Agricultural Geography of the Southwest Indians

By

George Francis Carter

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OF

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GEOGRAPHY

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DISSERTATION

Agricultural Geography of the Southwest Indians

A survey of the crops grown by the agricultural Indians of the southwestern United States was made in the summers of 1940 and 1941. By study of this material it was possible to define cultural areas of the Southwest in terms of crop types.

The material is presented as a series of distributional studies. Corn, common beans, tepary beans, lima beans, cotton, and squash are analyzed in detail as to their entrance into and distribution in the Southwest. From this consideration there arises as a major theme the dual source of Southwestern agriculture. The crop distributions clearly indicate an eastern United States origin for Pueblo agriculture and a west Mexican origin for Hohokam agriculture.

Several minor theses are developed in this dissertation. The time and place of domestication of plants is discussed in relation to the antiquity of cultures in America and in relation to multiple centers of plant domestication. It is found that the current claims of cultural antiquity are generally too low. Also there is conclusive evidence of several separate centers of plant domestication.

A climatic section is included. This consideration was prompted because of the tendency to account for crop distributions in terms of climatic limitations. It is demonstrated that climate could not have caused the type of crop distribution that exists in the Southwest.

A final section summarizes the areal grouping of crops and divides the Southwest into agricultural regions.

GRADUATE STUDIES

Field of Study: GEOGRAPHY.

Geography of Latin America. Professor C. O. Sauer.
Classification of Culture Areas. Professor C. O. Sauer.
Destructive Exploitation. Professor C. O. Sauer.
Conservation of Natural Resources. Professor C. O. Sauer.
Research in Southwestern Climatology. Professor C. O. Sauer.
Western Regions. Professor J. O. M. Broek.
Principles of Geography. Professor J. B. Leighly.
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PUBLICATIONS

Aboriginal use of medicinal plants in southern California. *California Garden*, 29, No. 9, 4–8, April, 1938, and 29, No. 11, 4–5, May, 1938.

Lima bean farming and soil erosion in the Encinitas area. *Yearbook of the Association of Pacific Coast Geographers*, 4, 15–20, 1938.

Archeological notes on a midden at Point Sal. *American Antiquity*, 6, No. 3, 214–226, January, 1941.

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PREFACE

This study is centered on the specific problem of areal differentiation in the Southwest in terms of the type of aboriginal crops grown in the area. It is little known that clear cut divisions in crop distributions occur. A new basis of judgement concerning cultural origins can be established through consideration of these distributions. It is with crop distributions in the Southwest as they exist today and as they have existed in the past that this paper is concerned.

In order to simplify the presentation of material, discussion of regional complexes of crops is not taken up immediately. Greater clarity will result if the individual crops are discussed in turn and the synthesis of crop complexes by areas is left for the final section.

This paper is based upon two seasons of field work in the Southwest and the extensive crop collections made at that time. Practically all the agricultural Indians of the Southwest were visited, crops were collected and notes were made upon agricultural methods. The information gained is varied in quality and quantity because of differences in reception, willingness of the Indians to talk, etc. A month was spent among the Hopi pueblos and their agriculture was thoroughly studied. In sharp contrast Santa Domingo pueblo allowed no collecting or information gathering.

The usual ethnologic method is to use one or two paid informants in each tribe. This was not done in this work. The method of inquiry more closely resembled a door-to-door canvass of each community with the same general questions asked of many individuals. An effort was made to find individuals who were willing to talk freely. Such people were given free rein and question asking was kept at a minimum.

The advantage of the door-to-door method lay in the unexpected information gained and the check that multiple informants afforded as to the veracity of the individual. Little deliberate misinformation was encountered. The young people often did not know recent crops from the old crops, but the old people always could be counted upon to recognize recent material in the collection from their village.

I have made a careful study of the crop material collected. W. W. Mackie of the University of California, Department of Agronomy, has been of great assistance, particularly in reference to the bean collection. Dr. Edgar Anderson of the Missouri Botanical Garden has studied the corn collection and has been a prolific source of helpful information. Dr. L. H. Bailey of the Bailey Hortorium, and Dr. T. W. Whitaker of the United States Horticultural Field Station at La Jolla, California have identified the cucurbit seeds. To all of these men I am indebted for extensive aid.

The second summer's field work was done under the United States Indian Service and I am indebted to Messrs Collier, Beatty, and Harper for their kind assistance in this project. I hope in future papers to partially repay them by publishing the notes on agricultural methods and nutritional aspects of the crop complexes of the Southwest.

Dr. C. O. Sauer has most profoundly affected this thesis. Much stimulus has been derived both from long conversations with him and from reading his papers on the geography of the southwestern United States and northwestern Mexico as well as his considerations of American agricultural origins.

CHAPTER I

SOUTHWESTERN BACKGROUND:

Map 1 shows the distribution of the major archeologic areas in the Southwest. The Yuman people of the Colorado river (Cocopa, Yuma, Mohave, Maricopa, etc.) and the adjacent mountains to the east (Walapai, Havasupai, Yavapai) are shown in area one. The Yumans are a people of little known antecedents but are generally thought of as a people from the Great Basin. Colton (1939) has applied the term Patayan to the Yuman culture as a whole. The Hohokam people are mapped as holding the Santa Cruz, San Pedro, lower Gila and lower Salt river basins. This culture is best known from the published work of the Gila Pueblo at Snake Town in the Gila valley (see Gladwin, 1937 etc.). The full extent of the culture and its history can hardly be said to have been explored but it is clear that it forms one of the cultural nuclei of the Southwest.

The Mogollon culture is indicated as forming a wedge driven into the east side of the Hohokam-Anasazi boundary. Too little is as yet known of this culture as to its origins and cultural or temporal position to do much with it. Little is known of its crops, hence this paper will add little to the controversy which rages about its place in the Southwest, except the negative evidence that agriculturally it seems not to have affected the cultures about it.

The Anasazi area includes the peoples of the mountain and plateau area of Arizona, New Mexico, and parts of the Colorado and Utah. Archeologically it is divisible into the two major cultures of the Basket Makers and the Pueblos. The Basket Maker peoples were a non-agricultural, non-pottery making people who in their later periods adopted both of these arts. The Pueblo people represent an influx into the Basket Maker area of a new people who brought new cultural elements and in part displaced and in part fused with the Basket Maker peoples. They are represented today by the Pueblos still present in the Southwest. Within the Pueblo area proper three subdivisions are frequently referred to. These areas are: (1) about the San Juan river, in the Four Corners region (northeast Arizona and the adjacent corners of the three adjoining states), (2) the area of the Little Colorado drainage, and (3) the Rio Grande drainage.

After 1000 A. D. some of the pueblo peoples contacted the Hohokam people. The resulting modified Pueblo culture found in the area between the Hohokam and Pueblo is called Salado culture. About 1200 these people moved into the Gila-Salt valley and lived among the Hohokam. Around 1350 they withdrew. Some went east into the old Mogollon country. (The Mogollon people had moved south into adjacent Chihuahua.) Some of the Salado people moved north to join the Hopi and Zuni. Within the Pueblo area there once existed a division between the people of the Utah area north of the San Juan district who differed to an as yet undetermined extent from the peoples of the San Juan district and south. These people are herein referred to as the Northern Periphery culture.

The temporal sequence of these cultures must be dealt with in this paper. This is difficult to do because of the lack of agreement within the Southwest as to the exact correlation of the various cultural sequences. Most of the cultures are tied to the dating of the Anasazi area where the Douglas method of dating from tree rings has given a means of placing the arceheologic materials into a series subject to cross checking. By means of dateable trade materials the other cultures are tied as nearly as possible to this central area. The difficulties arise particularly in the tieing in of the Mogollon and Hohokam earliest periods. Gladwin (1937) has postulated beginning dates for the Hohokam so early that they have met with wide-spread opposition, and later temporal sequences postulated by Southwestern archeologists have tended to revise Gladwin's early dates. A chronology offered by Baldwin (1941) is given in table 1, along with Gladwin's original dating of the Hohokam cultures. It will be noted that the major disagreement is in the early periods postulated by Gladwin and questioned by Baldwin and most of the other Southwestern archeologists.

Gladwin's early dates are based on the theoretical time necessary for the cultural developments which took place. This is obviously a risky means of arriving at a date. It has been sharply attacked by the Puebloan specialists who still smart from their stinging readjustment of dates forced by the Douglas chronology based on tree rings. It will be indicated in this paper that there is more cause for postulating long developmental periods for the Hohokam than for the Basket Maker or Pueblo cultures. The notions of antiquity for the Anasazi were based on the supposition that much of the cultural development took place locally. The crop evidence shows, however, that the Anasazi area has been the recipient of several agricultural influxes some, if not all, of which were accompanied by further cultural additions of the sort which are so very apparent in the transition period from Basket Maker culture to the Pueblo culture.

For the Hohokam on the contrary, there is less evidence of such long continued and important introductions. Particularly in the early periods the culture must have been a relatively slow local development. The view is taken here, therefore, that although Gladwin may have postulated too early a beginning, Baldwin has certainly erred the other way. Lacking any method of exact dating, certainties are out. The agricultural picture indicates greater antiquity for the Hohokam agriculture than for the Anasazi agriculture. Start the Anasazi where one will, the Hohokam must have started that much earlier.

Map 2 shows the distribution of tribes as of 1650. This is close to the present distribution. The major change is to be found in the shrinking of the area held by the Pueblo and Piman peoples. The Ute, Navaho, and Apache have all driven into the area relatively recently. The contact between the Pueblos and the Pimans was broken off very late, in part in post contact times by the Apache activity. The disappearance of the peoples of the northern periphery and many of the peoples of the eastern periphery (Tano) prevents our gaining a picture of what their crops were. For the rest of the old-agriculturists of the Southwest (as opposed to the Navaho-Apache, the new agriculturists) a description of their crops is presented herein. The new agriculturists are largely omitted from this paper. What little material was collected from these people indicated that they copied the nearest Puebloan peoples and brought no agriculture with them.

CHAPTER II

DISTRIBUTION OF CUCURBITS IN THE AMERICAN SOUTHWEST:

One of the most useful of the Amerind crops for differentiating the agricultural areas within the Southwest are the American squashes and pumpkins. All of these belong to the genus Cucurbita. Material relative to this crop is abundant because of the work of a group of Russian and American geneticists. It is of great utility due to the existence of distinct domestic species within North America which will not hybridize (Erwin and Haber, 1929). Precise identification is, therefore, more commonly found in records of crop distributions both modern and ancient than has been true of corn and beans.

The cucurbits of Middle America have been studied by the Russian plant geneticists. From the extremely valuable reports of N. E. Zhiteneva (1929) and S. M. Bukasov (1930) concerning the distribution of cucurbits in Middle America one can arrive at conclusions concerning ultimate origins and routes of diffusion of certain species to the American Southwest. The work of N. I. Vavilov (1926) is not referred to in this discussion of cucurbits nor is it used extensively in this paper. This is due to the preliminary nature of Vavilov's report and its complete replacement by the more detailed works which appeared after the Russian geneticists had had time to grow, experiment with, and minutely study their enormous collections from Middle America.

The American cucurbits are loosely called pumpkins and squashes. Neither term refers to a species and all three species have forms referred to as squash or as pumpkins. Castetter and Erwin (1929) have proposed that we call all Cucurbita maxima "squash" and all Cucurbita pepo and moschata "pumpkins". Whitaker (1937) has commented, however, that their proposed terminology runs counter to accepted usage of the terms and fails to clarify the situation. Since there are no common names acceptable to all parties and in order to avoid ambiguity, the various species will be referred to by their species name, e.g. Cucurbita pepo will be called simply pepo.

In nomenclature I am following Bailey (1929), who divides the American cucurbits as follows:

Cucurbita pepo ------	large fruited, soft shelled, edible pumpkin
Cucurbita pepo variety ovifera--	the yellow flowered gourds (as opposed to the white flowered gourds, Lagenaria)
Cucurbita pepo variety melopepo-	the bush summer squash, soft shelled, non durable fruit a. the scallop or pattypan b. the marrow and crookneck
Cucurbita maxima -------	large fruited "squash" e.g. the Hubbard
Cucurbita maxima turbaniformis	turban type of maxima
Cucurbita moschata -----	the large, hard shelled, cushaw-type pumpkin
Cucurbita texana -------	the inedible gourd of Texas, considered by Bailey to be of pepo type.

Keys to the recognition of the various species by leaf and by seed character are given by Bailey (1929); Erwin and Haber (1929), and Whitaker and Jagger (1937) have given a key to recognition of the various species by their stems. These keys have been used in identification of materials in the field. Interested persons are referred to the original descriptions.

The seed collected ethnologically has been checked for identification by L. H. Bailey and T. W. Whitaker. The material has not been grown and the identifications are therefore based upon seed characters alone. Considerable reliance is placed in the results, however, both because of the knowledge of cucurbits possessed by these two men and because the identifications checked very closely. I am indebted to both for their courteous aid.

Erwin (1936) through field work and study of the archeologic remains has shown that maxima was unknown in the United States and was probably unknown in Mexico in pre-contact times. Zhiteneva (1929, p. 207) found that maxima was not common north of Peru and Bolivia. Bukasov (1930, p. 531) states that maxima is limited to Peru, Bolivia, and Chile. It seems established therefore, that only moschata and pepo need be considered in a study of North American cucurbits in pre-contact times. Both species are known in the Southwest from archeologic sites. Maxima has been added to the Indian agricultural assemblage in quite recent times, and today all three species are grown in the Southwest.

When collecting the crops of the Southwestern Indians the duality of the agriculture as shown in the differences in crops between the plateau and the Gila-Colorado areas in types of corn and beans grown was impressive. It was then postulated that a similar difference may well have formerly existed in the types of cucurbits. The modern distribution of cucurbits shows a degree of mixing to the extent that meaningful distributions cannot be determined, with certainty. Hence a review of the literature has been combined with the material studied in the various museums and National Monuments of the Southwest to show the distributions as they developed in time and area.

It is difficult to use the archeologic literature for the Southwest because many references are non-specific, i.e. squash or pumpkin remains are referred to but no identification is given. Even more hampering in the early period is the confusion in terminology and identifications, e.g. early identifications of maxima in the Ozark Bluff-dweller culture and in the Pawnee archeology are now changed to pepo. Recent work by American botanists has gone far toward clarifying the situation, but only a small fraction of the old material has been re-examined and adequately identified.

Due to the nature of the sites occupied material is available principally from the Basket Maker caves and the cave dwelling period of the Pueblos (3). By Pueblo 3 times a rather complete mixing of cucurbit types existed. However, for the Basket Maker period moschata is well documented (6 sites) while pepo is reported but once (general reference by Guernsey and Kidder, 1921, p. 42). This latter identification was made in the period prior to the re-examination of the cucurbits. Erwin and Haber (1929, p. 348) upon re-examination of the cucurbit material collected by Guernsey and Kidder failed to report any pepo. Therefore, it seems probable that this identification is in error and that pepo is entirely absent from Basket Maker sites.

From Basket Maker 2 to Pueblo 2 times (300 to 900 A. D.) on the Colorado plateau the only type of cucurbit reported is moschata. In Pueblo 2 time, in the Little Colorado area, specifically in the Flagstaff area, where Hohokam people are known to have settled in this same period (McGregor, 1941) pepo makes its first well documented appearance. By Pueblo 3 times pepo had spread over the Little Colorado and San Juan areas and the scene was laid for the modern mixed picture.

Map 3 shows this distribution and spread of pepo. The earliest known sites are in the Flagstaff region in Pueblo 2 times, around 1000 A. D. As has been noted these finds are related to the appearance at Flagstaff in this period of Hohokam people who came up from the Verde valley, where they had penetrated by late Pioneer times (Colton, 1939, p. 48), 700-800 A. D. The limit of distribution for pepo in Pueblo 2 is, therefore, shown as a finger-like extension, reaching to Flagstaff via the Verde valley, and open to the south.

There is an occurrence of pepo in a cave at Vernal in northeastern Utah. Unfortunately, the material can not be accurately placed either temporally or culturally. Material from early Anasazi to modern Ute was present in the cave. If the material is early Anasazi, it poses a difficult problem. It has just been shown that pepo was introduced into the Southwest from the Gila-Colorado and was late in reaching the pueblo peoples. An early occurrence of pepo in the extreme northeast of the Pueblo territory would seem to deny this claim. <u>If</u> the cucurbit from Vernal is early Anasazi, it may represent a separate introduction of pepo into the Southwest. A hypothetical extension of pepo into the northern periphery area is shown on Map 8.

Map 4 shows the distribution and spread of moschata. The data on which the map is based is cited in chart 3. The earliest known sites are in the Four Corners region in Basket Maker 2 caves, dating perhaps as early as 300 A. D. No Pueblo I occurrences are known, and moschata is mentioned but twice in Pueblo 2. By Pueblo 3 times moschata had a very wide distribution. In all probability the distribution of moschata was identical with the spread of Anasazi agriculture. Such a spread is indicated by the dotted lines. The much greater frequency of occurrence of moschata in northern Arizona and New Mexico is quite noticeable.

The maps show very clearly the direction of movement from the centers where the different species are first noted. The movement of pepo from the south to north, and of moschata from north to south is implicit in the progressively expanding areas occupied.

It thus appears that originally there existed a dual distribution of cucurbit types. Pepo must be postulated as the type originally in the Gila-Colorado area for it appears first in areas adjacent to the Gila-Colorado, along with other Gila-Colorado traits (e.g. ball courts), and is later to appear in the northern areas. It is most unfortunate that we lack cucurbit material from Hohokam sites to clinch the argument, but the evidence, although circumstantial seems quite clear and is supplemented by ethnologic evidence.

Some traces of the pre-Pueblo 2 distribution still remain. The Papago still recognize "old" and "new" cucurbits, and claim a variety of pepo as aboriginal. The recent ethnologic reports for the Yuma (Forde, 1931) and Kamia (Gifford, 1931) state that pepo was the original type. Russell (1904) found pepo the dominant type among the Pima around 1900. These are faint traces, but taken with the archeologic evidence they serve to indicate a survival into historic time of the former condition of dependence on pepo in the more remote and climatically difficult parts of the Gila-Colorado area.

This in turn suggests that the penetration of moschata into the Gila-Colorado area was relatively slow and was late, perhaps in part post-contact in time. This would seem to have been especially true for the Papago. To a lesser extent it may reflect a climatic barrier. The Papago claim that their old cucurbit would produce a mature, sweet melon if the ground were wet only once, while the "new" melons would not (Papago near Baboquivari, 1940). The Yumans claim that "white man's squash" must be planted, earlier, i.e. in the cool weather (Mohave at Parker, and Yumas at Yuma, 1940). The Pima, however, had no preference in cucurbit type. This may be due to the Pima having had other types of cucurbits longer, e.g. moschata from the Salado people, or it may reflect the slightly less severe climatic conditions of their fields.

That climatic limitations are not overly severe for cucurbits is attested by the modern cucurbit distribution. All three types are widely grown although with varying frequency. Maxima and moschata are more frequently met with than pepo. Maxima is now grown over a wide area in competition with the old entrenched types. This seems to indicate not only that it met no climatic barrier but that little ritual significance is attached to cucurbits. Apparently no compunction is felt over substituting a new form. Part of the spread of maxima must be due to its popularity with the whites. It was brought to the Hopi by the Mormons, according to Hopi tradition (Whiting, 1939, p. 93). Its prominence in markets, seed catalogues, and probably in government seed issues, are likely reasons for rapid and recent spread.

The recency of this spread may be indicated by pointing out that the first known maximas in the United States were introduced into New England from South America around 1827 (Tapely, 1937, p. 15). The spread must, then, have occurred not earlier than the middle of the 19th century. The ubiquitous distribution of maxima is a measure of the rapidity with which these Indian peoples have modernly taken up crops that they can grow successfully. There seems to be no advantage of maxima over any other cucurbit, hence the acculturation would seem to have no other ground than emulation of the whiles combined with a willingness to try anything useful.

These demonstrable temporal and areal differences in localization of cucurbits in the Southwest throw interesting sidelights on the origin of the two North American cucurbits and of the cultures that were characterized by them. Considerable attention has been paid to the wild cucurbits of the Southern United States. These are pepo varieties or closely related to the pepo species. McKay (1932, p. 36), Small (1932, p. 22), and Erwin (1938, p. 255) have suggested that we may have in them the source of our domestic form of pepo. Two of these wild forms, considered especially likely intermediate stages in the domestication of the cucurbits, are found one in Florida (Small, 1930) and one in Texas (Erwin, 1938). McKay (1932, p. 40) postulates that these may represent semi-domesticates which were abandoned in favor of the superior cucurbits introduced from Mexico.

Pepo forms were being cultivated in the eastern United States prior to the introduction of corn and beans. In the Kentucky caves Webb and Funkhouser (1936) found evidence of an agricultural horizon containing pepo and Lagenaria siceraria (the bottle gourd) in addition to a group of locally domesticated plants. Corn, beans and moschata pumpkin were lacking. Strong has reported (1935, p. 295) an agricultural level in eastern Nebraska based on pepo and Lagenaria siceria but also lacking maize, beans and moschata. A similar pre-pottery, pre-corn, and bean level containing cucurbits has been reported from the Mammoth Cave vestibule by Nelson (1917). These locations and the locations of the postulated wild forms of pepo are shown on map 5. It will be seen that a wide area is covered by this pre-Central American agriculture.

This early eastern agriculture has been discussed by Jones (1936) in relation to the material from Kentucky. Agriculture in this area has been shown by Webb and Funkhouser (1936) to present a definite seriation. Non-agricultural levels are succeeded by an agriculture possessing gourd fragments, and the upper layers contain corn and pottery. Locally domesticated plants from the pre-corn and pre-pottery level are listed as Iva sp., Chenopodium sp., Ambrosia, and Helianthus annuus. All of these plants also occur at the Ozark Bluff dweller site. Gilmore (1930) considered the Chenopodium as the seed referred to as cultivated and eaten in the Southeast in historic times and reported as "belle dame sauvage". Gilmore also reported that identical seeds came from early historic Pawnee sites in Nebraska.

A widespread, rather well developed agriculture in the Southeast prior to the appearance of the typical Middle American plants such as corn, moschata, and kidney beans is thus well established. Certain elements of this agriculture carried on down to early historic times as is indicated by the case of the Chenopodium in the Southeast and among the Pawnee. The modern use of the sunflower is a case of our adoption of a plant from this indigenous United States agriculture.

A type of pepo domesticated in the Southeast is still cultivated by the Eastern Indians and by ourselves. The northern tribes of the eastern United States still grow pepo forms predominately, and state that pepo types are their ancient type of cucurbit. (See map 7) According to Tapely (1937, p. 4) the earliest cucurbits mentioned by the colonists in New England and New York are C. pepo melopepo types. This is the identical type described by Jones from the Kentucky cave culture (1936, p. 148). The bush summer squash (patisson) and the Connecticut field pumpkin, both pepo forms, are among the earliest forms described by the American colonists. There were many other forms of pepo in the north-eastern United States and that area appears to be a center of varietal differentiation which in the Russian system of plant geography characterizes a center of domestication. This variability seems to be limited to the United States, however, for Bukasov (1930, p. 531) noted that pepo occurred in Mexico and Guatemala in only a limited number of forms and in a few places. The distribution given is similar to that given for the tepary bean and the postulated origin is given as "beyond the northern limit of the Toltec civilization" (Bukasov, 1930, 531). (This must replace the postulates of the presence of pepo in Peru based on the resemblance of funerary urns to pepo forms; e.g., Safford, 1926; Erwin and Haber

1929, etc.) In view of the presence of wild, semi-domesticated (?) and domestic forms of pepo in the United States at a time when there is no evidence of contact with Mexico, and the presence of a series of other local domesticates (Helianthus tuberosus, Helianthus annuum, Iva sp., Chenopodium sp., etc.) it seems certain that the domestication of at least one form of our modern pepos occurred in the eastern United States. The occurrence in the southern United States of the known wild forms related to pepo make it seem likely that this domestication occurred in the area south of the Appalachians.

The wild forms of the American cucurbits are distinctly unattractive food sources. One of the commonest United States forms is aptly named foetedissima. All of the wild forms, including texana and okeechobeensis, are inedible. There is very little flesh inside the rind and what there is is quite bitter. Perhaps the Amerinds had a method of extracting this bitterness which was dropped when sweet types were evolved, but no trace of any such special treatment of cucurbits has survived.

One very widespread trait, however, is the utilization of the kernels of the seeds of the cultivated cucurbits as a source of food. In Mexico the seeds are sold like peanuts. The food thus attained is oleacous to such an extent that the Russian geneticists have suggested the cucurbits as a possible vegetable oil crop. Pangalo (1929, p. 18) found that 45% of the seed of cucurbits is oil and that cucurbits yield more oil per acre than flax, hemp, poppies, etc. It is highly significant that the type yielding the most fruits, hence the most seeds per acre were the small fruited, decorative cucurbits, C. pepo var. ovifera (Bailey). This type is hard shelled, bitter and inedible, except for its seeds, yet was kept in cultivation by the Indian people of the United States. McKay (1941, p. 36) states that pepo has some varieties of hard shelled inedible gourds some of which are almost identical with texana. Texana and the ornamental pepos are annuals. C. okeechobeensis, C. foetedissima, C. palmata, and C. digitata are perennial wild forms. The shift from perennial to annual is considered one of the signs of domestication (Ames, 1939). The extremely restricted and spotty distribution of C. texana suggests that it is an escape (more correctly an abandoned domesticate). C. texana and the ornamental gourds would then, by the view taken here, be domesticated forms used for their seeds.

Erwin (1928, p. 254) has followed a different line of reasoning and reached the conclusion that texana is a likely common ancestor to both the edible and ornamental pepos. The difference is slight. In either case texana is recognized as a pepo ancestor. If it is a direct ancestor, then it must have been cultivated at one time. Its spotty distribution and its annual habit suggest that this cultivation was sufficient to markedly modify the plant, hence it is more logically an escaped than a wild form.

It is postulated therefore that the cucurbits in general first attracted attention for their seeds. The sizeable gourd-like forms found all over the temperate Americas could not have gone unobserved, untried, and unexploited by such botanical pragmatists as the American Indians. The rich oiliness common to the seeds of the cucurbits, their relatively large size, and the ease of gathering would assure them a place in the Indian diet. In this way wild cucurbits in many places could have come into use and eventually into domestication. The end result of this was the three major species of American cucurbits.

We need to know more of the methods of preparation of cucurbits for consumption. Does the derivation of all (?) our "summer squash" (i.e. squash which will not keep and which is eaten in the immature form) from the pepos of the United States mean that this is the only area of such food habits? Does drying the flesh of cucurbits reduce the bitterness and does this widespread trait underlie the early utilization of cucurbits for flesh? The clues to how and why cucurbits were first domesticated may yet be revealed by further knowledge of primitive eating habits as yet unrecorded but still practiced.

Many forms besides the three commercial species of cucurbits are discussed by the Russians, and some of these are actual domesticates which have merely been neglected by our farmers. These will not be discussed here as they lie outside the primary area of investigation of this paper and the discussion of the three major forms will suffice to illustrate the principles of plant domestication involved.

Map 6 shows the distribution in North and South America of the commercially important cucurbits. Zhiteneva (1929, p. 207) found that these various cucurbits have sharply distinct distributions; e.g. it was noted above that pepo was almost lacking in Central America and Mexico. Maxima was unknown north of Peru, and moschata seems to have been rather closely limited to Central America. Such distributions fit the hypothesis of original widespread use of wild cucurbits for seeds and the eventual domestication in various areas of differing species. By this view the characteristic area of each species should contain related wild forms, and be the seat of origin of the species.

Maxima is found in Peru, Chile, and Bolivia. There are two distinct forms, maxima and maxima turbaniformis. Zhiteneva (1929, p. 205) found sufficient differences in the flower to establish turbaniformis as a separate species, and believed it to be of Brazilian origin. Although Peru is the area known to be occupied by maxima, the nearest wild relative is found to the east of the Andes (Tapely, 1937), in Uruguay and Argentina. Since this area was not explored by the Russians we know little of it. The presence of the wild relative there suggests that the domestication of maxima may have taken place in the same general area in which Mangelsdorf and Reeves (1939) have already postulated that corn was domesticated. The presence of two distinct forms raises the possibility of distinct domestication of similar forms. Unfortunately we know too little of detailed distributions in the Andean country to work with the data, but the possibility exists that turbaniformis is Brazilian and maxima is north Argentinian in origin. In the Middle American area there again appear two domestic varieties of a single species, in this case moschata. Here, however, the Russians covered the area with comparative thoroughness and found that the two forms are areally distinct (Zhiteneva, 1929, p. 207). There is a white seeded form which is Mexican, and a brown seeded form which is northern South American. One may, of course, postulate an early domestication of a single form of moschata; the diffusion of this form into two areas which became separated and the subsequent differentiation of two distinct forms. But it is equally possible that Central America was the home of several wild forms of cucurbits related to moschata as modernly defined, and that out of the varied forms of this species in two separated areas, two separate varieties were domesticated. Against this theory is the intra-specific fertility of the cucurbits. Proof or refutation must await the detailed work of the plant geneticist. It is advanced as a hypothesis which deserves investigation.

The pepos are the best known of the American cucurbits. If there were divergent origins of the varieties of pepo, one would expect this to be reflected in the botanical descriptions of the pepo varieties. Some such evidence does exist. Bailey (1929, pp. 94-96) divides the pepos into three groups: pepo, pepo melopepo, and pepo ovifera. Erwin (1938, p. 254) describes pepo as "a multifarious species and embraces a number of diverse types."

The absence of certain forms of pepos in the northeastern United States in the colonial period has been noted by Tapely (1937, p. 4). The patisson, the field pumpkin, and the Danish squash were common; the crookneck and the marrow types were seemingly absent. Bukasov (1930) gave the distribution of pepo as from Canada to Guatemala with its center of diversity in Canada and the United States. He stated specifically that there was little diversity in Mexico, but that there were distinct types in distinct areas. In Guatemala he found warty, short fruited types. In Central Mexico he found an endemic, long seeded type which has never become a commercial variety. In northern Mexico he found pepos of small, oval seeded form quite distinct from the long seeded form or the warty forms to the south.

Patisson and ovifera types are lacking in Mexico according to Bukasov; crook neck types were originally lacking in northeastern United States according to Tapely. It is unfortunate that Bukasov does not specify whether or not his Guatemalan warty forms are crook necks. Since he states that the long seeded forms of Central Mexico have never become commercial varieties but fails to state the same for the Guatemalan, one might assume that the warty forms are our commercial crook necks. If so, then reciprocal absence of patisson and crook neck would strongly suggest that the eastern United States is the home of the patisson and the home of the crook neck form of pepo.

There thus seem to have been four centers of pepo in North America: the field pumpkin, the Danish squash, and the patisson in eastern United States; the form with small, oval seeds of northern Mexico (possibly the same form as found in adjacent Southwestern United States); the Central Mexican form with long seeds; and the Guatemalan warty forms.

The degree of independence of the various forms is not easy to state. A rather clear case has been presented for an eastern United States origin of at least one group of pepos. Bukasov (1930) speaks of the long forms of Central Mexico as endemic, hence a local origin must be accepted as likely. The Guatemalan group have an island-like distribution that is as easily accounted for on an independent domestication basis as on derivation from sources unknown. The north Mexican pepo is also quite distinct, has wild forms within its area which Bukasov considered as likely progenitors (especially C. foetedissima), and the area is known to have been a center where at least one other plant was domesticated (the tepary bean). The evidence then favors plural domestication of pepo.

The degree of independence of the Mexican centers is still obscure, but the complete separation of the eastern United States center from the Mexican centers is quite clear. If dual domestication of the species is admitted, it is difficult to argue against three or even four independent centers if the requisite wild forms are present. The domestic forms are divergent and areally distinct. Since these conditions are met, the evidence to date suggests four centers of origin for pepo.

The survival of the original cucurbit distributions in so great purity argues for failure of domesticated plants to diffuse when they were in competition with plants of similar qualities. It can also be used to argue that the domestication of the various cucurbits was roughly contemporary. The area covered by any one cucurbit would then be a measure of how far that cucurbit spread before it encountered another area already possessed of an equally good cucurbit. Had one cucurbit been domesticated far in advance of all other types, it is postulated that its spread would have been unchecked, and the domestication of the other cucurbits might well never have occurred. The operation of such a selective factor is well illustrated by the fact that corn, which was apparently domesticated in the same area and probably at the same time as C. maxima spread to the extreme corners of agricultural America. Similarly, beans, almost all of whose forms were domesticated in Central America, spread over vast areas. Indeed the only agricultural area of America unpenetrated by the kidney bean of Central America was that area where a different species of bean was domesticated, i.e. the Gila-Sonora area occupied by the tepary bean.

The discussion in this section as well as Sauer's (1936) discussion of cultivated plants suggests that domestication was a process that went on in many places. Wild plants of useful type had wide ranges with genus, species, and varietal diversification already established prior to the beginning of domestication. For some of these, e.g. the cucurbits, we have clear evidence of plural domestication. It seems probable, therefore, that the differences in our domesticated plants stems at least as often from the pre-domesticate level as from the post-domesticate level. This is the more probable as the degree of difference increases. By this view, a species difference in any domestic plant should lead to the investigation of the likelihood of separate domestication.

In this connection it is important to note that the cucurbits are normally open or cross pollinated plants. Their failure to hybridize in nature, and their almost complete sterility when artificially crossed indicates a truly great divergence. All forms of maize will hybridize and maize has a universal distribution in the agricultural Americas. The cucurbits will not hybridize and their distributions are mutually exclusive in the Americas. By the lines of reasoning advanced we must postulate a single center of domestication for the former and a multiple domestication from various wild forms for the latter.

Sauer (1936) has presented the evidence for plural origins of American agriculture based on a consideration of the duplication of starch crops. The considerations above extend our insight further into these processes of domestication, and make certain the independent development of agriculture in many centers.

It is interesting to consider the implications of the above as it effects the Southwest. The Basket Maker agriculture has been shown to begin with moschata as its cucurbit, and this crop is accompanied by corn in the earliest levels. If Basket Maker culture were postulated to have sprung from contact with the earliest Eastern agriculture it should be marked by pepo and the absence of corn. Since this is not the case, it is clear the Basket Maker agricultural beginnings must either lie to the south, i.e. among the Hohokam or derive from some eastern source of later date than the Kentucky cave agriculture. However, it has been demonstrated that the Hohokam had pepo and that active exchange of crops did not take place between the Hohokam and the Anasazi before Pueblo II times. It, therefore, becomes necessary to postulate that the Basket Maker agricultural beginnings stem from the cultures that arrived in the eastern United States bearing the Central American crops of maize, beans (P. vulgaris), and moschata.

The Ozark Bluff-dweller agriculture is reported by Harrington (1924) to possess the plants of the Kentucky cave agriculture but also the Central American crops and to have a series of traits in common with the Basket Maker culture. The beans present are dark colored, as are the first beans to appear in the Basket Maker cultures. The squash is moschata as is the Basket Maker type (Erwin, 1936, p. 442). Relationship to the Kentucky cave agriculture, as noted by Jones (1936), is extremely close as is evidenced by the presence in both sites of Iva, Chenopodium, Ambrosia, and Helianthus, etc., many if not all of which were cultivated. The Ozark Bluff-dweller would then seem to represent a transition between the early agricultural stage of the eastern United States and the later agriculture based more completely on the Central American domesticates.

Basket Maker agriculture can not have been derived directly from it, however, for while the Basket Maker agriculture has but one type of corn, and that an early maize type, the Bluff-dwellers possessed a variety of maize types (Gilmore, 1932, p. 93) including types with big grains which will be shown to be of late introduction into the United States. Basket Maker agriculture must derive from a culture which possessed but a single type of corn.

One might object that the Basket Makers selected but one of several types of corn from the culture from which they were borrowing agriculture. It must be noted, however, that this corn is an early form and one having so few advantages that in later periods it was completely replaced by other types. It seems clear, therefore, that possession of but this one type of corn is evidence that it was the only corn available to the Basket Makers. Strong's Stern's Creek culture (1935, p. 193), as noted previously, belongs to the pre-Central American agriculture and his later cultures seem too late in type. It therefore becomes necessary to postulate an intervening culture, possessing moschata, and but a single variety of Basket Maker-like corn. A culture containing Basket Maker-like corn and Basket Maker pictographs has been reported by Renaud (1930) from western Oklahoma. Cultures possible fitting the hypothesis have been reported from upper levels of the Kentucky caves by Webb and Funkhouser (1932, p. 10) but the descriptions are too meager to allow positive interpretation of the cultural implications of the material.

The cultural and temporal significance of pepo among the Hohokam remains to be discussed. Map 7 shows that at a hypothetical early period, prior to the introduction of Central American agriculture into the eastern United States, two areas of pepo existed, a large Eastern area, and a Southwestern area whose extent south of the Mexican border is unknown. Between the two areas lies a zone lacking evidence of early agriculture, in part lacking evidence of agriculture at any time.

The closest agricultural people to the Hohokam were the Basket Maker people. But these people have been shown to be a peripheral development of an eastern culture, i.e. to have derived their cucurbit from the eastern United States. A comparison of Hohokam and Basket Maker shows that Hohokam agriculture was flourishing in an area of extreme climatic difficulty when Basket Maker agriculture was just beginning. If we accept Gladwin's dating (see chronology in introduction) of the earliest levels at Snaketown, Hohokam agriculture was flourishing long before the Basket Maker people began cultivating crops. At a time when the Basket Maker agriculture was still developing and adding new plants to its assemblage, the Hohokam are postulated to have already advanced to irrigation (500 A. D.).

When the Hohokam and the Eastern agricultures are contrasted on the same basis, it seems clear that the Kentucky cave agriculture is older than the Hohokam. Not only are there more plant domesticates, but the evidence of agriculture prior to Central American influence is clear. For the Hohokam we know that the tepary bean was domesticated either by them or in the area immediately south of them, but we lack any proof of agriculture prior to the appearance of the Mexican crop of corn. Much of this is weak negative evidence for we know very little as yet of early Hohokam, its origins, or its food plants. However, the evidence to date suggests that while the Hohokam clearly represent an early agricultural horizon, the Eastern agriculture is still earlier.

The similarity in cucurbits between the early Eastern agriculture and the Hohokam suggests the possibilities of early contact. If we postulate a contact prior to the spread of the Central American crops to the United States, it amounts to showing a continuous agriculture of the Kentucky cave type to have extended as far west as the Gila-Salt basin. For this we lack any evidence at present. The answer to the problem lies in western Texas and southern and eastern New Mexico, and this area is too little known at present for its negative evidence to be taken as final. Smith (1931, p. 66) found corn in the Big Bend caves. Mera (1938, p. 48) found no agriculture in the caves of the Guadalupe mountains of southeastern New Mexico, etc. Setzler (1935, p. 109) summing up the work in that area found that corn, beans, and squash were cultivated in the western part of the Big Bend but that there was no evidence of maize agriculture around the Pecos river region. Since then, however, some Pecos river agriculture has now been demonstrated (Jennings, 1940, p. 9). Crop material from the Pecos river was examined at the Laboratory of Anthropology, Santa Fe, New Mexico. It contained both tepary and kidney beans and thus suggests late and mixed origins.

The culture is described as being close to Mogollon. Presence of tepary beans indicates a western agricultural origin. Thus there is no demonstrable contact between the early eastern and early Gila agriculture. The agricultural material from the area between the Pecos and the Rio Grande may well prove, therefore, to be but a development marginal to the southern Arizona and northwest Sonora agricultural complex.

The distribution of cucurbits in the United States at 1000 A. D., then, can be tentatively reconstructed as given on map 8. The Hohokam and Colorado river Yumans are shown as having pepo, and the Hohokam are shown as extending up the Verde river. There are no dates from the Yuman area but it is here postulated that they were agricultural by this time. The Anasazi are shown as an extension of the Southeastern area which is characterized by pepo. The Mogollon and the Patayan cultures are left blank for lack of evidence either as to the source of their agricultures or of the type of cucurbits they possessed. The amount of mixing of moschata and pepo types in the eastern United States is obscure. Were it not for the appearance of moschata in Basket Maker culture without pepo, a general mixing might be postulated in the eastern United States. However, since it has been demonstrated that in the Southwest two cucurbit species were grown in proximity to each other for 500 years before agricultural exchange occurred, a similar situation may have occurred in the Southeast and the two cucurbits are mapped as characteristically occupying separate areas. The Northern periphery is tentatively shown as characterized by pepo. Since this is based solely on the material from Vernal, Utah, it is only weakly indicated. Corn types, however, also tend to support an origin separate from the rest of the Southwest. Arrows indicate the postulated lines of movement of the agriculture.

CHAPTER III

DISTRIBUTION OF MAIZE IN THE SOUTHWEST:

Concerning the distribution of Zea mays in the New World and its origins one must again turn to the Russian geneticists and to a small group of American geneticists. The greatest recent advances in our knowledge derive from Mangelsdorf and Reeves (1939) consideration of the origin of corn and from the surveys of the distribution of varieties of corn in Middle America carried out by the Russian plant geneticists. These works have been used for general background. Lengthy correspondence with Dr. Anderson of the Missouri Botanical Gardens concerning results obtained from study of the corn collections made in 1940-1941 and access to unpublished work by Anderson and Cutler has greatly aided me in building the general picture of the origin and distribution of the races of corn in the Southwest.

The archeologic literature for the Southwest has been combed for references to maize. In the main the material is of little use because of the lack of adequate identification, description, and lack of careful statement of exact cultural position. It must be said, however, that the later papers are infinitely better than the early ones. In the main, however, agricultural materials have received about the same amount of care that dendrochronological material received in the pre-Douglas Southwestern period.

Ethnologically, however, corn has yielded more detailed insight into the cultural divisions of the Southwest than have the cucurbits. The cucurbits show the main outline most clearly; maize follows that outline, but reveals detail within the major framework. The figures used in the following discussion are based on the collections of 1940-1941 and on field observations.

Gila-Colorado Area

In the Gila-Colorado area there is a distinct type of corn. It is 10-12-14 rowed; percentages run 60% 10 rowed, 25% 12 rowed, 15% 14 rowed. The row count is consistently low among all the tribes of this area. In color the corn is 90% white or light yellow. Red, blue, etc. occur rarely and seem most probably due to mixture with Puebloan or recent corn introductions. The ear length averages 5 inches, and the diameter averages 1 inch. This is notably smaller than the Pueblo corn. Kernel texture is uniformly flour except for rare examples of flint corn especially among the Pima.

Flint corn among the Pima, atypical for the area, may be due to the contact with Puebloan people. The Salado people are known to have lived in this area from 1200 to 1400 and would have possessed flint corn. If Pima flint corn came from the Salado people, it would indicate that the Pima are the Hohokam. The transfer of the single gene for flintness to the Hohokam corn would have been expectable due to its utility. (Flint corn is more insect resistant in storage).

The kernel of the Gila-Colorado corn type is small, shallow, either rounded or more often flat topped and striated by the husks. The cob shape is uniformly tapered both to the butt and the tip, and the stem is tiny.

Opposed to this is the "Pueblo" type of corn. Pueblo is in quotes to indicate that this term is used quite loosely. In reality there is today no single Pueblo type, but a series of differing types. Characteristics of the Pueblo group as opposed to the Gila-Colorado group can, however, be cited. "Pueblo" corn is larger, normal ears range between 6 and 18 inches long and from 1½ inches to 2 inches in diameter. The butts of the cobs tend to be big, often exaggeratedly so, and the stem is often nearly as large as the butt. The grains are larger than the Gila-Colorado, often deep and triangular. The incidence of flint corn is high. There is a great variety of colors; blue, red, salmon, pink, yellow, white, striped, speckled, black, brown, etc. all occur. So great diversity of color has been found by Bukasov (1930) and Kuleshov (1929) in various areas in Middle America but only where different races of corn overlapped. It is here postulated that this great diversity of colors in the Southwest is likewise the result of mixing of races of corn.

A comparison of the descriptions for Pueblo and Gila-Colorado corn will show that the two types are markedly divergent. The corn of the Gila-Colorado area is very uniform in all characteristics and must be postulated as being relatively pure and representing but one race of corn. The variety of color, and regional variation in form suggests that the "Pueblo" corn is greatly mixed and hence of plural origins.

Those who argue for the non-identity of the Pima-Papago and the Hohokam could argue for the recent introduction of the Gila-Colorado corn. A comparison of the ethnologic distribution of Gila-Colorado corn and of the tepary bean shows that the two crops have identical distributions. Among the Pueblo tribes only the Hopi and Zuni have Gila-Colorado corn in any purity of form and even among them it is a minor element. The tepary bean is also limited to the Hopi and Zuni in pre-contact times. The tepary bean can be shown to be earlier than 1000 A. D. in the Anasazi area (see the section on the tepary bean) and a similar date is not an unreasonable postulate to draw for its companion crop.

Archeologically, the description given for Hohokam corn by Jones (in Gladwin, H. S. et al. 1937, p. 158) fits the description of Gila-Colorado corn. It is described as small, and apparently flour corn. Cobs from the Ventana cave in the Papago country being excavated by Haury were examined at the Arizona State Museum at Tucson and these belong to the Gila-Colorado type. Cobs from Ventana cave ranged from $2\frac{1}{2}$ inches to 4 inches long and averaged 3.2 inches in length. Row numbers ranged from 8 to 14 with 10 and 12 the common numbers. The resemblance in cob type and row number strongly suggests that this is Gila-Colorado corn and that the size difference is due to recent increases in size. Such recent increase in size can be demonstrated for the Pueblo area where the archeologic material is more abundant.

Corn cobs of Gila-Colorado type are described from Winona (McGregor, 1941), a site near Flagstaff known to be of Hohokam occupance. Similar ears are described from Kinishba, a site adjacent to the Hohokam area and known to be strongly Hohokam influenced (Baldwin, 1939, reports flint kernels, but this is a single gene difference and less important than the cob and row number). At both of these sites the tepary bean which will be demonstrated to be Hohokam in origin also occurs. Gila-Colorado type ears have also been described from the Chaco canyon (Brand, 1937). The Chaco has been postulated on other grounds as an area early influenced by developments to the south (Gladwin, 1934). At Hope, New Mexico (material examined at the Laboratory of Anthropology) cobs of Hohokam type have been found associated with tepary beans in a culture that is Mogollon in aspect. Since the Mogollon were distinctly acculturated by the Hohokam the evidence still favors a Hohokam, hence Gila-Colorado source for this type. At Alamogordo in New Mexico (material examined at Santa Fe, courtesy of Donald Lehmer) and at El Paso and in the Big Bend country of Texas (Gladwin, 1937, p. 38) still other similar ears have been found.

Those ears cited from the literature are so identified on the basis of extreme small size and low row number. Those examined in the field have been found to have the characteristic reduced butt of the Gila-Colorado type as well. The correlation of this type of corn with the southern Arizona and southern New Mexico area and adjacent Texas is thus well established. It seems equally well established that the type is associated with Mogollon and Hohokam cultures or their peripheries. Archeologically and modernly, then, there is but one type of corn in the Gila-Colorado area.

Pueblo area:

It has already been indicated that there is today no such thing as a Pueblo type corn. Great variation occurs in butt type, size, grain type, row number, and grain texture and these variations have rather distinct regional localizations.

Some cobs are markedly expanded at the stem and are here referred to as big butt cobs. Cobs with big butts vary widely in the percentage in which they occur among the modern Pueblo tribes, and are completely lacking among the Gila-Colorado tribes. The table below shows that big butted corn is strongly concentrated at Picuris and Taos. San Ildefonso, San Juan, and Isleta fall into an intermediate group wherein the percentage of big butts is relatively high. Field observations form the basis of placing Jemez at least with the intermediate group if not with Picuris and Taos. Acoma, Laguna, the Hopi, Cochiti and San Felipe fall into a third group marked by the minor presence of big butt corn.

Table 3

Percentages of Big Butts

Picuris and Taos	90%
San Ildefonso and San Juan	55%
Isleta	40%
Acoma	25%
Laguna	20%
Hopi	18%
Cochiti--San Felipe	10%
Yuma	0%

In general then the percentage of big butts increases to the north and to the east. The outstanding exception is the Cochiti and San Felipe area. The high concentration of big butts at Picuris and Taos and probably at Jemez argues for these pueblos as the points of entrance of the type. The presence of the type at Jemez in the midst of Pueblos unaffected by contamination with the type argues for its intrusion into the area rather than diffusion through the area, and for its quite recent introduction. For these reasons an introduction to Jemez of the big butt type by the people from Pecos might be postulated.

The big butt types are associated with relatively high row number and enormous sized ears. Ears between 12 and 18 inches long among the Pueblo people almost always prove to be of big butt type and this great size has operated to make them favorites with the Pueblo people. That their spread is recent and rapid is attested not only by their distribution but by the almost universal claim of the old people that their "old" corn was much smaller and the complete absence of such giant ears from archeological collections.

Size itself varies among the Pueblos but the Pueblo corns again form a group as opposed to the Gila-Colorado type. Within the Puebloan groups the major division in length is that between the relatively long ears of the Rio Grande and the shorter ears of the Hopi and Acoma area. Zuni certainly belongs in this Hopi-Acoma group and Jemez belongs in the longest eared Rio Grande group. To some extent the increase in size from the Southwest to the Northeast still holds. Large ears would then also appear to be of relatively recent and certainly of Northeastern introduction.

Table 4

Length of Ears: Average in Inches

San Ildefonso and San Juan	10
Laguna	9
Cochiti and San Felipe	9
Picuris and Taos	9
Isleta	8.5
Hopi	7.3
Acoma	7.2
Yuma	5

The distribution of big grains is much more even than that of big butts and on this basis an earlier introduction may be postulated. In low percentage of big grains only the Hopi are clearly set off from the other Pueblo groups listed here, although Acoma is as close to the Hopi as to the rest of the Pueblo group.

Table 5

Grain Type: Percentage of Big Grains

San Ildefonso and San Juan	100%
Cochiti and San Felipe	95%
Picuris and Taos	90%
Isleta	90%
Laguna	87%
Acoma	70%
Hopi	50%
Yuma	20%

Figures on row count gave only moderately significant results. The Rio Grande pueblos have 12, 14, 16 as the commonest row numbers, but 18 and 20 rowed ears occur occasionally. The Hopi have ears of lower row count, with 45% of the ears having 12 rows, 78% of the ears having 12 and 14 rows. In this respect, the Hopi are intermediate between the Rio Grande and the Gila-Colorado where the row count is characteristically 60% of 10 rows, 25% of 12 rows.

A consideration of the distribution of corn types in the Southwest today thus leads to the uncovering of two major areas: the Gila-Colorado as opposed to the Pueblo. But within the Pueblo area the Rio Grande area forms a subdivision from which the Hopi, Zuni, and to a lesser extent Acoma and Laguna, depart very noticeably. On the basis of the attenuation of the traits of big butts, great length, high row number, and big grains toward the Southwest, it must be postulated either that these traits are of Northeastern origin, or that these traits are "diluted" by crossing with Gila-Colorado types to the Southwest. Since the big butts show an uneven distribution on the Rio Grande for which there is no apparent reason connectable to Gila-Colorado contacts, the distribution follows the division in bean types as will be shown later, and, moreover, since the Hopi-Zuni corn a distinct type and not a simple blend with Gila-Colorado corn, it is here postulated that these traits are of later and of Northeastern origin in the Southwest.

Archeologically this is borne out by an examination of corn descriptions in the literature and in the museum collections in the Southwest. The earliest Anasazi agriculture is Basket Maker II, dating around 300 A. D. The earliest sites are in northeastern Arizona and adjacent southern Utah and Colorado. Morriss (1939, p. 5) states that a site near Durango, Colorado promises to date pre 0 A. D. The corn found in these sites averages 5 inches in length, over 1 inch in diameter, and is characterized by row counts of 10 to 18 with 14 the dominant number. The butts of the cobs are reduced in size so that the characteristic tapering both to butt and tip found in the Gila-Colorado corn is reproduced here. The kernels are small, and generally very round in type. The closest resemblances are found in the modern Gila-Colorado corn. Collins (1921) also recognized the resemblances of Basket Maker corn to the Gila-Colorado corn and classified both types as Tropical Flint corn. Anderson's later and more definitive work also recognizes this relationship and will be discussed below.

There are, however, differences between Basket Maker and Gila-Colorado corn. The earliest Basket Maker corn is uniformly flint in kernel texture; later Basket Maker corn begins to show flour admixture. The cobs of Basket Maker corn are stouter than the Gila-Colorado type and have a greater number of rows. At comparable times there may well have been a considerable size difference between the two types, for while modern Gila-Colorado corn averages about the same as the Basket

Maker II corn, archeologic corn from the Gila-Colorado area averages less than 3 inches in length.

Further, early Basket Maker corn is red or brown in coloration and was noted by Collins (1921) to differ from all other Southwestern corns known to him in having color in the endosperm. Kuleshov (1929) has noted that the races of corn tend each to have its own range of colors. In the disparity between the uniformly red and brown colors of Basket Maker II corn as opposed to the uniformly light coloration of the Gila-Colorado corn we have a further differentiation of the two types. It must be admitted, however, that we are contrasting corn types separated in time by 1600 years and that we lack full knowledge of the changes of the types through time.

Anderson (unpublished manuscript on corn from Mummy Cave) has argued that the coloration of the Basket Maker corn in the result of parching. By baking Pima corn in an oven he has produced similar coloration. He, therefore, concludes that in light of the similarity in cob etc. that the two corn types are very closely related. This argument rests on the assumption that all the Basket Maker corn preserved for us was parched, for all Basket Maker 2 corn so far found has been of these dull brown or red colors. This seems an unreasonable assumption for almost none of the Pueblo corn found archeologically is parched although we know that all of the Pueblo people now parch corn. I have seen parched corn kernels from archeological collections from the Kayenta district, but such occurrences are so rare that they have never been reported.

Further, the theory of the discoloration of corn by parching seems to rest in part on a misunderstanding of the Southwestern method of corn parching. In the Southwest corn is treated by two methods: a. steaming overnight in an earth oven, b. parching in hot sand in an olla. It is the steaming method which has usually been referred to as parching. This is an unfortunate use of the term and "steamed" corn would seem a much better term to use for this process.

Both practices, however, destroy the original color of the corn. Steaming produces kernels that closely resemble dry sweet corn of a dull brown color. But while sweet corn is wrinkled and translucent, steamed corn in plump and opaque. Anderson has sent me kernels of Canyon del Muerto corn which match exactly kernels of Pima corn which he parched in an oven. Both kernels when split, however, reveal soft white starchy endosperm. Steamed corn when split reveals a glassy endosperm with no soft starch. Early Basket Maker flint corn reveals glassy hard flint endosperm with some soft floury endosperm beneath the heavy flint cap. The three types would, then, seem to be distinct. There may, of course, have been some method of lightly roasting dry corn (as opposed to the steaming or boiling of green corn). No trace of such a process survives today, however, while steaming, boiling or roasting-in-the-husks of corn in the milk is practised throughout the Southwest and apparently throughout the Northeastern United States.

Steamed corn is prepared in large quantities for winter use and is preserved either on the cob or shelled off and stored. Parched corn is prepared much as we do pop corn, i.e. it is made up for an occasion and consumed on the spot. Archeologically, then, one should expect to find some steamed corn, but rarely, if ever, to find parched corn. In the Southwest to date there is no report of parched corn, no report of steamed corn, but as was noted above, it occurs at least in the Kayenta area.

Archeologically one finds light yellow flour kernels of corn which have not darkened with age, e.g. at Montezuma's Castle, a Pueblo 3 site on the Verde river in Arizona. These kernels, which are 600 years old, have not altered in color, are in an area where Gila-Colorado corn might be expected and do resemble Gila-Colorado kernels. It is clear, therefore, that Gila-Colorado corn does not always darken with age to approach the Basket Maker corn colorations although it might under different conditions and greater age.

If we could argue that Basket Maker corn has not been darkened by steaming, and Gila-Colorado corn does not darken with ageing and has probably not been darkened by any roasting treatment, it would be clear that we were dealing with two separate corn colorations, and that Kuleshov's race-color linkage applies here and indicates separate derivations of these two types of corn. It is my belief that we can so argue. However, Anderson is prepared to argue to the contrary on the basis of the Canyon del Muerto corn and the degree of similarity between the Canyon del Muerto corn and modern, oven parched, mature Pima corn. In the discussion of the methods of preparation above, it was indicated that the different kernels can be told apart, and that barring some unknown method of preparation of flour corn, the bringing of Basket Maker corn and Gila-Colorado corn to comparability by roasting the latter is not a valid argument.

Further, the Canyon del Muerto is not early Basket Maker corn, is atypical for Basket Maker, and although Morriss thinks that a date of 500 A. D. is likely for it, a date of 700 A. D. is stated as possible (Anderson, unpublished manuscript). There were no associated objects found with the corn which made a really close designation of age possible. It is here suggested that this may well be late Basket Maker corn and the grain type and pure flour texture may then be due to later cultural contacts.

Much more likely as indicating the direction from which Basket Maker corn came to the Southwest is the find made by Renaud in western Oklahoma. He found a culture which had corn of but a single type. The grains were uniformly of a reddish brown color as are most Basket Maker 2 kernels. There were further Basket Maker resemblances, e.g. pictographs of square shouldered men, etc.

Characteristics present in modern Pueblo corn but absent from the Basket Maker 2 culture are flour corn, large ears, big butts, and big grains. These traits must, then, be reckoned as later. Since only flour corn is found among the Gila-Colorado corn, and since some of these traits appear prior to any demonstrable contact with the Gila-Colorado area, and some are localized in the northeastern part of the Southwest, an eastern origin must be postulated for them.

The closest resemblances to the Basket Maker corn today among the Pueblo peoples are found among the Hopi and Zuni peoples. The differences are mainly due to some introductions of big grain, big butts, many colors, and reductions in row count. Several of these features have been shown to be of late and northeastern origin. The rest may be due to mixing with Gila-Colorado corn. Hough (1914) also recognized that the Hopi corn most closely preserved the early Pueblo type, though he did not compare it to the Basket Maker corn. Hopi-Zuni corn certainly resembles the early Pueblo corn much more than does the modern Rio Grande corn. The resemblance of Hopi-Zuni corn to Basket Maker corn may reflect the presence of considerable amounts of intermixing with

with Basket Maker corn. One might infer from this that if there is any Basket Maker blood or culture left it may well be among these peoples who have most nearly preserved the early type of corn.

The development of Puebloan corn is, therefore, a very complex thing. To an original introduction of Basket Maker corn there has been added further types of corn in early Pueblo times. The first additions appear in Basket Maker 3 times with the appearance of flour corn. Throughout Pueblo times further additions were made. A series of introductions of corn types brought in big butts, big seeds, dent kernels, long cobs, etc. into the north and eastern part of the Southwest. Those pueblos adjacent to the Gila-Colorado area also gained corn types from that area, but apparently later and in less quantity than the importations from the Northeast. One of the measures of the wide range of introductions is to be found in the great variation of colors that resulted from this hybridization of diverse races of corn.

Anderson and Cutler (Races of Zea Mays; their recognition and classification---unpublished manuscript made available through the courtesy of the senior author) have discussed the term "race" as applied to corn and have shown that the problem of determining the different types among corn is closely parallel to determining the races of man. The factors used for differentiation in corn are: cob shape and size, plant type and growth habit, kernel type, and tassel type. On this basis they come to the recognition of five races of North American corn. There are Pueblo, Pima-Papago, Guatemalan Big Grain, Guatemalan Tropical Flint, and Mexican Pyramidal.

Pima-Papago corn as used by Anderson and Cutler is identical to Gila-Colorado as described here. I prefer the latter term because it denotes more fully the area held by the corn in the United States and because it is not linked to any one ethnic group. It was noted above that Anderson thinks of this race of corn as extremely similar to the Basket Maker corn. This similarity is undeniable, but it has been pointed out that there are ample differences to warrant considering Basket Maker corn and Pima-Papago (Gila-Colorado) corn as sub races of one of the major races of corn. One may well consider them as the representatives of one of the earliest waves of corn moving northward from Mexico towards the United States. Basket Maker corn would then be an early introduction from Mexico via the east coast, and Gila-Colorado corn an early introduction via the west coast. The relationship between the two types may, then, be no nearer than that they sprang from a similar stock of South American corn perhaps as yet little modified by the tripsacum hybridization postulated by Mangelsdorf and Reeves (1939).

Anderson and Cutler do not attempt to break down the Puebloan corn. They describe it as characteristically big cobbed, big shanked, with long straight rows, big grains, with square to occasional enlarged butt. They describe the kernel as either flint, flour, or semi-dent and usually colored. The tassel is larger than the Gila-Colorado corn and the plant tends to develop a bunchy or squatty form. They consider it to be allied to the Big Grain race of Guatemala. Guatemalan Big Grained corn they find to be characterized by big shanked cobs, large crescent shaped seeds, conspicuously enlarged cob base, and the presence of bright colors. It is obvious that these are the traits which appear late in the northeast part of the Puebloan area. If my prior arguments hold, then this must be a relatively late introduction and can not represent the early Pueblo corn.

Not yet accounted for is the dent corn which appears in middle Pueblo times, Pueblo 2 and 3. Anderson and Cutler state that our corn belt dent corn is based upon Mexican Pyramidal corn. Mexican Pyramidal is limited to the plateau of Mexico, is very peculiar in plant type, and its presence in the Southwest arouses the suspicion of still further migrations of corn into North America.

Material is insufficient to date to determine whether dent and Big Grain corn entered the Southwest together or separately. A separate origin is suggested in the finding of a culture characterized by the predominance of dent corn (Morss, 1931, p. 59), in the Fremont river region of Utah. Similar corn, typical of the modern dent corns of the corn belt occur at Vernal Utah (material examined at the Laboratory of Anthropology, Santa Fe, courtesy of Mr. S. Stubbs). The culture levels at this last site contained everything from Basket Maker to modern Ute material, and no assignment to cultural level is possible. The material is unquestionably old. The Fremont river culture is Pueblo 2 in age and the purity of the corn type strongly suggests that the source of the dent corn in the Pueblo area proper may have been from the northern periphery.

This conclusion is strengthened by the disappearance of dent corn from the later Pueblo levels. Dent corn is rare in Pueblo 3 collections, and was apparently unknown at the time of the contact. Today it is being re-introduced as a commercial crop. It finds little favor, however, for it is little adapted to the conditions of the Southwest.

If its original introduction into the Southwest was in the higher and cooler areas of the valleys of the Rockies in Utah and Colorado, its failure to survive in the lower and hotter areas to the south may have been climatic.

The appearance of dent corn, associated in at least one instance with pepo pumpkin seed (at Vernal, Utah) suggests that the agriculture of the Northern Periphery culture came from an area where these two crops are areally associated. It is the northern Mississippi valley that has been shown to be characterized by pepo pumpkin and dent corn.

A reconstruction of this picture is obviously hypothetical in the present state of our knowledge, but is here attempted. Two waves of corn reached the Southwest around the time of Christ. One wave came up the west side of Mexico and entered the Gila-Salt valley. The other wave came up the east side of Mexico and entered the Southwest only after crossing the plains. It entered the Southwest either by skirting the southern border of the Rockies or by filtering over one of the passes through the Rockies. The early appearance of Basket Maker agriculture in the San Juan area suggests a south-of-the-Rockies route whose precise location will be discussed in the climatic section.

Rather shortly thereafter further types of corn were introduced. Exactly what the earliest Pueblo corn was is not known. The very early appearance of flour corn (late Basket Maker at Canyon del Muerto) suggests that it may have been some as yet unrecognized race. Or it may have been Guatemalan Tropical flint corn which had genetic factors for floury endosperm. Clearly Puebloan in time are introductions containing Big Grain corn of ultimate Guatemalan source and dent corn which contained Mexican Pyramidal genes. Mexican Pyramidal corn can only come from the vicinity of Mexico City. Finally, at a date as yet unknown, but suspected as very late, Bug Butt corn of Guatemalan type was introduced. All of these races of corn came to the Southwest from the east for they are lacking in the part of the Southwest adjacent to northwest Mexico.

The meeting of all these races of corn in the Southwest is postulated as one of the causes of the great variety of coloring found in this area. That the mixing of types was not complete is shown by the survival today of recognizeable sub areas within the Anasazi area. The primary division between Gila-Colorado and Pueblo remains very sharp even today. Even Hopi and Zuni have distinctly Puebloan corn, and the Hopi distinguish sharply between corn of Gila-Colorado type and Puebloan corn.

If maize came in successive waves from the Eastern United States to the Southwest the counterparts of Southwestern corn should be found in the Eastern United States. Will and Hyde (1917, p. 285) state that the early Pueblo corn "differed very little from the types usually grown by tribes in other parts of the country and familiar to us today" but that in the elapsed centuries from early Pueblo to the present the Southwest has developed types peculiar to itself. One may conclude, therefore, that Puebloan corn is closely related to Eastern corn.

If corn came from Mexico in a series of introductions, there should be survivals of the earlier forms on the peripheries of Eastern agriculture. The latest arrivals from Mexico should be found in the lower Mississippi cultures. From the material at hand the conditions indicating successive introductions seem fulfilled. Swanton (1911, p. 74) quotes Du Bratz descriptions of corn from the Natchez of the lower

Mississippi which could be nothing but Big Butt corn, the last type to arrive in the Southwest.

Longely (1938) has discussed the distribution of chromosome types in the corn of the United States. He found that the northern corns had very few chromosomes, but that the nearer one went to Mexico the more chromosomes per plant were found. When this is considered in light of Mangelsdorf and Reeves (1939) postulate of the derivation of the knobs on the chromosomes of corn by crossing with tripsacum in Mexico, it seems likely that the northern corns must represent types which began their spread to North America prior to the contamination of the original South American corn with tripsacum. The distribution of knobbed chromosomes of maize, then, supports the theory that corn in the eastern United States should show multiple introductions of corn and that the first introductions should be furthest north.

Even more spectacular support of the theory is found in Will and Hyde's consideration of corn growing among the Indians of the Upper Missouri (1917). In addition to giving one of the most meaningful discussions of the agriculture of an Indian people which we possess, they describe briefly the distribution of corn over the United States and comment on certain Southwestern and Eastern relationships. Will and Hyde's description of the distribution of corn types has been mapped (map 9) in order to show its correspondence with the postulated agricultural areas deduced from cucurbit distributions (see map 8) and its agreement with the theoretical postulate of successive introductions of corn and the "areal stratification" which resulted.

Through Minnesota, Wisconsin, Michigan and New England they found that flint corns were the only, or the dominant types of corn. South of this came a corn belt characterized by 8 rowed flour corns which were next to the flints in hardiness and earliness. They pressed upon the flints because of their superior qualities for grinding and for making "steam corn" (here usually boiled corn). It was this early flour corn of 8 rowed type which the Iroquois possessed. The Algonquian people to the north of them had the early flint varieties. The 8 rowed flour varieties were the dominant type of the upper Missouri, but the fints dominated in northern and western North Dakota and in Minnesota.

South of the 8 rowed flour corn, along the lower Missouri, i.e. below the mouth of the Platte, and extending eastward until it merged with the dent corns of the area east of the Mississippi lay an area of large eared, many rowed flour corns. This corn is stated to be closely related to the dent corns of the east and of the south. The dent corns proper are stated to be of Southeastern distribution and to continue into Mexico.

Will had examined considerable corn from the Southwest (Will and Hyde, 1917, p. 286, and Will in Kidder and Guernsey, 1919, p. 154) and was able to point out relationships between the Eastern corn and the Southwestern corn. He noted that the Basket Makers had several flint corns, among them a white flint corn which was very similar to the white flint corn found in the northern flint belt. In the early cave dwellings (Pueblo 3?) he found larger kerneled flour corn. This would apparently be Big Grain corn as described by Anderson.

Using the material already presented one can more fully postulate a series of introductions and relationships. The flint corn of the northern flint belt and the flint corn of the Basket Makers should expectably be related. Will thinks that it is. The stumbling block lies in the greater row number of the Basket Maker corn, but again it is necessary to point out that we are comparing two types separated for over 1500 years. Further, there is evidence that corn of large row number is not successful in the north and small rowed corn must, therefore, have been bred for. Will and Hyde (1917, p. 27) refer to the selection of a large eared strain from the Mandan corn which failed to gain popularity because the large ears were too slow drying out. That a large eared strain was present to be selected suggests that the Mandan and Basket Maker corn may have had relatively thick cobs as a common trait.

It will be observed also that "Basket Maker" corn is associated with pepo pumpkin in the Northeast and with moschata pumpkin in the Southwest. But as was pointed out in the discussion of the cucurbits, the pre-corn agriculturists of the Southeast could have picked up corn rapidly from the people who introduced Middle American crops. The evidence here would suggest that the Basket Makers derived their agriculture (corn, beans, and squash) from the Middle American complex while the agriculture of the northern flint belt is to be thought of as the pre-Middle American agriculture plus corn and beans.

The second wave of agriculture to enter the Eastern United States apparently was 8 rowed flour corns. Flour corns appear in late Basket Maker times, e.g. at Canyon del Muerto, and early Pueblo corns show a notable decrease in row count from the Basket Maker 2 flints. It seems probable, then, that this second wave of agriculture entered the Southwest also.

Also early to appear in the Southwest, definitely earlier than the many rowed, large eared forms, are the dent corns. It has been noted that there is faint evidence to connect this type with the Northern Periphery culture of the Southwest. Since the dents have a southern and eastern distribution today, for introduction into the Southwest one must postulate a previous period when they were spread over the whole of the South. Their present restriction to the Southwest would then be looked upon as the result of displacement to the west by the later introduction of large eared, many rowed corn from Mexico.

Only this large eared many rowed corn, the latest of the corn introductions, betrays its direct route from Mexico. By its position of dominance to the west of the Mississippi the large eared, many rowed, flour corns suggest that they were introduced from the east coast of Mexico. The other types could have entered the South either via the east Mexican coast route or via the Caribbean route. Longely (1938, p. 193) found the corn of the Southeast United States to resemble the corn of the Caribbean and concluded that it had reached the United States via Florida. However, Kroeber (1939, p. 219) presents very strong arguments against an Antillean-Florida connection. Kroeber considers the East and Southwest too independent and favors either a Texas coastal or sea borne introduction of Eastern agriculture (1939, p. 221).

Whatever the routes and whatever the times, the recurrent nature of the introduction of corn into the eastern United States and the resulting horizontal stratification is clear. The Southwestern picture makes it clear that most if not all of the corn types reaching the

Eastern United States also reached the Southwest. Since a type of corn which is distinct from the eastern corn is found in the Gila-Colorado area both anciently and modernly, it is clear that the routes to be considered for the eastern corn are other than the west coast of Mexico.

The postulated sequence of importations of corn into the Southwest is indicated by arrows (map 92). No attempt has been made to follow the actual routes. It must be remembered that at the time flint corn was being introduced into the Southwest, the flint corn area must have been far south of its present position. Similarly the dent corn introduction must have occurred when the dent corns had a distribution which extended nearer the Southwest.

Sweet corn in the Southwest:

Sweet corn was rarely met with in the Southwest. The Pima, Hopi, and Zuni possess sweet corn. The Tewa claim to have formerly grown it, but no longer do so. The scarcity of sweet corn among most of the Pueblos is striking. Sweet corn is known archeologically from but two sites in the Southwest. Jones (1935, p. 62) has reported the finding of a single grain of sweet corn from the Jemez cave in New Mexico, which dates from 1250 to 1300 A. D. Erwin (1938, p. 388) has reported an ear of sweet corn from the Aztec ruin that dates from the 1200 to 1300 A. D. period. The scarcity of these finds is highly significant.

Outside the Southwest sweet corn is equally scarce, and poorly known. Erwin (1933) has reviewed the evidence of pre-Columbian use of sweet corn in American and concluded that the evidence is opposed to any extensive use of sweet corn at that time. He based his conclusion on theabsence of sweet corn in the extensive collections from the Southwest, its absence from the large area of Mexico which he traversed in 1934, and his failure to find any acceptable reference to sweet corn in the Americas before 1828.

However, Erwin gave less weight to Will and Hyde's descriptions of sweet corn on the upper Missouri than it deserves. Will and Hyde (1924) describe sweet corn as being grown and being used for specific dishes which are distinctly Indian. Some of these uses of sweet corn are ceremonial. Will and Hyde differentiate clearly between true sweet corn and steamed corn, which they correctly state is often confused with sweet corn. It is very clear from their work among the tribes of the upper Missouri that they considered sweet corn an aboriginal food and the weight of evidence seems in their favor.

Erwin would seem to have erred in failing to recognize that there is not one, but several agricultures in the New World, and that the United States had some agricultural developments independent of Mexico. The historical references which Erwin rejects refer to the derivation of sweet corn from the Indians of the northeastern United States where the corn types are known to be related to the Mandan. It seems rather certain, therefore, that while use of sweet corn was not universal, it was a trait present in certain agricultural areas.

According to Erwin (1933, p. 388) sweet corn is a mutant form which can occur in flint, flour or dent types of corn. The finding of sweet corn in seemingly independent areas, e.g. the Southwest, the Northeast, and in Peru (Hendry, 1930) suggests that it is a mutation which tends to repeat and has occurred in several different areas. It is impossible, then, to point to any one area as the home of sweet corn. There is evidence, however, that one center of origin of sweet maize lay in the Gila-Sonora area and that here at least sweet maize was appreciated and maintained.

According to Hendry (1930, p. 512) Sturtevant reported sweet corn from San Pedro, Sonora, an area which lies midway between the Cocopa and the Tarahumar. This is the area which on other evidence is a likely source for the Hohokam agriculture. The specific type of sweet corn described is amylea sacharata (floury sweet). Since this area is the center of the small floury corn of the Gila-Sonora area this is further evidence of the probable antiquity of the form. Amylea sacharata is also the type of sweet corn dominantly grown today by the Hopi, Zuni, Yuma, Pima, Papago, etc.

It can be pointed out that the two archeological finds of sweet corn occur in the period after the established contact between the Hohokam and the Anasazi at Flagstaff. It may also be noted that the distribution of sweet corn in the Gila-Colorado area and among the Hopi and Zuni closely parallels the distribution of tepary beans, pepo pumpkin, and Gila-Colorado corn all of which are of known Gila-Sonora origin. Only the Tewa fail to fit this picture. The presence of sweet corn there may, then, be late, a separate center, or represent some special contact with the Hopi (as is suggested by the known derivation of the people of the village of Hano on the first mesa at Hopi from the Tewa).

The weight of the evidence to date certainly favors a spread of floury sweet corn from the Gila area to the Anasazi area at approximately the same time as the tepary bean. It seems very probable, then, that floury sweet corn will be found to have its Southwestern origin in the

Gila-Sonoran agricultural hearth. This argument is no denial of the Northeastern center of sweet corn. On the contrary it is confidently expected that the Northeast will prove to be the source of our commercial flint and dent type of sweet corns.

CHAPTER IV

THE TEPARY BEAN -- Phaseolus acutifolius

The modern distribution of the tepary bean is such as to suggest a southern and western origin (see map 10). Teparies are almost the only beans grown among the Pima, Papago, Cocopa, Yuma, and Mohave. Although this may be attributed to the failure of frijole beans to compete with the tepary under the severe climatic conditions of the desert parts of the Southwest, the limitation of the tepary bean to the Pueblos adjacent to this Gila-Salt area until historic times cannot be accounted for climatically and must be accounted for culturally. The people of the Gila-Colorado area claim the tepary as their original bean. The Pima, Papago, Cocopa and Yuma designate frijole beans as Mexican or White man's beans. The Mohave still grow teparies to the exclusion of frijole beans.

The only pueblo peoples that grew tepary beans in pre-contact times were the Hopi and Zuni. These are the pueblos closest to the Gila-Colorado area. Among the Hopi of Second Mesa the tepary bean plays an important part in ritual (field work 1941). It is significant that both Hopi and Zuni have traditional accounts of southern origins for some of their clans. It is here postulated that these groups of southern origin may have brought tepary beans to the Hopi and Zuni. Probable dates for such occurrences will be shown to be well after 1000 A.D., probably after 1200, and quite possibly as late as arcund 1400 when the Verde and Tonto basins and the Little Colorado were abandoned.

The position of the tepary bean among the Hopi is particularly enlightening as to the recency of the introduction of teparies. There are more varities at Second Mesa than on the other Mesas.

The dye bean is a blue-black kidney bean (Phaseolus vulgaris) on First and Third Mesa but is a black tepary at Second Mesa. The tepary bean enters importantly into certain ceremonies on Second Mesa, must be eaten by the dancers before any other food, etc. At First Mesa when I inquired about specific varieties of teparies I was told to go to Second Mesa. When I showed Second Mesa teparies to the people at Oraibi (Third Mesa), many claimed never to have seen some of the varieties. The partial localization of the beans on this Mesa argues for their relatively late introduction. Since the beans play an important role in ritual and are used in dyeing in preference to the more ancient kidney bean, it seems probable that migrants carried the bean to Second Mesa. If the bean were casually introduced it seems doubtful that it would displace an ancient bean in ritual and technology. Further evidence that crops of Hohokam origin are centered at Second Mesa is given by Hough (1919, p. 237). He found that sweet corn was found most commonly on Second Mesa and was referred to Second Mesa by the peoples of the other Mesas. The evidence favors a late introduction of tepary beans and sweet corn by migrants from the south who settled at Second Mesa.

The nearest early source of tepary growing people would have been the Flagstaff area where since Pueblo 2 times tepary beans had been grown. Colton (1939, p. 60) has shown that the Tusayan (Hopi) peoples were undisturbed from 900 to 1250 but that around 1300 strong cultural mixtures occurred. In this period after 1300 the tepary bean was probably introduced to the Hopi, probably by peoples who settled at Second Mesa.

The above also indicates heterogeneous composition for the Hopi and argues for discretion in use of informants and migration myths, but does not deny the validity of migration myths. The various clans seem in part to have varied origins, hence varied migration myths. An assemblage of origin traditions should be expected simply because they record the differing experiences of different groups. The agricultural evidence suggests that this traditional material should be most complex among the Hopi and Zuni.

There is an outlying occurrence of tepary beans on the Rio Grande along the Jemez river where Jemez, Zia, and Santa Anna grow tepary beans. Only white and tan varieties were collected. The white variety is ubiquitous but the particular tan variety is found nowhere else except among the Hopi. It is known that at the time of the Pueblo revolt many Rio Grande people fled to the Hopi country and lived there for a number of years. (Letter from Erik Reed, Sept. 30, 1941 states that sixteen families from Jemez lived at Walpi for about 20 years after the 1696 Pueblo rebellion, returning home in the summer of 1716.) Many of these people moved back to the Rio Grande and re-established themselves. This is particularly true of Jemez for whom the traditions are specific for time and place. The isolated distribution of the tepary on the Rio Grande argues for its late introduction. The specific Hopi relationship in bean type coupled with the historically known contact and the lack of archeologic teparies in the area is believed to be sufficient evidence for the historic diffusion of the Jemez river teparies.

The Walapai and the Yavapai seem to have taken up tepary beans from adjacent Yuman peoples but presumably quite late. The Havasupai present a more difficult picture. They claim (field work 1940) that tepary beans were introduced by the government post 1900. All the aspects of their agriculture, as described by Spier (1938) resemble the Hopi. They use the short, two handed Hopi digging stick in the same manner as the Hopi, have Hopi corn varieties and claim to have received all their crops from the Hopi. There seems to be no reason to doubt their tradition on this matter. If the agent introduced teparies in 1900, it is interesting to note that the failure of the Hopi to introduce tepary beans to the Havasupai may have implication both as to the lateness of teparies among the Hopi and of the time of agricultural acculturation of the Havasupai. Excavation in late Hopi archeology may well give definite answers to both of these questions.

The distribution and time of occurrence of teparies in archeological sites throws much light on the origin of the bean as well as on cultural relationships. The tepary bean is archeologically unknown in the San Juan and upper Rio Grande; i.e. generally north and east of the Little Colorado. Frijole beans are known in some abundance from the cliff dwellings of the San Juan and the upper Rio Grande and the absence of tepary beans in these areas is, therefore, highly significant. In consideration of the frequency of occurrence of tepary beans in the area south and west of the San Juan-upper Rio Grande it becomes certain that the tepary bean is of southern and western origin in the Southwest.

If the tepary bean derives from the southern part of the Southwest, it must be derived from either Mogollon or Hohokam cultures. Mogollon culture has eastern relationships (Haury, 1936, p. 126) while the tepary bean can be demonstrated both on distributional (as above) and botanical (to be discussed below) grounds to have Sonoran relationships. It would, therefore, seem that the tepary bean is related to the Hohokam culture. Due to the nature of Hohokam sites very little vegetable material has been preserved and we are greatly handicapped in working out the details of this origin. Teparies have been found in the St. Mary's ruin which is probably a Tucson variant of Hohokam (material in the Arizona State Museum). Tepary beans from the Hodges site near Tucson, a Hohokam site, dated earlier than 1300 A. D. (letter from E. W. Haury, Nov. 2, 1941).

However, greater significance can be drawn from a study of the occurrence along the Mogollon rim, in the Verde valley and near Flagstaff (see map 10). The distribution of these sites is peripheral to the Hohokam culture and in periods allowing for contact between Hohokam and northern cultures. Of particular interest is the frequency of tepary finds in the Verde valley and in the vicinity of Flagstaff where the Hohokam culture had such important influence and settlements. The similar distribution of ball courts up the Verde valley to Flagstaff, the presence of Hohokam villages near Flagstaff (McGregor, 1941, p. 247) and the simultaneous appearance of tepary beans and Hohokam culture at Flagstaff are among the clinching arguments for the Hohokam tepary association. A similar appearance of tepary beans in a culture demonstrably heavily influenced by the Hohokam occurs at Kinishba. Baldwin (1939) considers this ruin to represent a Hohokam-Anasazi blend, and puts the age of the culture between 1000 and 1400 A. D. Both tepary and kidney beans are found in this ruin. These distributions are almost exactly parallel to the pepo distributions, and the conclusion seems inescapable that both the tepary and pepo were basic crops in Hohokam agriculture.

Tepary beans from Hope, the most easterly occurrence, represent an eastern extension of a Mogollon-like culture about 1200 A. D.

This material from Hope was examined by me at the Laboratory of Anthropology at Santa Fe. The material mentioned by Jennings (1940, p. 9) as "mesquite beans" contains both charred tepary and common beans. A relatively early extension into this area of teparies among people of southern position in the Southwest is expectable. It is surprising, however, that the tepary did not spread up the Rio Grande valley. The absence of tepary bean in the Rio Grande valley, therefore, suggests that either a rather sharp cultural barrier existed between the people of the upper Rio Grande and the Mogollon affiliated peoples to the south, or that the Pueblo peoples had not yet moved into the lower Rio Grande valley. McGregor (1941, p. 349) divides the Rio Grande just below Albuquerque. The area south of Albuquerque he speaks of as being basically Mogollon. It seems probable that the tepary bean was spread throughout the Mogollon area. The failure of the tepary to cross the cultural boundary seems to indicate a rather great cultural barrier.

The time of appearance of teparies in Northern Arizona can be fixed and this in turn gives minimal dates for the appearance of the tepary in southern Arizona. This is represented on the map of teparies. The earliest site is in the vicinity of Flagstaff (Medicine Fort 700-1100) and the year 1000 may be taken as an approximate date for the appearance of the tepary bean on the plateau. Colton (1939, p. 48) states that the Hohokam were in the Verde valley in late Pioneer times (around 800 A. D.) and it seems likely that teparies were carried north by this corridor. The presence of teparies at Tuzigoot and Montezuma's Castle tend to support this thesis but are, unfortunately not closely dateable.

It seems very likely, although we have no such early dates to prove it, that the tepary bean had spread through the Mogollon rim by 1000 A. D. The presence of teparies at Kinishba and Reserve show that they could be and were grown in that area shortly after 1000 A. D. To the East the only dated site is Hope, New Mexico (1200 A. D.) Whether teparies ever extended east of this point is unknown. Teparies are not mentioned in the Big Bend or Pecos river cave dweller literature and it seems likely that Hope is the easternmost outpost.

To the west tepary growing ended with the Kamia of Imperial valley. No archeologic material is available or likely to be available in the Yuman area and the time of the Yuman agricultural beginnings must be derived from a consideration of their relationship to the Hohokam. Yuman pottery is red on buff, made with a paddle and anvil, and in design elements and vessel forms resembles the Hohokam. Most helpful of all, however, is the presence of clay figurines among the Diegueno, Kamia, and Yuma which in stylistic traits resemble Hohokam types. Coffee bean eye, straight reached nose, treatment of breasts and limbs are all reproduced in the Yuman figurines. This specific type of figurine is limited to the Santa Cruz phase of the Hohokam culture (Gladwin, 1937, p. 241). Dating in Hohokam is subject to fluctuation but the original date set would place the Santa Cruz phase between 700 and 900 A. D. and 800 would then be a reasonable date to put on the Yuman derivation of figurines from the Hohokam. The archeology of the western Yuman has never been published. Tentative dates of 900-1400 A. D. are given to the pottery making, Yuman culture which occupied the shores of the extinct Blake Sea of the Imperial valley. This culture came from the lower Colorado river and is already distinctly Yuman. A date of 800 A. D. for Yuman pottery beginnings is therefore conservative. It may be significant that this is the same period in which the Hohokam expanded into the Verde valley. It is, of course, possible that agriculture had been taken up by the Yumans at an earlier date. The Colorado river is, therefore, mapped as an area of tepary bean farming as of 800 A. D. Back of this time the reconstruction of the spread of the tepary bean is subject to even greater dating difficulties and dates are perhaps best avoided. Further knowledge of the origin and diffusion of tepary growing is dependent on archeologic and ethnographic work, particularly in Northwest Mexico. Some additional light on the spread of the tepary bean can, however, be derived from a consideration of its probable origin.

Origin of the tepary bean:

The tepary bean, Phaseolus acutifolius variety latifolius, was first described as a separate species by G. F. Freeman (1912). Prior to Freeman's time they had remained in the hands of the Indian peoples of the Southwest and had entered little into commerce. Teparies were early mentioned by name in Padre Luis Velarde's Relacion of Pimeria Alta in 1716 (Wyllys, 1931, p. 128). They were mentioned by Americans as early as 1858. This notice was reproduced by Russell in 1904 (p. 90, note 80) in a footnote wherein he states that in 1858 the Overland Mail bought a large quantity of beans called "taperis" from the Pima. Russell failed to catch the significance of the reference and failed to note the presence of tepary beans among the Pima. It was left to Freeman to recognize that these were a distinct species of bean, and worthy of recognition and adoption into our own agricultural complex. Freeman's work was based upon collections made among the Pima and Papago in 1910, only a few years after Russell's work among these same people. Where Russell (1904, pgs. 76 and 92) found but five varieties of beans and thought that perhaps one was pre-Spanish, Freeman (1912, p. 3) found "seventy-one apparently distinct sorts." (This is the acme of difference in point of view in its effect on field work.) Not all of Freeman's "beans" were teparies for a considerable assortment of Phaseolus vulgaris was also present. (25 varieties of P. vulgaris described; 44 varieties of P. acutifolius described)

Freeman (1912, p. 4) found that the Pima-Papago claimed to have had teparies for "a long time" but that they had secured "frijole" beans (P. vulgaris) from the white man. This is in sharp contrast to Russell's (1904, p. 76) guess that the original bean was a red frijole type. Freeman, and Castetter and Underhill (1935), have found the Pima-Papago to be emphatic in their claim that the tepary is their original bean and that the frijole bean is a post-white introduction. The early Spanish references to the tepary bean, the presence of archeologic teparies in the area, and the native tradition are all in harmony. There is thus every reason to think that the bean is of great antiquity in the region of southern Arizona.

On the basis of the drought and heat resistance of the bean, the presence of related wild forms in the area, and the Indian claims for their lengthy possession of the bean, Freeman concluded that the tepary had been domesticated in southern Arizona or northern Mexico. Castetter and Underhill (1935, p. 33), however, chose to follow

Vavilov in placing the origin of the cultivated tepary in Southern Mexico and Central America. Vavilov's work has now been superseded by the more detailed work of Ditmer, Ivanov and Popova (1937), and Bukasov (1930). These later works state clearly that the home of the tepary bean is not in the southern part of Mexico or in Central America, an area well known to the Russians, but is to be sought somewhere in northern Mexico or perhaps in Southwestern United States. Their statement is based on the lack of varietal diversity in Middle America. The enormous varietal diversity reported by Freeman would alone tend to indicate the Gila-Sonora area as the center of tepary domestication.

Shimkin has recently treated of the origin of the tepary bean on linguistic evidence (1939, p. 25). On such a basis he arrives at the conclusion that it is of non-Uto-Aztecan origin, hence of more southern origin than the Uto-Aztecans. He cites Sauer's postulate of a southern Mexican center of agriculture as the probable area of domestication. The value of the work is called into question by the use of the Hopi word "mori" as applying specifically to the tepary bean. "Mori", however, is a general Hopi word for bean and one would have to argue for the late, southern origin of all Hopi beans if this explanation were called upon.

Several writers have grasped at the true significance of the distribution of the tepary bean. Beals (1934) suggested that the tepary bean might well prove to be the aboriginal bean of the Pima-Papago area. Gilmore (1932, p. 25) noted the presence of kidney beans in Basket Maker levels and the absence of tepary beans in Pueblo horizons until Pueblo 2 times. He suggested a possible Southwestern domestication of the tepary. Gifford (1933, p. 316) has recently postulated the tepary as a local domesticate in imitation of P. vulgaris cultivation with "the extension of cultivation to another species which will grow under conditions too hot and arid for vulgaris." These various theories will be dealt with further below.

Related wild forms of teparies are distributed across the southern Southwestern United States and extend southward into Mexico. The habitat of the plant and its wild relatives is in mountain canyons where the moisture supply is both seasonally high and dependable (Freeman, 1912, p. 26). Of particular interest is the altitudinal range of Phaseolus acutifolius, the closest wild relative of the cultivated form. It is found between 3000 and 5000 feet elevation from west Texas to southern Arizona and in adjacent Mexico (notes from the herbarium at U. S. D. A. Field Station, Sacaton, Arizona). Freeman believed that the cultivated tepary was derived from a broader leaved form than that described by A. Gray as Phaseolus acutifolia, and preferred the broad leaved form collected by Wright in the valley of Sonora as the ancestral form.

It is important to note that the nearest related forms of the tepary are distinctly not lowland in habitat, but are at home in elevations that mean other than extreme desert conditions. The cultivated tepary, however, retains growth habits which rule out high, cold, and damp areas. Hendry (1919, p. 248) found that the tepary did not do well on the coast of California where the cool, foggy conditions upset its growth habit. It seems most probable then that the domestication of this bean was accomplished by a people living in the area of the nearest wild relative and in an environment marked by some heat and considerable drought, adjacent to canyons, and lying at an elevation of between 3000 and 5000 feet above sea level. Since the broad leaved forms of teparies grow wild in Southern Arizona (Freeman, 1912, p. 26), the possibility exists that the domestication occurred in the United States.

The question of whether domestication occurred within the United States or in Mexico is dependent upon our knowledge of Mexico. Unfortunately we know very little of crop distribution in Mexico. Lumholtz (1912, p. 287) describes the tepari as the small white bean of the Indians of Sonora and states that he had not seen them outside of Sonora. The distribution of the tepary in Mexico is only partially known from the Russian plant surveys (see map 11). They found it to be absent from the zone between Mexico City and Saltillo. They found it to be absent from Central America except for a sporadic occurrence in Guatemala on the Chiapas border. In Chiapas the Russians found teparies between Tapachula and Suchiapas (Bukasov, 1930, p. 485). These towns lie in the Rio Grande de Chiapas valley, in an interior location, at elevations between 1500 and 3500 feet. No wild forms are reported from the area and this occurrence of the beans appears as a detached island of teparies. These considerations weigh against the area as a center of origin.

The Russians next found tepary beans at Guadalajara, presumably in the market. That teparies are rare in Jalisco, however, is shown by their total absence in an extensive collection made by Isabel Kelly (Bean collections made by Isabel Kelly and Dan Stanislawski were examined by me at Berkeley, California.) to the west of Guadalajara. A similar collection of beans made by Dan Stanislawski in Michoacan, mostly from the plateau, also showed a complete lack of tepary beans. It may be, therefore, that southern Mexico lacks tepary beans except for sporadic occurrences. Bukasov knew of teparies in Sinaloa and among the Tarahumar. Such considerations led him to place the origin of the tepary in the general area of "the northern provinces of Mexico, New Mexico, Arizona, and Texas" (Bukasov, 1930, p. 485). This is obviously based on Freeman's description of the distribution of the wild forms, combined with the knowledge that the origin of the tepary was not in the parts of Mexico explored by the Russians themselves. On the above information Bukasov postulated a continuous distribution of tepary beans on the west coast of Mexico from Guatemala north (see map 11).

The evidence to date indicates a great variety of teparies among the Pima. Such a condition almost certainly continues among the Pima Bajo, probably extends to the Opata.

The position of the bean among the Tarahumar is not clear. Teparies are reported for them "linguistically." Hendry has stated that the word "tepari" is of Tarahumar origin (1918, p. 312). Shimpkin (1939, p. 25) states that the Tarahumar word for the tepary is "muniki" and Bukasov (1930) says it is "escomite." Whatever the Tarahumar word for tepary it seems clear that they are growing teparies today. Tarahumar archeology has been reported upon by Zing (1940) who attempts to show Basket Maker affinities for the entire culture. However, the corn type, as described by Zingg(1940, p. 15), is neither Anasazi nor Gila-Colorado but seems related to the Valley of Mexico.

This certainly suggests a late and southern origin of agriculture among the Tarahumar. Since Valley of Mexico type of corn has been shown to be relatively late and of Eastern origin in the Southwest there is absolutely no indication that these people could have passed crops northward to found the Basket Maker culture. Zing has demonstrated archeologically that beans are late in Tarahumar agriculture. If these are tepary beans and the preceding corn is Mexican, then mixed agricultural origins must be postulated.

It seems, then, that by the time Jalisco is reached the distribution of teparies becomes discontinuous and the tepary, if grown at all, is a very minor element in the bean assemblage. The center of tepary bean distribution is thus found to coincide with the known wild forms and its domestication must be postulated as having occurred in some area well north of Jalisco, below 5000 feet, hence off the plateau, and above 3000 feet, hence not in the hot, low coastal valleys.

This restricts the consideration to the intermediate country of the west slope of the Sierra Madre or to the higher, hence cooler, upper valleys of the rivers. No more suitable place is at present known to the author than the upper Sonora river, in the valley of Sonora where the most closely related wild forms of the bean are found. This general area, of the upper Yaqui and Sonora rivers is therefore postulated as the place of domestication of Phaseolus acutifolius.

Since fully developed tepary beans appear at Flagstaff, Arizona by 1000 A. D. it is obvious that this domestication must have occurred at an early date. Since the domestic bean is unchanged in the 900 years elapsed since then, but represents an enormous advance over the wild form in seed size, a period several times 1000 years must be postulated for the beginning of domestication. The agricultural beginnings of the tepary bean must, therefore, reach back several millenia B. C. This is also indicated by the absence of the kidney bean in the tepary bean area, for if the tepary bean were not sufficiently developed to be approximately as good as the kidney bean, prior to the introduction of the kidney bean into the margin of the tepary bean area, the tepary bean would have been abandoned in favor of the kidney bean.

The question of what ethnic group accomplished the domestication of the tepary bean can not be settled here. The area is historically Pima territory. The Opata, by their wedged-in distribution, betray a later, intrusive position. It may, then, have been the Pima who domesticated the tepary, although we lack as yet any knowledge of the real antiquity of the Pima.

Whether or not the modern Pima are the descendants of the Hohokam, they have retained the Hohokam crops. Whether or not the Hohokam were Pima they had at an early date the crop domesticated in the modern Piman area. It is at least possible that the Hohokam were Piman and came from this valley of Sonora around the time of Christ or earlier into the Santa Cruz and San Pedro valleys, and thence to the Gila. The botanical material suggests that the Hohokam were a people marginal to the main body of their culture who gradually pushed or were pushed into a climatically undesirable area. In this area they developed irrigation and on the secure base this gave them they erected their unusual and rich culture. These lines of thought suggest antiquity rather than recency and tend to support Gladwin's postulated dates of Hohokam beginnings rather than to destroy them. The early Hohokam periods should have been long and difficult because of the necessity to acclimate their crops to the most extreme conditions of heat and drought in North America.

Gifford's postulate (1933, p. 316) of the domestication of the tepary bean as an extension to a more heat and drought resistant form may now be taken up. It seems unlikely that the tepary is an extension of bean growing to a local, wild form, capable of resisting the excessive heat of the Gila-Colorado area. Two lines of reasoning may be advanced. The evidence presented here tends to indicate that the domestication of the tepary did not take place in low, hot country, but in the higher and considerably more temperate and moist valleys of the Sonora and Yaqui rivers. The frijole bean would do quite well there, hence there would have been no such incentive as he envisions.

Further, the choice of the Amerind, when faced with the alternative of domesticating a new form or of adapting a new form to his particular situation has always been to adapt the domestic crop to his needs. Corn and kidney beans were thus changed from their tropical requirements until they were able to produce in the extreme conditions of North Dakota and the St. Lawrence Valley. The adaptation of beans from tropical America to withstand the heat and drought of the northwest of Mexico would have been a lesser task. It would also have been a lesser task than developing a modern tepary bean from the minute seeded forms of the wild teparies. As Sauer (1936) has pointed out, it is inconceivable that a people would enter upon the long difficult task of a new domestication when a similar food plant was already at hand. Gifford, however, must be given credit for recognizing that the localization of the tepary in the Gila-Colorado area was a significant fact that needed explanation.

Such lines of reasoning lead to the postulate of a center of plant domestication in Northwest Mexico and southern Arizona. To the cucurbit already postulated for this center we must add the tepary bean. When corn was diffused to the area, it was taken up and adapted to the local conditions. If corn could be so adapted, it seems highly probable that beans and squash could have been similarly adapted. That they were not, as has been argued above, indicates that the tepary bean and the pepo pumpkin were already well developed prior to the introduction of corn. What the other pre-corn crops of the area were is not known. If one of the minor starch plants of the Mexican area should prove to be localized in the northwest of Mexico, it might be hazarded that this was the former starch source.

Pre-corn agricultural levels are therefore expectable in northwest Mexico. To date they are unreported, but the area is very poorly known. In age these levels should far antedate Basket Maker levels, hence they will not be easy to find. If the culture avoided caves, our only knowledge of them may be limited to such reconstructions as have been attempted here.

CHAPTER V

DISTRIBUTION OF PHASEOLUS VULGARIS, THE KIDNEY BEAN:

Phaseolus vulgaris, the frijole or kidney bean, has a distribution that is distinctly separate from the tepary bean. The kidney bean is found among all the Pueblo tribes, while the tepary bean is found only among those Pueblo groups who were adjacent to the Gila-Colorado area. Similarly, the frijole bean is absent from all the tribes of the Gila-Colorado area except where it is demonstrably post-contact, or as among the Pima might be due to late Pueblo (Salado) contact. Thus a dual division of the Southwest again appears, and the division parallels the corn and climatic division. That the division is not purely climatic is indicated in that the tepary bean could be widely grown in Puebloan areas where it is unknown, e.g. in the Rio Grande valley. Similarly, the Pima and even the Papago are beginning to grow pinto and pink beans (frijoles) today under the spur of white man's economics and in defiance of environmental "restrictions."

On the other hand, it seems likely that the Pima and Papago growing of frijole beans is purely for a cash crop for Hendry (1918) and Freeman (1912) have both demonstrated that in extreme heat the tepary will far out-yield the frijole bean.

Within the Puebloan area there may be distinguished areas of differing types of frijole beans. The principal division lies between the Hopi-Zuni area as opposed to the Rio Grande area. The beans of the Rio Grande are generally small, dull coated, and there are relatively few varieties. The beans of the Hopi and Zuni are large, bright colored and glossy coated. This, it will be noted, parallels the division within the Puebloan corn types.

Overlaying these pre-contact bean types are to be found the bean varieties introduced by the Spanish and the Americans. Among the Rio Grande Pueblos about Santa Fe and among the Spanish American peoples there are to be found the bayo and the bollito. These have close relatives, if not exact counterparts, in Jalisco, Mexico, and are quite different from the rest of the Rio Grande beans. They are being abandoned today in favor of American beans. Since their counterparts are known in Jalisco, are found among the Spanish Americans of the Santa Fe region, and are largely limited to the Pueblos near the center of Spanish influence at Santa Fe, it is here postulated that they represent a Spanish introduction into the Rio Grande.

The pink bean and the pinto bean are ubiquitous in the Southwest today. They are grown by the Papago and by Taos, the "poles" of the Southwestern area, and virtually everywhere in between. The pink bean is foreign to the area and is almost universally recognized by the Indians as "white man's beans". According to Hendry (1918, p. 295) they are natives of Chile, have been a favorite type in Central Mexico since conquest times, and are known in northern Mexico as Yura mon (white man's beans). The origin of the pinto bean is not known.

Under this double layer of beans of Spanish origin and of American origins lies the remnant of the old bean cultures.

Within the Rio Grande area, Picuris and Taos form a unit apart. They share a mottled, red, flat, string bean which both pueblos claim is their ancient type of bean. At Taos the claim was made that this is the only bean which is eaten during the ceremonies. None of the other Pueblos have this bean except the Hopi. The Hopi call it by the name of a former superintendent of the reservation and state that he introduced the bean to the reservation. It seems clearly to be a bean type which was peculiar to Taos and Picuris at the time of the contact. It is not present in any of the archeologic collections examined. Since numerous samples of beans from the San Juan-Kayenta region were examined the absence of this bean is considered significant.

Bean collections from Isleta, Santa Clara, and Cochiti contained in common a small yellow bean and a small brown bean. There were a few minor variants of these forms such as the presence or absence of spots, veining, etc. but these two fundamental types are so uniform in size, dullness of seed coat, etc. as to suggest that they constitute a uniform type. The occurrence of these beans at widely separated pueblos suggests that there once was a continuous distribution along the Rio Grande. Today these beans have receded to a minor role among these pueblos and are well on the way to extinction. At Cochiti, the sample collected was the last said to be in the village, and the seed was several years old. The poverty of varieties is notable and the persistent statements along the Rio Grande as to the slight importance of beans suggests that this area was never one of extensive bean culture.

On the Jemez river, pueblos of Jemez, Zia, and Santa Ana, great difficulty was experienced both summers in finding other than commercial types of beans. The people recalled "old" beans but claimed that they no longer grew them. Some tepary beans were collected here and others described tepary beans as formerly grown in this area. In the section on tepary beans it is postulated that these beans are of late, post 1680 date. Their presence here suggests that these people had relatively poor beans and substituted teparies for them. Lacking an adequate collection it is impossible to place these pueblos within the bean area but a provisional grouping with Cochiti, Isleta, and Santa Clara is advanced.

The Hopi and Zuni are sharply divergent from the Rio Grande pueblos both in bean types, and number of varieties. The Hopi have four separate species of beans and a total of 32 varieties. In contrast to this the Rio Grande pueblos average less than 6 varieties even when the Spanish and American varieties are counted in.

Hopi vulgaris beans run through a surprising range of colors, sizes and shapes. The vast majority of them are large, kidney shaped, and almost all are glossy coated. The Hopi share seven varieties of P. vulgaris with the Zuni, and have eight varieties not known to the Zuni. If one does not count the vayo and the pink bean, which are late introductions to both cultures, the count in common is reduced to but nine varieties. It thus appears that the two Pueblos are far from having identical bean assemblages. So diversified an assemblage among the Hopi is surprising in view of the difficult climatic area in which they farm, and suggests that these beans are of ancient adaptation to the arid, short growth season of the Southwest. This is borne out by the comparisons of the Hopi type seeds with Basket Maker 3 beans. The resemblances in size and shape are striking.

The Zuni have 5 forms of vulgaris beans not known anciently to the Hopi. This includes 3 types of calico beans, and the probable home of the calico beans among the Zunis seems probable. Although the Hopi grow a few calico beans today, they have but one variety as compared to the Zuni's three. Whiting (1939, p. 83) has postulated a recent appearance of the calico bean among the Hopi on the basis of the Hopi name for the bean. If these postulates are true, Hopi and Zuni bean assemblages are shown to be even more differentiated. The differences in varieties however do not obscure the essential unity of the Hopi and Zuni bean assemblages. Hopi and Zuni beans are more closely related to each other than to any other Pueblo.

Acoma is intermediate between the Rio Grande pueblos and the Zuni, and has an impoverished assortment of Zuni beans, including the characteristic Zuni calico beans. But in the few varieties, 9 as compared to Hopi 32 and Zuni 24, and in smaller size and the presence of small yellow beans resembling the Rio Grande beans, Acoma betrays Rio Grande affinities.

It is interesting to interpret these differences in bean distribution. Taos and Picuris have now been shown to differ from the other Pueblos both in type of corn grown and in forms of P. vulgaris cultivated. The rest of the Rio Grande valley differs from the Hopi-Zuni area both in bean and corn type. Since the beans of the Hopi-Zuni and the Hohokam differ in species and will not cross, the difference can not be ascribed to the effect of hybridizing as was possible in the corn. That the corn and the beans vary together, therefore suggests that we are dealing with subdivisions of Puebloan agriculture whose roots are archeologically ancient and are bound up with separate origins in space and in time. Since Hopi corn and beans resemble Basket Maker corn and beans more closely than do the crops of any other pueblos, it seems likely that the crops surviving among the Hopi and Zuni represent a survival in modified form of Basket Maker agriculture. A map (number 12) shows the division of the Southwest on the basis of bean types.

Several archeological collections of beans were studied in the Southwest and some conclusions can be drawn from them. All of the material seen falls into the Hopi-Zuni group. All the material, however, came from northern Arizona. The absence of the small Rio Grande beans is striking and leads to the postulate that they are relatively late in the Southwest and from an eastern source as was suggested for some of the corn types which are similarly distributed.

Within the Hopi-Zuni area it is desirable to make distinctions between the two groups. The modern Hopi collection is complete and can be checked with Whiting's collection, a duplicate of which he very generously made available to me. The Zuni collection is probably not complete. The archeologic collections are naturally far from representing the total varieties grown by the various ancient Pueblos. Comparisons are therefore of limited validity. The following are advanced to show more the possibilities of the method than to advance positive relationships. From Kiet Siel there are 4 varieties of beans; 2 are found today only among the Hopi, 1 is found both among the Hopi and Zuni, and 1 is found only among the Zuni. Relationship to the Hopi would seem indicated.

Of four varieties at Turkey House in the Tsegi canyon, 2 are found only at Zuni and 2 are found today both at Hopi and Zuni, and relationship to Zuni seems indicated. Of 5 varieties from Gourd Cave in the Tsegi canyon, 3 are found at Zuni and 2 are common to both Hopi and Zuni and a fairly certain Zuni relationship is indicated. Of 3 varieties at Walnut canyon near Flagstaff, 2 are Zuni in type and 1 is common to both Hopi and Zuni and a Zuni relationship is again indicated.

It is unfortunate that we lack more bean samples from the archeology of the Rio Grande. The antiquity of the small beans typical of the area today is of some interest. Since they are lacking among Basket Maker 3 collections seen, and the Pueblo 3 of the Kayenta and Tsegi country, it must be postulated that they entered the Southwest either by some route other than the San Juan or entered later. The distributional evidence suggests that they entered the Southwest later.

Note on relation of beans to agricultural beginnings:

Much emphasis has been placed on the archeologic fact that beans only appear toward the end of Basket Maker time while corn and squash were grown much earlier. Successive waves of peoples or cultures or both have been postulated to bring crops in this order. To some extent successive imports demonstrably did occur. The evidence of new crops arriving during the period of transition from Basket Maker to Pueblo at a time when change in physical type proves the appearance of a new people is suggestive. Morris, however, considers these cultural changes to have taken place prior to the change in physical type (Morris, 1939, p. 20). It seems highly probable that both events occurred; i. e. sometimes the crops travelled with the physical type but often the crops preceded the physical type.

Consideration of the methods of utilization combined with a comparison of the Pueblo versus the Navajo and Apache throws some light on the problem of the appearance of the kidney bean.

When the Basket Maker people began taking over agriculture, they must have taken first that crop which would fit best into their culture. In Basket Maker 1 times it is generally believed that a hunting and gathering, nomadic, and non-pottery type of economy was dominant. Even if a wide variety of agricultural materials were available to such a culture it seems logical that they would take up first that crop or those crops which best fitted into their culture. Of the corn, bean, squash complex, corn would fit best and beans poorest. Corn can be grown with a minimum interruption of a hunting-wandering type of existence. It can be planted and left for long periods, and it is not necessary to harvest the crop at any specific time. Pumpkins are also easily handled, require little care during the growing season, and can be harvested at any convenient time in the fall. Beans, on the other hand, are much more difficult to raise. They are more subject to rodent and insect attack, must be kept free of weeds (especially in the arid Southwest where the majority of the beans are bush beans and not climbing beans and are grown apart from the corn). At the Mesa Verde demonstration plot corn, beans, and squash are grown with a minimum of care. The corn and squash will do well but the beans have never survived the rabbit and squirrel inroads (Franke and Watson, 1936).

The accounts of Apache agriculture reveal a moving existence with the crops receiving a minimum of care. The Mescalero Apache describe small plantings in the well watered canyons above Alamogordo. These were returned to perhaps once or twice during a summer and given a light weeding and harvested at any convenient time (field notes 1941 and Opler, 1935). The grain thus derived was a valuable carbohydrate addition to the diet and could easily fit into the pattern of seed usage. The Western Apache (White Mountain, San Carlos, Tonto, and Cibeque) had apparently been longer in contact with Puebloan peoples and had added squash and perhaps beans to their agricultural complex (Goodwin, 1935 and Field Notes at White River 1941). That the Apache began their agricultural career with corn alone clearly was not due to limitations of crop materials available, but was due to the selection of <u>the</u> crop most suited to their way of life. It seems quite possible that this is a parallel of Basket Maker agricultural beginnings.

Corn can be roasted, parched, or ground and eaten exactly as the wild seeds are utilized. Pumpkins are also easily prepared. Preparation of dried squash or roasting of hard shell pumpkins would be an easy culinary practice. Dried beans, however, must be boiled a long time to become edible. If early bean culture did not begin post-pottery, it seems likely that the early use of beans may have been as a green vegetable. Only later, when the use of dry beans had been developed, would the pottery and bean association be imperative.

The universal Pueblo Indian practice today, however, (and it almost certainly reflects the ancient practice) is to start beans without soaking and to boil them for considerable lengths of time. Protracted stone boiling would thus be necessary on a pre-pottery level and the great inconvenience a most probable barrier to the introduction of this food plant until after the development of pottery. Thus the delayed appearance of beans in Basket Maker levels may well be technologic, and pre-pottery corn and squash agriculture may be expectable while pre-pottery bean agriculture is not.

It is also interesting to speculate on the effects of increasingly sedentary life on the people and their vulnerability to invasion. It seems probable that agricultural peoples would find it difficult to penetrate an area held by non agricultural, nomadic, hunters and gatherers such as the Basket Maker people were. Once, however, these latter were sufficiently agricultural to become sedentary, they would no longer present such a barrier and would be vulnerable to invasion by the neighboring agriculturalists. Some such sequence as this may be implied in the Basket Maker to Pueblo cultural and physical shifts.

CHAPTER VII

LIMA BEAN -- Phaseolus lunatus:

The position of the lima bean in the Southwest had been under active discussion since 1939 when Whiting (1939) postulated a pre-Spanish age for it among the Hopi. Since then lima beans have been found in several archeologic sites and the pre-historic occurrence is well established.

Ethnologically, lima beans are well known among the Hopi whence beans have been obtained for breeding purposes and where they have been well described by Whiting. For some unknown reason the fact that the Pima grow lima beans has been completely overlooked. Field work in 1940 and 1941 established, however, that limas are rather widely grown throughout the Pima reservations both on the Gila and the Salt. The distribution of lima beans southward into Mexico is totally unknown.

The lima bean was domesticated in the Guatemala-Chiapas area according to Ditmer (1937) and Ivanov (1937). Since their conclusion is based upon a very extensive collection of domesticated and wild forms from all of middle America and Peru and a detailed study of the botanical forms of the plant, this homeland must be accepted rather than the Peruvian origin postulated by De Candolle (1885, p. 344-345) and others. The case for Peruvian origin has rested on the finding of lima beans in archeologic levels of some but not of great antiquity. The evidence from variations in the flower advanced by Ditmers (1937) shows Peru to have obtained its beans from Middle America and to have elaborated differing seed varieties from a limited stock of botanical varieties.

Within the Southwest Lima beans are known from five sites, Wupatki, Murder House, Tonto, Hodges and Montezuma's Castle (see map 13 for locations). Map number 13 shows that these occurrences form a connecting link between the Pima and the Hopi and leads southward towards Mexico. Further, the distribution follows the Verde valley which has been shown to have served as the corridor up which Hohokam influences moved to Flagstaff. Since lima beans are known neither ethnologically nor archeologically among the Pueblos to the north of east of the Hopi, one must view the lima bean as deriving from the south.

All of the sites in the Southwest fall within the 200 year span between 1200 and 1400. This combined with their very limited distribution suggests their late pre-historic introduction. The dates, augmented by the occurrence of lima beans in a Hohokam site (Hodges) near Tucson, make it clear that the Hohokam must have been the southern Arizona intermediaries who passed the bean to the people of the Salado culture. Salado people may have carried the bean to the Hopi after the retreat of the Salado culture from the Gila-Salt area post 1350. Since some of the Salado people went east and south, eventually to Casas Grande in Chihuahua, lima beans should be expectable in the late Chihuahua archeology also.

Steen and Jones have recently summarized the position of the lima bean in the Southwest (Steen and Jones, 1941, p. 197). They follow De Candolle in placing the origin of the lima bean in Peru, but, as was shown above, this has been replaced by more recent work. They cite the archeologic occurrence of limas at Wupatki as reported by Reed and Brewer (1937, p. 19), cite Whiting's evidence of ceremonial use of the lima as evidence of antiquity of the bean among the Hopi, cite the finding of lima beans at the Hodges site near Tucson, and cite the material from the Tonto ruin, being reported for the first time by them. They do not attempt to draw any other conclusion than that the bean is pre-Spanish in the Southwest.

When Murder House and Montezuma's Castle are added to these archeologic sites, and knowledge of the Pima growing of the bean ethnologically is added, conclusions become possible and a late entrance into the Southwest via the West Mexican corridor seems clearly indicated.

The west Mexican origin, the association with Hohokam sites, the limitation today to the Pima and to the Hopi, the distribution of the archeologic sites along the same corridor by which tepary beans reached the Hopi, all indicate a Hohokam source for this bean in the Southwest. The limitation of the bean to the Hopi and its absence at Zuni remain to be explained.

CHAPTER VIII

COTTON IN THE SOUTHWEST

The cotton of the American Southwest was described by Lewton (1912) and assigned to a separate species, Gossypium hopi. It hybridizes with Gossypium hirsutum, the upland cotton on which our cotton industry is based, but Jones (1936) has found that the segregation in the second generation is sufficient to indicate that the relationship is not close. This aboriginal cotton is possessed of the two extremely valuable traits of exceedingly rapid growth and very fine fiber. The fineness of the fiber and the relationship of fiber texture to strength has only recently been appreciated and the cotton is now being bred up from near extinction for commercial production.

Cotton is mentioned in the early chronicles of the Spanish explorations, the archeological reports of the region, and has had some ethnological study. The bulk of this work has been exhaustively covered recently by Jones (1936). The following discussion draws heavily from his work.

Cotton was unknown in the region east of the Mississippi in pre-contact times (Wissler, 1942, P. 43), but is well documented for the Southwest both in contact and archeologic times. The center of domestication of the upland cottons seems to have been in central, western Mexico (Sauer, 1936, p. 290). Since there is no trace of the plant to the northeast in pre-contact times it must have reached the Southwest via the west side of Mexico. It must belong, then, in the tepary-lima-pepo pumpkin, Gila-Colorado corn assemblage.

Since Hopi cotton has been shown to be rather sharply divergent from the commercial upland cottons of Mexico, the possibility arises that it is another separate domesticate. The tepary bean is established as a domesticate of this west Mèxican area. The pepo pumpkin of the area is a probable local domesticate. The association of the crops strengthens the possibility of a separate domestication for the cotton also. Unfortunately, little is known of the extent of the wild cottons of Mexico and it is impossible to attempt to fix the possible center of domestication of hopi cotton.

That we are dealing with but this one species in the Southwest seems well established. Haury and Conrad (1938, p. 227) have shown that archeologic cotton from Arizona cliff dwellings is of the hopi type. Strains of Gossypium hopi collected from the Hopi and Pima are still being grown at Sacaton by the Department of Agriculture. Unfortunately, cotton growing has nearly, if not completely ceased among the Pueblo people today, hence it is difficult to be sure of the cotton type formerly grown at the other Pueblos. White (1941) has recently obtained cotton from Santa Ana pueblo on the Rio Grande, which he has shown is related to Hopi cotton. His proof is based upon the observed botanical relationships of the two cottons. There seems no reason to doubt, therefore, that there is but the one species of cotton in the aboriginal Southwest.

If the Hohokam people spread this plant to the Hopi it should have been carried up the Verde valley with the tepary bean to the Flagstaff area about 1000 A. D. Cotton is reported at Flagstaff from this period by Bartlett (1934, p. 46). An alternative route of diffusion to the Pueblo peoples would be via the Mogollon culture. But if this were the case the Zuni, the nearest to the Mogollon, and not the Hopi should have been the first to have received cotton and been the great cotton producers of the Pueblos.

One could press the argument for the Mogollon source of cotton for the Pueblos on the basis of the excellent, humid corridor supplied by the Mogollon rim. It would be possible to postulate that hopi cotton was adapted to short seasons and high altitudes in Mexico and entered the Southwest by leaping from the northern Sierra Madre to the Mogollon rim. This is seemingly denied, however, by Brand's report (1935, p. 304) of the absence of Basket Maker or Pueblo 1 and perhaps even Pueblo 2 in the requisite areas of Chihuahua and Sonora. Sayles (1936, p. 100) found that the pottery making period in Chihuahua began about 1000 A. D. and derived from the north.

Hence it is clear that cotton among the Pueblos must derive from the Hohokam. One should expect it to appear relatively late among the Pueblos, and to be associated with the tepary bean, pepo pumpkin, etc.

For a discussion of archeologic cotton we need to know when cotton was first grown by people as opposed to when it first appeared as a trade article. It seems highly probable that cotton goods were traded far in advance of the spread of cotton growing. Those sites which have their perishable materials preserved should have plenty of evidence in the form of seeds, and bolls, if cotton were grown. There is, for instance, great quantities of such evidence at the Tonto ruins and there is, thus, no doubt that cotton was grown there. Reagan (1927) says that cotton seed is found at Mesa Verde, and that cotton is common in the Tsegi area of northeast Arizona. This is the area which shares corn and bean types with the Hopi. It is interesting to see that the cultural connections in Pueblo 3 followed the crop relationships. The general absence of mention of bolls and seeds from other areas suggests rather strongly that little if any cotton was grown in those areas.

The possibility can not be overlooked that cotton may have spread faster than other crops. The rate of diffusion of a crop must in part have been set by the comparative advantage of the crop. The tepary bean has little if any advantage over the kidney bean except in the extreme heat of the Gila-Colorado basin. One pumpkin has little advantage over any other pumpkin. But cotton as a fiber source is infinitely superior to feather cord, fur cord, agave fiber, or apocynum fiber. It may, therefore, have outrun its companion crops. We must await careful archeologic investigation of the matter to determine what really occurred.

It has frequently been stated that cotton occurs in Pueblo 1 times. The only case cited is from 785 A. D. from a site in the White Mountains of Arizona (Douglas, 1940, p. 167). The earliest occurrence of cotton in the Hohokam area is in the Colonial period, 500-900 A. D. (McGregor, 1941, p. 155). That the earliest appearance of cotton should be in the Puebloan area is no more significant than the occurrence of the earliest dated tepary finds in the Pueblo area. Plant geography indicates that this plant came from the west coast of Mexico, and its earliest occurrence in the United States must have been in the Gila-Colorado area.

The archeologic picture is not clear at present due to too little attention having been paid to the plant materials. Jones'(1936) thorough sifting of the evidence can be summarized as follows: cotton infrequent archeologically on the Rio Grande, plentiful in the San Juan area but secondary to other fiber sources, scarce in the Mimbres area. Since Mimbres is the final period in the Mogollon culture, the scarcity of cotton argues against their early possession of this crop. The early importance of cotton in the San Juan area in the archeologic period parallels the relationships of the other crops. It has already been noted that the beans and the corn of the Hopi and Zuni have relationships to the San Juan area and not to the Rio Grande. That cotton spread more readily to the San Juan than to the Rio Grande is evidence of the Hopi-Zuni relationship to the San Juan. The failure of cotton to spread equally rapidly to the Rio Grande is evidence that the divergence in crops between the Hopi-Zuni area and the Rio Grande is not a recent development. A rather sharp cultural cleavage seems implied.

At the time of the contact we get a rather dim picture of the status of cotton among the Southwestern peoples. There is very little mention of cotton on the Rio Grande. The Piro and Tiquex peoples (Rio Grande from the vicinity of Bernalillo south to El Paso) are mentioned as cultivating cotton. This is the area of probable irrigation on the Rio Grande. Cotton was apparently not grown north of this area. Bandelier (1892) reviewed the Spanish sources and drew an identical line for the northern limit of cotton growing. This has often been taken to be a climatic limitation but the figures on temperatures and rainfall (see climatic section) deny this. Therefore, the reasons must be cultural. The Zuni grew little, if any, cotton according to the Spanish sources. The Hopi grew great quantities of it (Espejo (Hammond and Rey, 1929) describes riding through a league of cotton fields between First and Second Mesa). The Pima, by all accounts, were intensive cotton farmers.

It is noteworthy that the Pima are described as using cotton clothing; the Pueblo peoples are described as only partially using cotton clothing. According to the Spanish accounts feather, fur, and fibers other than cotton were more frequent as items of clothing among the Pueblos than was cotton. Coronado was unable to raise a tribute of 300 pieces of cloth on the Rio Grande, but the Hopi gave Luxan and Espejo so much cotton cloth that even though one doubts their statistical veracity, one must accept the presence among the Hopi of a truly great weaving industry. It becomes increasingly clear, therefore, that the importance of cotton culture has a steeply declining gradient from the Pima through the Hopi to the Rio Grande. This same fact is expressed in Douglas' (1940, p. 167) placement of the center of cotton textile development in the Southwest corner of the Anasazi area.

Ethnologically the picture still holds. The center of cotton weaving still lies among the Hopi. From the evidence presented above it is clear that this is a legacy from the pre-Spanish period. The only important cotton growers today are the Pima. But, due to commercial pressure they no longer grow their native cotton. Due to their proximity to stores and their possession of cash crops, their weaving industry is extinct. This is a great loss, for if Pima weaving were still extant it might well prove not only to be superior to any Pueblo work but also prove to be the source of Pueblo techniques and skills.

All lines of evidence and reasoning, therefore, indicate that the source of cotton is from the Hohokam, to the Pueblos via the Hopi; that the spread was relatively late and that the crop had not yet reached its climatic limits. Cotton in the Southwest must also be referred, therefore, to the Gila-Sonora crop complex.

CHAPTER IX

CLIMATE AND CROP DISTRIBUTION IN THE SOUTHWEST

Because of the tendency to account for distributions of crops on the basis of environmental limitation it seems appropriate to discuss climate and crops in the Southwest. This discussion of crops has so far had to depend on climate for very little in explanation of the observed distributions. Instead, it has been rather conclusively shown that the primary divisions in crop distributions are based on historical origins. To what extent, if any, climatic limitations have controlled or accentuated these distributions of crops in the Southwest remains to be explored.

Climatic limitations seldom operate to the exclusion of man. The method of planting and cultivation is as important in determining the distribution of a given plant as is the climate. E.g. a desert is useless to an agriculturist until he learns to irrigate, but the desert may then become a granary. It becomes obvious then that there are really three factors to be considered: the human skills, the plant adaptations, and the climate. No one of the three can be divorced from the rest without ignoring the reality of the relationship.

It has been the custom to discuss "*the* limit of corn growing" in America, without realizing that there is not one limit, but as many limits as there are regions of corn growing dependent upon a specialized corn type. Kuleshov (1931) has shown that there are many such centers in America. It is not reasonable then to assume that the limit of corn growing can be set the world over or even in the Americas by the climatic limits which can be determined from a study of the northern limit of corn growing, e.g., in the Dakotas. The same principle applies to cotton, beans, squash, etc. It is futile to discuss climatic limits and barriers until the type of plants and cultural techniques available to the group under discussion are understood.

Unfortunately we lack the data needed for a really meaningful discussion of climate and crops because of our lack of knowledge concerning the adaptations of the Southwestern crops. Little information is available concerning the growth habits of the individual crops. Some fragmentary data are available from the experimental growing of the collections made in 1940-1941. For some plants, however, we shall never possess direct evidence of the climatic adaptation, e.g. Basket Maker corn, Northern Periphery corn, etc. The published studies of plant adaptations have mostly centered on important commercial varieties. Thus we know considerable concerning the adptations of corn from Iowa, but the applicability of such data to Southwestern corn growing is highly questionable because Southwest corn is very different in its growth habits and climatic adaptations.

The climatic limits of the plants may, theoretically, be approached by viewing the degree to which they seem to have been limited to specific climatic zones. Without a check on the characteristics of the crops, however, this is extremely risky. It is supremely easy to conclude that a crop is limited to a specific area by climate when the limitation is in reality cultural and chances to coincide with a climatic boundary. Indeed a "climatic boundary" is man-made to suit the need, hence it is almost always possible to find coincidence between crop and <u>some</u> climatic "limit." Nor does one gain much from comparing crop and climatic limits deduced from natural vegetation areas, for natural vegetation is exposed to conditions from which cultivated crops are shielded.

It is also obvious that the "climatic limits" within the Southwest must have varied throughout the archeologic period as new crops were introduced. Each culture had differing plants. Among the Anasazi these differences in plants varied widely both through time and area. To these variable factors one must add the probability that agricultural skills varied from period to period. It is obvious, then, that the problem is complex and can not be approached from any single-factor measure.

The problem of climatic limits, then, proves to be an exceedingly complex one to which we largely lack the keys. An attempt will nevertheless be made to point out some significant climatic facts and to interpret their influence on Southwestern cultures.

The average annual precipitation for the Southwest is shown on map 14. Three divisions are made. The green colored areas are those which have over 20 inches. This is the amount generally considered by white farmers to be necessary for successful dry farming. The small area of the Southwest which has this amount of precipitation is striking. Most of this area is of high elevation; much of it so high as to be agriculturally useless. A second division is shown which has under 10 inches of annual precipitation. Ten inches is used because the Hopi, who hold the most difficult farming area of the Southwest are near the 10 inch isarithm. In this area of less than 10 inches precipitation not even the Indian dry-farmers could succeed before the development of irrigation. It is important to note that besides the areas usually recognized as being of extreme aridity, most of the Rio Grande valley, nearly all of the Upper Colorado valley, most of the San Juan and Little Colorado valleys were similarly limited in amount of rainfall. East of the Rio Grande annual precipitation steadily increases toward the Mississippi.

The agricultural success of the Indians in the areas having between 10 and 20 inches of annual precipitation is due in part to the distribution of rainfall in the Southwest. A high percentage of the rainfall comes in the summer season. There is a strong concentration of rainfall in July and August. This is the middle of the growing season and this rainfall is therefore extremely efficient. An area having a stronger concentration of warm season rainfall would have an advantage over other areas in that the rain would be available at the time needed. In order to show the distribution of warm season rainfall, map 15 has been prepared. The Southwest is again divided into three areas. The Hopi are again used to set the minimum amount of warm season precipitation. The Hopi occupy an area which has between 4 and 6 inches of precipitation in the warm season. All areas having below 4 inches in the warm season are therefore mapped as being too dry for utilization under dry farming conditions. The areas of excessive summer drought again appear in the west. They differ little from the areas of deficient annual precipitation except that the Rio Grande valley is not included in the area of extreme drought. The Rio Grande, then, is an area of stronger summer concentration of its rainfall.

The value of over 10 inches in the warm season has been chosen to limit the areas of superior agricultural possibilities. This figure is chosen because the amount in the warm season exceeds the minimum amount for agriculture in the entire year (see above). It is, of course, an arbitrary choice, but does express a better agricultural possibility than found in the rest of the Southwest. The importance of relief and the increasing amount of precipitation in the warm season as one goes east of the Rio Grande is again apparent. The Southwest is thereby again shown to be climatically an area marginal to better areas to the east.

The tongue of moderately good climatic conditions which appears in the southeastern corner of Arizona, again appears on the map for summer rainfall. The figures (15 inches for the year and 12 inches in the warm season) show a great concentration of precipitation in the warm season.

Amount of rainfall alone, however, does not determine the agricultural limits. The length of growing season also must be considered. Map number 18 showing the length of the frost free season, is therefore, included. The isarithms for 100 and for 120 days are shown. The Puebloan crops have a length of growing season nearer 120 days than 100 days. The major part of the Southwest is shown as open to an agriculture equipped with plants capable of maturing in 120 days or less. The major areas excluded are the southern Rocky Mountains.

The strip of short season territory running south from the Rocky mountains to and including the Mogollon rim, although near the border line for 120 day crops, is predominantly usable. On the more detailed maps of the length of growing season in Arizona given in the 1941

Yearbook of Agriculture only a very small part of this area is shown as having under 120 frost free days.

Length of the frost free season alone can not determine the agricultural utility of a site. It is the coincidence of moisture and temperature which makes an area agriculturally useful. Southwestern Arizona has a growing season of over 250 days. The precipitation is strongly concentrated in a brief part of this period. It is only the part where the frost free season and the rainy season overlap that was agriculturally useful prior to the development of irrigation.

A map (number 16) has been made to show the distribution of those areas having less than 2 inches of rainfall in spring. Southwestern and southern Arizona, southeastern New Mexico and the Rio Grande valley again appear as low in precipitation. In addition there is a great area in northeastern Arizona and adjacent New Mexico, and extending up the Colorado river valley in Utah which appears as low in spring precipitation. Since northeastern Arizona is one of the principal centers of the Pueblo culture it is clear that even this extremely low amount of rainfall is not too little, to allow the starting of crops in spring with the appearance of favorable temperatures. It is certain, however, that two inches of precipitation scattered over 3 months is too little to be very effective.

Map 17 has therefore been made to show the areas which have less than 2 inches of winter rainfall. Low winter rainfall characterizes a broad belt of territory on the eastern margin of the Southwest. The entire Pecos and Rio Grande valleys lie within this area. An extension of this area reaches northwestward to the Colorado river valley in Utah via the southern San Juan Drainage. An outlier of this area of low winter rainfall is found in extreme southwestern Arizona. To the east of the Pecos the amount of winter rainfall increases steadily toward the Mississippi.

A comparison of the two maps of low cool-season precipitation will show that they overlap in part. Those areas which have less than 2 inches of precipitation in either spring or winter are very dry indeed. In such areas it is doubtful that much moisture is stored in the soil. If no moisture is stored in the soil, planting can not be started in spring but must be delayed until the late summer rains. This, however, shortens the growing season too much for successful agriculture in most of this area.

Map 19 shows the result of combining the maps of cool season (spring and winter) precipitation, warm season precipitation, average annual precipitation, and growing season. In each case the areas judged closed to agriculture without irrigation is white. The green areas therefore represent the available agricultural lands for dry farmers. Several important things appear in this map. It was pointed out above that the area east of the Rio Grande is generally superior to the Southwest in all climatic values and improves steadily as one goes farther east. Or, to say it in reverse, the major climatic barrier to crops coming from the east is the Rio Grande-San Juan strip of aridity. An extension of good agricultural conditions reaches into the northern drainage of the San Juan area. An area of good conditions is found throughout the whole of northeastern Arizona with the exception of the Little Colorado and adjacent Colorado river valley. New Mexico is open to dry farming except for the Rio Grande valley and the southern portion of the state. Southwestern Arizona is entirely closed to non-irrigation peoples except for the small section in the southeastern corner mentioned as having a relatively high rainfall with a high concentration of that rainfall in the warm season.

It may be objected that this discussion has ignored the subject of climatic change. This is indeed true and has several causes. Climatic change is a large and difficult subject in itself and it was felt that unless an extensive study were made on this subject alone, little could be done with it.

There seems to be no evidence of climatic change of any great magnitude in the past 2000 years. The dendrochronologists deal with minor climatic fluctuations or variations but have not demonstrated any long term changes. Since most of the agriculture in the Southwest has a history of less than 2000 years, it would seem therefore that climatic change can not have affected it markedly.

In the remoter periods of time when plant domestication was being undertaken we know almost nothing concerning precise climatic conditions. At any rate, such considerations affect the Southwest little for as has been indicated, only the tepary bean seems a probable Southwestern domesticate. Pending positive evidence to the contrary, climatic change is therefore thrust aside as unimportant for this thesis.

CHAPTER X

CLIMATE AND AGRICULTURE:

Since we lack complete and detailed maps and descriptions of site locations for the Southwest by cultural periods it is obvious that one can do little with the climatic limits of the various archeologic cultures. The modern tribes will, therefore, be discussed as to their agricultural practices, site locations, and climatic limits. Conclusions as to archeologic conditions will be drawn where possible.

When discussing climatic limitations of agriculture and adaptations of crops it is desirable to have records taken in or near the fields. This is rarely possible but can be approximated and the differences can be to some extent accounted for. The following stations have been used to give climatic data relative to the modern pueblos:

Station	Pueblo or tribe
Yuma	Yuma, Cocopa, Kamia
Parker	Mohave
Sacaton	Pima, Papago
Keams Canyon	Hopi
Laguna	Laguna, Acoma
Albuquerque	Isleta, Sandia, Santa Ana, Jemez, Zia, Cochiti, San Felipe, Santo Domingo
Espanola	Santa Clara, San Ildefonso, Tesuque, San Juan
Taos	Taos
Jemez Springs	Archeologic Rio Grande pueblos

The lower Colorado river:

The Cocopa, Mohave, and Yumas occupy the lower valley of the Colorado river. This area is the hottest part of North America. The average maximum temperatures are extremely high (see chart 7). The growing season is extremely long: 357 days at Yuma, 251 days at Parker. Today this means three crops per year for the Yuma and two or more for the Mohave. Aboriginally, however, there was but one crop, for the people were dependent upon the flooding of the river for the planting of their crop.

The river flooded in May and June hence planting began in late June or early July when the river receded. This placed the planting and growing period in the time of extreme heat. Rainfall at Yuma and at Parker is under 5 inches and is so distributed through the year that no month has 1 inch of rainfall. For all practical purposes, then, the crops were grown without rainfall.

Seeds were placed in holes made with the digging stick in the mud in the fields which had been cleared prior to the flooding of the river. The crop had to make a quick start, rapid growth, and mature on the moisture which was in the mud. Hence despite the apparent long growing season as determined from the frost free season, a premium was placed on rapid growth, short season crops. On a pre-irrigation basis this area was in fact one of exceedingly short growing season with the limit set by the period in which water was available. Moisture is rapidly exhausted from soils under field temperatures which can exceed 120 degrees Fahrenheit, and especially from soils which tend to crack open in the manner of the Colorado river silts and clays. The Yuma and Mohave claim of 60 days to maturation for corn and beans expresses the rapidity with which the crops are forced to produce.

The tepary bean is as rapid in growth habit as the small yellow corn of this area. Some of its peculiar adaptations are known from Freeman's (1912) study of this bean. The tepary will absorb water at an extremely rapid rate hence will germinate with much greater rapidity than will the kidney bean. Tepary beans planted in irrigated ground at Oraibi, Arizona in July 1941 were up in 5 days while kidney beans planted at the same time took 10 days to germinate. These growth habits reflect the degree of adaptation to the imperative need of rapid growth to utilize the moisture available.

Eastern corn will not survive under these rigorous conditions. Even with irrigation Puebloan corn can not be maintained in this area; frijole beans fail during the summer heat; black eye beans (Vigna sinensis) grow but show clear signs of poor growth. In their poor adaptation to this area these plants betray their late and "foreign" origin. The small yellow corn common to the area, the tepary bean, and the cucurbits thrive and thereby demonstrate either nativity, local adaptation through a great period of time, or derivation from a land where they had already developed high heat resistance.

None of these plants were domesticated in the lower Colorado valley nor can any great antiquity be demonstrated for Yuman agriculture. One must therefore postulate either derivation from a torrid homeland or adaptation to torrid conditions elsewhere, preferably in an adjacent area. Corn is known to be of South American origin (Mangelsdorf and Reeve, 1939) and such extremes of heat as are met with here are not to be found elsewhere in the entire range of corn growing. The adaptation of corn, at least, would then seem to have occurred somewhere on the fringe of this heat center of North America.

In actual practice, then, the limiting factor was not so much the deficiency of rainfall but the short period in which moisture was available. The potentially long growth period was thus nullified prior to the development of irrigation. High heat and short season became the factors governing the choice of crops. For this particular agriculture the usual calculations of length of frost free season, annual and seasonal precipitation, ratio of precipitation to evaporation (precipitation efficiency) are meaningless. The need was for plants capable of withstanding great heat and making a rapid growth. This area of climatically long growing season was for pre-irrigation agriculturists the shortest season agricultural area of America.

The lower Gila-Salt basin:

This designation is applied to that part of Arizona which lies south and west of the Mogollon rim. Today the Pima-Papago peoples farm much the same areas that they held at the time of their contact with the Spanish.

Climatically the area is varied. The heart of the area, the Gila river from Gila Bend to the San Pedro and the Salt river below the mountains, is desert. The land held by the Papago to the south of the lower Gila and west of the Santa Cruz is also desert and increases in intensity as one proceeds westward. The San Pedro and the Santa Cruz valleys, however, rapidly improve climatically as one ascends their valleys toward the Mexican border.

In terms of rainfall during the warm season (see map number 15) this is reflected in less than 4 inches of rain south and west of Gila Bend, but over 10 inches of rainfall in the upper Santa Cruz and San Pedro valleys. Judging by the success of the Hopi farmers with but 6 inches of rainfall in the growing season, ten inches of rainfall during the growing season in the upper Santa Cruz--San Pedro valleys is sufficient to produce a crop without any irrigation or dependence on flood waters. Hopi crops are exceedingly drought resistant, but so too are the crops of the Pima and Papago. E.g. the Papago claim that they will get some return from crops wet by flood waters but once and will get an excellent crop if the land is wet twice.

The Pima are now farming an area that can not be cultivated without irrigation. Their crops have been shown to be of west Mexican origin. They are extremely quick growing and highly heat resistant. In species, variety and climatic adaptation, this is clearly the source of the Colorado Yuman crops. The area now held by the Pima and formerly held by the Hohokam is not the home of these crops either. The area from which they were introduced must, therefore, lie to the south. The adaptation of these crops to the low elevation, high heat, and low rainfall must have occurred somewhere between that homeland and this specialized agricultural area.

In the San Bernardino valley of southeast Arizona Sauer and Brand (1930, p. 427) found sites located about the alluvial bottoms for which they report no canals or other evidence of irrigation.

It is apparent that along the border of southeastern Arizona the area having 10 or more inches of rainfall combined with lowered temperatures due to the increased elevation could be, and was, dry farmed. (See maps 14 and 15)

One has, then, in this area a steady improvement of conditions for agriculture as one proceeds up the Gila to the Santa Cruz and San Pedro rivers and up these latter valleys toward the border. See map 19 for the temperature changes and chart 7 for the precipitation change. Average rainfall of 12 inches during the warm season combined with not too great heat as at Nogales, is a very good agricultural prospect. The summer rains begin at Nogales in July and frost is not expectable until early November. In terms of available moisture the area is well suited to quick growth crops. It must be emphasized, however, that only crops which can make a quick start and complete their growth in the relatively brief period between the first rains and the first frost can succeed in the area.

An agricultural people coming from the south would have found conditions rapidly becoming more difficult as they moved north and west into the Gila valley. Likely methods of expansion into the area would have been either by following the ranges instead of the valleys and depending on the supplementing of precipitation by the use of arroyo flooding or by following the valleys and depending on river flooding.

One has in this area the conditions needed for the adaptation of the plants which eventually reached the lower Colorado tribes. With growing at first dependent on precipitation, quick growth crops would be developed. An increasing degree of drought and heat resistance would be required as the agriculture expanded into the Gila area.

As the drought became greater, dependence on arroyo floods and river floods would place an increasing premium on quick-growth plants which would make a crop while moisture was available from the brief runoff from the mountains.

By these lines of reasoning the Papago who wait for the rains before they begin their planting, and who plant in the areas flooded by arroyos must represent one of the earliest types of agricultural expansion into the area. The Yumans of the lower Colorado river who utilize the flooding of the river but don't use canals would then represent another old agricultural form which survived on the margin of the Gila agricultural area. Canals have been shown to have been developed by the Hohokam by 500 A. D. This suggests that the Colorado Yumans may have received agriculture prior to that time.

During the months of July, August, and September the Gila area is 6 degrees cooler than the Colorado river area. This seems to have been a sufficient temperature difference to permit some growing of limas and a temporary growing of frijoles, and perhaps the introduction of some Puebloan corn. Some flint corn of probable Puebloan origin occurs among the Pima. Colored Puebloan corns, however, are absent among the Pima-Papago today, or, at best occur rarely. One old Papago inquired curiously if there were any people who grew fields of colored corn and expressed disbelief when assured that the Pueblo peoples did so. He stated that he had never seen but an occasional ear of colored corn, never a field of it. The scarcity of Puebloan corn in the Pima area where large groups of Puebloan people (Salado) are known to have lived from 1250 to 1400 seems to indicate a climatic limitation. Since the Hohokam and Pima irrigated their fields, the barrier can not have been one of moisture. The barrier must then have been the excessive heat. Puebloan beans are not found among the Pima. Beans are subject to "premature absiscion" (dropping of the blossoms before fruit is set) when temperatures are too high. The high heat of the Gila-Colorado area was an important factor in preventing Puebloan crops entering the Gila-Colorado area.

In Freeman's time (1912) the Pima-Papago people apparently grew a wide variety of vulgaris beans, but none of the types illustrated by Freeman are grown today either by the Pima-Papago or the Pueblo tribes. This raises the difficult question of the time and origin of these beans. Because there seems to have been some climatic reasons for their abandonment, these problems are introduced here. At Big Fields in the Papago country I was told that they formerly had "other kinds of beans, but we don't see them anymore. The Mexicans brought them and they are still to be seen in Mexico." Study of bean collections from Jalisco by Isabel Kelly and from Michoacan by Dan Stanislawski shows similarities to the beans illustrated by Freeman (1912). It is, therefore, probable that the native tradition is correct.

The utter disappearance of these beans in the past 30 years suggests both that they were foreign to the area and that they had not been long maintained in the area at the time that Freeman collected them. Freeman, by experimental growing of these beans alongside teparies showed that these vulgaris beans could not withstand extremes of heat, short season or drought. Their maintenance in the area must have depended on frequent introduction of new seed. Their disappearance is a modern parallel to the disappearance of the Pueblo beans which must have been introduced by the Salado people in the 13th century A. D.

The evidence of the inability of Puebloan corn and beans to penetrate the Gila-Colorado area is important to an understanding of southwestern crop distributions. If Puebloan corn and beans will not grow in the Gila-Colorado basin, then corn and bean types common to the two areas must have come from the Gila-Colorado area.

The Pueblo area:

The Pueblo area differs in many respects from the Gila-Colorado area. Temperatures are lower in all seasons due to the increased elevation. Rainfall varies over the area (see map 14) but is never so low as is found in the lower Colorado area. Only at high elevations is it as adequate as in the upper Santa Cruz and San Pedro valleys. However, due to the lower temperatures, what rain falls is subject to less rapid evaporation and is more effective in moistening the ground. Winter precipitation, although light is especially effective for at this season much of the precipitation comes from cyclonic storms, hence in less intense form, and much less runoff occurs. As a result of these factors there is sufficient soil moisture available in spring to start the crop and planting need not wait on the beginning of rain or the flooding or receding of a river. As a result the crops are able to utilize the full length of the frost free season for growth.

The importance of spring rains to the Pueblo peoples has been well illustrated by Franke and Watsons' (1936) study of the corn growing in the demonstration corn field on Mesa Verde National Park.

Corn was grown under Indian conditions for 17 years with but 2 failures. Both failures were due to abnormally light winter and spring rainfall. Without adequate soil moisture the corn failed to live through the hot dry interval until the late summer rains began.

By far the largest area lacking in both spring and winter rains is southern New Mexico and adjacent Texas. Of considerable archeologic interest is the extension of this area of great drought in the cool season up almost the entire length of the Rio Grande valley and its extension northwestward via the Puerco and Jemez river to the south side of the San Juan river and thence down the San Juan to include part of the adjacent Colorado river valley. It would be interesting to plot the early Anasazi sites of the San Juan in relation to this area, but the material is not at hand to do so.

It is interesting to note, that much of the area climatically most favorable to agriculture, e.g. the Mogollon mesa, was not held at the time of the conquest by Puebloan peoples. Even the strip of relatively good rainfall in the mountains east of Alamogordo was held by the Apache. It is true that much of this area of better rainfall is high country but the archeologic evidence clearly indicates that much of it was habitable by Puebloan agriculturists in the past. It is difficult to interpret its present abandonment as other than a forced evacuation.

In the discussion of the Gila-Colorado area it was noted that Puebloan crops, e.g. corn and beans, do not survive under the extreme conditions of heat and drought met there. One may not argue for the separateness of the two agricultural areas on a climatic basis, however, for Gila-Colorado crops succeed well in the Puebloan area. Indeed possession of crops of 90 day growth season would have widened considerably the area which the Pueblo people could have farmed. That Gila-Colorado crops actually did penetrate the Pueblo area and succeeded under the most difficult of conditions is attested by the presence of cotton, lima beans, tepary beans, and Gila-Colorado corn among the Hopi. The crop differences between the two areas are not, then, environmental in their basis but are due to cultural causes.

The discussion of the Pueblo area has been rather general and has thereby ignored the importance of the specific site. Generalized climatic maps such as this discussion has been based on never give the exact picture of field conditions. The Puebloan location of fields in sheltered coves, at the mouth of an arroyo which one can depend on for flood waters, etc. makes a general climatic map of limited usefulness. It would be extremely valuable to investigate the site location and microclimatology of many sites from each of the archeologic periods and areas of the Southwest. Such an undertaking lies outside the scope of this paper. Some comments on climatic conditions as measured near some of the present Pueblos will, however, be given below.

Hopi-Zuni:

For the Hopi, Keams Canyon is the nearest meteorological station. Hopi farmers have fields around the agency at Keams Canyon and the bulk of the Hopi fields are at the foot of the mesas in comparable locations. The average date for the last killing frost is May 19, and thereafter the Hopi has on the average 133 days before the next frost. However, the first rains sufficient for wetting the ground do not come before the first part of July and killing frost is expectable 90 days later. The bulk of the Hopi crops need 120 days or more for maturation. Seemingly the Hopi has an impossible agricultural situation, but by planting as early as possible, even at great risk of frost damage, and by utilizing the moisture in the soil from the winter rains to start his crops 6 weeks before rain is expected the Hopi manages a precarious agricultural existence.

Corn, beans, and cucurbits are all started in May. Rains are not expected until after the first of July and often do not arrive until the early part of August. The plants, therefore, must make their start on moisture in the ground from winter rains and maintain themselves for from one to two months with no further moisture. The precipitation for January through April averages 3.82 inches and it is this moisture that is vital for starting the crop. April and May are dry months and when planting time arrives the moist earth may be at some depth. If moist earth is to be found 12 inches deep, the seeds must be placed at that depth. The Hopi planting technique is designed to reach this moisture. The planting stick used is short, varying from 14 inches to 2 feet. Each hill is a special task. Kneeling, a narrow rectangular hole is dug to moist levels. The soil in the bottom of the hole is then loosened "to soften the ground that the roots may strike deep" (Louis Mansfield, Hopi farmer). The seeds are then placed and the soil filled back. No other method would serve under these conditions for this method alone assures the placing of the seeds at moist levels, and loosens a minimum of soil, lest it blow away.

In order to meet these requirements of deep planting the Hopi have developed corn capable of reaching the surface from great depths. Collins (1914, p. 261) studied the peculiar developments of the Hopi corn and reported that it would come up from depths of 10 to 12 inches. He found this deep sprouting ability in Zuni corn and Navaho corn from Shiprock. The linking of the deep sprouting ability to Hopi and Zuni corn raises the probability that it is a quality associated with the Hopi-Zuni corn type as described in the section on corn. The time and place of development of this deep sprouting quality would be interesting to know. When the spread of Anasazi culture reached out into areas of as little moisture as the Hopi and Zuni areas, such an adaptation must already have been in existence.

Hopi plants are up by early June and then must survive a trying period. For at least a month they will be subject to strong, dry, sand-bearing winds. During this time little vegetative activity goes on. The corn grows slowly, the beans form small bushes, and the melons begin to put out runners. Root systems, are, however, developed and deeply implanted. When the rains begin the plant is in position to accelerate its growth and finish its cycle in the very short period before the fall frosts.

Of all the people in the Southwest the Hopi have been least affected in their agriculture by recent innovations. Peaches and watermelons are the only important additions to their culture. Chili is little used for it can only be raised in the minute irrigated gardens. Few plants, indeed, could invade this most exacting of agricultural areas. The tepary bean, quick growing corns of the Gila-Colorado type, and the lima bean had penetrated this area in late archeologic times. As has been pointed out, the success of these crops among the Hopi shows that it was not an environmental difference which gave rise to two separate agricultures. In post Spanish times only a few bean varieties have been introduced, and these came from Zuni, or Taos where they had already been acclimated to short seasons and severe conditions.

The Zuni resemble the Hopi in their agricultural complex. Their types of corn, beans, and squash are similar and both tribes have sufficient winter rainfall to start their crops in spring on accumulated soil moisture. Temperature conditions are comparable (slightly warmer at Keams Canyon), but rainfall in the growing season is one inch higher at Zuni.

Since there is no marked difference between the Hopi and Zuni in their climate one can point to the absence of lima beans, and the probable failure of the Zuni to cultivate cotton in pre-contact times as further evidence of the dominance of cultural over environmental causes in the creation of the agricultural differentiation in the Southwest.

Laguna-Acoma:

The Laguna and Acoma people are Keres in speech and thus must be considered offshoots of the main body of the Keresan peoples on the Rio Grande above Bernalillo. According to Gunn (1917) Laguna was founded in 1699 by peoples from the Rio Grande river in the vicinity of Santa Fe. Acoma may not be of any really great antiquity although it is, of course, pre-1540.

Climatic conditions are relatively poor here for agriculture. The spring rains are meager, the summer rains are only slightly better than at Keams Canyon and they are accompanied by higher temperatures, hence evaporation is high and the efficiency of the precipitation is lowered. Planting begins in May and continues into June. The length of the growing season is relatively long (Laguna 170 days, Hopi 133, Taos 145).

It is difficult to see why these people left the Rio Grande for this area. If they had knowledge of irrigation, they were trading an unfailing water supply for the hazards of seasonal rainfall of the most marginal sort. It seems much more reasonable to assume that they had no knowledge of irrigation at that time, and that the Laguna area was, therefore, definitely superior in agricultural potentialities. Even this is not a sufficient explanation however, for a much shorter move back into the canyons of the Jemez mountains would have afforded them a much better situation (see discussion of Jemez springs below).

Rio Grande area:

Albuquerque has been selected as the meteorological station for that part of the Rio Grande valley where the Pueblos of Isleta, Sandia, Santa Ana, Zia, Jemez, Cochiti, San Felipe and Santo Domingo are located. The meteorological records are taken on the campus of the University at some elevation above the river floor. This gives a growing season of two weeks longer than is actually found on the valley floor. The discussion is based on this data, however, because the station is close to the above pueblos and because the traditions of most of the Pueblos tell of utilizing not the river bottom lands but the lands at the base of the mountains.

The climatological data indicates this section of the Rio to be closed to pre-irrigation agriculture. The temperatures in the growing season are higher than for the Hopi. From November through March inclusive the greatest rainfall in any month is .51 inches. When less than half an inch of precipitation occurs in any month it means that practically no moisture is available for storage in the ground. As a result crops can not be started in this area in the spring but must wait until the late summer rains arrive. The summer rains are too light (3.67 inches as compared to Hopi 4.92 or Laguna 5.67) to mature a crop. It has been indicated that tradition and archeology place the bulk of the Rio Grande pueblos in the mesa country back from the Rio Grande. Tradition, archeology and climatology, therefore, are in agreement here.

In order to give an idea of the magnitude of improvement of agricultural conditions along the Rio Grande as the elevation increases to approximately that of the prehistoric Pueblos of Puye, Frijoles, etc., figures are given for Jemez Springs. This station is located west of the Rio Grande, in a canyon at an elevation of 6,100 feet (Albuquerque 5,196). Eleven inches of rain fall during the average growing season of 170 days. July, August, and September have had no killing frost in the 20 years of record and the entire month of June rarely has frost. Rainfall in July, August, and September amounts to 7.42 inches. This amount of rainfall taken with a moist soil for starting the crop is ample for raising corn and beans even without having recourse to establishing fields on sites subject to flooding. It seems highly probable that the beginnings of Anasazi agriculture can be placed in areas and situations similarly favored and that the expansion of Anasazi culture was dependent upon development of such specialized techniques as deep planting and use of arroyo flood waters.

Espanola has been selected to represent the upper Rio Grande pueblo area. This area, occupied by Santa Clara, San Ildefonso, San Juan, Tesuque, Nambe, and Pojaque is somewhat different from its neighboring region to the south but still apparently falls into the same climatic category. The growing season is shorter, (164 days at Espanola, 196 days at Albuquerque) but is still amply long. The rainfall in the growing season is slightly higher but still too low for dry farming. Only 2.25 inches of rain fall from November 1 to March 31 and little if any moisture is stored in the soil for starting a crop.

In this area, as in the Albuquerque area the people claim to have lived away from the river, and to have practiced arroyo-flood agriculture. San Ildefonso still plants beans on the mesa tops because they do better under cooler and moister conditions. They claim that corn also does better on the mesas and is less bothered by worms. Santa Clara makes similar claims, and the complaint is often heard that squash can not be successfully grown near the river but succeeds in the drier lands. These claims suggest a poor crop adjustment to the climate of the Rio Grande valley. This, in turn, implies a relatively recent locus in the hot valley of the Rio Grande.

Taos and Picuris present a special problem. They are at high elevations, have the shortest growing season of any Pueblo outside the Hopi area, and have the coolest temperatures of all the agricultural areas here discussed. Corn, beans, and cucurbits are nevertheless grown successfully. I lack data that might indicate that the Taos crops differ greatly from the other Pueblo crops in length of season, temperature requirements, etc. The fact that the growing season at Keams Canyon is 12 days shorter than the season at Taos does not indicate any difference in favor of a greater specialization at Taos. Although at Taos temperatures are comparable to the Hopi temperatures, and the growing season is longer at Taos than at Keams Canyon, cotton was grown at Keams Canyon but not at Taos. The climatic data suggest that the lack was cultural rather than environmental.

In considering the distributions of crops in the Southwest the major conclusions from survey of the climate are these: The Puebloan crops (except the Puebloan pumpkin) can not be grown in the Gila-Colorado area because of the short season and the extreme heat. There is, however, no climatic barrier in the Pueblo area to Gila-Colorado crops. The complete division in crop types must, then, still mean cultural barriers rather than climatic barriers. Since Puebloan crops will not grow advantageously in the Gila-Colorado area but Gila-Colorado crops will grow well in the Puebloan area, crops common to both areas must be derived from the Gila-Colorado area. Climatic conditions improve east of the Rio Grande and south of the Gila. Hence it is in these directions that one must look for the routes of entry of the two agricultures.

Climatic Routes to the Southwest:

The origin of corn, the key crop of the Southwest, lies in South America. To reach the Southwest it must have spread northward through the agricultural parts of Mexico. Since two separate agricultures are to be dealt with, it becomes necessary to postulate either two routes or two waves of agriculture via one route.

Climatically there are two possible corridors, each with a dual sub-division. On the west side of Mexico agriculture could come up the west coast, proceeding from tropical savanna climate in Sinaloa (Aw), to sub-tropical rainy summer climate in southern Sonora (Cw), to steppe (BS) in northern Sonora and finally into desert (BW) in southern Arizona. This route is well established. Sauer (1932) has shown that it was the principal trade and cultural artery from the center of Mexico leading north. Agricultural peoples formed an unbroken belt from the Middle American agricultural centers to the United States along this line. It leads progressively into climatically more difficult country and agricultural expansion northward along it would expectably be slow as it spread north of southern Sonora. The crop types reaching the northern end of this corridor would expectably be extremely adapted to heat and drought.

Theoretically a similar corridor could have existed up the Sierra Madre of western Mexico, leading from the Valley of Mexico through the belt of sub-tropical rainy summer (Cw) climate that follows the Sierra northward. This corridor would expectably be marked by crops adapted to highland conditions. The path would lead through the Sierra to northern Sonora and thence to the Mogollon rim and thence to Flagstaff. Of the actual functioning of this corridor we have no evidence. Brand (1935, p. 304), Sayles (1936, p. 100 and 103), Carey (1931) have all surveyed the area of northern Chihuahua where such a culture would be expected and found nothing prior to late Pueblo 2 or early Pueblo 3 times. This is not only obviously too late but the cultures found are of obvious northern derivation. There is no culture in the Southwest [illegible] some or part of the [illegible] genetically related to the [illegible] that would indicate such a derivation unless it be the Mogollon. Haury (1936) believes the Mogollon to be of eastern derivation and to date there is neither direct nor inferential evidence that they were bearers of new agricultural material. It thus seems clear that only one corridor operated on the west side of Mexico.

On the east side of Mexico a similar climatic corridor existed. Climatically it was an infinitely better one. In the lowlands tropical savanna climate (Aw) leads into humid sub-tropical (Cfa) climate which extends unbroken into the Southeastern United States. Middle American crops could travel up this corridor with a minimum of modification. More varieties should have been able to penetrate to the United States by this route and the movement of varieties by diffusion or by migration could be direct and relatively rapid. Purely on climatic grounds, this is <u>the</u> corridor to the United States. Culturally we know little of its operation. At the north it is generally believed that such influences were blocked by the presence of non-agricultural tribes along the Texas coast.

In the discussion of corn types in the eastern United States it was shown that the big cobbed many rowed flour corns came up the east coast of Mexico to enter the United States. The non-agricultural tribes of the Texas coast may have been by-passed. Unless one postulates an agriculture borne by a boat culture, this east Mexican corridor must be accepted as the most likely corridor from Middle America to the Southeastern United States. If a boat culture carried agriculture to the Southeast, it should have crossed from the Antilles to Florida. Boat cultures were there and the distance is short.

Longelly (1938) has indicated that the corn of part of the southeast of the United States is genetically related to the Caribbean corn, and postulates its entrance via Florida. The possibility, therefore, can not be dismissed that both Florida and Texas served as corridors to bring corn to the United States. In the discussion of corn in the United States, it was shown that in the eastern United States there is clear evidence of multiple introductions of corn. The evidence is not clear, however, as to the route or routes of introduction. The presence of corn types which are non-Caribbean, e.g. Mexican pyramidal, etc. makes it certain that the east coastal route was one of the routes. It seems probable that this was the principal route.

Mason (1935) has discussed the possibility of contacts with Mexico across Texas. He points out that the Huastec of northern Vera Cruz are a Mayan extension north along the east Mexican coast. They have been in their present position for at least 2000 years. He has attempted to demonstrate that the Huastec influence extended north at least to Matagordo Bay in Texas and probably extended north into the southern plains of the United States to influence the Caddoan peoples. The agricultural picture as developed here supports such a thesis.

West coastal and East coastal Mexido and possibly Florida then are the routes by which agriculture from Middle America must have reached the United States, and consequently the routes by which agriculture must have reached the Southwest. The West Mexican corridor leads to the Gila-Salt basin where the Hohokam culture possessed specialized heat and drought resistant and quick growth crops. The Eastern Mexican corridor leads to the Eastern United States and served to introduce slightly modified tropical crops with little initial drought resistance, of tropical growing season, with only moderate heat tolerance, and little cold tolerance.

Crops which reached the United States by this latter route must have spread progressively slower as they spread northward into areas of greater cold, shorter season, and changing length of day. To the east they could move relatively freely. To the west and northwest they must have moved quite slowly due to the problems inherent in the drought conditions of the plains. Provided sufficient time for adaptation, however, there would be no reason for their westward spread to be stopped short of complete desert.

The climatic consideration thus shows no barrier to agricultural diffusion to the Southwest either by the west coast or by the east coast of Mexico. The latter route has been shown to be the better one and to lead eventually into the Southwest from the Great Plains. If both these corridors functioned, one might expect to find two separate agricultures in the Southwest. It has already been indicated that two separate agricultural complexes do exist in the Southwest and that the differences between them are mainly due to cultural rather than environmental causes.

CHAPTER XI

IRRIGATION AND AGRICULTURE

The preceding climatic discussion was based largely on the assumption that the Southwest was dry farmed. Irrigation was, however, known in the Southwest. Knowledge of the presence or absence of this trait is fundamental to an understanding of crop-climate-land use relationships in the Southwest. It is therefore proposed to discuss the distribution of irrigation in the Southwest.

Hodge (1907, p. 620-621) has stated that it was once assumed that irrigation was not practiced by the Southwestern Indians except to a very limited extent until after they came under the influence of Spanish missionaries. On the basis of knowledge of the extensive canal system of the Gila-Salt area he abandoned this belief and credited the Southwestern Indians in general with knowledge of irrigation. Hodge added, however, this significant statement: "In the valleys of the Rio Grande and its tributaries, in New Mexico, small reservoirs were the means of supplying water to the ancient villages; <u>and even today only the rudest methods of irrigation are employed by the Pueblo tribes</u>." He attempted further to bolster the evidence of Pueblo irrigation by citing irrigation ditches in the Chaco canyon. More recent work has denied the presence of canals in the Chaco (Brand, 1937, p. 114).

The translations of the Spanish accounts are notable for their failure to mention irrigation in the Pueblo area outside those areas adjacent to the Hohokam culture. Espejo and Luxan were both struck by the irrigating ditches at Acomita. It must have been an unusual sight to them for they both described the development there in detail. Luxan (Hammond and Rey, 1938, p. 87) said of them:

"We found many irrigated fields with canals and dams as if Spaniards had built them." Since their expedition was in 1582 there seems to be little doubt that these were aboriginal works, not Spanish influenced works. Espejo also mentioned the irrigation from the springs at modern Ojo Caliente, near ancient Hawikuh, and modern Zuni. These men had traversed the Rio Grande with but a single mention of irrigation and it is indeed strange that so close and interested observers should become suddenly irrigation-conscious here.

Bustamente, Escalante and Barrado, etc. (Bolton, 1916) mentioned agriculture in their accounts of exploration in the Pueblo area but fail to mention irrigation. Benavides (Ager, 1916, p. 24), however, writing in 1630, says of the Tewa villages of the Rio Grande: "The land is very fertile because a religious has brought it water for the irrigation of its seed lands." Since the Spanish accounts are sprinkled with mentions of the canals of the Pimeria, but are almost totally lacking in mention of any irrigation on the Rio Grande until nearly 100 years after the contact, and then specifically state that the ditches in question were the result of Spanish influence, a pre-Spanish absence of irrigation on the Rio Grande is strongly suggested.

The Rio Grande pueblos in 1940 and 1941 (field work) still retained a tradition of an early period when irrigation was unknown. The people of Santa Ana claim that they formerly farmed on the mesa tops. Cochiti and Jemez claim to have been placed in their present positions by the Spaniards and formerly to have lived in the mountains. Santa Clara retains the memory of a pre-Spanish location in the adjacent foothills away from the river. San Ildefonso claims to have farmed in the mountains and on the mesas. In all cases these people state that in those days there was plenty of rain for the crops and that irrigation was not necessary.

The archeologic evidence is equally clear. Bandelier (1892) walked over much of the Southwest and made careful studies of the sites of the principal pueblos of the area. He noted that the placing of village sites on the mesas back from the Rio Grande was evidence of the failure to utilize the irrigating possibilities of the river. He found no sign of ditches at Hot Springs, Rio Ojo Caliente, or El Rito and noted that garden plots yielded well at the latter today without irrigation. On the Chama river he could find no evidence of ditches or any legend or reports of there ever having been any. He recorded that the ancient towns of the Tewa were in the mountains back from the river; that the sites of the Tano in the Galisteo basin and of the people of Santa Fe afforded no possibility of irrigation. Similarly, for Santa Anna, Jemez, and Cochiti he found that there was no evidence of irrigation and good evidence of dwelling in the mountains in pre-Spanish times.

Only for the Piro and the Tiwa of the lower Rio Grande did he find any evidence for irrigation. For the Tiwa he cited the concentration of 8 pueblos in a 13 mile strip near Bernalillo as evidence. For the Piro he states that they irrigated the river bottom: "The number and extent of these fields and of the irrigating ditches connected with them, attracted the attention of the Spanish explorers at an early day." (Bandelier, 1892, p. 237) It is notable that the evidence is indirect and inconclusive for no pre-historic ditches are known from any part of this area. Irrigation must certainly have been less developed than in the Gila, Salt, Little Colorado, and

Mimbres where the ancient ditches are still discernible.

In the Zuni country Bandelier found irrigation ditches on the Rio Puerco. In the Mimbres valley he found irrigation ditches that he believed proved that the Mimbres (Mogollon) had practiced irrigation. In light of the discovery that Salado peoples from the Hohokam villages on the Gila settled in the Mimbres river valley after the Mogollon had vacated it, we must await detailed studies to determine which of these cultures actually built these canals. In the Little Colorado valley he found irrigation ditches and was told of others which were cemented up with calcareous deposits. Irrigation ditches are known in the Verde valley (Mindeleff, 1892, p. 194). These occurrences of irrigation ditches and the fairly certain irrigation area of the Piro are given on map 21. The area thus encompassed includes but the southern margin of the Pueblo area; i.e., just that area which was adjacent to the Hohokam cultural incluences.

A Hohokam origin for the trait thus seems indicated. For such an assumption we have many lines of supporting evidence. Irrigation canals have been described numerous times for the Gila-Salt area from Spanish contact times to the present. Kino and Manje (in Bolton, 1936), Bartlett (1856), Emory (1848), Bandelier (1892), Turner (1929), Haury (1936), and Gladwin (1937) have all described the irrigation systems of this area. The descriptions are numerous, lengthy, and detailed. There is no question of the vast development of a canal system here, and the scattered references to possible irrigation works elsewhere in the Southwest are insignificant beside the magnitude of irrigation developments in this area.

Haury (1936) has dated a canal built by the Hohokam at 800 A. D., and a probable date of canal building beginning at 500 A. D. has been postulated by Gladwin (1937). McGregor (1941) has also postulated a pre 500 A. D. beginning of irrigation among the Hohokam. It is clear, therefore, that irrigation was relatively ancient among the Hohokam, that it is relatively recent among the Pueblos and was limited prehistorically to only a few of the Pueblo peoples.

Within the Gila-Salt basin we have some knowledge of the operation of these canals. Bandelier (1892) traced irrigating ditches which ran at right angles to the Gila river to the base of Mount Graham where living streams were tapped. He stated that the Maricopa still used such ditches to lead the mountain torrents to their fields and that the Opata and Pima were positive as to their former use of such canals. Such canals utilized the water available from the heavy summer thunderstorms which occur annually on the higher mountains of southern Arizona, New Mexico and northwest Mexico. Sauer and Brand (1930) have also pointed out the farming possibilities at arroyo mouths and along the axis of the main streams in the Gila-Sonora area. They considered the agricultural prospect by such flood water farming to be excellent and mention the presence of canals along the main streams and on the mountain slopes. These latter they note as being used to carry arroyo flood waters to the fields.

Bandelier considered the Gila a very poor source for irrigating water due to its great fluctuation in volume, and the fact that it is lowest at the time when its water was most needed for irrigation. The relation of the volume of the Gila to the needs of the Pima can be gathered from Bartlett and Emory. Emory (1848, p. 85) described riding $15\frac{1}{2}$ miles through fields under cultivation with acequias carrying the full flow of the river. In that year Emory stated that the canals carried a scarcely diminshed flow of water back to the river. Bartlett (1862, p. 232) described an area 15 miles long and 2 to 4 miles wide nearly the whole of which was occupied by fields and villages with the entire plain intersected by irrigating ditches. The Pima were using the full flow of the Gila and in that year having barely enough water to suffice. It would appear therefore, that despite wide fluctuations in flow the Pima were irrigating a large piece of land. The evidence above would suggest that in the 1850's they were cultivating an amount closer to the minimum that could be irrigated by the Gila than the maximum for they were using land sufficient to utilize only the minimumflow of the river. Apparently they were making no use of arroyo flood waters. The great system of canals formerly in use also indicates that far more land could be irrigated from the Gila by people of a cultural level comparable to the Pima.

The relatively low water in the river during the irrigating season must have been somewhat a blessing in that it removed the scourge of flooded crops, breached canals, and washed out diversion dams, etc. Indeed it may be questioned if a great canal system would ever have been developed on the Gila if it had been necessary to cope with the full flood volume of the river.

The Papago still utilize the mountain torrents for the irrigation of their fields. The water is led by ditches to the field area and spread. Apparently this is what the early Hohokam did and probably long continued to do as is evidenced by the presence in Bandelier's time of canals still traceable over long distances and by the survival of the method among the Maricopa, and the tradition of its former use among the Pima and Opata (Bandelier, 1892, p. 17). Sauer and Brand (1930) describe sites in southeastern Arizona whose location near arroyo mouths irrespective of the presence of permanent water supply strongly suggests the modern Papago villages. The great extension of the Hohokam people in the Colonial and Sedentary periods, 700-1100 A. D. into areas lacking irrigable streams indicates much use of arroyo flood irrigation.

Puebloan use of arroyo flood farming has been described by Kirk Bryan (1929). He states that at the time of contact the Hopi, Zuni, Acoma, Tano, and part of the Tiwa and Piro must have been largely dependent on arroyo flood farming. By this term he means dependence on moisteneing of fields by the natural spreading of flood waters over the field areas. This is not considered as irrigation in this paper for there are no ditches dug and little if any control over the spreading of the water. This method is at sharp variance from the Papago method where permanent canals are maintained for the distribution of the flood waters. The Papago method is the general archeologic situation in southeastern Arizona where Sauer and Brand (1930) and Bandelier (1892) found canals generally used to distribute flood waters. Bandelier states that this method of land use extends into Mexico among the Pima and Opata and describes canals in the upper Yaqui river and in the Casas Grande country.

The Pueblo use of areas subject to sheet flooding is obviously a step toward irrigation and such a practice must have enabled the Puebloan peoples to utilize areas which on a climatic analysis seem agriculturally impossible. The method falls short, however, of true irrigation. A terminology to clearly differentiate the various methods of utilizing water for agriculture in the Southwest is suggested below.

Suggested Terminology:

<u>Irrigation</u>---use of permanent streams by canals; e.g. the Pima and the Hohokam.

<u>Arroyo flood irrigation</u>---use of arroyos by distributing their flood waters by means of canals; e.g. the Papago, Opata, Maricopa.

<u>Arroyo flood farming</u>---utilization of land naturally flooded by arroyos (but without canals for distributing the waters); e.g. Pueblo area in general.

<u>Flood water farming</u>---utilization of land flooded by the major rivers; planting done after the water recedes; e.g. the Yuma and Mohave.

<u>Dry farming</u>---dependence wholly on rainfall; e.g. Pueblo area.

The Hopi and Zuni are the pueblo people among whom, on the basis of crop distributions, one would expect to find irrigation. It is interesting to note therefore, that both of these pueblos had rather highly developed irrigation based on springs. The near neighbors of these people who had a permanent stream nearby developed irrigation, apparently under influence of the Hopi and Zuni. The true irrigation practised by the Havasupai can hardly be viewed as other than a Hopi inspired craft just as the Havasupai crops are Hopi borrowings en masse. The irrigation development at Acoma is probably likewise to be viewed as an agricultural technique which accompanied Zuni crops to that neighboring pueblo.

It seems most probable that it is to the utilization of the flood waters from mountain torrents and the learning to direct the spreading of these torrents that we must look for the formative steps of the development of the Hohokam canal and irrigation skill. The utilization of small flood waters seems the logical formative step to using the large, permanent streams. The progression from the utilization of the flooding arroyos by distribution of their water through canals to utilization of the Gila itself would have been a simple step. Large canal irrigation probably was developed by 500 A. D. That the development was local and not introduced from some Mexican source is attested by the absence of records of irrigation south of the Opata-Pima group in Mexico (Beals, 1932, p. 99) (Sauer, 1936, p. 280).

Some have questioned the Pima as the cultural descendants of the Hohokam. Some have described Pima as only semi-agricultural. Those who doubt of the high order of Pima agricultural skill and use the argument of poor agriculture to indicate a hiatus between Hohokam and Pima should consider the eye-witness accounts of the Pima utilizing the full volume of the Gila, their cultivation of a strip of the Gila valley fully 15 miles long, and the enormous bulk of supplies they were able to supply American pioneers, etc. E.g. Russell (1905, p. 90, note 80) states that the Pima sold the United States government 100,000 pounds of wheat in 1858. Stimulated by this market they increased their production and sold 1,000,000 pounds of wheat in 1862. When the California Column passed through the Pima fed nearly 1000 men for many months.

Emory (1848, p. 83) was impressed with the beauty, order, and disposition of the arrangements for irrigation and drainage of the land. He found the fields to be subdivided by ridges of earth into rectangles 200 by 100 feet and surrounded by fences of cane, and wattle and sticks. Bartlett (1856, p. 232) described an area 15 miles long and 2 to 4 miles wide as under irrigation and raising the most luxuriant of crops. It is difficult to picture a people so equipped with irrigated land as other than highly developed agriculturists.

If the agricultural area described by Bartlett be taken at its minimum dimensions of 15 by 2 miles, an area of roughly 20,000 acres was under irrigation. Yields of unimproved Pima corn average better than 20 bushels per acre (King, and Leding, 1926, p. 28). If the land were planted to corn alone a harvest of 400,000 bushels of corn would have been available to these people. These figures may well be compared to Stevens' (1936, p. 954-955) figures for the Hopi in a comparable period. He estimated the total production of corn to be 2,500,000 pounds. The population was then just under 2000 people, hence there was a yield per capita of 1250 pounds.

The Pima in 1850 probably had a population comparable to their present one of 5000 people, or if one uses Kroeber's figure (1940, p. 136) taken from Mooney and referring to an earlier period, 4000 people. Using 20 bushels per acre and 56 pounds per bushel one then arrives at a per capita yield of 4480 pounds of corn if the population was 5000 or 5,600 pounds if the population was 4000 people. It will be remembered that the total land cultivated was figured as 15 by 2 miles rather than 15 by 3 miles (Bartlett's statement was 15 miles long by 2 to 4 miles wide.). Even if one reduces this figure by half to allow for waste land, village sites, etc. one is left with a per capita food production of approximately twice that of the Hopi. The Hopi consumed but half of their production and stored the remainder as insurance against crop failures. Because of their irrigation the Pima were assured of adequate annual crops, hence had to maintain no such margin. Even at the minimum figure of twice the Hopi production they should have been able to maintain nearly four times their population. Perhaps the allusions to the Pima not utilizing their canals to their maximum is based on this over-abundance of food.

One must come, therefore, to the realization that in agricultural skills and in the security and amount of sustenance, the Pima were far in advance of the Puebloans as represented by the Hopi. In pre-contact times this discrepancy must have been equally marked. The possessors of irrigation were the Gila-Colorado people. The relatively high culture of the Hohokam was built upon the secure sustenance base this made possible. Hohokam plus irrigation could go farther than the non-irrigating culture from which they sprang. Whether or not the Pima are the lineal descendants of the Hohokam they continue the Hohokam agricultural heritage in but slightly diminished form. In consideration of the known attrition by the Apache and Navajo in the 18th and 19th centuries, the maintenance of so high a level of agriculture by the Pima argues for even greater heights in earlier times.

In any climatic consideration of crop distribution and limitation one must, therefore, bear in mind that until relatively late in their history the Pueblo peoples did not practice irrigation. The Hohokam peoples, however, have been shown to have possessed irrigation from about 500 A. D. At least the Hopi and Zuni, however, practised arroyo flood farming. By this means they could use areas which would have been too arid for normal farming. In the Hopi country crops can be raised without dependence on the arroyo flooding in good years. The use of the floods seems then to have been, at least in part, insurance against the frequent bad years.

If the Puebloan peoples possessed neither true irrigation nor flood water farming until relatively late in their development, then the Rio Grande valley with its severe drought conditions must have been closed to them. Use of arroyo flood farming would be limited to areas near higher areas where the rainfall would be dependably concentrated. The location of the Rio Grande Pueblos at higher elevations and their relative scarcity on the Rio Grande reflects this condition.

CHAPTER XII

AGE OF CULTURES AS DEDUCED FROM THE EVIDENCE ON PLANT DOMESTICATION:

There has been frequent reference throughout this paper to temporal relationships as shown by the crop relationships. Some further remarks on the length of time implied in the domestication of plants and the meaning of this time span for American archeology are added here.

It has been shown that the Basket Maker culture is a peripheral development springing from some earlier eastern agriculture. This obviously means that Basket Maker, far from being the earliest agriculture in the United States, is one of the latest. The early knowledge of Basket Maker peoples together with the primitiveness of the culture once led American archeologists to give dates as ancient as 2500 B. C. to the beginnings of this culture. When the tree ring dates shortened up these postulated beginnings to around the time of Christ, a revulsion against early dates swept American archeology. Instead of reaching the conclusion that Basket Maker culture was not the earliest agriculture in the United States, the tendency has been to continue to consider the Basket Makers as the earliest and to make all other cultures even later. This viewpoint has been shown in this paper to be completely in error. The agriculture both of the southeastern United States and of the Hohokam is clearly older than the Basket Maker culture.

The opposition to antiquity of American cultures is so great that one finds the recent anthropologic literature filled with references to the failure to find any evidence of cultures in Middle America earlier than 500 A. D. This has been extended to become evidence against any antiquity for developed cultures in Middle America.

One can not, however, have a great cultural development such as was found in Middle America without a long developmental period. The evidence from plant domestication gives an entirely new perspective to the antiquity of these centers, and, by extension, to the antiquity of the Southwestern areas.

One may, of course, claim that the developments in Middle America are not entirely local but spring from introductions from the Old World. The plant evidence is emphatic in denying this. The only domesticated plant common to both the Old and the New World in pre-Columbian times was the bottle gourd, Lagenaria vulgaris. Lagenaria is an Old World plant. How and when it reached the New World is not known. This is a spectacular exception, however, to the generally completely separate plant assemblages.

The plurality of centers of domestication of plants in the New World, moreover, precludes the possibilitiy that any single introduction of a people with a cultivated plant started the domestication of plants in the New World. If the various centers of plant domestication were stimulated by contact from overseas, agriculture would have begun earlier in one center than in another. There is, however, no evidence that any one center of plant domestication in the New World is of vastly greater antiquity than the others.

The basic datum point for discussing antiquity for agriculture in America must be a consideration of the time required for the domestication of a plant. Such a discussion must be based on botanical knowledge. Fortunately a botanist's view of the problem is available.

A most enlightening discussion of the time involved in plant domestication is to be found in Oaks Ames "Economic Annuals and Human Cultures" (1929). On the basis of lack of wild ancestors and great development of varietal forms etc., he concludes that New World agriculture is at least as ancient as that of the Old World. For Old World agriculture Ames states that since no major change has been wrought in plant types in the past 5000 years, but vast changes had been made in those plant types between the time of their initial domestication and 5000 years ago it follows that the length of the period of agriculture back of 5000 years ago must be several times longer than that since. When he turns to America he finds a similar botanical situation and argues that similar stretches of time are implied. Multiplicity of races and varieties of plants is as great in the New World as in the Old World. Wild ancestors are equally lacking for important plants. Ames finds a period of two or even ten thousand years is insufficient time for the development of the American plant assemblage to the state of perfection it had attained as of O A. D. "The biological evidence indicates that man...developed horticulture and agriculture in both hemispheres at a time which may well have reached far back into the Pleistocene." Unless the anthropologists can refute Ames' arguments they must radically change their chronologies and ways of thinking about American cultural beginnings.

Ames is not the only botanist to postulate dates for agricultural levels far earlier than most anthropologists seem willing to admit. The Russian geneticists paid little attention to chronology but speak in terms of 3000 or 5000 years. Jones (1936, p. 164) considers 2000 B. C. a likely date for the pre corn-pottery agricultural levels of the southeastern United States. This, apparently, he intended as a date of the actual material found. Since the plant forms discussed are clearly domesticates, such a date implies much greater antiquity for the beginning of domestication.

Domestication was not an invention in the usual sense. When man began using plants, he began the accumulation of knowledge concerning plants. The use of plants by man must have reacted on the plant as well as on man. The beginnings of domestication may well have been unconscious. The cutting of useless plants near a useful plant, the leaving useful plants when seeking firewood, or building material, etc. would all be steps toward caring for plants. These measures would be reflected in modifications of the plants themselves. In a sense, any use of a plant by man modifies the plant. After immense stretches of time certain plants may have become incapable of maintaining themselves without man's aid. Man meanwhile would have slipped into horticulture. This reasoning amounts to starting agriculture in the plant gathering stage.

The importance of this line of reasoning to American archeology is obvious. If the Southeastern United States is an independent center of plant domestication with highly developed domesticated plants, then in the upper Pleistocene seed gathering people must have already been in the lower Mississippi valley gathering seeds and roots of sunflowers, seeds (?) of wild gourds, seeds of Iva and Chenopodium, etc.

Middle America has a much greater list of plant domesticates than has North America. The plants are, however, no farther evolved from the wild forms that are those of the southeastern United States. Agricultural beginnings in that area then should be of similar antiquity. The greater variety of domesticated plants is to be attributed not to greater age but to a greater variety of plants available for exploitation. The claim of lack of cultural evidence prior to 500 A. D. in an area which is a center of plant domestication is, therefore, evidence only that the archeologist has not yet scratched the surface.

Within the Southwest it was pointed out that the Basket Maker culture has no crop which can be shown to have been domesticated locally. There is, therefore, no need to postulate any antiquity for the culture. It is surprising that agriculture did not penetrate the area earlier. The extreme climatic adaptation of plants necessary for survival in the area must be considered a major reason for this delayed development. The plants which entered the Southwest by crossing the Great Plains would have had to undergo selection and adaption for a long period of time prior to their successful entrance into the Southwest.

The introduction of the Middle American crops (corn, kidney beans, moschata squash) into the Southwest must have been very much later than into the Southeast where the climate was similar to the climate of the east coast of Mexico. Since corn appears among the Basket Makers by 300 A. D., the introduction into the southeastern United States must have been many hundreds of years earlier.

It is difficult to approach the amount of time necessary for these adaptations to be accomplished. Consider, however, the degree of adaptation of the Southwestern corn. The corn of the Mississippi valley attains a great height, is shallow rooted, is planted at slight depth, requires a great deal of rainfall, will not withstand temperatures of over 100 degrees without damage. Puebloan corn, e.g. the Hopi corn, will withstand great drought, heavy, sand laden winds, produces a small plant (but good ears), and can be planted at depths of 12 to 14 inches. Collins (1914) remarks that the mesocotyl, the organ whose elongation makes possible the deep planting of Hopi corn, is but a vestigial organ in Eastern corn. These are profound alterations. It is not reasonable to believe that they were accomplished in a brief period of years.

Or, consider the case for the corn of North Dakota. Since 1840 we have advanced the northern boundary of corn growing little or none. Despite the advantage of knowledge of chromosomes and genes, dominance and hybrid vigor, and the enormous start of the ready adapted plant material, 100 years of effort has found no better plant for the northern border of corn growing than the types there in 1500 A. D. Further, those corn types had already been grown in North Dakota for 200 or 300 years prior to 1500 (Will, 1924, p. 203). What, then, was the period of time necessary under primitive methods to modify corn from the southern United States with a growing season of 130 to 200 days, killed by the barest touch of frost, stagnating if the temperature falls below 60° F. to a tough, hardy compact plant, 3 to 4 feet high, with a growing season of 60 days, some frost resistance, and great resistance to cold, wind, and drought. A thousand years may be far too little to allow for such a development.

Nor can one point to revolutionary changes and successes of our botanists and plant breeders as evidence of what the Indian could have done. The Indian lacked the technical skill and knowledge that allows an agronomist to accomplish in a year what formerly took centuries. Even more important, the Indian began with limitated variety and developed an enormous wealth of plants and forms adapted to a wide range of conditions. Many of the "miracles" accomplished by the modern agronomists are nothing more than selection and spectacular combination of genetic traits that the Indian developed in centuries past. Few indeed are the traits which our agronomists have developed de novo. But the Indian peoples were moving their crops into new areas and all traits had to be developed without the aid of a broad genetic base from which to select highly specialized adaptations.

If it took a thousand years to develop corn capable of entering the Southwest by 300 A. D., a date of beginning of expansion of corn westward from the Southeast must have been 700 B. C. If it took a thousand years to develop Mandan corn, then a date of 300 A. D. is indicated. Such dates are of necessity high speculative.

If the thought of Middle American influences in the Mississippi valley by 700 B. C. is a shock to the American archeologists who argue for a date of 900 A. D. for the beginnings of agriculture in the Southeast (Ford and Willy, 1941), their postulate must seem preposterous to anyone who has considered the degree of modification which tropical corn underwent before it could be grown in the St. Lawrence valley or in North Dakota.

Hohokam crops have been shown to be separate from the Southeastern-Anasazi crop complex. The tepary bean and the cucurbit have been shown to be domesticates of the west coast of Mexico. For both plants a northwest Mexican origin is indicated. Due to our lack of knowledge of western Mexico's crop materials it is not possible to give as full evidence of the adaptations and the time implications as for the eastern corn complex. The 60 day corn of the lower Colorado with its ability to withstand temperatures of 120 degrees is as highly specialized as is the corn of North Dakota. Similar antiquity would seem to be indicated.

It was demonstrated that the tepary bean was sufficiently far advanced in improvement over the minute seeded wild form to be preferred over the kidney bean. Similarly Cucurbita moschata never displaced the pepo pumpkins of Northwest Mexico. Similar times of domestication must, therefore, be postulated for both Middle America and northwest Mexico.

So early a date need not apply to the Hohokam culture, for the Hohokam culture must represent a later expansion into an area of great climatic difficulty. The severity of the climatic conditions to which the plants were adapted argues, however, for a great period of time. The presence of the Hohokam culture in the Gila valley by 0 A. D. or earlier, argues for a long period of development prior to that date. Far from shortening Gladwin's suggested chronology, this would suggest that evidence of much older cultures than any yet claimed should be found in the San Pedro-Santa Cruz-Gila valleys and that the early levels at Snaketown may indeed reach back to 200 or 300 B. C., or even much farther.

CHAPTER XIII

AREAL DIFFERENTIATION WITHIN THE SOUTHWEST ON THE BASIS OF CROP ASSEMBLAGES:

It becomes clear that the distribution of crops within the Southwest is not haphazard, but forms repeating patterns. Significant groupings of crops occur and are areally restricted. On this basis one can recognize the following crop or agricultural areas. (See map 22).

I Gila-Sonora

This area is characterized by the single race of corn here referred to as the Gila-Colorado race. The area is unique in the United States in growing the tepary bean to the exclusion of the vulgaris bean. It possesses a pepo pumpkin for which we have no evidence that it could have been derived from the eastern United States source of pepos. It was certainly the source of cotton and sweet corn and lima beans for the Pueblo cultures. It is also the only center in North America where irrigation is found, and the probable independent development of irrigation in this area has been demonstrated.

The cultures of this area then, must have been virile, productive and ancient. Just who began the culture and carried it through to the modern picture is largely the archeologist's problem. From the crop evidence, and the evidence from irrigation, it can be stated that the Pima and Papago are exactly what one would expect the modern survivals of these people to be. It is clear, too, that the Hohokam were also the bearers of this agricultural assemblage.

It is difficult for this writer to see any other conclusion than that the Pima are the cultural descendants of the Hohokam. Who the Hohokam were is a problem not easily answered, but the crop evidence indicates that they were a people deriving from northern Sonora who developed irrigation in the Gila drainage and from this basis advanced to their areally unique height of culture.

II Completely separate from the Gila-Sonora agriculture area until late in its development and in part never influenced by the Gila-Sonora agriculture lies the Anasazi or plateau agricultural area. As pointed out in the discussion of corn types, this is not marked by complete agricultural unity. It has, however, corn which is related more closely to units within the plateau than to the Gila-Sonora area. Its aboriginal cucurbit was originally, and is still predominately, of a type different from the Gila-Sonora area. Prior to 1000 A. D. but one species of beans was found throughout the area and this species was different from that found in the Gila-Sonora area. Even the fiber source was different, cotton being Gila-Sonoran while apocynium was characteristic of the Anasazi. The plateau or Anasazi area is, therefore, completely separate in origin from the Gila-Sonora area and an Eastern origin has been demonstrated for Anasazi agriculture. The various subdivisions of the plateau agriculture will now be summarized.

IIa San Juan Basket Maker

In the region of the San Juan river, i.e. in northeastern Arizona, northwestern New Mexico, and adjacent Utah and Colorado, shortly after 0 A. D. there began an agricultural development.

Unlike the Gila-Colorado development to the south this area had no locally domesticated crops. Its pumpkin, moschata, was domesticated in Middle America. Its corn was of the Gila-Colorado race but differed sufficiently to warrant its being set up as a separate type. The precise origin of this corn, other that it came to the United States from Mexico, is as yet unknown. The absence to the south of identical type corn argues that it must have entered this area from the east. There are no beans in the area in its early period (Basket Maker 2) and when beans do appear they are kidney beans, not tepary beans, and again some origin other than southern is indicated. In fibers, too, this culture betrays a non southern origin for Apocynum and human hair rather than cotton was characteristic. Since agricultural peoples are not found to the west or north of this area at this period, and since its agricultural material is different from that found in the only ancient agricultural area to the south, an eastern source must be postulated. The Basket Maker agriculture no longer exists, or, if it can be said to survive at all, is found among the people of the next area to be described.

IIb San Juan-Little Colorado Pueblo

The Basket Maker people show in their later period (Basket Maker 3) the influence of other cultural contacts by the addition of further varieties of corn to their agriculture. Mixing of the corn types occurred and a new agriculture arose marked by the agricultural assemblage which is best preserved today among the Hopi and Zuni. These are the tribes who have "Puebloan" corn in the form most commonly found archeologically in the Mesa Verde, Kayenta, Little Colorado areas. The beans of this area were, and are, large frijole types. That the agriculture was not completely uniform is shown by the differences which exist between the frijole bean assemblages of the Hopi and Zuni. The cucurbit common to these cultures was the moschata pumpkin. Cotton appeared relatively early, but the archeological picture can not yet be clarified as to the time when cultivation of cotton as opposed to the occurrence of traded fabrics began. From comparison with the other crops and the continuation of apocynum as the principal fiber into late Pueblo times (Haury, 1934) and the failure of most of the Pueblo peoples of the Rio Grande to raise cotton a relatively late date for the introduction of cotton growing must be postulated. It is probable that cotton growing reached the Pueblos first in this region along with the tepary bean and the pepo pumpkin in Pueblo 2 times due to the contacts at that time with the Hohokam peoples to the south. The same arguments apply to irrigation. It was practised archeologically in this area and is continued in a limited manner by the Hopi and the Zuni today. The failure of this trait to spread widely, and its limitation to the area adjacent to the high development of irrigation found to the immediate south, all suggest a late introduction into this area.

The differences within the area referred to in discussing the divergence in bean varieties between the Hopi and Zuni extends to other crops as well. Both tribes grow tepary beans which are derived from the cultures to the south of them. Only the Hopi, however, grow lima beans, which also derive from the south. Differing contacts in the north and east in earlier periods must be called upon to account for the differences in the kidney bean assemblages of the two groups.

It was made clear in the discussion of the separate crops that the Hopi and Zuni differ markedly from the other Puebloan groups. It is clear from the archeologic material that they have continued the agriculture of the now abandoned Kayenta and San Juan areas whose people had absorbed the Basket Maker agriculture. It is also clear that they have in late Pueblo times been strongly acculturated by the peoples to the south of them. Theirs is, therefore, the most complex and hence the richest of the Southwestern agricultures.

IIc Central Rio Grande Pueblo (Pueblos of San Juan through Isleta, including the Jemez river pueblos)

This area has Pueblo corn which is modified in size, grain type, butt type, etc. The bean assemblage is markedly different and markedly poorer than the San Juan-Little Colorado assemblage. The pumpkin is moschata. Apocynum is found in the early period and cotton growing had reached less than half of the pueblos at the time of the contact. Irrigation had limitations similar to cotton growing, and the conclusion must be reached that these two traits from the Hohokam area were late in reaching this area. The attenuation of the characteristic traits of the corn and beans of this area as one proceeds southwest indicates that the elements which differentiate this culture derive from the north and east. For lack of sufficient archeologic material the time of arrival of this agriculture can not be set. According to Indian claims (field work 1940-1941) and Kidder's report of small corn at Pecos, the modification in corn type is very late. Other than a southern origin must be postulated since the corn and beans are not found in or adjacent to the Gila-Colorado area.

IIe Northern Rio Grande Pueblo

In this area one finds a continuation of the modified Pueblo corn of the Rio Grande. The bean assemblage is here reduced to one type which is unique in the Southwest, and the ancient pumpkin is claimed to have been pepo instead of moschata as in the Central Rio Grande area. Due to the sharp divergence in pumpkin and bean type the area must be set off as a separate unit. Its source is a difficult problem. It may represent the latest introduction of agriculture from the plains. In this case it must have derived from a culture having pepo pumpkin and a large, mottled pink bean. These elements suggest a northern plains origin. From the slight evidence now at hand it would also be possible to derive this agriculture from the Northern Periphery.

IId Northern Periphery

This area is postulated on the descriptions by Morss (1931, p. 59) of dent corn as typical of the Fremont river culture, and on the identification of dent corn and pepo pumpkin seed from Vernal, Utah (Material at the Laboratory of Anthropology, Santa Fe, New Mexico). If this culture is characterized by such crops, its point of origin must lie in the area referred to in the discussion of the cucurbits as the Northeast. Its relative late appearance in the Southwest (Pueblo 2 time), its lack of close relationship to the San Juan cultures (Steward, 1941), and its divergent crop types all argue for a separate agricultural introduction into the area from out of the northern Great Plains. Its far northern position and lack of contact with Southern cultures suggests that it entered the Southwest via the Rocky Mountain passes rather than by a south of the Rockies entrance.

Ib Southern Rio Grande area

The extinction of the Piro people and the lack of archeologic material from this area leaves a great gap in our knowledge. The presence of irrigation and cotton in this area suggests that the area south of Albuquerque may have been markedly different from the upper Rio Grande. The presence of Mogollon affiliated culture on the Pecos river whose crop assemblage included tepary beans, and the finding of small Gila-Colorado type corn in the Tularosa basin by Donald Lehmer suggests Hohokam via Mogollon influences. A theoretical relationship to the Hohokam via the Mogollon in tentatively advanced.

These areas are shown on map 22. The areas are shown as distinct but it should be remembered that overlapping actually occurs. The Gila-Sonora area is shown as including typically the Colorado river to Needles, extending parallel to the Mogollon rim but below it, and extending east of the Rio Grande. The distribution of the agriculture into Mexico is left open for lack of knowledge of crop extension in that area.

The San Juan Basket Maker agricultural area shown is quite small, but is intended to only enclose that area where the typical, early Basket Maker agriculture has been reported. An arrow has been drawn from the plains area to the San Juan and labelled to indicate a pre-300 A. D. introduction of agriculture into this area from the southeast. The argument for eastern and southern origin based on the evidence from cucurbits and corn and beans has already been presented. The date has been arrived at through the use of tree rings dating from the earliest reported Basket Maker site.

The San Juan-Little Colorado pueblo area is shown as deriving from both the old San Juan Basket Maker agriculture and from a fresh introduction from the plains area which arrived in Pueblo 1 times, 700 A. D. That this material also came from the plains is likewise deduced from the absence of similar crops in the Gila-Sonora area to the south.

The central Rio Grande area is shown as a Pueblo 3 introduction. This is a guess. It must have been after Pueblo 1 times for the crops of the San Juan-Little Colorado area are distinct. If the two sets of crops had been introduced at the same time, or if the San Juan-Little Colorado crops had been introduced from the east after the Central Rio Grande crops, a mixing of crops should have occurred. A Pueblo 2 or 3 appearance of this culture thus seems indicated.

The northern Rio Grande area has no indicated origin. It may be derived from the Northern Periphery culture, or it may be of Plains origin. Its cucurbit type suggests a northern Plains origin, but more material is needed to work out its origin in time and space.

The Northern Periphery agriculture is shown as deriving from the northern Plains, from Nebraska via Northern Utah. This route is favored, because a Pueblo 2 date seems established for the Northern Periphery culture and any attempt to introduce this agriculture via the southern route postulated for the other cultures would have led to mixing of crop types. Again, however, there is too little archeological material from the area and from the adjacent areas for definitive results.

From this consideration, one thing becomes clear. The Anasazi area of the Southwest is agriculturally to be considered a peripheral area into which successive waves of agricultural peoples penetrated. All important introductions of crop materials until Pueblo 2 times clearly came from the east. Since each of the major introductions of crops from the east was composed of distinct assemblages of plants, one must assume that waves of agricultural peoples or just waves of agriculture were arriving in the Great Plains and eventually penetrating the Southwest. Such a picture, although not sufficiently complex to meet all the requirements of this thesis, is presented by Wedel (1940) and Strong (1935). It is significant that they draw their cultures from the Mississippi area and not from the Southwest.

It is here postulated that some of these successive groups of agricultural peoples who entered the Great Plains also entered the Southwest. Entrance may have been voluntary, e.g. resulting from knowledge of the area in hunting trips; or it may have been forced, e.g. by prolonged and extreme drought (see Wedel, 1940), or by pressure from other peoples.

The arrival of successive waves of agriculture from the east is a certainty. The arrival in the Southwest of but one complex of agricultural material from the western side of Mexico is equally well established. We return, then, to the conditions postulated in the climatic section of this paper. The difficult, western corridor through which only the most specialized of crops could pass functioned much less frequently than did the eastern corridor.

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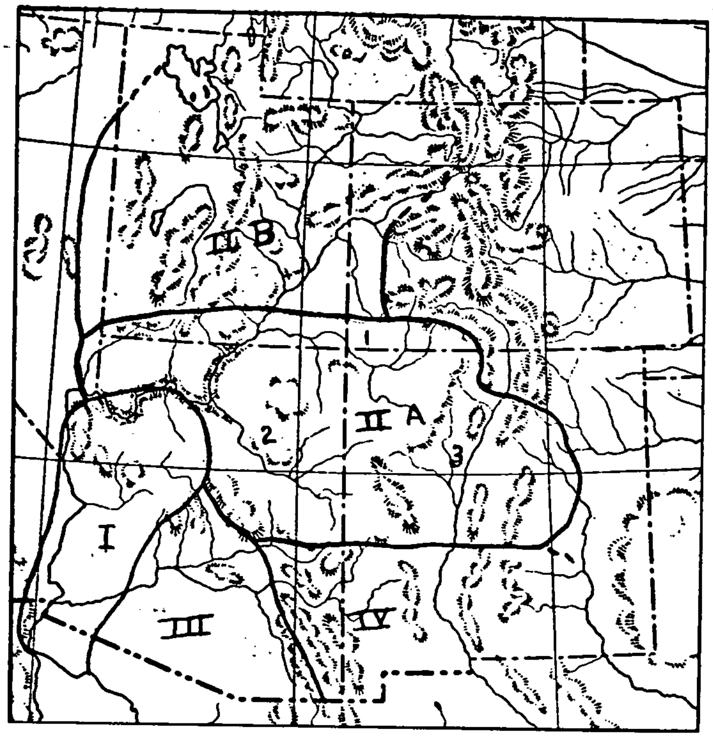
The collections of plant materials referred to in this paper are available as follows:

Complete collection: in the Anthropology Museum, University of California, E. W. Gifford.

Duplicate cucurbit collection: U.S.D.A. Field Station at Torrey Pines, California, T. W. Whitaker.

Duplicate corn and bean collection: University of California, Department of Agronomy, W. W. Mackie.

Duplicate corn collection: Missouri Botanical Garden, St. Louis, Missouri, E. Anderson.



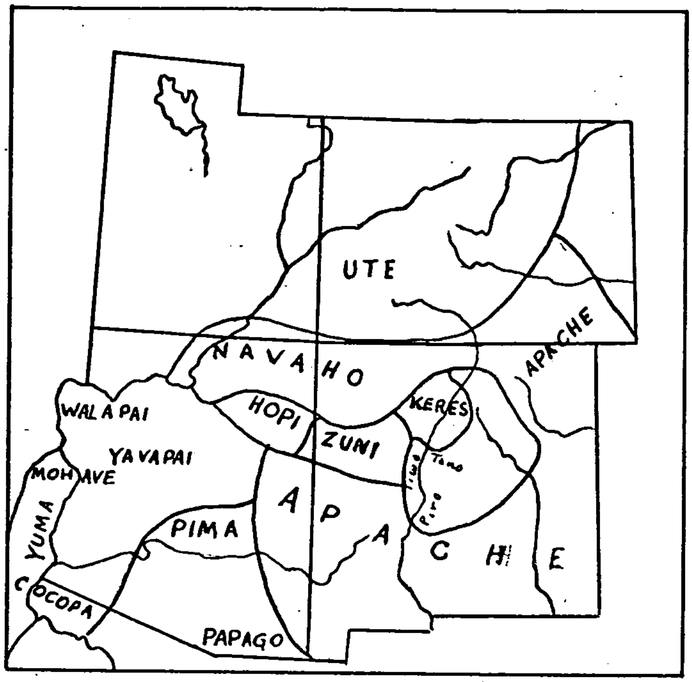
I Yuman (Patayan)

II Anasazi (Puebloan- Basket Maker)
- A. San Juan Puebloan
  - 1. San Juan
  - 2. Little Colorado
  - 3. Rio Grande
- B. Northern Periphery

III Hohokam

IV Mogollon

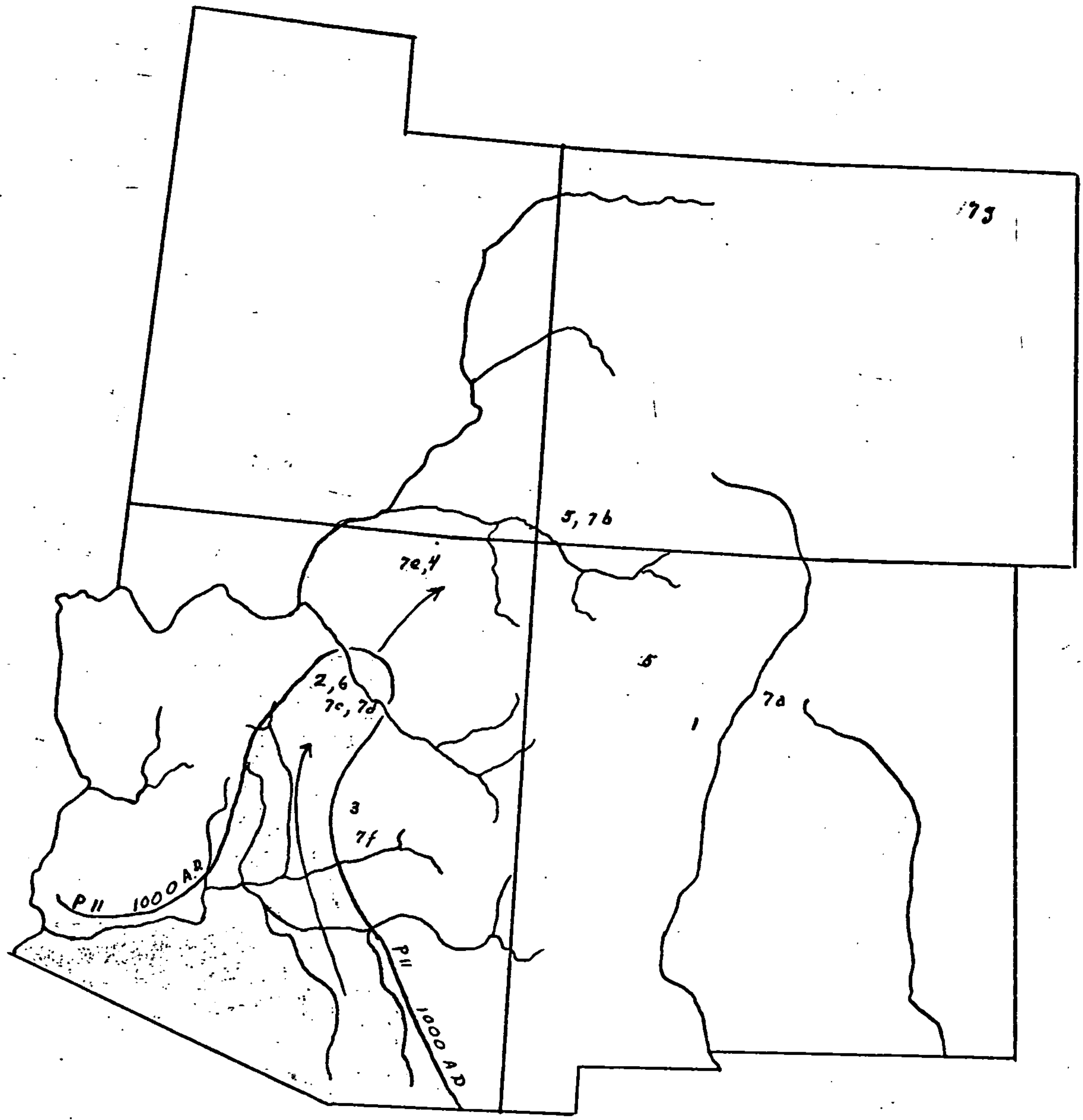
MAP 2



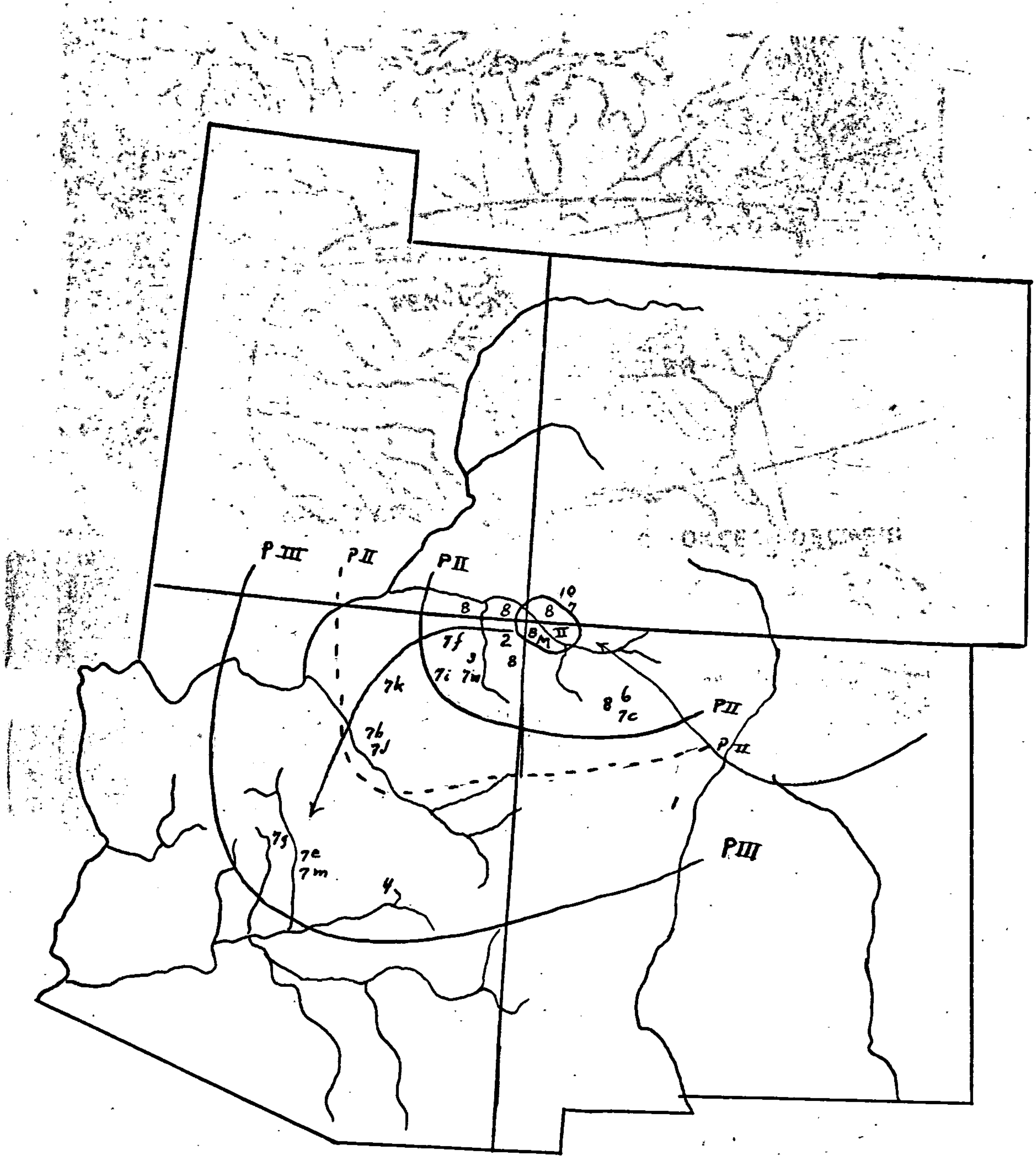
Distribution of tribes-- 1650

(Adapted from the Atlas of Historical Geography of the United States)

MAP 3

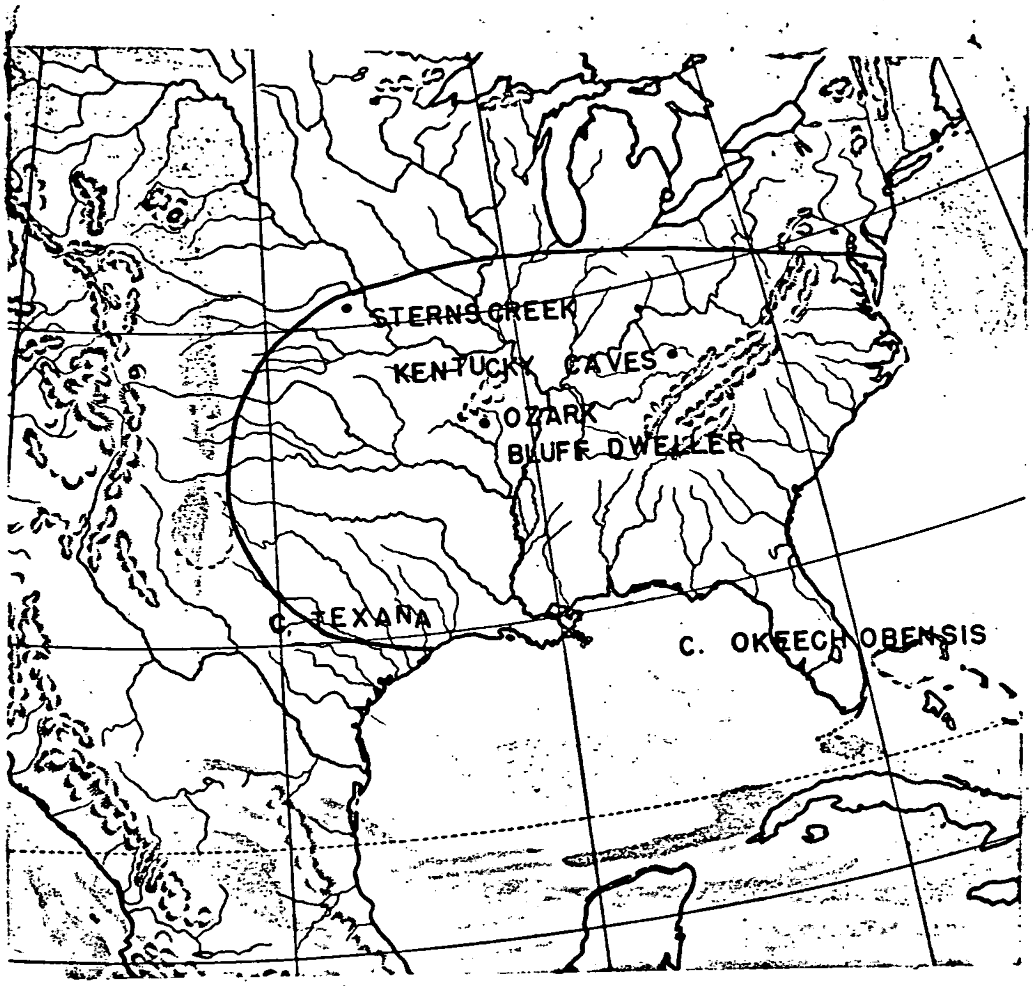


Archeologic distribution of Cucurbita pepo
(Numbers and letters refer to chart 2)

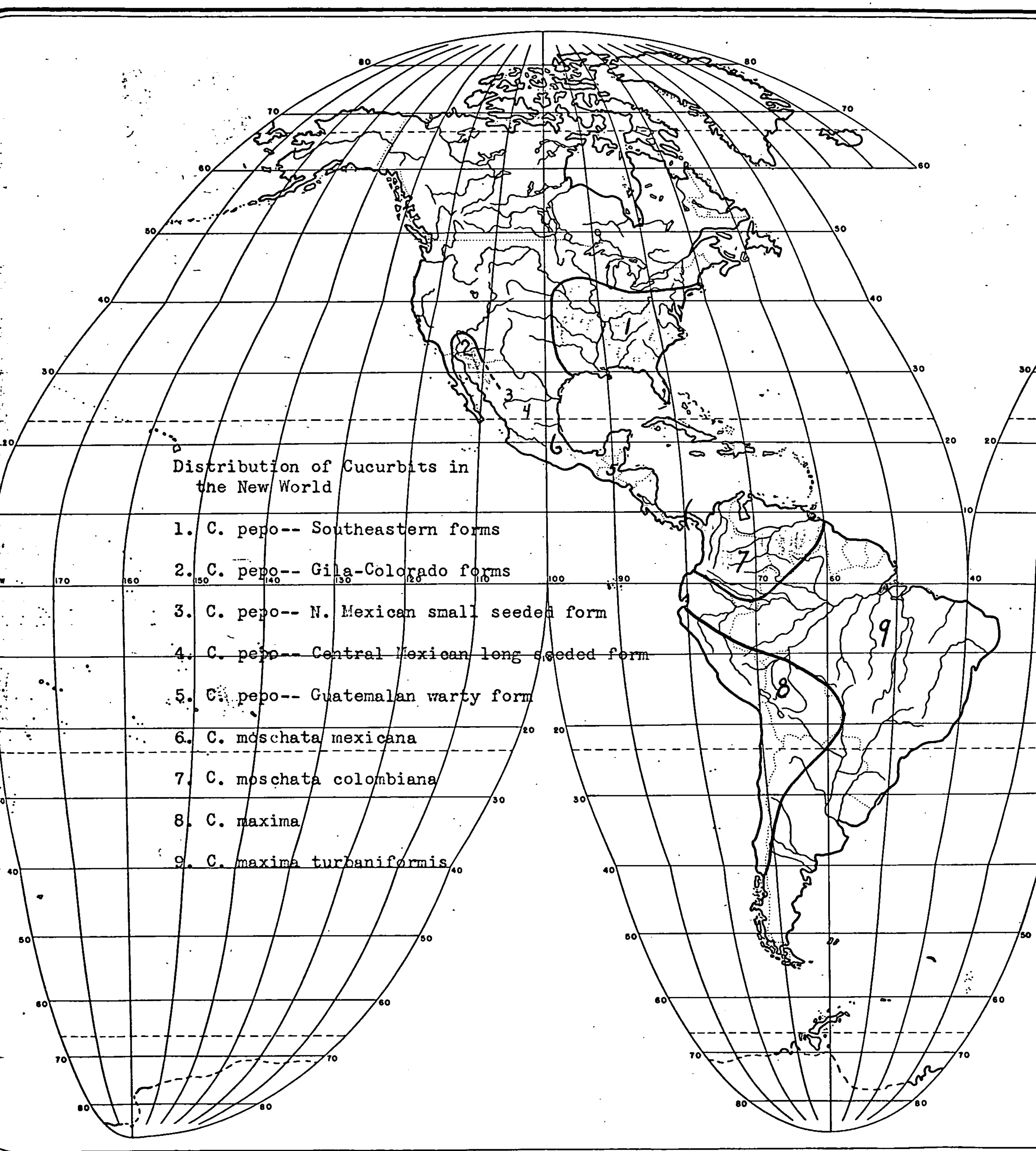


Archeologic distribution of Cucurbita moschata
(Numbers and letters refer to chart 3)

Map 5



Pre-Central American Agriculture of the Eastern United States



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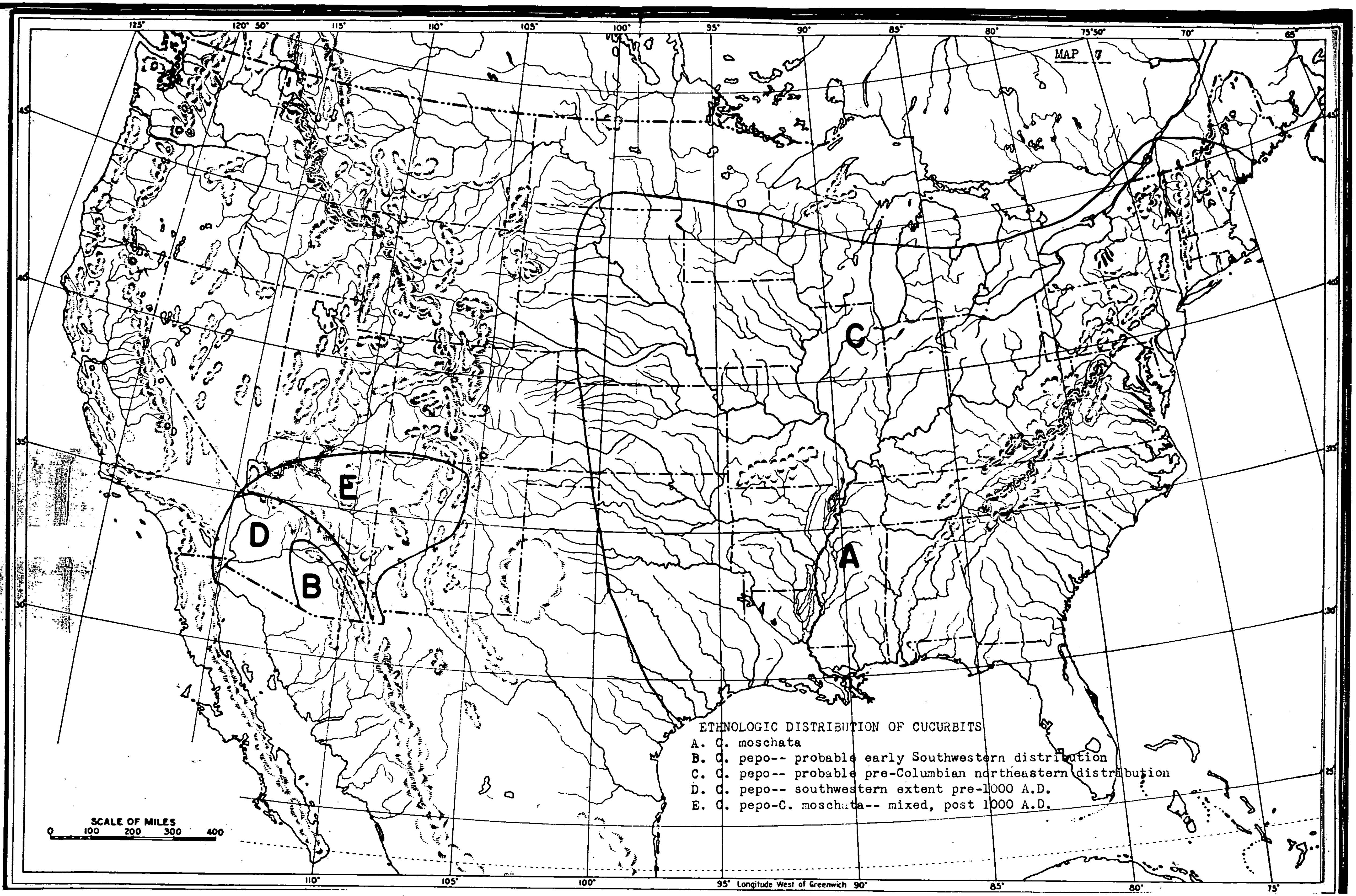
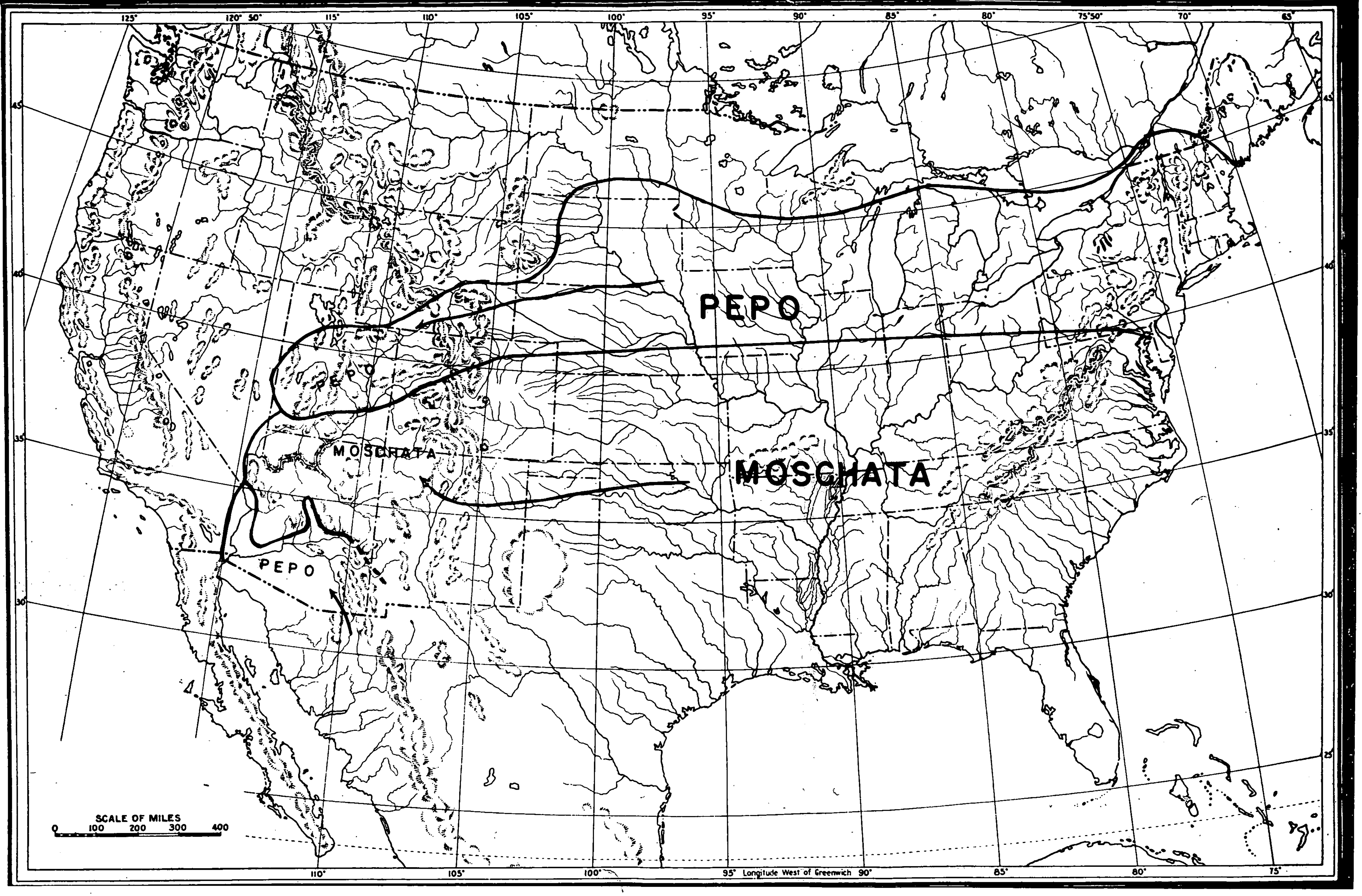
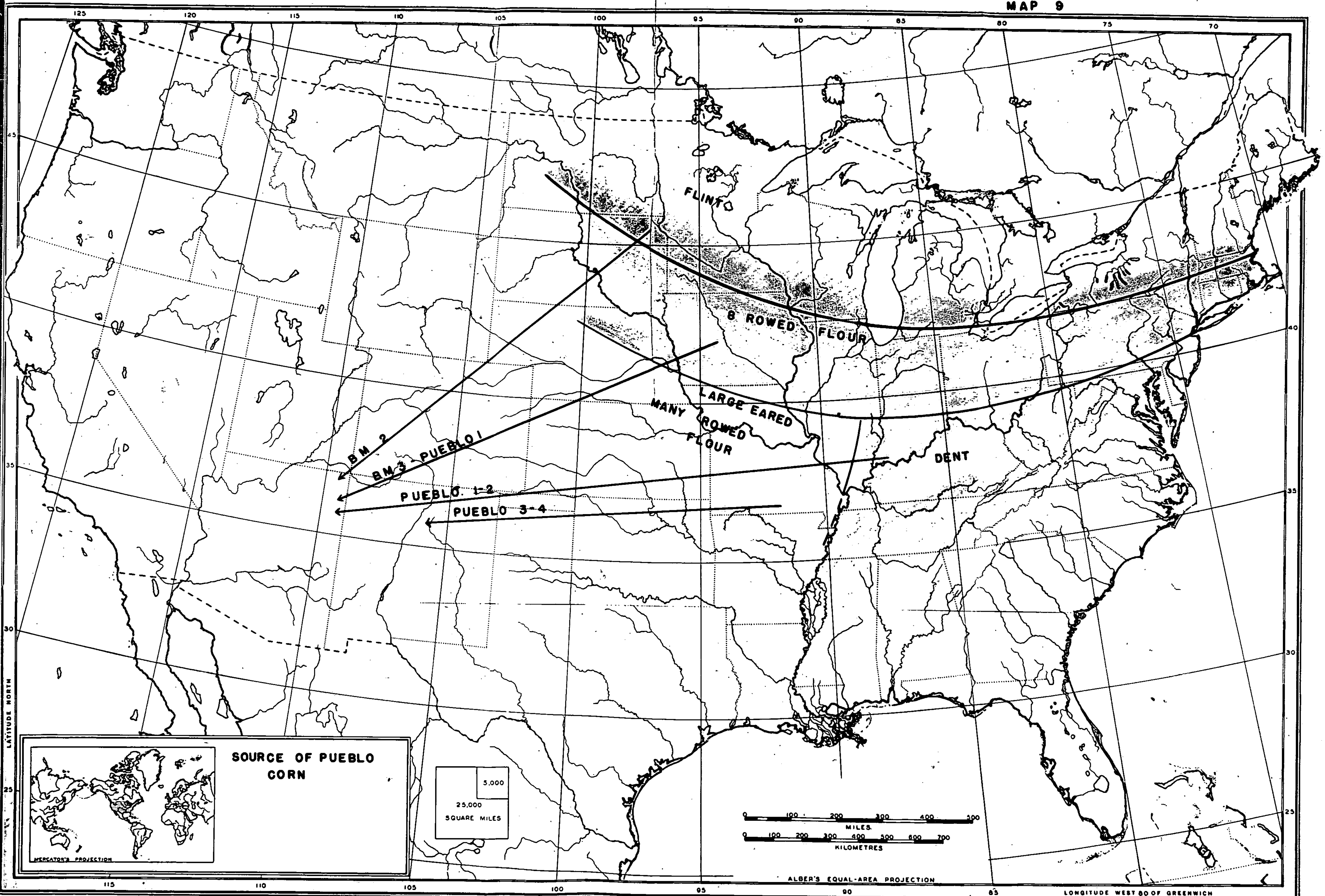

MAP 7
C
E
D
B
A
ETHNOLOGIC DISTRIBUTION OF CUCURBITS
A. C. moschata
B. C. pepo-- probable early Southwestern distribution
C. C. pepo-- probable pre-Columbian northeastern distribution
D. C. pepo-- southwestern extent pre-1000 A.D.
E. C. pepo-C. moschata-- mixed, post 1000 A.D.
SCALE OF MILES
0 100 200 300 400
Longitude West of Greenwich



PEPO
PEPO
MOSCHATA
MOSCHATA
PEPO
SCALE OF MILES
0 100 200 300 400
125° 120° 50° 115° 110° 105° 100° 95° 90° 85° 80° 75° 50° 70° 65°
45 40 35 30 25
110° 105° 100° 95° Longitude West of Greenwich 90° 85° 80° 75°

MAP 9



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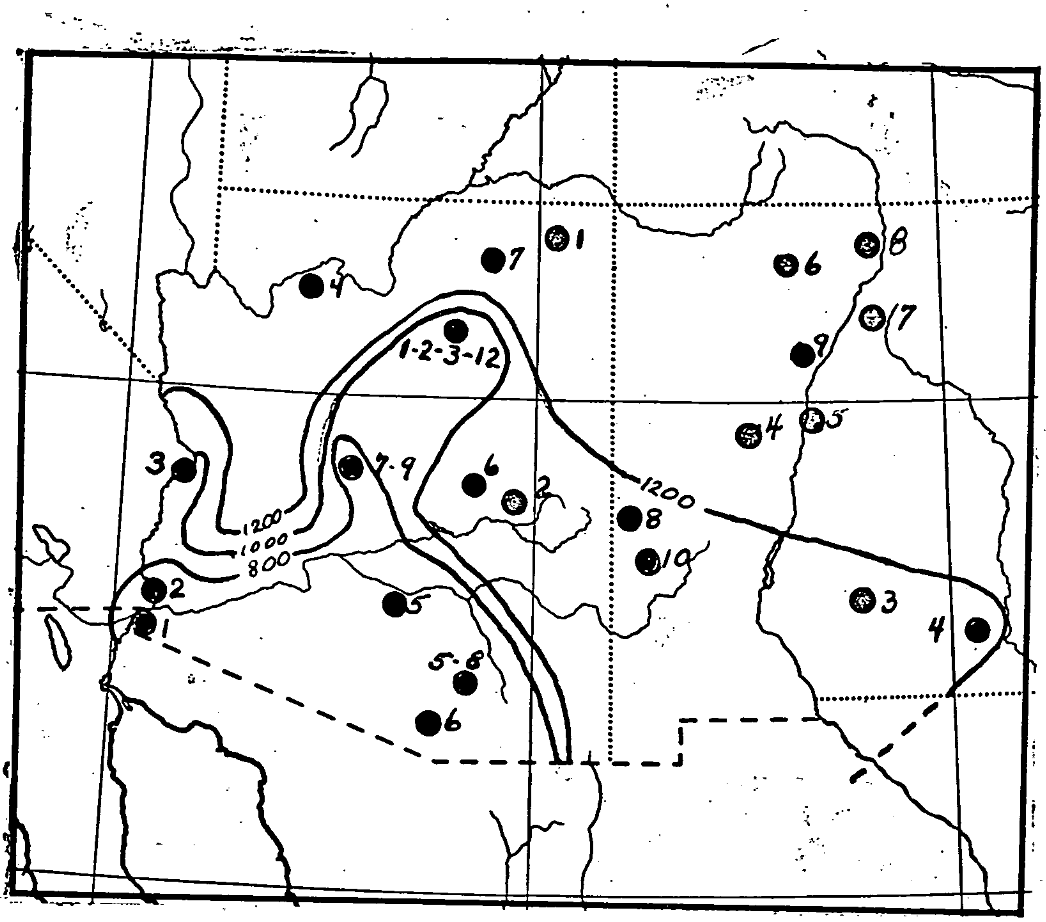


DISTRIBUTION OF THE TEPARY BEAN

Modern ● 1-9

Tribes growing teparies
1. Cocopa
2. Yuma
3. Mohave
4. Havasupai
5. Pima
6. Papago
7. Hopi
8. Zuni
9. Jemez river Pueblos

◉ 1-8

Tribes not growing teparies
1. Navaho
2. White Mountain Apache
3. Mescalero Apache
4. Laguna-Acoma
5. Isleta
6. Jicarilla Apache
7. Upper Rio Grande Pueblos
8. Taos-Picuris

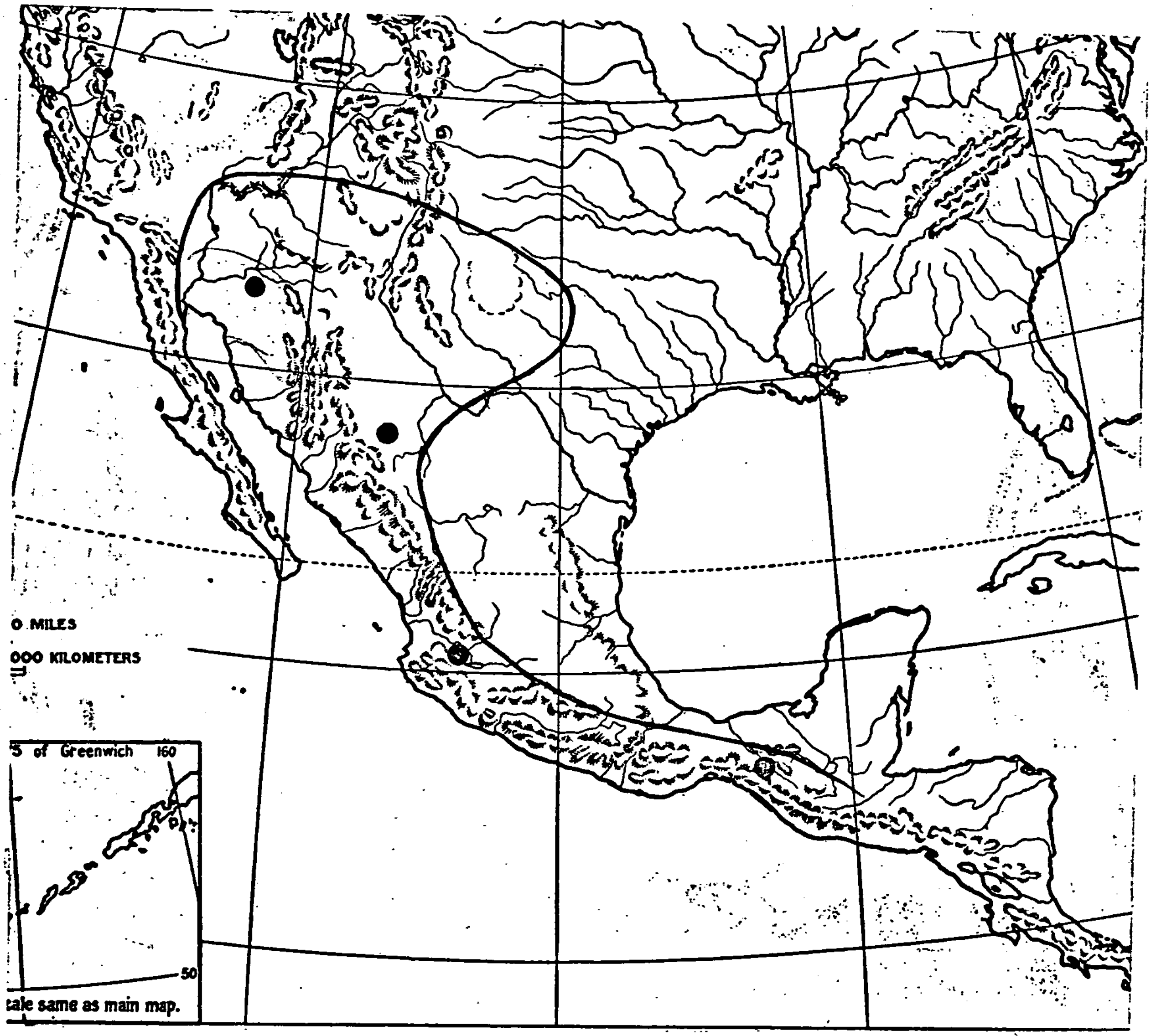
Archeologic distribution: ● 1-12

Flagstaff area: 1- Dead Man's Mesa Fort, 900-1100: 2- Medecine Fort, 900-1100
3-Winona, 100-1200: 12-Wupatki, 1100-1300

Verde Valley: 7-Tusigoot, 1100-1400; Montezuma Well, 1300-1400

Tucson area: 5-Hodges site, 1300: 8- St. Mary's ruin.

Southern New Mexico: 10-Reserve, 4-Hope, 1150-1300

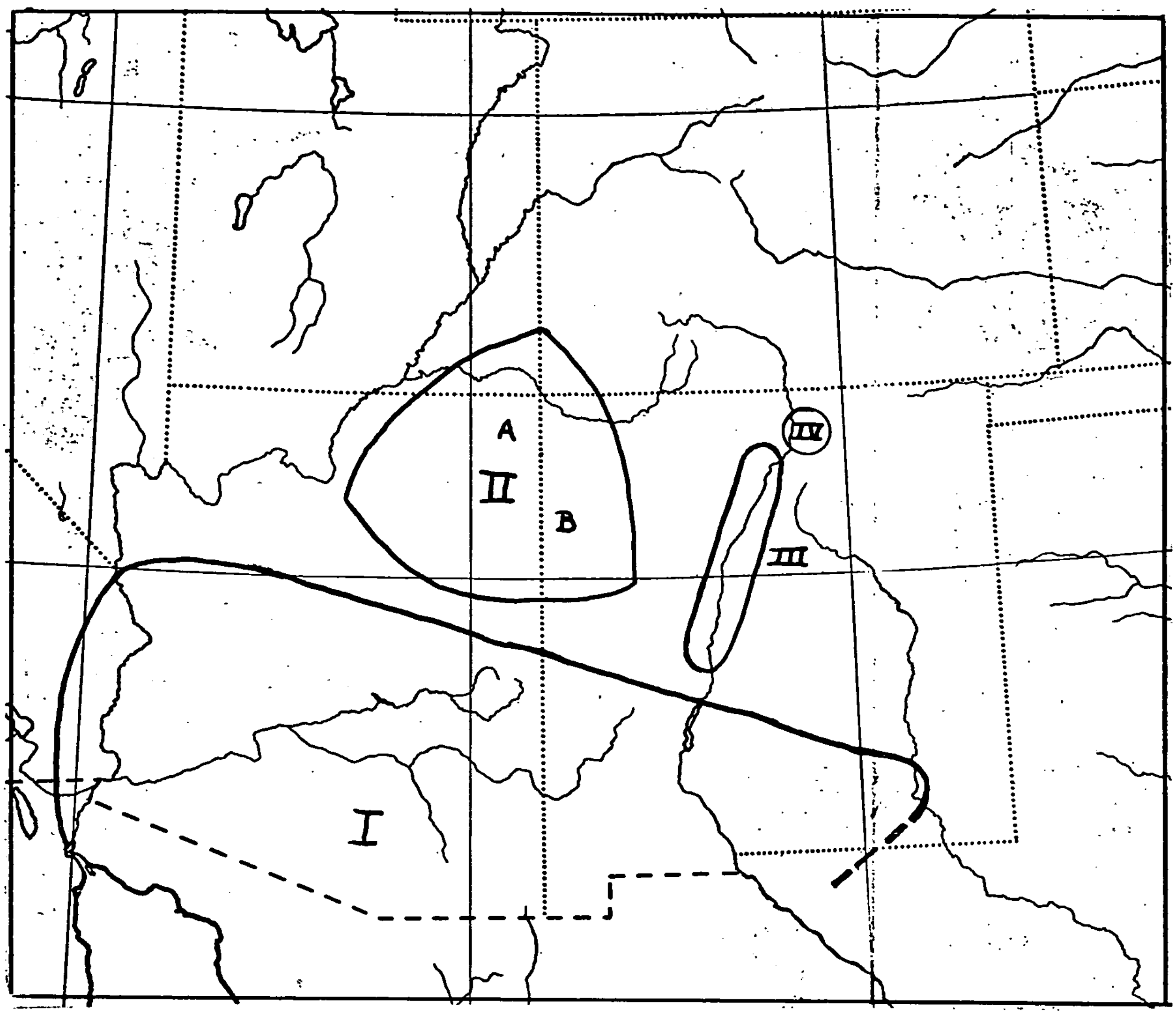


DISTRIBUTION OF THE TEPARY BEAN IN MEXICO

● Occurrences of tepary beans known to Bukasov

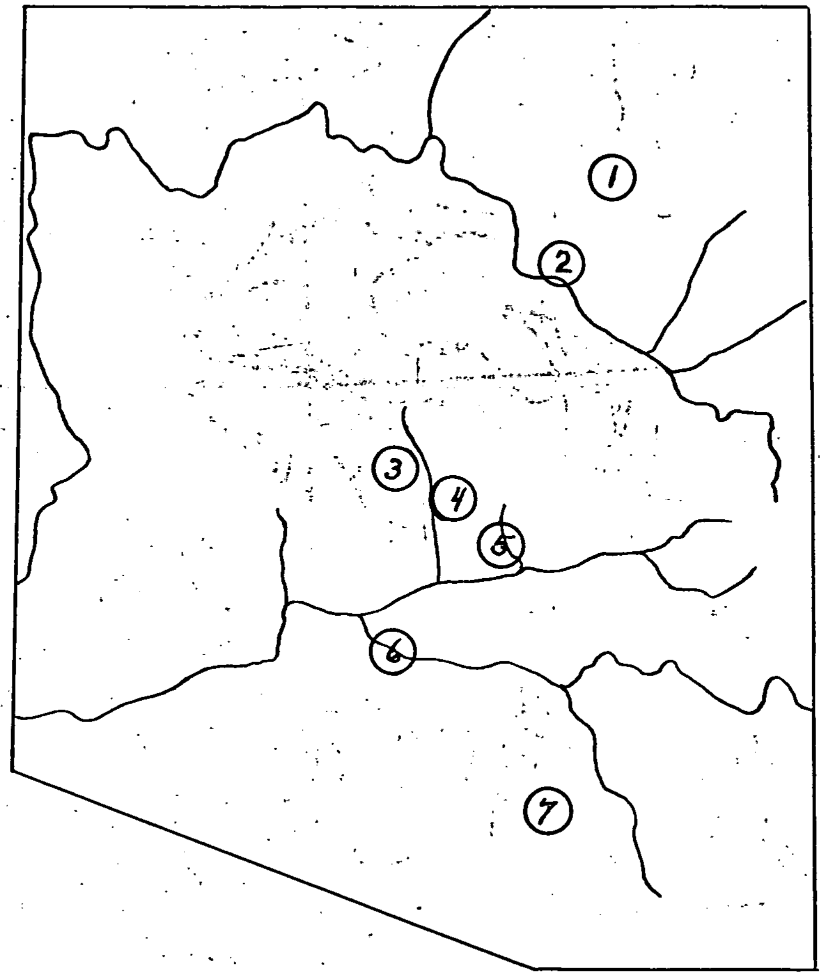
Extent of tepary bean growing as postulated by Bukasov

Area of varietal diversity and home of the related wild forms



Bean areas of the American Southwest

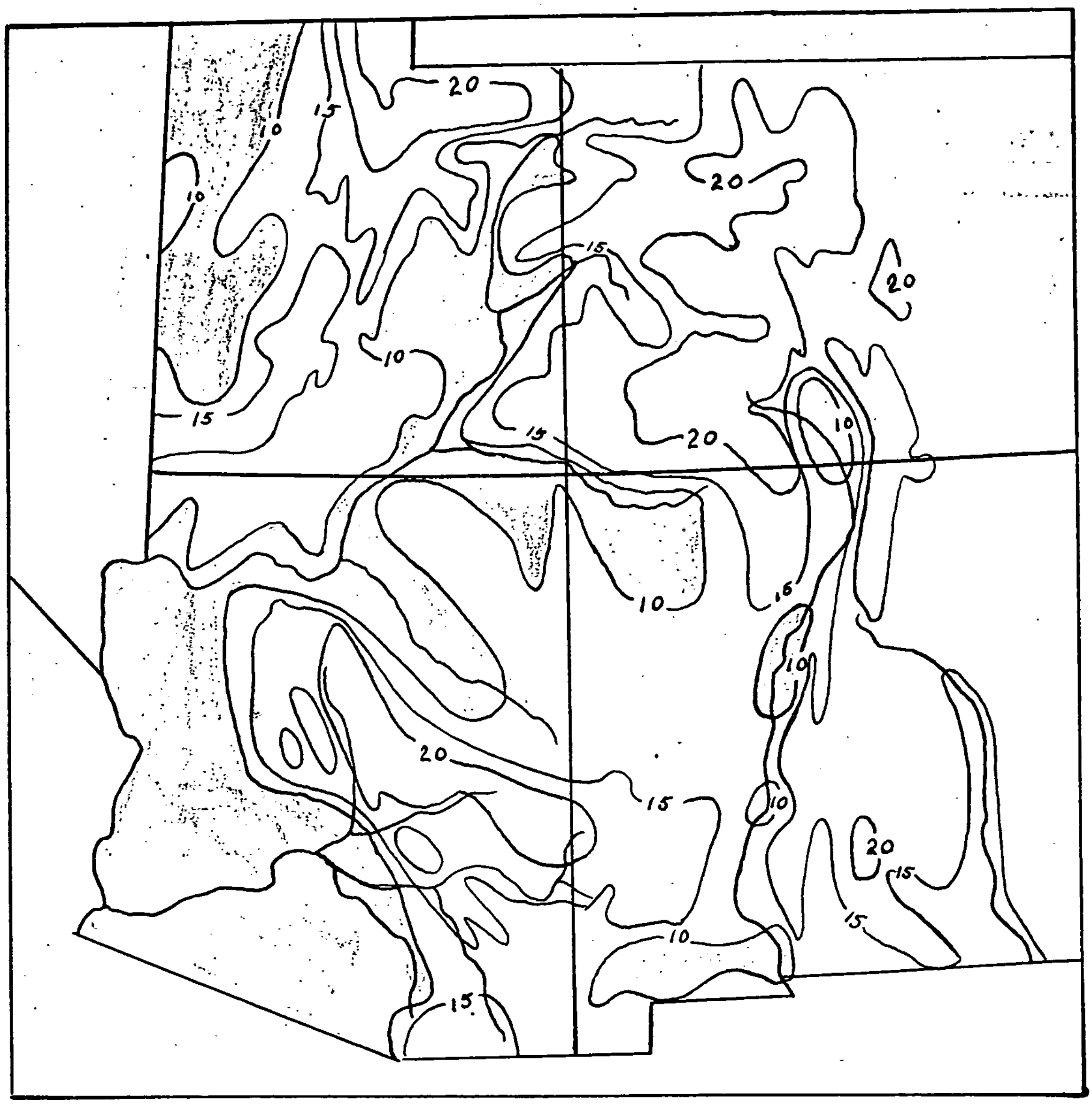
I Tepary bean
II Large kidney bean
A. Hopi
B. Zuni
III Small, dull, kidney bean-- Rio Grande
IV Large, flat, mottled, red, kidney bean-- Picuris-Taos



Distribution of the Lima bean

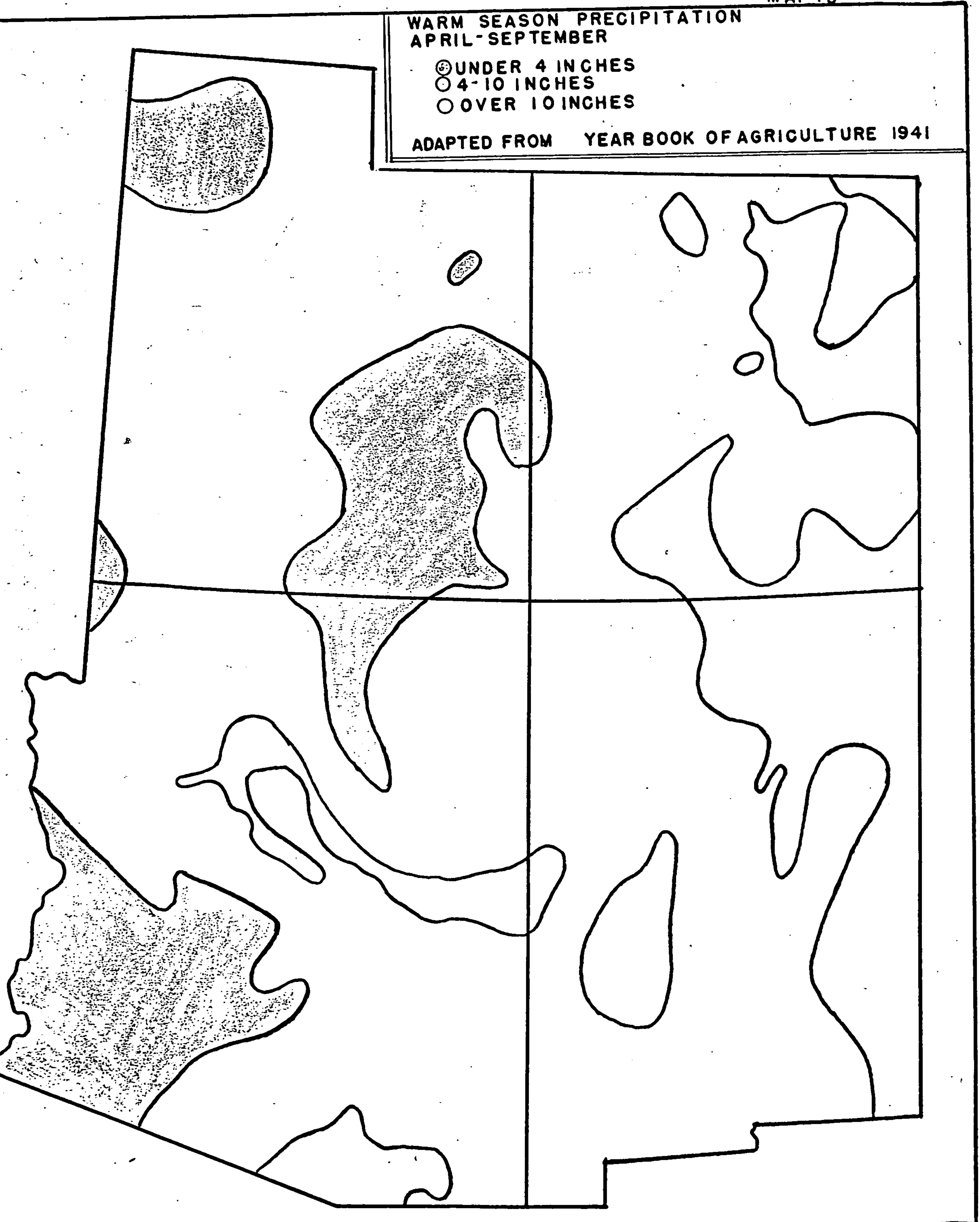
1. Hopi--ethnologic
2. Wupatki--1200 A.D.-- prehistoric Hopi
3. Murder House
4. Montezuma's Castle-- 1300?
5. Tonto-- 1350-- Salado culture
6. Pima--ethnologic
7. Hodges site-- pre 1300-- Hohokam

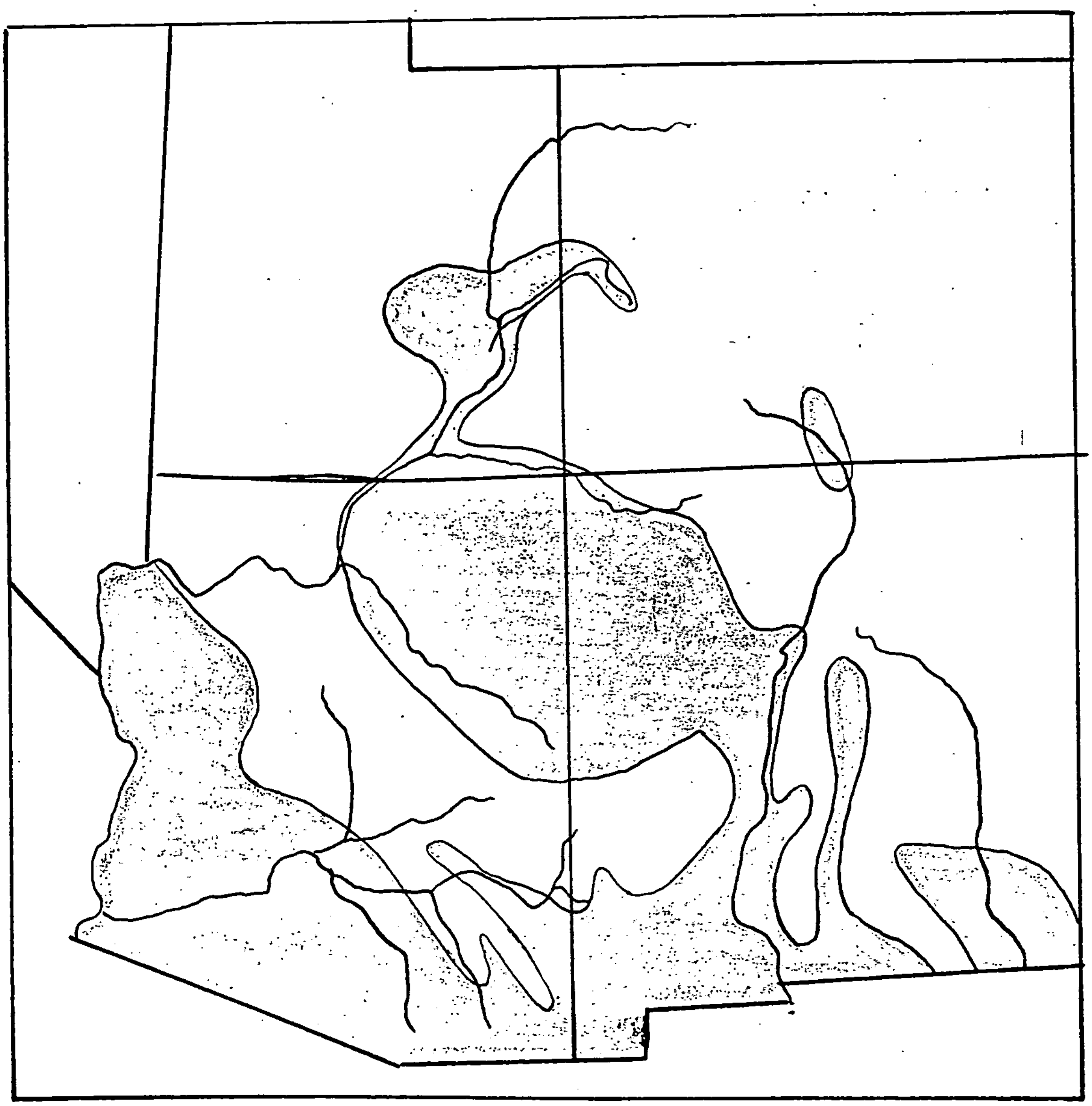
Map 14



Average Annual Precipitation

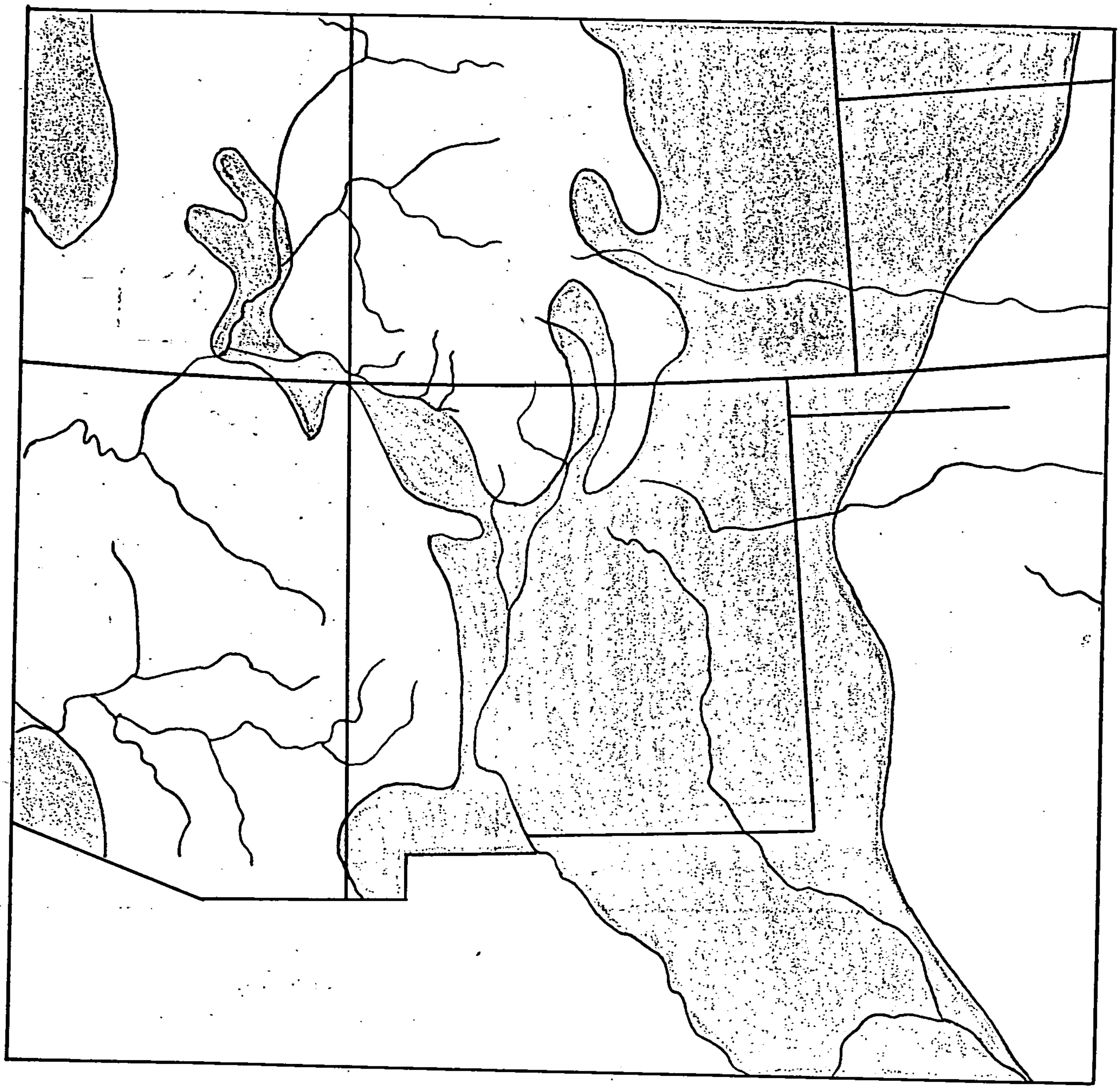
MAP 15


WARM SEASON PRECIPITATION
APRIL-SEPTEMBER
UNDER 4 INCHES
4-10 INCHES
OVER 10 INCHES
ADAPTED FROM YEAR BOOK OF AGRICULTURE 1941



SPRING DROUGHT

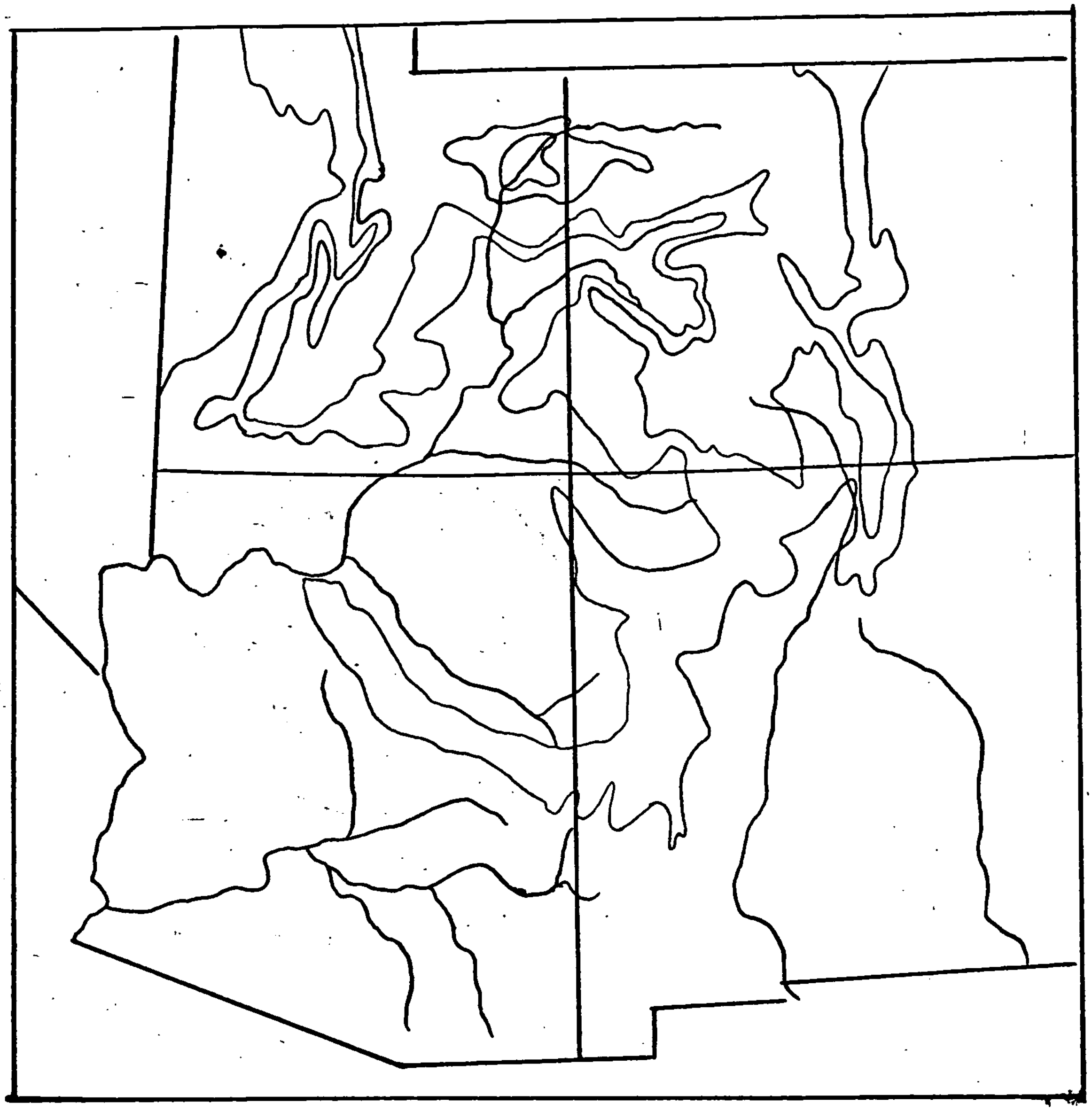
less than 2 inches in spring



WINTER DROUGHT

less than two inches of precipitation in winter

Map 18

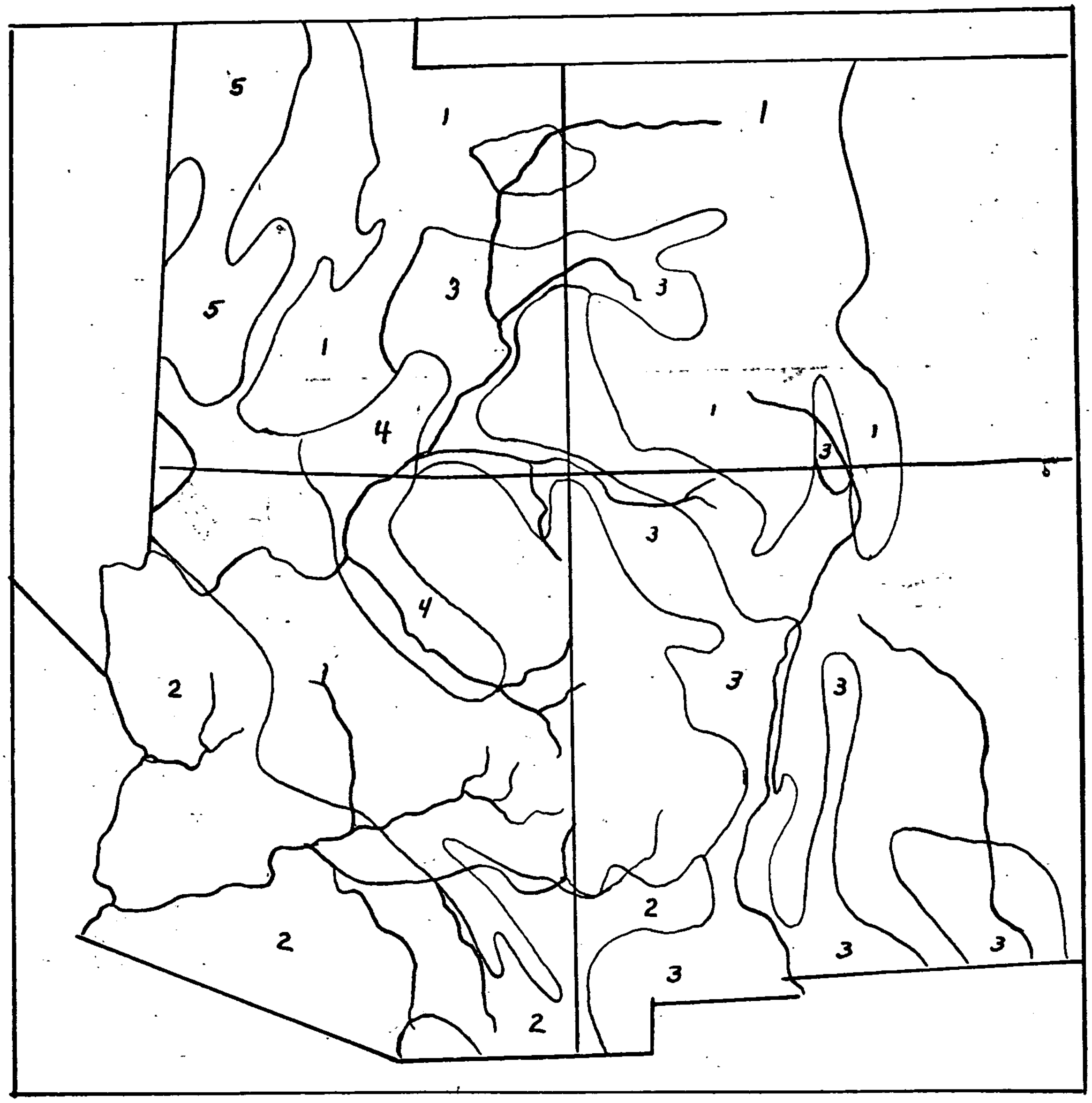


Growing season

less than 90 days

90 to 120 days

over 120 days

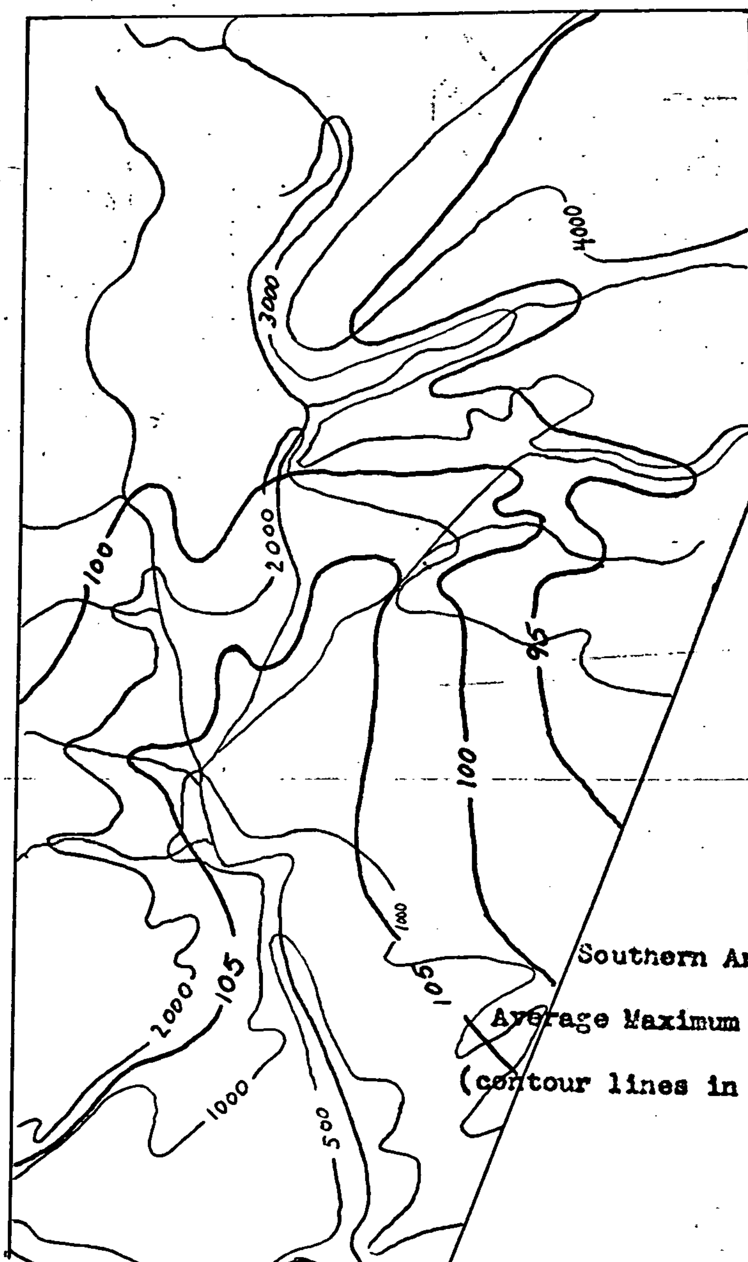


Availability of land to pre-irrigation farmers

climatically useful

climatically closed
1. season too short
2. too dry and too warm in the cool season
3. too dry in the cool season
4. too dry in the warm season
5. total precipitation too low

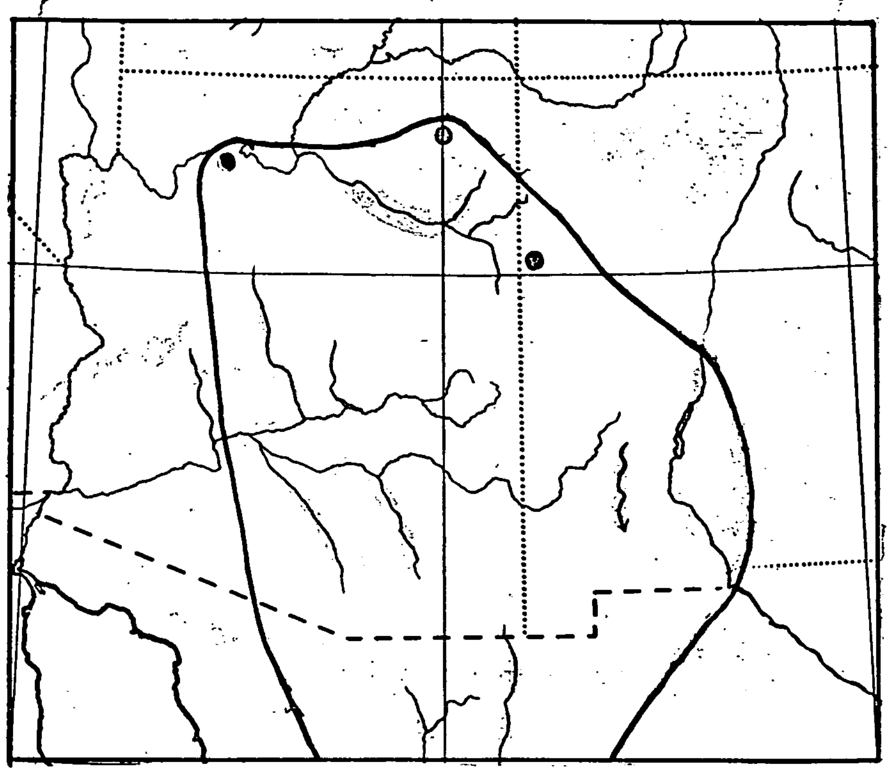
Map 20



Southern Arizona

Average Maximum July Temperature

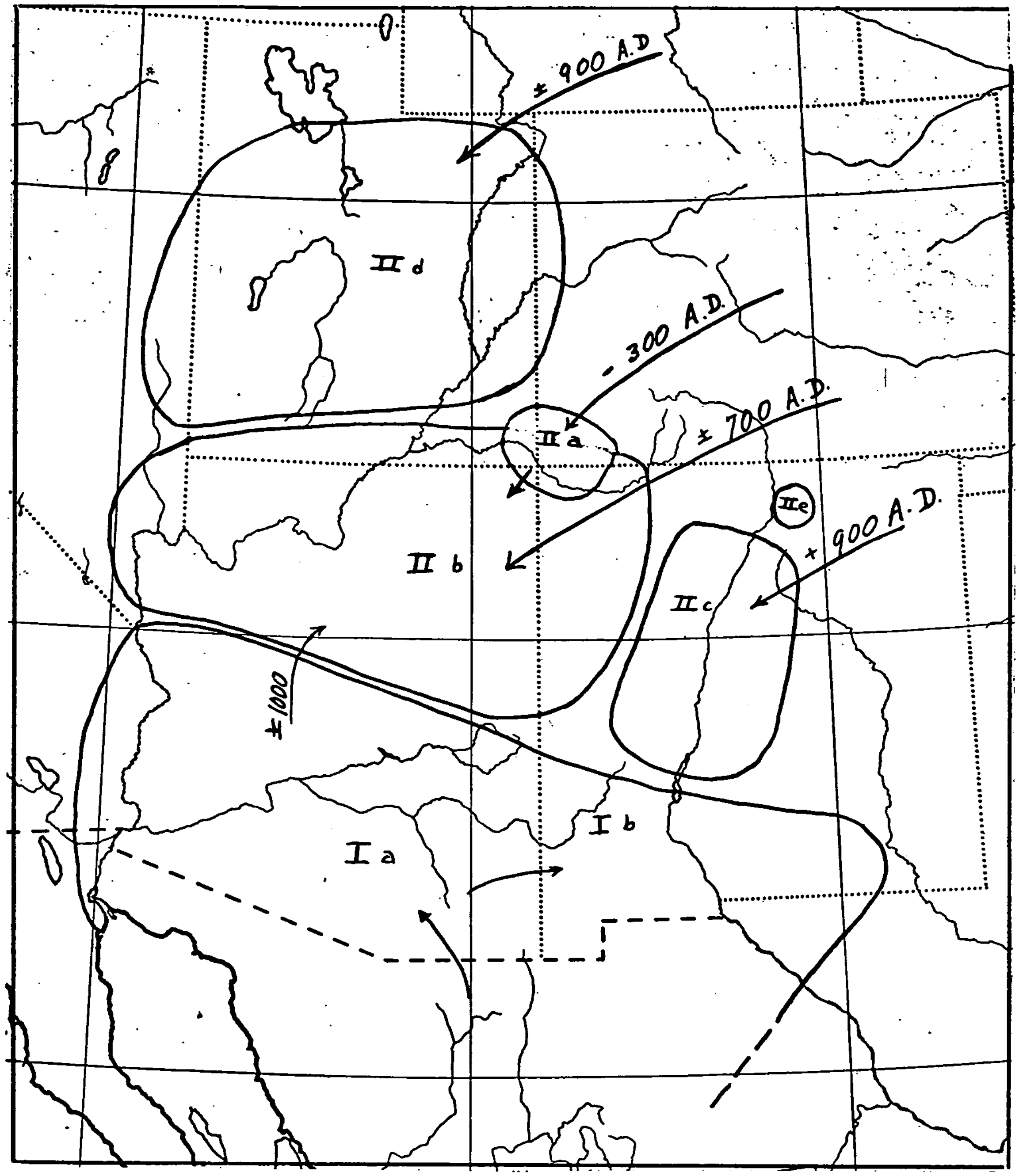
(contour lines in red)



Irrigation in the Southwest-- 1500

Streams where prehistoric irrigation ditches are known,
or where irrigation was reported by the Spanish (Rio Grande)

Modern tribes whose irrigation is probably pre-contact
Havasupai
Hopi-Zuni--(from springs)



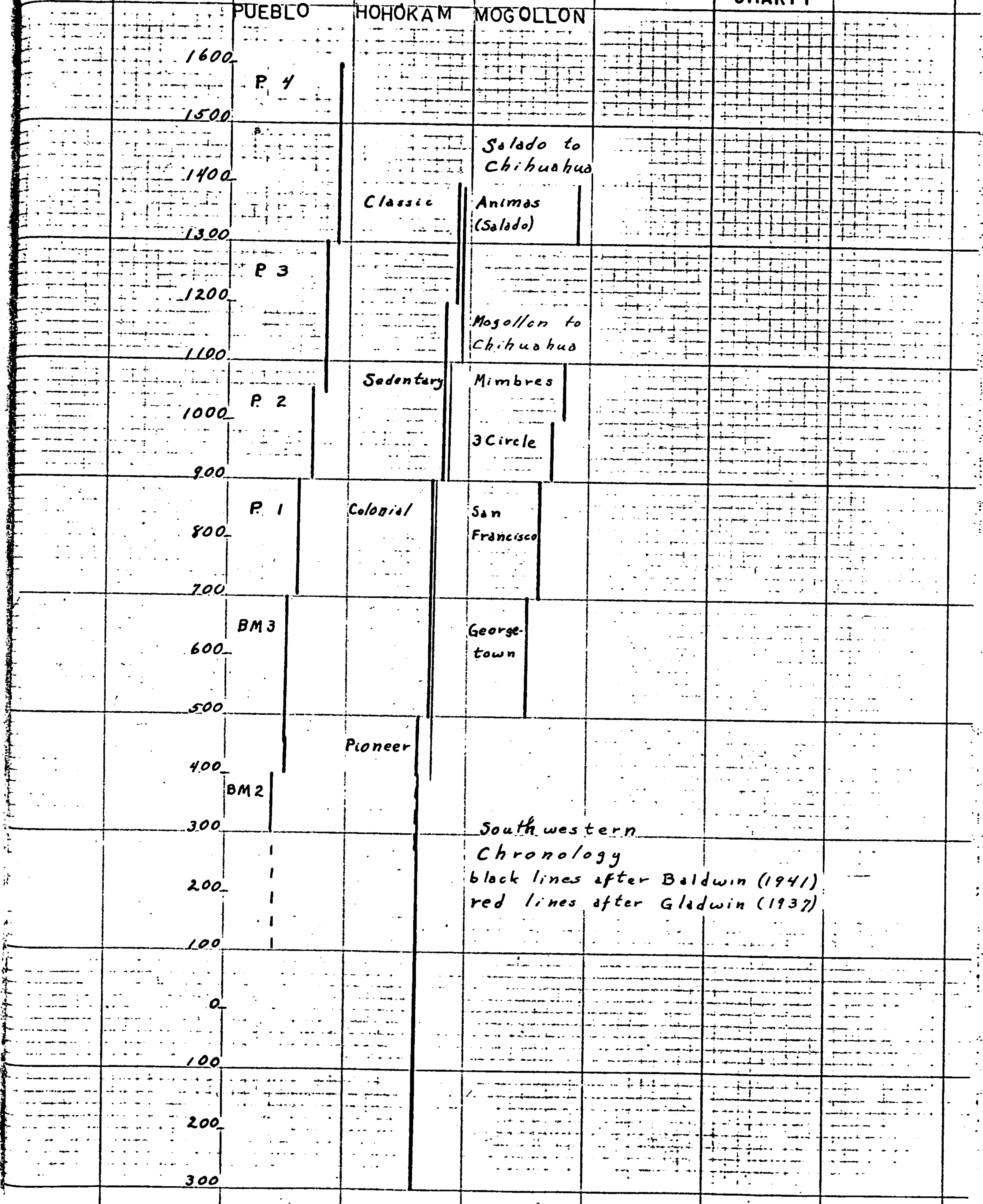
Agricultural Areas of the Southwest--1000 A.D.

I Gila-Colorado
- a. Hohokam-Piman-Yuman
- b. Mogollon (Tentative)

II Puebloan
- a. Basket Maker
- b. Central Puebloan
- c. Rio Grande
- d. Northern Periphery
- e. ~~Picuris-Taos-~~ Northern Rio Grande Pueblo

arrows indicate direction of crop movements but not the routes
plus and minus signs indicate later and earlier in time

CHART I



PUEBLO
HOHOKAM
MOGOLLON
1600
1500
1400
1300
1200
1100
1000
900
800
700
600
500
400
300
200
100
0
100
200
300
P. 4
P 3
P. 2
P. 1
BM3
BM2
Classic
Sedentary
Colonial
Pioneer
Salado to Chihuahua
Animas (Salado)
Mogollon to Chihuahua
Mimbres
3 Circle
San Francisco
George-town
South western Chronology
black lines after Baldwin (1941)
red lines after Gladwin (1937)

CHART NO. 2

Cucurbita pepo

	San Juan	Little Colorado	Rio Grande	Upper Gila	Chaco
Pueblo 4			7d	3	
Pueblo 3	4, 7b, 7e, 9	7c, 9	1	7f	5
Pueblo 2	2,6,7d				
Pueblo 1					
BM 3					
BM 2					

1. Alexander and Reiter, 1935, p. 63.
2. Bartlett, 1934, p. 67.
3. Haury, 1934.
4. Judd, 1930, p. 66.
5. Erwin and Haber, 1929, p. 346
6. McGregor, 1941, p. 297
7. Field Data

   a. Near Pindi, New Mexico -- 1350-1450
   b. Mesa Verde, Step House, Colorado
   c. Walnut Canyon, Arizona
   d. Medicine Fort, Arizona -- 700-900
   e. Gourd Cave, Nitsir Canyon, Arizona
   f. Upper Tonto Cliff Dwelling, Arizona
   g. Vernal, Utah

CHART NO. 3

Cucurbita moschata

	San Juan	Little Colorado	Rio Grande	Upper Gila	Verde	Gila - Colorado
Pueblo 4				4		
Pueblo 3	7a,7f 7i,8	7b,7c, 7d,7g, 7h,7j, 7k,7l, 8	1,7m		7e	
Pueblo 2	8 9,5					
Pueblo 1	9 (?)					
BM 3	2,3					
BM 2	3,7l, 8					

1. Alexander and Reiter, 1935, p. 63.
2. " " " " " "
3. Ames, 1939, p. 83.
4. Haury, 1934, p. 59
5. Martin, 1929, p. 27.
6. Brand, 1937, p. 107.
7. Field Notes
   - a. Mesa Verde, Step House
   - b. Aztec
   - c. Chaco
   - d. Walnut Canyon
   - e. Montezuma's Castle 1000-1400

7. (cont.)
   - f. Gourd Cave, Nitsir Canyon
   - g. Hidden House, Verde Valley
   - h. Wupatki
   - i. Turkey Cave
   - j. Turkey Tanks Cave
   - k. Hole in Rock - 1
   - m. Upper Tonto Cliff Dwelling
   - n. Tsegi Canyon
8. Erwin and Haber, 1929, pp. 342, 346, and 348.

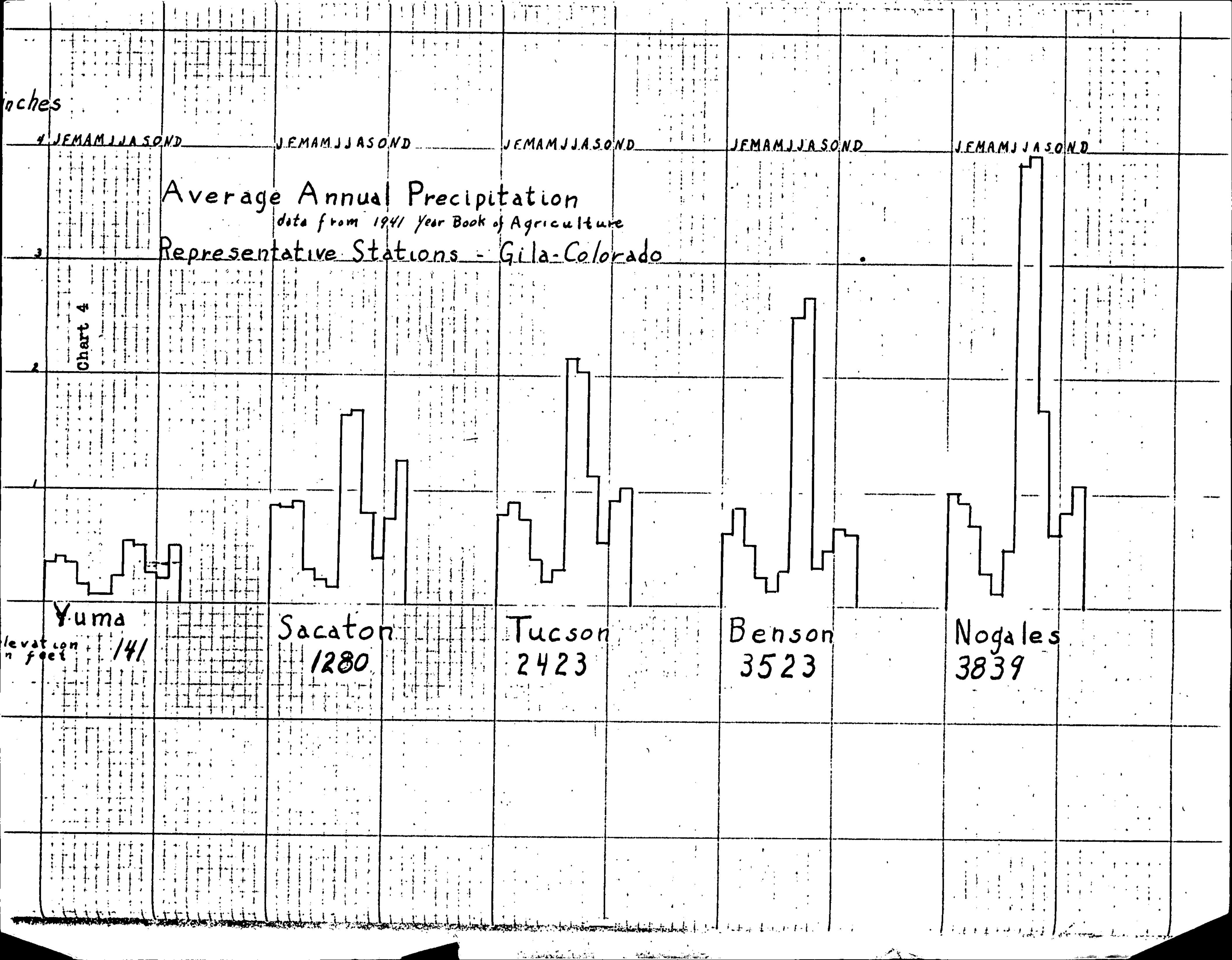
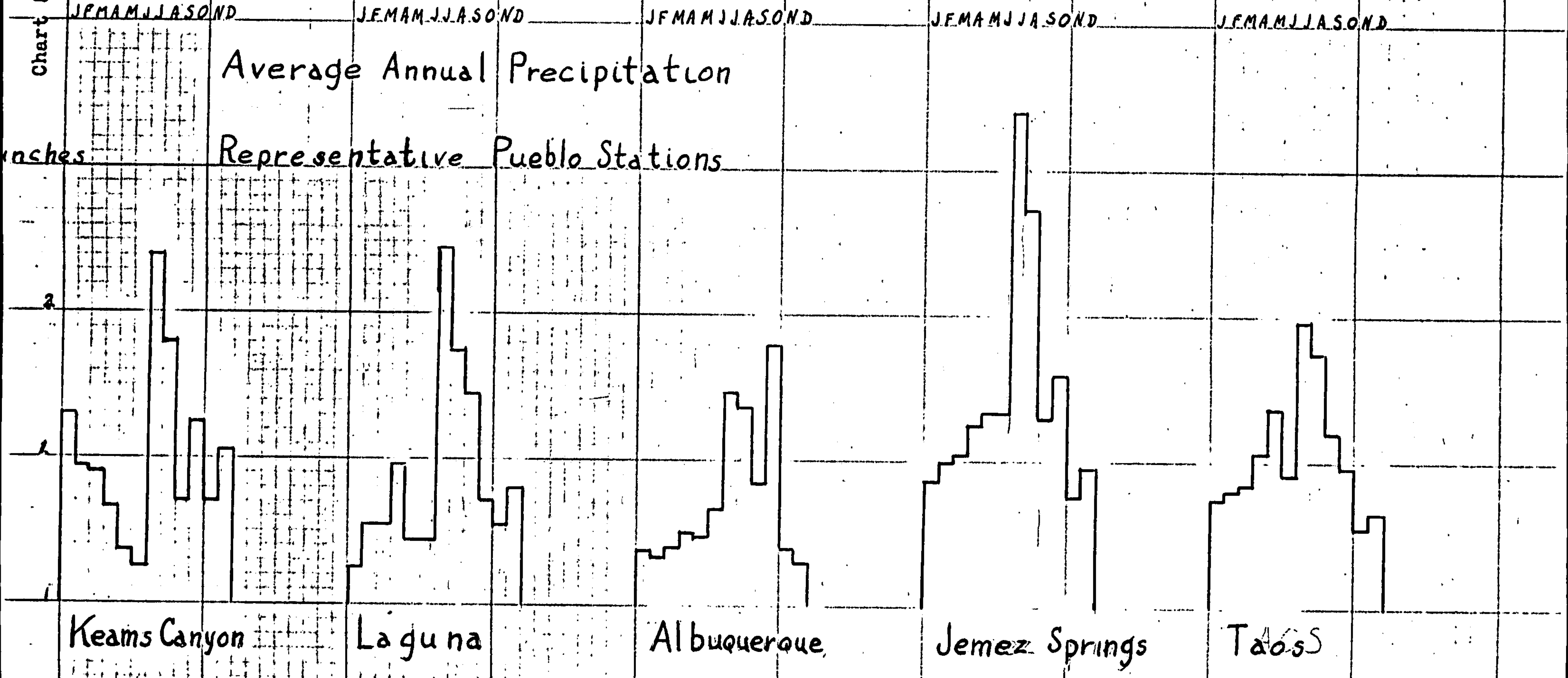
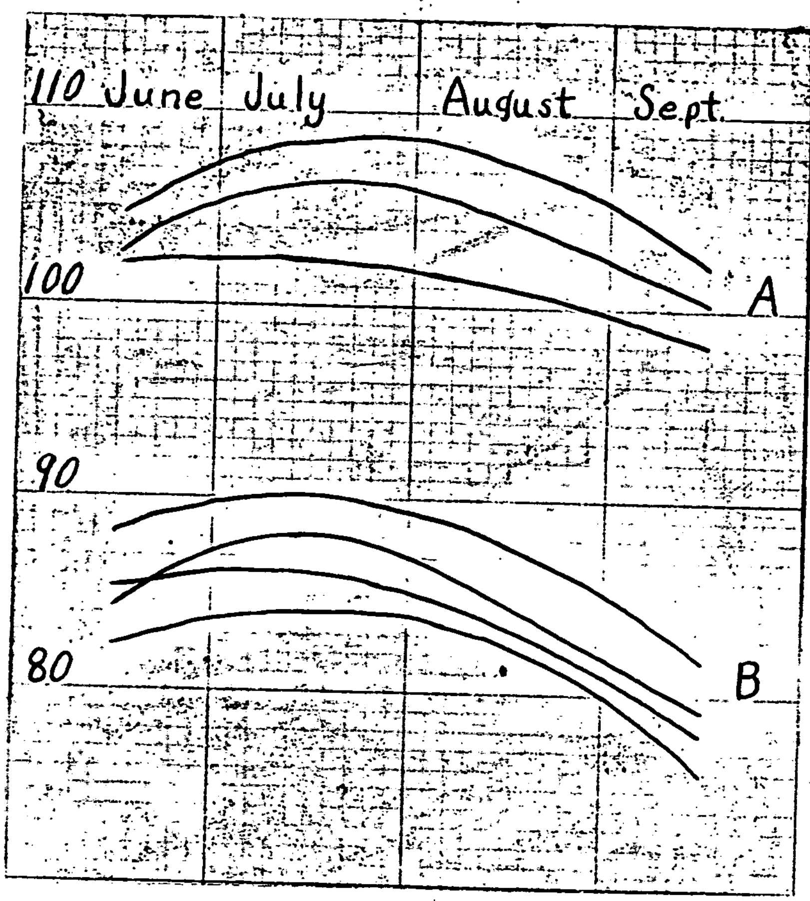


Chart 4
Average Annual Precipitation
data from 1941 Year Book of Agriculture
Representative Stations - Gila-Colorado
inches
4
3
2
1
J F M A M J J A S O N D
J F M A M J J A S O N D
J F M A M J J A S O N D
J F M A M J J A S O N D
J F M A M J J A S O N D
Yuma
levation
n feet
141
Sacaton
1280
Tucson
2423
Benson
3523
Nogales
3839

Chart 5



Average Annual Precipitation
Representative Pueblo Stations
inches
2
1
J F M A M J J A S O N D
Keams Canyon
Laguna
Albuquerque
Jemez Springs
Taos



Average maximum temperatures for the growing season for representative stations.

A. Gila-Colorado: Parker, Yuma, Sacaton

B. Pueblo area: Laguna, Keams Canyon, Black Rock, Taos

Chart 7

AVERAGE LENGTH OF FROST FREE SEASON