean, and several species of grasses distributed in the more southerly areas had much narrower distributions in the north. On the other hand deer, mountain sheep, and several species of small mammals, including rabbits, rats, and prairie dogs, were as abundant in the mountains and on the mesas of the north as in the south.

In the south and west of the Southwest, along the courses of the Gila, Salt, and Colorado rivers, Pima-Papago and Yuman speakers enjoyed year-round water, abundant fish, long growing seasons, and rich silt deposits from river floods. Yet their terrains did not provide large mammals, small mammals, or even wild plants in the amounts available in the eastern half of the Southwest. Nevertheless, mescal, mesquite, screw bean, panic grass, and scores of other species were available, if in sparser distributions. The desert-dwelling Papago did not, except for a very few local communities, enjoy continuous running water.

Between the river dwellers in the south and west, and the mountain-steppe-desert dwellers in the east, were the Upland Yumans situated throughout the mesas and deserts of what is now central Arizona. Only the Walapai occupied land not suitable for horticulture, yet only the Havasupai engaged in much farming.

To get an impression about overall culture similarities and differences for the 37 tribes in this sample, see figure 3, which is a two-dimensional mapping of the cultural distances among the tribes. As in the previous figure, the closer any pair of the constellation of points, the more similar the cultures. The measure for "total culture" is based on 292 variables covering information about technology, subsistence economy, economic organization, settlement pattern, community organization, kinship organization, political organization, sodalities, warfare, ceremonies, life cycle observances, shamanism, and magic. Figure 3 shows that the Yuman speakers form a chain from Quechan at the top to Kewevkapaya and Walapai at the bottom. The clear break between River Yuman and Upland Yuman environments, so noticeable in figure 2, does not occur. Indeed, language relations are a much better fit with overall similarity of Yuman cultures than are environmental areas. The riverine farmers and fishers are linked to the nonfarming or very minimally farming Walapai and Yavapai through the riverplain farming Havasupai. The Uto-Aztecan-speaking Pima and Papago with critically different environments—fertile river plain versus desert—are separated from all other Southwestern cultures, even though the Pima environment was more similar to the Kewevkapaya and the Maricopa than it was to Papago.

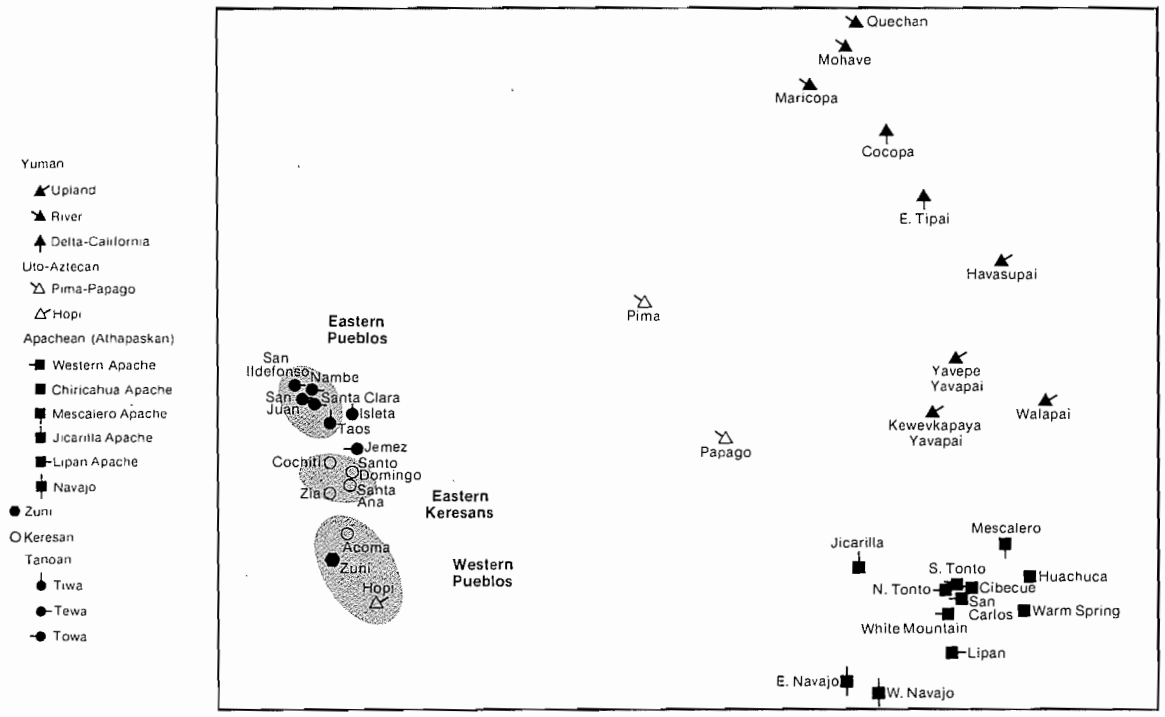


Fig. 3. Total culture in aboriginal Southwest. MINISSA smallest space analysis in 2 dimensions. Ranked G-coefficients based on 292 variables (1,577 attributes). K = .13 in 13 iterations.

The Athapaskan speakers form a third recognizable distribution. The Western Apache are in the center with the Mescalero, Chiricahua, and Lipan forming a semicircle on one side, while the Navajo and Jicarilla are pulled off toward the other side. The cultural affiliations of the Navajo and Jicarilla are much better accounted for by language affiliation than by environmental similarities, as figure 2 attests. The Athapaskan speakers who probably began moving into the Southwest during the early sixteenth century maintained considerable similarities even though they came to occupy a vast area.

The double column of Pueblo cultures, separated a considerable distance in the euclidian space from the other three distributions of cultures, reproduces a predictable order among the Tanoan-speaking Eastern Pueblos at the top through Hopi at the bottom. Indeed, while addressing ecological, kinship, sodality, and ritual information, Eggan (1950) suggested that all the Pueblos once shared a common "social structure." The Tanoan speakers moved east into a new environment and their structures were reshaped. Keresans, Eggan averred, lent support to this view by retaining some early Pueblo features but changing others toward forms similar to the Tanoans. They formed a "bridge" between Eastern and Western Pueblos. The Western Pueblos retained the basic structures and were used as the bases for comparison. Figure 3 demonstrates that the Tanoan speakers (San Ildefonso through Jemez) are linked to the Eastern Keresan speakers (Cochiti through Zia), who are linked to the Western Keresan-speaking Acoma, who are linked to the Zuni, who are linked to the Hopi.

It is doubtful that the differences in environments account for the differences in culture, but a look at figure 2 will attest that the Keresan speakers occupy environments more similar to the Western Pueblos than to the Eastern Pueblos, except for Jemez. Thus it is reasonable to ask whether environmental differences, or the organization for agricultural production with irrigation, made possible by bottomland of the Rio Grande and its tributaries, or both, accounts for the differences among Eastern Pueblos, Eastern Keresans, and Western Pueblos—keeping in mind that culture similarities for the Pueblos, as for other groups in the Southwest, fit more closely with language similarities than with environmental similarities, and furthermore increasing the scope of the question to account for other environments and economic organizations in the Southwest.

Technology, Subsistence, and Economic Organization

At contact some form of horticulture was practiced by all groups in this Southwestern sample, except perhaps for the Kewevkapaya, Mescalero, Chiricahua, and Lipan Apache, and albeit minimally for the Yavepe and the Walapai. Figures 4 and 5 are two representations of the relations among tribal technologies as they are

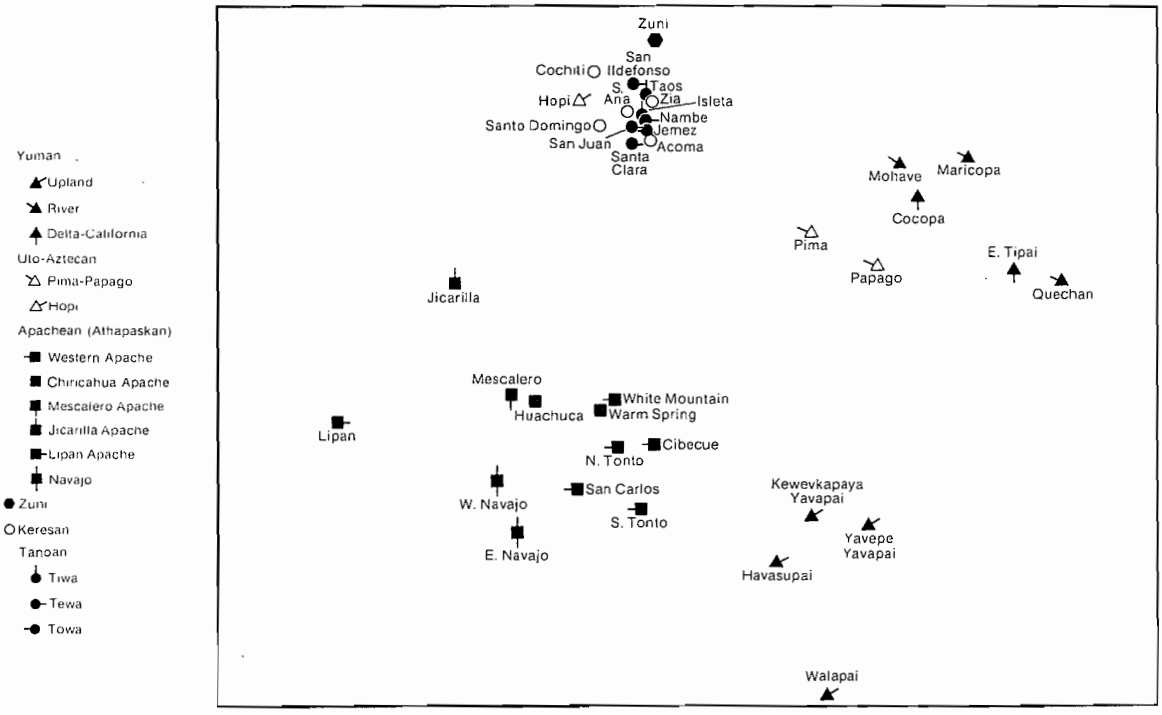


Fig. 4. Technology in aboriginal Southwest. MINISSA smallest space analysis in 2 dimensions. Ranked G-coefficients based on 46 variables (204 attributes). K = .15 in 12 iterations.

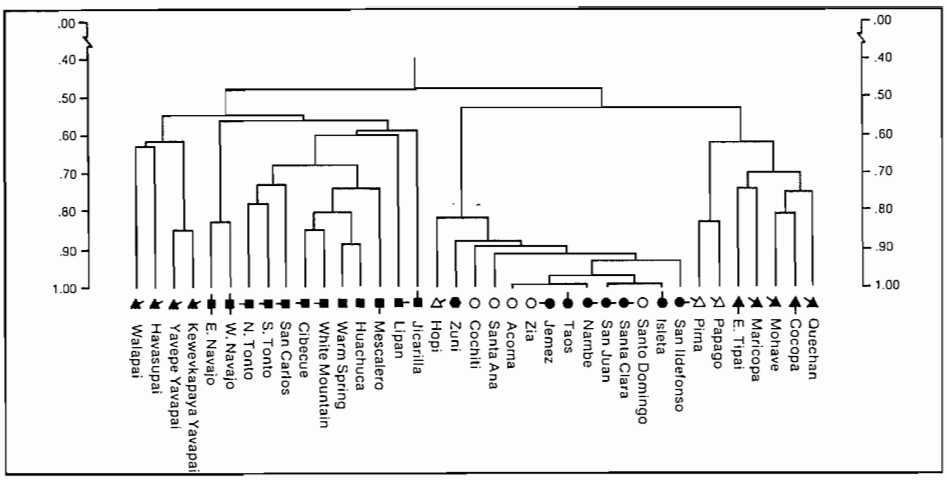


Fig. 5. Technology in aboriginal Southwest. Jorgensen's nonmetric tree in one dimension. G-coefficients based on 46 variables (204 attributes).

measured from 46 variables covering information on techniques and equipment for hunting, fishing, gathering wild plants, horticulture, food preparation and preservation, boats, housing, clothing, and weaving. Figure 4 represents the relations in two dimensions but does not preserve metric information. Figure 5 represents the relations in one dimension, but it preserves the information about the strength of the associations between pairs and among sets.

It is evident that the groups in the Southwest, when compared for technology, organize into: Pueblo, River Yuman and Pima-Papago, Upland Yuman (Pai), and Athapaskan clusters. The overall resemblance among the Pueblos is obvious from both figures, even though the Eastern Pueblos practice farming with an irrigation system of canals, dams, and ditches and gravity flow; Eastern Keresans use dams, ditches, and terraces; and Western Pueblos use dams and terraces. The various forms of water impoundment and diversion—from the Western Pueblo forms of controlled wash-offs and heavy rains to the Eastern Pueblo uses of main canals and a tributary system—are used in a context of marked similarity of technological items and techniques. This is quite remarkable considering that the Rio Grande and mountainous areas inhabited by most of the Tanoan speakers had relatively abundant fish resources (annually 50–100 pounds of fish per average square mile of territory), more grass species, a greater amount of browse, more abundant large game, and, for the more southerly Tanoans, even more species of mesquite, mescal, and cacti than the Keresans and Western Pueblos. Nevertheless, farming tools and techniques (aside from differences in irrigation), food storage, gathering poles and tongs, digging sticks, fence enclosures for hunting, pitfalls, clothing, and the like, are remarkably similar for these groups.

Most similar to the Pueblos are the Pima, Papago, and River Yuman farmers, referred to collectively as the Pima-Yuman group. Although the environments of the Pueblo and Pima-Yuman sets are very different, the similarities among their gathering, farming, and hunting technologies help set them off from the Upland Yuman and Athapaskan groups. It is important to note that the River Yumans, including the Maricopa of the Gila River, used simple fish-procuring tools such as hand nets, weirless traps, and obstructions, and obtained large quantities of fish. The Pima had weirless traps, but procured very little fish. On the other hand, for centuries the Pima, probably the Papago (wherever the conditions permitted), or their precursors had extensive canal irrigation systems replete with dikes, dams, and tributary systems. Yet in aboriginal times the River Yumans, including the Gila-dwelling Maricopa, did not borrow irrigation practices from the Pima or Papago. The Pima and Papago had more formal and extensive food storage than the Yumans.

The Athapaskans shared many features of clothing, housing, hunting, and gathering; and their farming technology did not include irrigation, except for the Navajo and Jicarilla, who used natural floods and some dams to control runoff. Apparently some Western Apaches used some irrigation techniques, where practicable, in the nineteenth century (Griffin, Leone, and Basso 1971).

The Upland Yumans, probably erstwhile farmers, are positioned somewhat closer to the Athapaskan group than to the River Yumans. In that all but the Havasupai seem to have given up farming, or were forced to give it up, their technology reflects their gathering and hunting subsistence economies.

Compare the distribution of the Southwestern cultures for environment (fig. 2) and technology (fig. 4). Except for the Navajo, Jicarilla, and Pima, the fit between environment and technology is very close, much closer than between environment and any other subclassification of cultural phenomena. These distribu-

tions suggest that people in similar environments tend to have similar technologies. On the other hand, the Navajo and Apache in the Pueblo area did not adopt all the Pueblo farming technology or Eastern Pueblo fishing techniques. And in the Pima-Yuman group, Pimas did not adopt all River Yuman fishing techniques while River Yumans did not adopt Pima irrigation techniques. In example after example, regardless of the multidimensional measures of environment-culture relations, cultural similarity aligns more along the lines of linguistic relatedness than it does along the lines of environmental similarity.

In order to compare similarities and differences, subsistence economy was measured using 30 variables covering information about the relative importance of agriculture, fishing, hunting, and gathering in the diet; whether the resources were produced or procured locally or whether they were obtained extra-locally, and the amounts for each source; the nature or types of resources procured or produced, the manner in which they were transported and stored, and the duration of the storage.

Practically every farming group in the Southwest raised maize, beans, and squashes, although the Yavapai and Walapai, at least by the mid-eighteenth century farmed only maize (and perhaps squashes), and very little at that, while the River Yumans also planted sunflowers and several varieties of wild grasses. It cannot be inferred from the presence of farming that farm products were dominant in the diets of all farmers.

A comparison of technology with subsistence economy shows how different two distributions can be. Technology articulates people with their environments, and subsistence economy (as it is measured here) shows relative differences in the outcomes of those articulations. For instance, Castetter and Bell (1951) referred to the Papago as desert-dwelling Pima, a retrogression from the Gila River Pima subsistence economy, which was a simple function of different environments. There is no doubt about the similarity of Pima-Papago technology, but in different environments this rather similar technology yielded very different subsistence economies. Whereas the Pima obtained 60 to 70 percent of their subsistence from maize, beans, and squashes produced locally, the Papago probably obtained no more than 20 percent of their subsistence from farm products, and perhaps one-third of these products came from trade with River Yumans and Pimas, feasts given by Pimas, and ceremonial gifts from the Pima. The Papago obtained the bulk of their food from wild plants, and some of those resources, too, were obtained extra-locally through gathering on Pima territory and through gifting. The smallest amount of Pima subsistence came from game and fish, and the Papago from game alone. So the harsh desert environment with its diffuse and sparse resources did not provide much game; furthermore, considerable distances were covered by the Papago to collect plants. Yet on the river floodplains the Pima obtained a predictable, abundant, localized food supply—enough to allow for gifting and exchanging for meat and so forth.

Figures 6 and 7 display distributions of the Pima and River Yumans, whose cluster is far removed from the Papago. The Pima and River Yumans obtained their dominant or co-dominant sources of food from agriculture, although the probable percentages of contribution varied from a low of perhaps 25 to 30 percent for the Maricopa on the rich Gila River to 60 to 70 percent for the Pima on the same river. The Colorado River Yumans probably obtained 30 to 50 percent of their sustenance from agriculture. All these people used multiple storage techniques (jars, ollas, room storage, platform storage, even caves, and every household had a separate, semisubterranean storage structure) but tended not to store crops for seed or for food more than one year. The River Yumans obtained as much of their diets from fish as they did from mescal, mesquite, and other wild plants, while the Pima did not fish so intensively or so well. None of these groups traded for agricultural products, although the Pima, and to a much lesser extent the River Yumans, traded agricultural products for animal products. There is no good environmental reason for the variation in the use of farm products among these people (see Castetter and Bell 1951:248–251). The River Yumans could have developed canal irrigation, but they did not. Furthermore, they could have planted more agricultural land, but they did not. Even the Maricopa on the Gila River did not begin to develop canal irrigation until after 1850. The paucity of water in Papago environments accounts for Papago difference from Pima and River Yuman subsistence.

Among the Pueblos, all of whom obtained more than 50 percent of their total sustenance from agricultural products, there is a looser grouping than for technology. The grouping reflects the roles played by hunting among the Keresans and Taos, pulling them somewhat toward the Athapaskans, and a modest amount of fishing among the Tewa, putting them at the top of the distribution. All the Pueblos stored their food and seed crops in rooms, and some also used walled-in overhangs. They tended to store foods, especially seed crops, for more than one year as a hedge against a poor yield. All the Pueblos collected wild plants in their areas as an important source of food (probably no more than 20%). The Zuni obtained some wild plants extra-locally, and all the Pueblos, except the Keresans, traded agricultural products for game. The Keresans seem to have had too little of the former and enough of the latter.

It is relevant to mention that not one of the groups whose major or codominant sources of food were agricultural products traded for agricultural products, yet

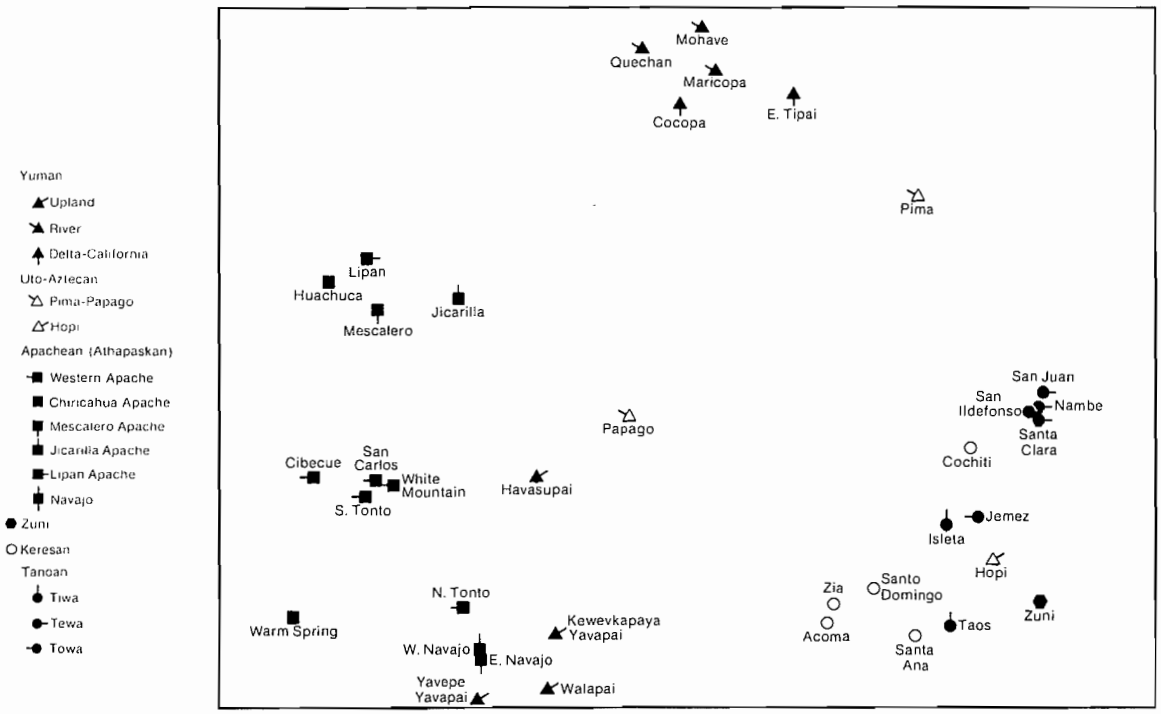


Fig. 6. Subsistence economy in aboriginal Southwest. MINISSA smallest space analysis in 2 dimensions. Ranked G-coefficients based on 30 variables (182 attributes). K = .16 in 11 iterations.

the Mohave, Quechan, Pima, Hopi, Zuni, and Tanoans traded for game. Virtually all other groups in the sample (Upland Yumans, Athapaskans, and Papagos) acquired food products through trade, raid, gifts, or some combination of these. Thus, of all the farming groups whose productive resource areas were relatively localized to river plains, river bottoms, washes, and fertile areas on mesas, those whose territories were bordered or crossed by the Athapaskans were (1) most dependent on agriculture, whether or not they practiced canal irrigation, and (2) most circumscribed in the amount of area available to them to pursue the more diffusely distributed wild plants and game. The Mohave, who were not bordered by Athapaskans, traded crops to the innocuous Walapai, and also gifted them regularly, perhaps partly out of good will because the relationship was markedly assymetrical, with the Mohave giving and the Walapai receiving. The Papago stood in somewhat the same relationship to the Quechan.

Some generalizations should be offered at this point, but they should be regarded as concluding hypotheses that require confirmation from further information provided below, as well as comparative ethnohistoric tests that have not been conducted. When the Athapaskans moved into the Southwest, filling much space left unoccupied by the contractions of Pueblo, Mogollon, and Hohokam farming settlements, they also began to crowd Pueblos, Pimas, Papagos, and Upland Yumans out of hunting territories and potential farming territories. Whereas Athapaskans began trading products of the hunt for products of the farm with the Pueblos, and even attending ceremonies at which they were feasted, they intermittently raided the crops of these farmers and they also raided and battled the Pima, Papago, and Yavapai. It is doubtful, but remotely possible, that these new relationships caused Pueblos and Pimas to become more dependent on crops than they had been, say, prior to the sixteenth century. The development of forms of irrigation since about A.D. 1000 argues against such a view. On the other hand, it is quite possible that the reduction of the territory available to the Yavapai, coupled with Apache threats, helped push the Yavapai groups to give up most of their farming and to accommodate to the Western Apache (for which the evidence is very strong), and it undoubtedly helped restrict Papago territory and divide the Pima population. Partly because they desired products from the hunt and partly to deflect some raids, the Pueblo farmers might well have continued to host Athapaskans.

The Athapaskans certainly helped to cause many changes in aboriginal Southwest economies, but Ute raiders and traders (Jorgensen 1965; Schroeder 1965) and River Yuman warriors and traders also helped to shape the seventeenth- and eighteenth-century configurations.

The Navajo farmed more extensively than the Yavapai or Walapai, at least during the eighteenth and nine-

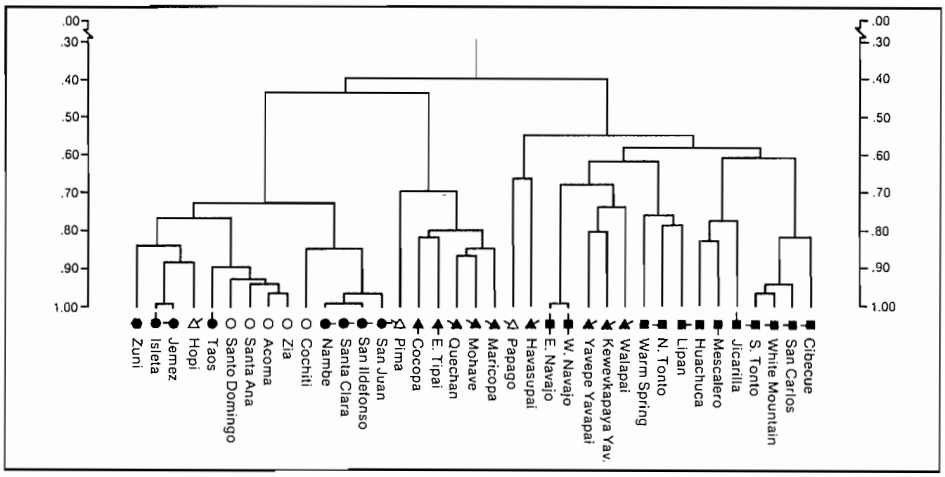


Fig. 7. Subsistence economy in aboriginal Southwest. Jorgensen's nonmetric tree in one dimension. G-coefficients based on 30 variables (182 attributes).

teenth centuries, and the Yavapai and Walapai were more dependent on wild plant foods, particularly mescal and saguaro cactus, than were the Navajo. They were probably equally dependent on large and small game. The Yavapai traded with Navajo and Apaches. The Kewevkapaya intermarried with Northern Tonto (Western Apache), organized into matricentered clans and band organizations, and came to be known as Yavapai Apaches (Schroeder 1974). Furthermore, Yavapai often joined Western Apache raids on Pima and Maricopa villages and conducted their own raids on Walapai and Havasupai. Like the Athapaskans, however, they did not raid the Quechan and Mohave, who were formidable opponents. It seems as though the Western Apaches, the Navajos, and the Quechan and Mohave used the Upland Yuman groups as buffers between them. The Colorado River Yumans used the Yavapai and the Walapai as trade connections to the Pueblos, and even the Mohave did not stop the Yavapai from attacking their friends the Walapai. The Yavapai groups maintained internal friendships.

The Warm Spring Chiricahua and the Northern Tonto component of the Western Apache are outliers between the Navajo–Upland Yuman group and the Western Apache group (figs. 6–7). They relied less on farming and more on gathering than the Navajos or the Western Apaches. On environmental evidence alone one would expect the Warm Spring Chiricahua to be placed closer to Huachuca.

The Western Apache cluster represents a subsistence economy in which wild plants contributed the most to the diet, followed by large and small game, and finally agriculture. The Western Apaches did not get much more than 25 percent of their sustenance from agricultural products, whether they raised their own crops or plundered them from Yavapai, Pima, Papago, or Maricopa. Nevertheless, the exceptional storability and nutritional qualities of agricultural products enhanced their value, and these facts were not lost on Western Apaches as either farmers or raiders (see Griffin, Leone, and Basso 1971).

The cluster of most easterly Apacheans represents people in several micro-environments, but what they shared was a modest amount of fishing (only the Warm Spring among the other Athapaskans fished). The Jicarilla farmed more than the other members of the set, and the Lipan and Huachuca were most dependent on gathering. The other similarities are that all four groups covered enormous territories in quest of game, plants, and plunder.

Some generalizations from subsistence economic comparisons are that those who produced the most food did not raid or trade for agricultural products. Those who produced little or no food raided, traded, or received agricultural products as gifts. The Yavapai were raided for food but also joined the Western Apaches and did some raiding to get food. The Athapaskans dominated hunting in the Southwest, but only the Navajo among all Athapaskans depended more on hunting than gathering, and for them, hunting was secondary to farming. The Athapaskan response to diffusely distributed resources was to use large territories while restricting the movements of non-Athapaskans.

Figures 8 and 9 represent the relations among the 37 culture units in this Southwest sample as measured by information on 67 variables pertaining to economic organization. The variables cover questions about the organization of labor by sex, age, specialization, and task groups for subsistence pursuits, housing, the production of tools, and so forth. They also cover the organization of reciprocity and distribution of goods, including sharing of access to resources, gift exchange,

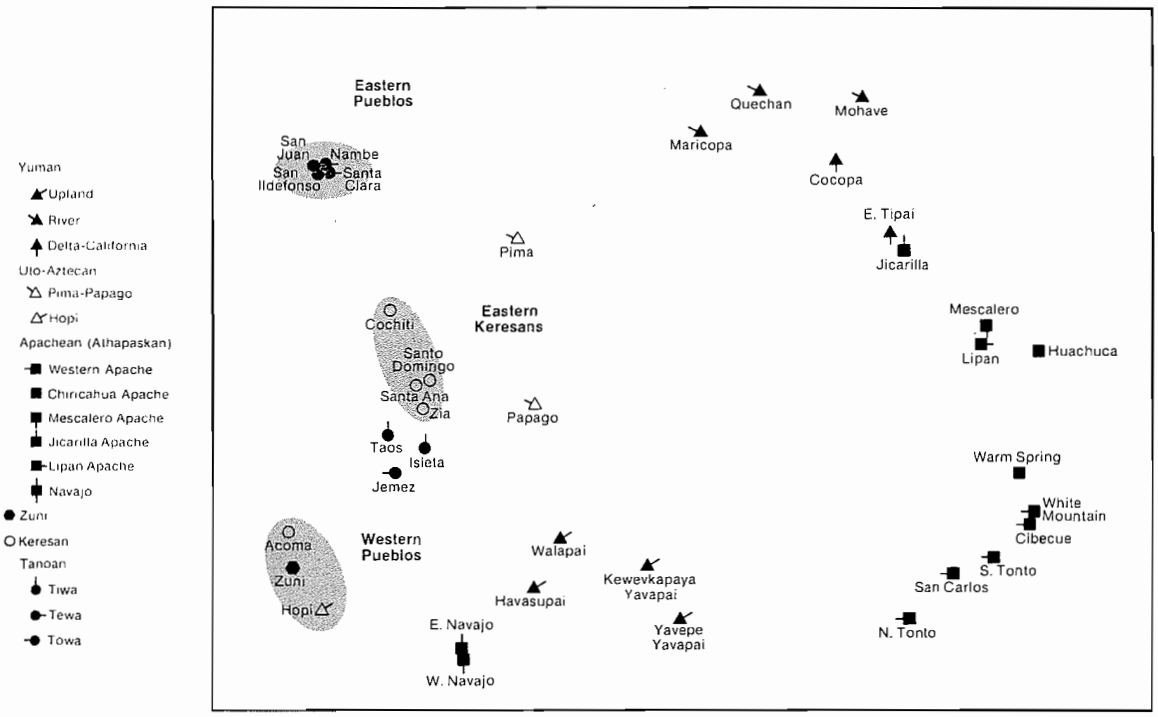


Fig. 8. Economic organization in aboriginal Southwest. MINISSA smallest space analysis in 2 dimensions. Ranked G-coefficients based on 67 variables (409 attributes). K = .13 in 12 iterations.

barter and trade. Two further sets of variables deal with the ownership and inheritance of property including strategic resources for production. In these distributions the differences among the Western Pueblos (Hopi, Zuni, Acoma), most of the Eastern Pueblos (San Juan, Nambe, Santa Clara, San Ildefonso), and the Eastern Keresans (plus the Tanoan Pueblos of Jemez, Isleta, and Taos) are apparent, yet they still form one large group. The Upland Yuman group is separated a considerable distance from the River Yumans, as are the Pima and Papago. Except for the Navajo, the Athapaskans form an uninterrupted semicircle distribution in figure 8 from the easternmost Apaches at the top to the westernmost at the bottom.

Among the Pueblos, it was the nuclear or perhaps bilateral stem family that either owned or had usufruct rights to garden plots and house sites among all the Eastern Keresans and all the Tanoan speakers, except for the Jemez and Isleta, in the sample. The Isleta sites were owned by individual men, whereas among the Jemez ownership was vested in the matriclan. Among all the Western Pueblos garden plots and houses were owned by matriclans.

In terms of the supervision of these resources, the dike, dam, and canal systems of the Eastern Pueblos required some communal effort, although farming itself was a family affair. The Eastern Pueblos, apparently prior to Spanish contact, developed political and religious sodalities composed of men (not necessarily related) of special status and real power capable of causing the villagers to maintain the central canals and dams, contribute labor toward producing crops for the leaders of the village sodality, participate in communal rituals, and so forth. Indeed, these leaders can be viewed as the supervisors of each village's communal property—corporeal such as land and houses, and incorporeal such as the major ceremonials. Thus, family "ownership" of farm and house sites is better defined as usufruct rights because the political-religious leaders of the villages could confiscate houses and land from village members who did not perform their communal duties.

Among the Eastern Pueblos, none of the villages or bilateral families within villages claimed ownership to fishing sites on the rivers; and of all Pueblos, Eastern and Western, only the ambilocal bilateral families among the Tewa villages (San Juan, Nambe, San Ildefonso, Santa Clara) claimed ownership of key gathering sites and key hunting sites. Thus, the key strategic resources for all Pueblos, as is inferred from the contribution of food to the diet, are farming sites, which are located in environments with relatively scarce and diffuse resources in the west, and more abundant and localized resources in the east. All Pueblos recognized ownership of farm plots, but ownership of other food resource sites was very rare. Furthermore, access to game for Pueblos was somewhat restricted by Athapaskan and Ute hunters.

The farming work—clearing, planting, weeding, harvesting—among all Pueblos was done predominantly by kin-related men working in task groups on family

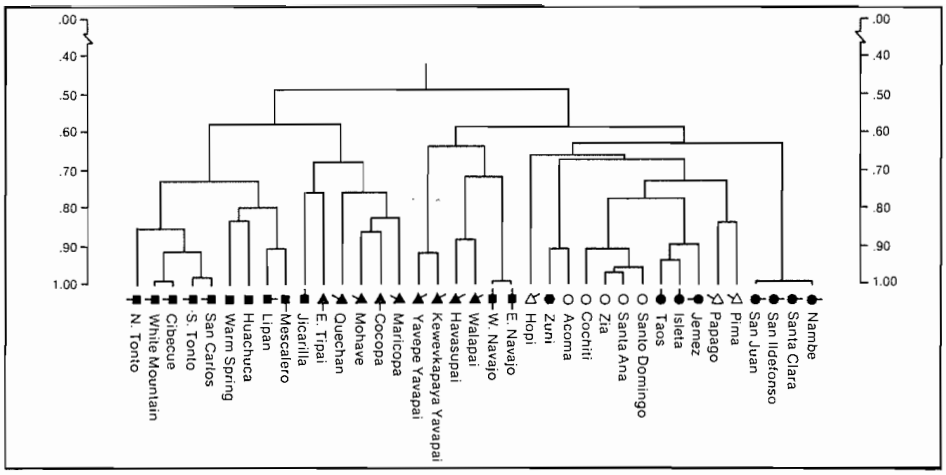


Fig. 9. Economic organization in aboriginal Southwest. Jorgensen's nonmetric tree in one dimension. G-coefficients based on 67 variables (409 attributes).

or extended family gardens.* In the west the men were matrikinsmen, and in the east they were bilateral kinsmen. Except for the communal tasks in the east of constructing and maintaining the major dams and canals, work on lateral ditches and dikes, whether to control flow from the canals in the east or from runoffs in the west, was done by the family farmers.

Except for the Tewa villages and Santo Domingo (Keresans), who organized themselves into small hunting task groups of men and women, kin and nonkin, the Pueblos generally organized themselves into small groups of male kinsmen to hunt and dress skins. The women did the gathering of wild plants in all the villages, but they did not organize task groups to do so. Nevertheless, a few women would gather in the same area at the same time to keep mutual company.

Women did the cooking and made the pottery in all the Pueblos. They also did the bulk of the weaving everywhere but among the Hopi and at Santa Ana, where men predominated, and among the Tewa villages, where both sexes did weaving. Houses were made jointly by men and women. The men shaped the stones and built the walls and roofs, and the women plastered the walls. Whereas weaving and potting were individual pursuits, houses were built by task groups of matrikinsmen in the west and bilateral kinsmen in the east.

There were no intravillage markets, although the Pueblos engaged in some intervillage trade and were incorporated into trade networks through the Upland and River Yumans to shells from California, and through Athapaskans and Utes to meat and hides from the mountains and plains. The vast majority of all exchanges of food and goods within villages and between villages was reciprocal and equal, and it was conducted by individuals rather than by special agents of some sort. Among kin and friends—within or between villages—the exchanges were recognized as gifts, although gift reciprocation could occur at a later date. Among strangers, between Utes and Taos, for instance, there was bargaining. At Hopi and Zuni practically all reciprocity of goods and food was attended by ceremonial etiquette, but among all other Pueblos some reciprocity was ceremonial and some was not.

Redistribution† of food and goods within a village was primarily conducted by individual families in various ceremonials and life cycle–attendant rituals. The amount collected in any family redistributed to kin and others in a year was modest and conformed to local etiquette, while the amount collected and redistributed by any single kinship-based sodality in the west or sodality in the east was somewhat greater. There was no explicit extra-local redistribution, although kin and friends from other Pueblo villages were feasted, and non-Pueblos too were often hosted at ceremonies.

Among the Tewa villages the political-religious leaders had storehouses, filled with produce derived from communal labor. The products were used to feed themselves and to be redistributed among needy people from time to time. Overall, however, reciprocity was the dominant mode of exchange within and among villages, and redistribution was tied to ceremonialism. Whole villages did not redistribute to other villages, even

* As used here, "task groups" are defined as units of co-workers who regularly (daily, seasonally, or annually) coalesce to accomplish jointly some task. Each member need not provide the same resources, or skills, or labor to accomplish the task. Membership is rather stable over a period of a few years.

† "Redistribution" is defined as the centralized collection of food or chattels by kinship groups, or sodalities, or villages, or some authority, followed by the distribution of these chattels or food to people other than those who produced and collected it, but perhaps including those who collected it.

among the Eastern Pueblos where there was centralization of political control over the key economic resources.

In this assessment it is not intended to make light of the real differences in the organization of production between Eastern and Western Pueblos. The centralized authorities in the east demanded communal labor and ritual behavior and ultimately controlled the garden and house sites. In the west clans controlled garden and house sites. Whether canal irrigation demanded the development of centralized control in the hands of people who represented whole villages rather than kinship groups is an unsolved problem, but to help answer the question a comparison of the Eastern Pueblo economic organization with the Pima and Papago economic organization is needed.

Among the Pima, and for the Papago who had access to regular sources of water for canal irrigation purposes, fishing, gathering, and hunting sites were not owned, but farming land was owned by each village. A village was a group of bilateral kinsmen who predominantly resided patrilocally and who inherited garden plots, which became inalienable, from fathers to sons. Nevertheless, this inalienable land was considered to be owned ultimately by all Pima or all Papago, past and present. A village, then, was a patrideme (patrilocal bilateral kinship unit), composed of several related families under the direction of a headman whose only coercive force was public opinion. The land that was farmed and inherited through the generations by specific patrilocal bilateral families was, as among the Eastern Pueblos, owned only in usufruct. Yet a village headman among the Pima had no coercive authority to reassign lands and to command communal services, whereas Eastern Pueblo sodality leaders exercised such powers.

The differences between the organization of production for the canal irrigation Pueblos and the Pima-Papago are dramatic. For the latter a village headman, himself the leader of the village kinship group, helped organize his kinsmen to clear fields, build dams, and dig major canals. There were no community fields, and the work on the major canals as well as the minor ditches was done communally. When new land was to be opened, perhaps three such villages would join together under their headmen and construct the canal network and clear the land. The work was reciprocal and each participant chose his own land when the work was completed. The multiple-village reciprocity was stimulated by threats of attacks from Apaches, so that several villages chose to locate their fields close to one another. It is also possible that villages joined together because of the desirability of enlisting many hands to build the major canal systems and subsequently to keep them clean and operable. After the main canal was dug for each set of villages located on the canal, the men of the villages kept their sections of the main canal cleaned and there was no one with overarching authority to see to it that the canals were maintained.

In marked contrast to the Eastern Pueblos, the Pima-Papago developed and maintained extensive canal irrigation systems with nothing more than kinship group labor, nominally directed by headmen who, from time to time (during the seventeenth and eighteenth centuries and the nineteenth century prior to the reservation period) brought their villages together in labor-reciprocating farming efforts. It took more than individual or family effort to irrigate, but the Pima-Papago coordinated their efforts without centralized political and religious authority, and without community fields and storehouses for the benefit of the authorities. Needy families among Pima and Papago were given food, and they reciprocated in kind when possible. Sometimes the men of the village worked in their kinsman-headman's field as a form of generosity and appreciation. The headman, in fact, was being reciprocated with labor for his managerial contributions. The labor was not compulsory.

Intervillage reciprocity of food was ceremonial. Each year a harvest ceremony was held by one Pima village for perhaps three or four other villages. The villagers of the host village fed the visitors and gifted them with corn. In subsequent years the visiting villages served as hosts. Furthermore, as the giant saguaro cacti ripened each year, the Pima-Papago villages took turns sequentially in the same year in holding rainmaking ceremonies. The ceremonies were attended with the consumption of an alcoholic beverage made from the cactus.

The reciprocal and convivial organization of labor under nominal authority, and the reciprocal distribution of food products—whether or not the distributions were attended by ceremonialism—stands in marked contrast to the organization of production of the Eastern Pueblos, even though farming was ultimately a family enterprise for all farmers in the Southwest. The Pima-Papago division of labor by sex, task groups, and specialization was about the same as for the Pueblos. Task groups of male kinsmen did the bulk of the farming and hunting. Men worked the hides individually, yet they joined into reciprocating task groups to do the heavy work on the houses. Women did the collecting of wild plants, and the weeding and harvesting of crops. Women also made the pottery and basketry whereas men made the tools that men used. There was no pronounced craft specialization.

It is interesting to encounter among the Colorado River Yumans and the Maricopa some differences from other Southwest farmers in the division of labor by sex. It is likely that the organization of Yuman production is not derived from the same base as the rest of the Southwest but was shaped from a California base (Jorgenson 1980). The Yuman speakers form a separate

cluster in this nonmetric analysis. It seems that River Yuman women contributed more labor to the farming enterprise than did their female counterparts everywhere except among the Western Apache. The River Yumans could have gained all their sustenance from farming their well-watered and fertile river plains, and although farming contributed more to the food supply than any other food source for most groups, River Yumans varied from 30 to 50 percent agricultural dependency. Except for some Mohave, who carried water to their fields in large basketry ollas, the River Yumans relied on flood irrigation for which they exercised some controls with dams, dikes, and ditches (but not canals).

Critical differences from the other Southwestern farmers, beyond the amount of River Yuman dependence on agriculture, were: the totally individual nature of farm-site ownership by the male who cleared the site (or sites as one man often used several sites), and the individual family nature of farming. There were no task groups of kinsmen to reciprocate labor, and the larger kinship groups, such as the multi-local patriclans, did not retain ultimate ownership of land. If disputes occurred between men about property boundaries following a flood that obliterated markers, the disputants, more or less in this order, settled their problem by: talking, enlisting friends to help in a shoving fight, or finally by means of a controlled stick fight. The winner set the boundary markers. Often these disputes were between men of the same patriclan, as River Yuman settlements tended to be dispersed homesteads of patrikinsmen. Indeed, a segment of a clan might fraction from a settlement and resettle several miles distant from their closest kinsmen in order to open new fields. Each patriclan came to be located in many dispersed locales.

Along with garden sites, key gathering sites too were owned by individual men, even though women did the gathering. Gathering sites for mescal, screw bean, and mesquite were localized on the river plains. Fishing was extremely important for the River Yumans, and good fishing sites were used repeatedly; nevertheless, sites were not owned, and fishing was an individual affair for all but the Mohaves who organized into task groups of patrikin to fish. None of the River Yumans had fishing specialists. Hunting areas, like fishing sites, were free and available to all.

Of all the important localized resources, then, only garden and gathering sites were owned. And for these resource areas, owners did not grant access to other people who wished to use them. On the other hand, food was reciprocated locally and extra-locally, so people in need as well as people who were not in need received food. Furthermore, mourning ceremonies, hosted by the near kinsmen and friends of a recent decedent, were times to collect, redistribute, and even destroy property on behalf of the departed member. These ceremonies were used to invite kinsmen and friends from near and distant settlements, and the hosts for one ceremony were soon the visitors at several others.

Ceremonialism, in general, was not developed nearly so much among the River Yumans as it was among the Pima, and it was focused more on war exploits and honoring deceased individuals (one at a time as well as groups of specific people) than on propitiating gods, crops, or the natural elements and their relations to gods and crops. The differences in River Yuman ritual organization from the organization of Pima ritual, say, is not explainable by environmental or ecological variables.

All River Yumans were warriors. The Maricopa, Cocopa, Halchidhoma, Cocomaricopa, Kavelchadom and several others were primarily defensive warriors, whereas the Mohave and Quechan were offensive warriors, raiders, and traders. Warfare goals were neither to acquire crops nor to destroy crops. Yumans had plenty of food. The explicit motive for warfare was personal gain. Furthermore, the greatest warriors were also the most ambitious farmers and traders (Mohave and Quechan).

It is possible, and should be treated as a concluding hypothesis, that the Mohave and Quechan displaced several Yuman-speaking groups (such as the Kavelchadom) from their positions on the Colorado River and usurped their territories. The Mohave and Quechan were friendly—allowing each other to farm—but through harassment of their downriver and Gila River congeners, caused them to farm less. It is possible that the Pima and Papago, suffering attacks from the Apaches, and the Maricopa and Kavelchadom, suffering attacks from the Quechan and Mohaves, served as buffers between Apache expansion westward and Mohave-Quechan raiding eastward. In contrast the Mohave and Quechan had good relations with Papago, Walapai, Yavapai, and Havasupai and did not raid them. They used them as middlemen in some trade with Pueblos and crossed Upland Yuman territory in order to conduct other trade. It is significant that the closest Apache neighbors of the Yavapai were friendly, and they did not move west beyond the Upland Yumans for raiding. Yet out of fear the Yavapai and Walapai farmed almost not at all, although farming potentialities in much of the Yavapai territory were good. It is possible that the Yavapai, in particular, became the preeminent gatherers in the Southwest because they were allowed to occupy that subsistence niche and only that niche. It is suggested, then, that the organization of economic production for the River Yumans was focused on warfare whose causes might have been economic at one time, but whose effect might have become its own cause. It is clear that no overriding ecological factors stopped River Yumans from fishing more, farming more, using canal irrigation, storing more crops, or

organizing themselves into centrally controlled governments. Indeed, the Quechan recognized themselves as a tribe with war leaders of definite rank. They joined together to wage war, to conduct mesquite ceremonies, and to help their tribal mates should they come under attack. But there was no communal labor and no authority to exact it.

The Apaches form a crescent-shaped distribution in figure 8, and as can be seen in figure 9, the internal relations among the Western Apaches are closer than those among the more easterly Apaches. The great differences between Western and Eastern Apaches were the role that horticulture played in their respective subsistence economies and the nature of ownership of key productive resources.

Goodwin's (1942) epic work on the Western Apache has been supplemented, often from Goodwin's notes, by the works of Basso (1970, 1971) and Kaut (1974). The Western Apache were organized into multilocal matrilineal clans whose local segments owned farmland, sometimes as clans and sometimes as individual members of clans. But farming was only one Western Apache subsistence pursuit, and the local clan segments or even individuals also owned some key gathering sites for mescal and mesquite. The farmland, in particular, was guarded against trespass, although members of other clans could join the owners and be given access to farming and choice collecting sites. There is no doubt that farming and farm-site ownership were critical to the Apache clan organization, for as populations grew or droughts occurred there seems to have been leapfrogging of clan segments in search of land. The movement for land in the eighteenth and nineteenth centuries, coupled with raiding for crops and goods, established adversary relations with the Pima and more friendly relations with the Yavapai.

The Western Apache farmers and raiders were organized much differently from the sedentary Pueblos, Pima, and River Yumans. Whereas the Yumans left their home areas for brief periods to raid and trade, Western Apaches ranged seasonally through several biotic zones, moving less often in summers (near their farm sites and water) than in winters.

Although farmland ownership seems to have been critical to the multilocal distribution of matrilineal clans, key gathering and some hunting sites, too, were claimed by local clan segments. Male affines hunted in small units of two to five, while young boys formed teams to hunt rabbits and other small game. Women matrikin formed small groups to go collecting, but they retained individual ownership of their goods. Men, women, and children formed work groups for farming, as among the River Yumans, yet men did the heaviest work as among other Southwest groups.

Hunting and gathering areas were made freely available to anyone who wished to use them, although protracted use by nonowners generally required permission from the owners. The more communitarian ethic toward hunting and gathering areas contrasted sharply with the private clan ethic toward farm-site ownership, and it is certainly a possibility that the availability of access to hunting and gathering sites made it easier for clans to fission and establish new farm sites, hunting and gathering across the lands of other clans while looking for new areas for themselves.

The local clan segments often let people from other clans join them and use farmland, if it was available. These local groups formed bands along with adjacent local groups. Band chiefs were influential, nominal leaders, but bands and even combinations of bands, such as the San Carlos, were egalitarian units that formed to conduct raiding for food, booty, and perhaps territorial expansion. Contributions of food to Western Apache diets from raiding were important during the winters. Clan segments could join and leave bands at their own instigation. So the Western Apache had all the flexibility and aggressiveness of hunting and raiding bands, yet the food supplies and definite territories of farmers. They could protect as well as attack, provide as well as steal. This was a considerable advantage over the Pueblo, Pima, Papago, and Upland Yuman groups, but no advantage over the Quechan and Mohave who engaged in trade and conducted devastating raids—but not for food—yet had more than enough to eat. It is very possible that attempts by Western Apache clan segments to establish farms and summer residences on the Gila River west of what is now Phoenix would have been short-lived and that the beleaguered Pima and Maricopa served as useful buffers between Apaches and Colorado River Yumans.

The eastern Apacheans, except for the Jicarilla, did not farm in the eighteenth and nineteenth centuries (prereservation), and their economic organizations show differences from their western congeners that seem to stem from the presence or absence of agriculture.

The various eastern Apacheans were organized into matrilocal and bilateral bands under the nominal authority of a good speaker. Yet families from several local residence groups representing more than one band might coalesce under one man to conduct a raid. Raiding was an important part of Apachean subsistence economy as it was in the west. Furthermore, eastern Apachean hunting and gathering was conducted in nearly the same fashion as in the west: individuals or small groups of male affines or boys hunted, while females related through the matriside kept one another company while gathering. Each woman kept whatever she gathered for her own family.

A difference was that men not only shared the game among the hunters but also gave away as much as one-half of their catch of deer and antelope beyond their

own families. A difference with the Pueblo, Pima, and River Yumans is that women, rather than men, dressed the skins. This labor custom dominates in the Great Basin and on the Plains.

It should be emphasized that a communitarian ethic attended the reciprocity of food not only within the local groups but also between groups. Life-crisis events were attended by distributions of food to guests from local and extra-local groups. Although Chiricahua local residence groups recognized ownership to key gathering and hunting sites, they provided access to anyone who desired to use the resources.

The fluidity of movement of the matrilocal, bilateral, extended-family camps of the eastern Apaches as they temporarily joined raiding and hunting parties, and the regular movements of larger residence groups in order to obtain wild plants, rendered them considerably less sedentary than Western Apache farmers, at least during summer months. Although the local residence groups among eastern Apacheans had as many as 300 people, most of the organization of work was on the family level, and reciprocity, ritual distributions, and free access to resource areas moved goods among families.

The Jicarilla Apache farmed as well as gathered, hunted, and raided. Their farming sites were owned by the matrilocal, bilateral extended families. In all other respects their economy was organized very similarly to the other eastern Apacheans, except that men usually carried the wild plants collected by the women. The role played by farming in Jicarilla economic organization has located the Jicarilla more closely to the Kamia, who are River Yumans, than to the Western Apaches. Jicarilla agriculture, which employed dikes and ditches, fishing, and dual organization of Holiness rites combined to pull Jicarilla toward Eastern Pueblos and River Yumans, while maintaining their outlier position in relation to other Athapaskans.

The Navajo were the most aberrant of all Athapaskans. They were similar to the Western Apache and Jicarilla in that they farmed, hunted, gathered, and raided. And as among the Western Apache, local clan units owned farmland. Indeed, the relation between the multilocal distributions of Navajo clans and the availability of farmland appears to parallel the relations among those phenomena for the Western Apache.

As can be seen in figures 8 and 9, the Navajo are placed between the Upland Yuman and Western Pueblo clusters, emphasizing the Navajo's greater dependence on farming and organization for farming than other Athapaskans, as well as greater organization for hunting and gathering than the Pueblos. Although raiding parties were formed and the booty that they garnered was important, Navajos spent more time each year near their farm sites than did Western Apaches. When sheep, too, were added as an overlay to farming, clan units became still more sedentary, even though the population continued to expand and fill more geographic niches.

The organization of production among the Navajo was more similar to Pueblo organization than for the other Athapaskans. For instance, men worked the hides and built the houses, and they also formed small task groups to clear land and divert flood water for farming. The farming was not so codominant as among the Apaches. On the other hand, Navajo women herded the sheep in postcontact times.

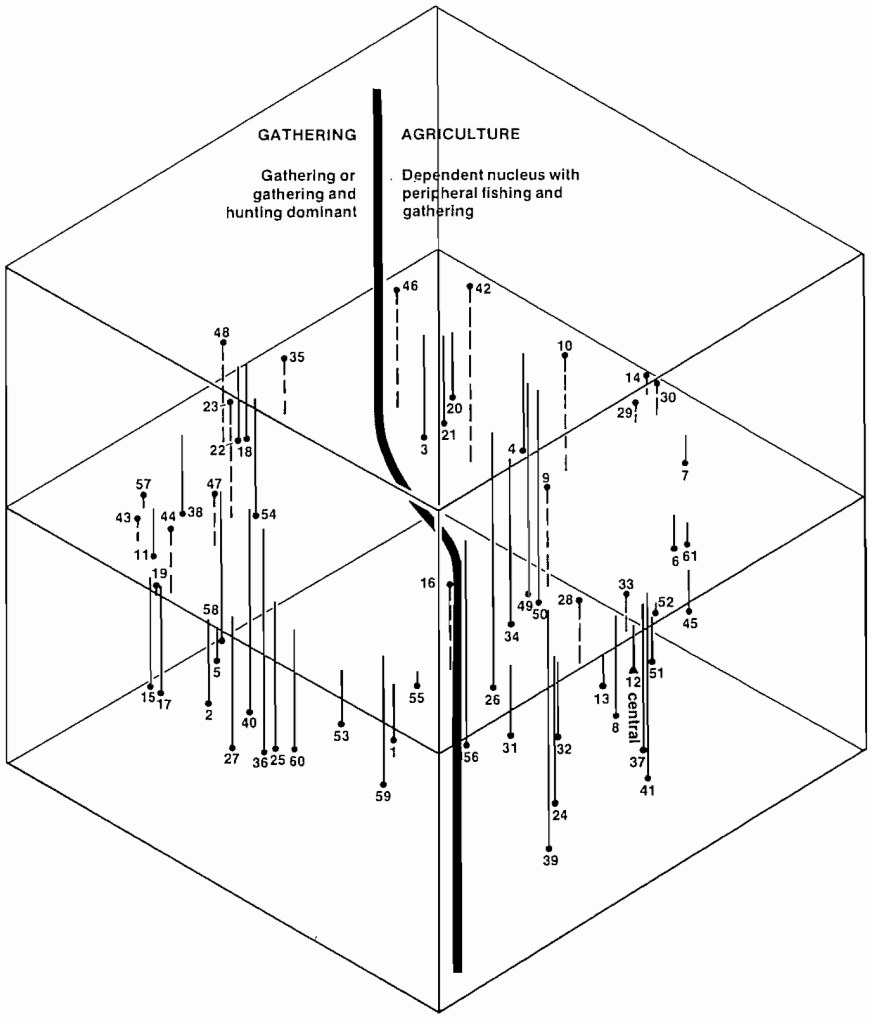
The local clan elements (Aberle 1961) reciprocated food internally and redistributed food while serving as hosts to several ceremonies. Much of the reciprocity and redistribution was laden with ceremonial etiquette, although access to local resources was granted without ceremonial fanfare. Extra-local units were not granted access to key farming sites, so that redistribution through ceremonial giving was the manner in which local clan units had access to the resources of other units from time to time. For barter and trade, Navajos bargained with nonkin whether in their own local community or elsewhere.

Thus, on the one hand the Navajo were in many ways organized more similarly to the Western Pueblos than to the Western Apache. On the other hand, they exploited a wider range of resources than the Pueblos, whose movements they restricted, and they also engaged in extensive hunting and raiding.

These analyses of intertribal relations for technology, subsistence economy, and organization of extraction and production have demonstrated that time and time again the people who spoke most similar languages tended to be most similar in culture. It has also been shown that environment is fairly closely related to technological and economic organizations, but that the fit is loose at best: River Yumans could have employed canal irrigation, but did not, and so forth. Furthermore, canal irrigation was organized much differently among Pueblos and Pima-Papagos.

Relations Among Environment, Subsistence, Organization of Production, and Demography

In the note on methodology at the end of the chapter there is a discussion of some technical information about the differences between tests for the relations among tribes (Q-mode) and tests for the relations among variables (R-mode). In order to manage the enormous data set, the information has been reduced to 13 ordinal variables pertaining to the environment, and 70 ordinal variables pertaining to subsistence economy, economic organization, and demography. The 83 variables are analyzed in figure 10 (61 variables) and figure 11 (22 variables). It was necessary to separate the analyses because each variable in figure 10 has three



or more ordered categories while each variable in figure 11 has only two ordered categories. Both figures depict the relations among the variables in three dimensions. In general, relations among variables are more complex than relations among tribes, so higher dimensionality (three dimensions rather than two) is needed to show the complexity of the distances among variables. In figure 10 Goodman and Kruskal's (1954) Gamma has been employed in order to determine whether the order of pairs of ranks in one variable changes in the same direction, changes in the opposite direction, or shows no relation to the order of pairs of ranks in the other variable. Points, or variables, at opposite sides and opposite heights in the cube are negatively related (when one changes, the other changes in the opposite direction).

The complex relations between economy and environment in the aboriginal Southwest are most obvious in figure 10. But they are evident in figure 11 too. Indeed, the relations in figure 11 form a microcosm of the relations in figure 10. Practically all aborginal groups farmed, or once farmed; all gathered; all hunted; and some fished. How, then, to account for the various adaptations? Figure 10 forms a rather continuous circle in multidimensional space with variables pertaining to dominant hunters and gatherers on one side and variables pertaining to agriculture dependence on the other (this is true for fig. 11 also). On the righthand side of the circle the greatest concentration of points occurs, and this part of the distribution is broken into small arcs and semicircles that separate clusters of variables whose ordered ranks are most nearly similar. It is not surprising that these points focus on agricultural variables. Indeed, the tightest distribution occurs around variable 12, which measures the probable contribution to diets from agricultural foodstuffs that are produced locally—not bartered for, borrowed, stolen, or received as gifts. The order of ranks for this variable, and for the others in the cluster, tends to change in the same direction, yet variables, such as numbers 37 and 41, so closely related to variables 13, 8, 33, 52, and 51 in two dimensions, are also closely related to variables 24 and 39, as is demonstrated in the third dimension. Understanding the meaning of distances in three dimensions

Fig. 10. Environment, demography, subsistence economy and the organization of production in aboriginal Southwest. MINISSA smallest space analysis in 3 dimensions obtained from Gammas. K = .17 in 12 iterations. Based on the following 61 ordinal variables: 1, tribal altitude in 1,000-feet intervals; 2, tribal area annual average precipitation; 3, tribal area average temperature in January; 4, tribal area average temperature in July; 5, total number of the 19 types of land mammals available in tribal area; 6, quantity of fish available in tribal territory (average annual production in pounds per average square mile); 7, relative amount of fish used as food by tribe; 8, agriculture production; 9, agricultural products—nonfood; 10, agricultural products grown—food; 11, agricultural products grown—beverages, leaves, etc., procured locally; 12, probable contribution to diet of agricultural foodstuffs acquired locally; 13, animal husbandry—precontact; 14, probable contribution to diet of fish, shellfish, and large aquatic mammals procured locally; 15, local hunting—all types of game; 16, predominant types of animals for which groups hunt; 17, probable contribution to diet of hunting of large game, small mammals, and fowl procured locally, and leaves, etc., procured locally; 18, local gathering—contributions from all types of nuts, seeds, berries, roots, etc.; 19, predominant foods gathered; 20, external sources for roots, seeds, berries, fruits, tubers, leaves, etc.; 21, probable contribution to diet of gathered items procured extralocally; 22, probable contribution to diet of gathered items procured locally; 23, major storage place for food: most frequent or preferred; 24, maximum length of time stored food kept; 25, specialized pottery manufacture; 26, production task groups in gathering; 27, specialization in hunting; 28, production task groups in hunting; 29, production task groups in fishing and other aquatic animal procurement; 30, specialization in fishing and other aquatic animal procurement; 31, specialization in agriculture; 32, production task groups in agriculture; 33, sharing of access of local food resources as a form of distribution within the society (intracommunity); 34, ceremonialism or etiquette in intracommunity reciprocity of food and chattels; 35, ceremonialism or etiquette in intracommunity redistribution of food and chattels; 36, ceremonialism or etiquette in intracommunity use of privately owned food resources and chattels; 37, reciprocity distribution of food and chattels between (or among) societies; 38, sharing of access to local food resources as a form of distribution between (or among) societies; 39, ceremonialism or etiquette in intercommunity reciprocity of food and chattels; 40, ceremonialism or etiquette in intercommunity use of privately owned food resources and chattels; 41, barter or trade within communities for food and chattels; 42, gift exchange within communities for food and chattels; 43, barter or trade between (or among) communities for food and chattels; 44, agents of barter or trade between communities; 45, gift exchange between (or among) communities for food and chattels; 46, ownership of key gathering sites; 47, ownership of key hunting sites; 48, ownership of farming sites, including cultivated trees, but not tobacco plots; 49, ownership of men's chattels (movable property such as blankets, bows, knives); 50, ownership of women's chattels (such as blankets, clothes, tools); 51, density of community organization; 52, population density within territory controlled by community; 53, total number of 5 types of pines available in tribal territory; 54, total number of 13 types of cactus, mescal, mesquite, and yucca available in tribal territory; 55, total number of 12 types of grasses available in tribal territory; 56, total number of 11 types of roots, lilies, nuts, and berries available in tribal territory; 57, total number of herbs, roots, and tubers available; 58, total number of nuts and leaves available; 59, small land mammals available; 60, large land mammals available; 61, total number of 4 types of freshwater fishes in tribal territory.

aids the interpretation. Refer to the list of variables to coordinate numbers with variable definitions.

In the aboriginal Southwest, the more (as measured by ordered ranks) that people relied on local agricultural products, the larger was the size of the local community, the greater was the population density, the more probable was the local bartering for food and chattels between nonkin and the gifting between kin, and the more probable and the more varied were forms of extra-local (intercommunity or intertribal) reciprocity of goods and chattels. Somewhat less central to the cluster (variable 45), gift exchanges of food and chattels between people of different communities increased with population density, dependency on local agriculture, extra-local reciprocity, and the like.

Following these interrelations in the other direction, the more the agricultural dependence, the more likely that productive resource areas, such as garden sites, were owned by kin groups or political units, and access to these sites was not shared with nonowners; and that dogs and turkeys were raised.

Somewhat removed is a circle of points with interesting relations to the core variables. The top of the circle (variable 28) shows that male task groups tended to form to conduct the hunting and the farming (variable 32); that the maximum time that food was stored tended to increase, that people with special authority or knowledge were more apt to organize the agricultural pursuits, and that intercommunity reciprocity of food or chattels was probably attended by ceremonial etiquette. A special point in interpretation is that the ranked order for length of food storage period varies systematically with the local barter, extra-local reciprocity, and ceremonialism in extra-local reciprocity variables.

The larger cluster of variables on the righthand side represents high dependency on local agriculture, of course, and it is significant that access to garden sites is not shared with nonowners, that local barter occurs with nonkin, and that extra-local reciprocity, extra-local gift exchange, and ceremonialism in extra-local reciprocity organize intra- and intercommunity distributions of food and chattels. It can be inferred from these tests and from the previous analyses that the most dense populations produced the greatest amount of food, yet they maintained themselves in threatening social environments by formally gifting, hosting, and reciprocating with their neighbors. Perhaps it was better to give in a ceremonial fashion, than to lose one's productive resources to Athapaskans and Utes. The notable thing about this distribution is that no environmental variables are central or peripheral to it. That is to say, no environmental variables measured here increase their order in the same fashion as the demographic, subsistence economy, and economic organization variables. This result supports the expectation that farming dependency in the Southwest varies more because of cultural reasons than because of environmental reasons. Some people (for example, Hopi, Zuni, Acoma, some Eastern Keresans) were agriculture-dependent on meager environmental resources; some

were much less agricultural-dependent than they could have been on their rich resources (for example, Mohave, Quechan); and so forth.

The agriculture-dependent cluster forms a still larger semicircle with variables 6, 61, 7, 29, 30, and 14. It is instructive to note that the quantity of fish available in pounds per average square mile of tribal territory (variable 6), and the number of species of freshwater fishes available (variable 61), are closer to the agriculture cluster than are the variables associated with the use and procurement of fish. In short, the environmental variables that are most closely related to the agriculture cluster show that year-round running water sources are distantly related to farming dependency, yet the fish in these waters (not for Hopi, Zuni, etc.) are exploited little in relation to availability. Those who use the most fish also farm, and of those, only the Mohave had fishing task groups and only the Cochiti had fishing specialists. It does not follow that those who had the most fish available also used the most fish.

Everyone in the Southwest collected wild plants, and even where wild-plant foods were the dominant subsistence resource they were not so dominant as agriculture among the Pueblos and the Pima; therefore, it is not surprising that gathering-dependency does not form so neat a distribution as the agriculture-dependency semicircle. Indeed, variables related to gathering occur in several Euclidean microspaces as measured in figures 10 and 11. Of interest is that the two variables relating to gathering that are most closely related to farming dependency are organization of extraction variables. The circle of variables 26, 42, 4, 49, 50, and 34 form to the left of the agriculture-dependent distribution. Between the two are the variables, distantly related, measuring the types of nonfood agricultural crops grown (variable 9) and the types of agricultural crops grown (variable 10). The distribution of variables 9 and 10 demonstrates that neither is critical to agriculture-dependency, so that the societies that experiment with the greatest variety of food and nonfood crops are not the most agricultural-dependent (specifically the River Yumans). Yet there is a positive, distant, and complex set of relationships between these variables and the organization of agricultural production and gathering extraction.

Variable 42 measures the nature of the ownership of gathering sites. If key gathering sites are owned privately or by kinship groups, the gathering is probably done by task groups of women (variable 26). Where there are gathering task groups, there is ceremonialism in local reciprocity, male chattels tend to be owned individually and the same holds for female chattels (variables 49 and 50). Finally, temperatures increase in the summer months as measured by ranked order much as ceremonialism in local reciprocity, gathering task groups, and chattel ownership increases. Much more distantly there is a gift exchange of food and chattels within the local community (variable 46 is most closely related to ownership of gathering sites).

A last arc in the righthand side of the cube completes the "agriculture-dependent with peripheral fishing and gathering" variables. Variables 3, 21, and 20 show that as the ranks of mean January temperatures increase so do the types of wild food plants procured extra-locally and the ranked contribution of these plants to the diet.

It is not trivial to learn from these tests that if people are dependent on agriculture, they also collect wild plants, and that the organization of extraction for wild plants is somewhat similar to its organization of agricultural production counterpart, to wit: key gathering sites are owned, and they are worked by task groups; food and chattels are reciprocated with ceremonial etiquette locally, and gifts are exchanged extra-locally. The stress seems to be on the recognition of property rights, attended by formal etiquette to distribute products from these properties.

In the entire righthand section of the cube, the few environmental variables that occur—temperature variables, fish and water course variables, and the outlier variable 56, measuring the types of roots, berries, lilies, and nuts available—are not central, and the temperature variables are more closely related to the organization of gathering extraction than to anything else.

At the lefthand side of the cube (fig. 10) is a loose rectangle of points (variables 55, 1, 59, and 53) with a more distant relative (variable 16). Attention is focused on these points because they are primarily environmental and because they are not closely related to variables of subsistence economics or economic organization. They show that as altitude, as measured by ranked intervals, increases, so does the number of species of grasses available, the number of species of small land mammals available, the number of species of pines available and, more distantly, the number of species of mammals and birds hunted. In the other direction these variables vary most closely and positively in ordinal ranks with the number of large, nonherd, land mammals (for example, deer and mountain sheep) available (variable 60), the presence of specialists to organize or administer hunts (variable 27), the number of species of land mammals of all kinds (large and small, herd and nonherd) available (variable 5), and the amount of annual precipitation (variable 2). Except for the hunting specialists and the number of types of mammals and birds hunted—and the two are not closely related—there are scant relations between the availability of animals, the fodder and browse available for the animals, and the subsistence adaptations made by aboriginal Southwest inhabitants. There is one surprising result: pottery specialization (people with special skills or power, rather than people who support themselves solely from their craft) is more closely related to hunting

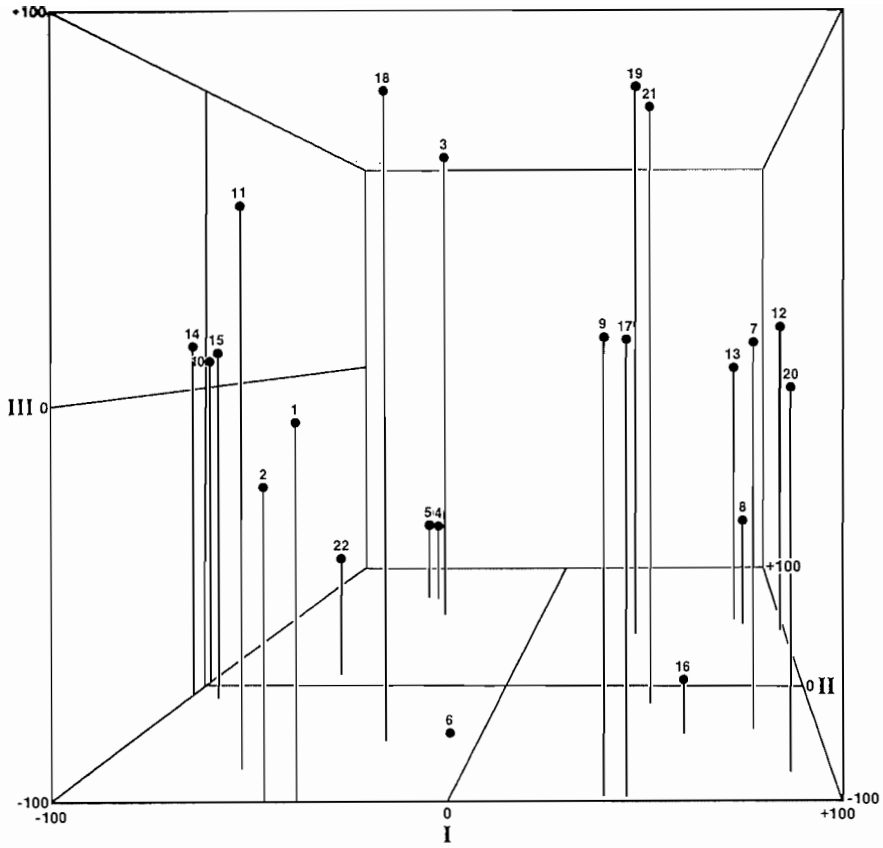


Fig. 11. Environment, subsistence economy, and the organization of production in aboriginal Southwest. MINISSA smallest space analysis in 3 dimensions obtained from combined Taus. K = .15 in 11 iterations. Based on the following 22 ordinal variables (2 ranks per variable): 1, external sources for agricultural products—food; 2, probable contribution to diet of agricultural foodstuffs acquired extralocally; 3, external sources for agricultural products—nonfood or beverage; 4, focal "fishing"—all types of aquatic animal procurement; 5, predominant aquatic animals for which groups fish, or hunt, or collect; 6, probable contribution to diet of fish, shellfish, and large aquatic animals procured extralocally; 7, external sources for game, small mammals, fowl; 8, probable contribution to diet of large game, small mammals, and fowl procured extralocally; 9, dominant land transportation of food or other goods; 10, dominant water transport of food or other goods; 11, specialized weaving of nets, baskets, or mats; 12, specialized weaving of cotton, wool, or hair garments; 13, production task groups for weaving cotton, wool, or hair garments; 14, specialization of boat building: all types of watercraft; 15, production task groups in boat building; 16, specialization in gathering; 17, reciprocity distribution of food and chattels within society; 18, redistribution of chattels and food within a society; 19, ceremonialism or etiquette in intercommunity redistribution of food and chattels; 20, ownership of common property following divorce; 21, total number of 11 types of oaks available in tribal territory; 22, large land mammals available (large herds including bison).

specialization and the availability of land mammals than to the agriculture-dependent cluster. This is probably because eastern Apacheans specialized in pottery, while Pimas, Papagos, and River Yumans did not. It is doubtful that pottery specialization is stimulated by the availability of mammals or even hunting specialists, because the Western Pueblos and Kewevkapayas had pottery specialists and relatively meager game, whereas all Southwesterners except the River Yumans had hunting specialists.

Continuing in a counterclockwise fashion, one can ferret out the intricate relations among variables pertaining to hunting and gathering and, wherever possible, the environmental variables related to them. The lefthand half of the cube is weakly linked to the righthand side through the mammal and mammal environment variables, and whereas the righthand side showed the agriculture-dependent, fishing, and gathering production relations, the lefthand side shows the organization of production and extraction when gathering is dominant or gathering and hunting are co-dominant. Except for perhaps one Upland Yuman and three Apachean groups, all 37 units in the sample gained some of their livelihood from local agriculture.

The close relations in two dimensions of variables 19, 44, 15, 17, 11, 43, and 57 show that as hunting contributes more to the diet, more types of wild plants are gathered, and the more likely that trade will be conducted and that special agents, or political unit leaders, will conduct trade between communities. Because only the Western Apache, the Navajo, and the Hopi used special agents (as well as anyone else who wished to

trade), it is obvious that use of special traders was inversely related to agricultural dependence. Although the relations are demonstrated in figure 11 rather than figure 10, it is also true that the number of types of agricultural foods acquired extra-locally (variable 1) and the ranked contribution of these foods to the diet (variable 2) are part of the complementary cluster in figure 11, while the extra-local sources for mammals and birds (variable 7) and the contribution to the diet of mammals and birds acquired extra-locally (variable 8) are part of the agriculture-dependent cluster in figure 11. Farmers received animal products through trade, while hunter-gatherer-farmers received agricultural products through trade, gifts, ceremonial feasts, and raids.

Although they play peripheral roles to the organization of production variables, the number of types of available herbs, roots, and tubers (variable 57) and the number of types of nuts and leaves available (variable 58) are linked to the hunting and gathering adaptations. Furthermore, the types of cactus, mescal, mesquite, and yucca available (variable 54) are also linked to hunting and gathering, but more specifically to the amount that wild plants contribute to the total diet. Analyses show that it was mescal, mesquite, screw bean, and the cacti that the Apachean, River and Upland Yuman, and Papago groups gathered in great quantities. It is important to know as well that other wild plants were rather more abundant where hunting and gathering outstripped or equaled agriculture in prominence, even if grasses, pines, oaks (variable 21, fig. 11), mammals, and birds were not more abundant.

One variable (38) on the edge of the distribution, and two variables (36, 40) that are centered among the wild plant variables (58, 54) and the large, nonherd mammal variable (60) show that access was provided to private (say, kinship unit–owned) hunting and gathering sites to both local residents and extra-local residents following some etiquette. Variable 47 shows that key hunting sites tended to be owned more as a function of the ownership of farm sites (variable 48), the number of types of storage structures used (variable 23), and, perhaps, the presence of barter and trade (variable 44), than as a function of the presence or absence of game. So whereas the agriculture-dependent people did not provide access to their key resources, hunters and gatherers did. On the other hand, extra-local reciprocity and gift exchange moved goods among dominant farmers, while that was much less true for the hunters and gatherers. However, the communitarian ethic applied to gathering resources generally required that people ask to use resources that they did not own, yet the farming sites owned by these same people were generally not available for use by nonowners, as the farming variable 48 demonstrates. So there was a marked difference between extractive-resource areas (hunting, gathering, fishing) and productive-resource areas (garden sites), and the people who were most dependent on garden sites had worked out several ways to make their farm and gathering products available short of providing access to their resource areas.

It is of interest to examine one last question. Figure 11 shows that whereas local redistribution of goods and chattels (variable 18) was most closely related to the variously co-dominant gathering-hunting-farming-fishing distributions of variables, ceremonial redistribution (variable 19) was most closely related to the agriculture-dependent distribution. They were closely related to each other only in the third dimension (height). It seems to follow that the dominant farmers were less communitarian and more formal in their property relations overall than those who relied less on farming. Farming sites and farming products were always controlled more carefully by their owners than nonfarm, or extractive, goods.

Some Brief Conclusions

These systematic comparisons of aboriginal environments and economies in the aboriginal Southwest in both Q-mode (the relations among tribes) and R-mode (the relations among variables) have yielded many nontrivial empirical generalizations, not the least of which is that although environment-culture relations are generally positive in the Q-mode, that is, as environments vary cultures tend to vary in the same direction, practically everywhere features of culture tend to override features of environment. For example, many people who once farmed or who could have farmed (Kewevkapaya, Mescalero Apache) did not. People who could have produced more from farming (Western Apache) did not. People who could have irrigated (River Yumans) did not.

In looking at the interplay of environment with the organization of production, it was found that, contrary to the hydraulic hypothesis, there was no clear relation between canal irrigation and centralized political-economic control. Localized kinship groups among the Pima joined together to accomplish on ad hoc bases tasks that were annual and obligatory among Eastern Pueblos.

Task groups were more characteristic of the agriculture-dependent people than those who were not; nevertheless, for all but some River Yumans and Western Apaches where agriculture labor tended to be co-dominated by the sexes, men did the bulk of the farming. Men also hunted and dressed skins, obviously an old complex in the Southwest. Only among some Apacheans (not the Navajo), who were recent interlopers in the Southwest, did women dress the skins. Among all groups in the Southwest the women did the bulk of

the gathering, but where gathering contributed much to subsistence, the men often helped the women carry the wild plants back to camp.

The organization of distribution analysis made it clear that all societies practiced reciprocity. Even the modest ceremonial distributions among River Yumans were reciprocal. Redistribution, except in the form of gifting of food, chattels and feasts that attended life crises and other ritual events among the Pueblos and Pima, were rare. These redistributions were sponsored by families, larger kinship groups, or kiva societies and shifted among several of these units depending on the year and the context.

These analyses have suggested that the behavior of the Athapaskans, Mohave, and Quechan seem to have exerted greater influence in shaping the nature of Southwest subsistence economies and economic organizations in the seventeenth and eighteenth centuries than did environment. Whereas it is trivially true that all units in the sample were "adapted," it is not trivial to learn that Yavapais were afraid to farm because of threats from some Western Apache raiders, that Pimas and Papagos were regularly attacked in the winters and had crops stolen by Apacheans and many were dislocated, and that Mohaves and Quechans attacked other River Yumans, but not for chattels or food, or, since the early nineteenth century, for land.

It seems that the predatory expansion of Athapaskans for farmland, hunting and gathering areas, and bounty, at least in late aboriginal times, was contained only by Upland Yuman buffers and the threat of River Yuman warfare. Pueblos and Pimas helped maintain themselves, after having their hunting and gathering territories restricted, by gifting and bartering crops and other moveable properties for products of the hunt with their sometimes adversaries.

The gathering base, which was women's work, and the farming base, which was men's work, were embedded in cultures (fig. 3) that demonstrated overall similarities associated more closely to language (a measure of historical inheritance and interaction) than to environments (fig. 2).

The importance of trade and raiding among River Yumans clearly influenced the shape of aboriginal adaptations in the Southwest, but it would be unnecessary sophistry to seek an explanation for River Yuman trade and noneconomic warfare, individual ownership of key resources, and failure to develop canal irrigation in terms of negative feedback mechanisms that, unknown to the participants, adapt the cultural system to the biological and abiological systems and the like, even though it is suggested above that at one time Mohave and Quechan might have garnered new farmland by dislocating some of their River Yuman congeners.

Although Kroeber (1939) did not test for relations between environment and culture, he showed again and again the "powerful dominance of history and culture over geography" (Driver 1962:8). Kroeber (1939:1) argued that while "cultures are rooted in nature . . . . they are no more produced by nature than a plant is produced or caused by the soil in which it is rooted."

It can be inferred from this analysis that canal irrigation was not possible where there was no source of predictable, running water; that hunting was not dominant where mammals and birds were sparse; and so forth. In the aboriginal context the environment provided some broad ranges within which people worked. Indeed, it is very probable that prehistoric farmers (Anasazi, Mogollon, and Hohokam) contracted their distributions following sustained drought, or some other deleterious and protracted environmental forces. Some groups survived and others probably did not, but even the canal irrigation people (Pima, Papago, Eastern Pueblos) "adapted" in different fashions.

Note on Ecological Adaptation

One point of logic that is most relevant, but that has been obscured by some advocates of "system ecology" in accounting for ecological adaptations, is that at any point in time any culture unit is "adapted" to its environment. Unless relations among phenomena are specified and measured through systematic comparisons and controls for a sample of culture units, there is no way to evaluate a generalization about the fit between natural environment and cultural environment, or natural environment and social structure, or cultural systems and biological systems, or whatever else one purports to explain. In talking about adaptation anthropologists have acted as if any and all ecological systems are composed of sets of populations that operate in definable natural environments. These natural environments, given the types of populations that operate within them, are alleged to have minimum to maximum carrying potential in reference to the several populations in their embrace. The natural environments, and all the relations among biological populations, are said to stand in specifiable relations with the human populations. Thus, it is alleged that farmers are dependent not only upon their seeds, the techniques they use to manage their crops, their storage techniques, their knowledge of precipitation patterns and soils and the like, but also upon things that the farmers need not or do not understand. For instance, it is alleged that in order for the human population to *survive* (a key term), it must *adapt* (a key term because it is a relational statement) to the other biological populations, and that these populations must adapt in their many interrelations in the environment. There is an interesting paradox here: on the one hand human populations (culture units) must maximize their survival

potential by creating and optimizing customs to adjust to threats of all types. Thus, the human population is conceptualized as a rational, economic man. On the other hand, the maximizing model of economic man is eschewed and the system is explicated as a nonrational, self-regulating mechanism making lawful adaptations. If the populations get out of balance—for instance, if the population of farmers outstrips its food supply because of a drought, and that drought likewise affects the wild plant and animal populations—survival is threatened. The human population, it is alleged, adapts to the environment without even knowing it. Adaptation, then, is interpreted as is adaptation in evolutionary biology: it is a nonrational or nonintentional process of adjustments. That is to say, the human population is part of a larger system of multivariate relations wherein an impulse generated or felt in one part influences the other parts, and the various populations must adapt to these impulses or be selected out. Human populations, it is contended, adapt themselves to the ranges of behavior of the other populations and the natural environment through customs that control and regulate their own population. Thus, human populations create and borrow techniques for subsistence and, often in unwitting responses to impulses from elsewhere in their system, create customs that serve as controls and regulatory mechanisms so that the human population can survive. The notion of controls and regulatory mechanisms allows the analyst to understand systems as organization of phenomena separate from the intentions, reasons, motives, and dispositions of the human agents in the system. Indeed, the system is alleged to be self-regulating (a nonrational model), and its behavior obeys lawful processes. In a fashion reminiscent of the British functionalists of the 1930s and 1940s, Ford (1972:1–17) has claimed that certain ritual customs of Eastern Pueblos are not at all what Eastern Pueblos think they are. He says that they are regulatory feedback mechanisms for assisting the survival of the population by storing and redistributing food to people in need. The customs, then, are unwittingly integrated into a system that "assists" survival of the population when the needs of some people outstrip their ability to satisfy those needs. Moreover, the nature of the system is such that the needs of some people will become dire at regular intervals, and the regulatory mechanisms will "assist" survival at these periods. It is not clear that anything of theoretical or empirical import turns on this view of environment (biological and nonbiological) and culture relations, because the key relational terms, that is, the explanatory statements or argument clinchers, such as "assist" and "survival" are not defined and measured, the ranges for the variables in the system are not specified and measured, the meaning of the key term "effective" variable is not clear because it is not demonstrated why some variables are "effective" and others are not, and the like. Furthermore, no differential equation models have been deployed to simulate a dynamic system, showing how survival is achieved through adaptations.

Note on Methodology

In conducting this comparative analysis it was of critical importance to follow formal procedures in order to demonstrate that relations were real and determinate. The goal was to compare the relations among tribes (Q-mode in matrix analysis language) and among variables (R-mode in matrix analysis language) to demonstrate that one tribe, say, was more closely related to another on the basis of the measurements of the shared cultural inventories of all tribes in the sample. "Real" in statistical language means that whenever tribes A and B practice the same customs 1, 2, and 3, they will be more similar than if they do not practice those customs. It is not enough to know whether a pair of tribes are very similar, or very different; it must also be known how similar a pair of tribes is in relation to all other tribes. In order to assess the meaning of any relationship between a pair of tribes, that relationship must be controlled by comparing each member of the pair with all other tribes in the sample. The relations among every pair of tribes in the sample must be measured to determine the closest relations among tribes. In figure 2, for instance, the 37 tribes form 666 pairs of relations, and all these pairs had to be analyzed in order to reduce the 666 relations to a two-dimensional mapping.

Thus, formal comparisons are controlled, whether in the analyses of tribes or variables. The methodology for comparisons and controls will require brief explication and can best be understood as part of the overall research design (see Jorgensen 1974 for a more extended discussion of comparative method).

The Variables

In order to measure relations among tribes and among variables it was necessary to formulate hypotheses about relations among environments and cultures, and to define and operationalize variables so that these hypotheses could be formally (statistically) and empirically evaluated. As part of the larger study Jorgenson (1980) defined 134 variables to measure environment, and 292 variables to measure culture. It was necessary to consult ethnographic, biological, historical, and other sources to rate each culture unit and culture-unit territory for the information pertinent to each variable.

The variable code is 180 pages long and cannot be reproduced here. It is available in Jorgensen (1980). The titles, but not the definition of each rank, for the

83 ordinal variables used for tests in the R-mode are listed with figures 10 and 11.

The Measures of Relationship

In order to determine the similarity or dissimilarity of a pair of tribes on several variables it is necessary to compare the tribes and measure the comparison. For measures in the Q-mode Driver and Kroeber's (1932) G was chosen, a measure of association closely related to Pearson's (Pearson and Heron 1913) r, which is exceptional in that it eliminates the d cell in a conventional four-cell table. Driver and Kroeber's

$$G = \frac{a}{\sqrt{a + b}\,\sqrt{a + c}}.$$

A four-cell table is, conventionally,

Tribe 2	Tribe 1 +	Tribe 1 −
+	a	b
−	c	d

where a = attributes of variables that are the same for tribes 1 and 2, b = the attributes of variables that are present in tribe 2 but absent in tribe 1, c = the attributes of variables that are present in tribe 1 but absent in tribe 2, and d = the attributes of variables in the total sample of variables for all tribes that are absent in both tribes 1 and 2. By excluding the d cell, the relations between pairs of tribes are not inflated by common absences.

For example, to measure a pair of tribes for their relationship on subsistence economy variables, of which there are 30 in this sample, each society would be rated for each variable. Each variable is composed of mutually exclusive attributes, that is to say, each society must be rated on one, but only one attribute for each variable. The variable "local agricultural products in the diet" has five ranked (ordinal) attributes: 0 percent, 1–10 percent, 11–25 percent, 26–50 percent, and 51–100 percent. Each culture unit must be rated for one of these ordinal attributes. By rating each culture unit for all 30 variables (encompassing 182 attributes, or 6 attributes per variable) the relationship can be measured for each pair of tribes on the subsistence economy information in question.

If the Mohave were the same as the Pima on 13 variables, but different from the Pima on 17 variables, the four-cell table would look like this:

Pima	Mohave +	Mohave −	
+	13	17	30
−	17	135	152
	30	152	182

$$G = \frac{13}{\sqrt{13 + 17}\,\sqrt{13 + 17}}$$

$$G = \frac{13}{30}$$

$$G = .43$$

In brief the table shows that whenever the same attribute is shared, an entire variable is accounted for in the a cell. Because variables are mutually exclusive and inclusive, whenever the Pima practices a custom that the Mohave do not practice (cell b), the Mohave practice a custom that the Pima do not practice (cell c). As a consequence, b = c. The d cell represents all 152 attributes of the 182 that neither culture unit practices. Because the number of attributes that neither member of a pair shares is potentially unlimited, and because b = c, Driver and Kroeber's G can be interpreted as the percentage of agreement between each pair of tribes. That is, a G of .43 for subsistence economy means that a pair of tribes are similar on 13 variables and different on 17, or 43 percent in agreement. G varies between .00 and 1.00.

The measures employed in the R-mode analysis were developed by Goodman and Kruskal (1954) as "regression free" measures of relationship between ordinal and between nominal variables. The 83 variables used in the R-mode tests are ordinal, that is, the attribute categories are ranked to mean that 1 is less than 2, 2 is less than 3, and so forth. On the other hand, ordinal ranks do not assume that the distance between each pair of ranks is equal. Thus, Goodman and Kruskal's Gamma measures whether the order of ranks in one variable predicts the order of ranks in the other, and vice versa. Gamma $= \frac{Ns - Nr}{Ns + Nr}$ where Ns = the number of pairs of cases having the same order on both variables, and Nr = the number of pairs of cases having reverse orders on both variables.

Gamma, which varies between −1.00 and +1.00, shows that there is no relation between ordered ranks at zero, that the ranks change in the same order at +1.00, and that they change in the reverse order at −1.00. Thus, in measuring the relation between the "contribution to diet from gathering" and the "species of herbs, roots, and tubers available" the ordered categories are being measured.

Species of herbs, roots, and tubers available	Contribution to diet from gathering		
	Tertiary	Secondary	Dominant
1–2	13	6	4
3–4	1	6	3
5–6	0	3	1

Gamma = .57

The Gamma is calculated using the 37 tribes as cases. In the Q-mode the variables are cases. Whereas the majority of tribes that depended least on wild plants had the fewest herbs, roots, and tubers in their territories, the relation between increased order of use and increased order of plants available is only modest.

For 22 of the 83 ordinal variables it was necessary to employ Goodman and Kruskal's (1954) Tau for nominal variables. That is because Gamma behaves erratically in four-cell tables, as well as in $2 \times N$ tables. So the 22 variables that have only two ordered categories each were ferreted out and measured separately from the other 61. For a four-cell table

$$\text{Tau} = \frac{\sum_{1}^{r}\sum_{1}^{c}\frac{n^2ij}{ni} - \frac{\sum_{1}^{c}n^2i}{n}}{n - \frac{\sum_{1}^{c}n^2i}{n}}$$

For example, to measure the relationship between "agricultural food acquired extra-locally" and "extra-local agricultural products in the diet" the two variables are placed in a table.

Extra-local agricultural products in diet	Agricultural food acquired extra-locally	
	None	Maize, beans, squashes
0%	18	1
1–10%	0	14

Tau = .88

There was no information on this question for four tribes, so those cases are excluded. The Tau shows that knowledge of either the column or the row variable allows a reduction in errors in predicting the distribution of the categories of the other variable by 88 percent. In the multivariate analysis in figure 11, signs (+ and −) were assigned to the Tau values so that negative predictions would separate variables and positive predictions would bring them together.

The Unidimensional and Multidimensional, Nonmetric, Multivariate Analyses

In analyzing the relations among culture units (Q-mode) two multivariate techniques have been used. Both are nonmetric techniques for finding the shortest distances in Euclidean spaces, but based on different algorithms. The unidimensional method referred to as Jorgensen's nonmetric trees (Jorgensen 1969) preserves some metric information in that bridges between the closest pairs show the Driver and Kroeber's G level at which the pair is joined (the largest G level is the shortest distance between the two points). For groups larger than two members, the bridges show the centroid (geometric center of gravity, or the shortest distance among all points in the group) for all G's among all culture units in the group.

The second method, called MINISSA by its authors (Roskam and Lingoes 1970; Lingoes and Roskam 1971), as used here is a multidimensional scaling program that converts coefficients of similarity (Driver and Kroeber's G, Goodman and Kruskal's Gamma and Tau) for a square matrix (Q- or R-mode) to distances from a specified Euclidean distance function and maps the distances into a set of ranks using special tie-breaking procedures. The relations among variables or tribes, as measured by ranks, are solved in as many dimensions up to 10 as are necessary. For complete analyses also see Guttman (1968) and Lingoes (1965, 1968, 1971).

The Guttman-Lingoes Coefficient of Alienation K is used to measure the amount of variation explained for solutions in two dimensions or greater. As a rule of thumb, K = .15 is employed as a reasonable fit. That is, about 85 percent of the variance among all of the points in the matrix is explained when K = .15. In general, the higher the dimensionality the lower the K. On the other hand, the lower the dimensionality, the simpler the interpretation of complex phenomena.

In the Q-mode the mapping of ranked variables required only two dimensions for extremely good fits. But in the R-mode three dimensions were required. The dimensions can be interpreted by looking at the front-to-back and side-to-side relations among points in two dimensions, and adding the up-to-down dimension in three dimensional solutions.