years of schooling. Unemployment dropped to 4 percent among those with 13 to 15 years of schooling and to 1.4 percent of those with college training (testimony of Charles Killingsworth, "Automation, Jobs and Manpower," Subcommittee on Employment and Manpower, U.S. Senate [The Clark Committee], 20 Sept. 1963).
12. In 1956, 13 percent of families had incomes of less than $2000. Of those with 8 or fewer years of education, 33.2 percent had incomes of less than $2000. Among all unattached individuals 54.1 percent had incomes of under $2000. Of those with 8 or fewer years of education, 80.3 percent had incomes under $2000. (National Policy Committee on Pockets of Poverty, Washington, D.C. Mimeographed, 6 Dec. 1963.)
13. "There is mounting realization of the injury to incentives and economic growth arising out of the magnitude of taxation. From this has come increasing determination to do something about it. This is all to the good. There is also a rising realization that there is something wrong about reducing taxes unless something also is done about curbing expenditures to avoid the need for big deficits in budgets. This also is good. But the general insistence on reducing expenditures falls short of that on reducing taxes. This failure to place equal emphasis on expenditure reduction can mean a danger of continuing big deficits." ("Important Trends in Our Economy," United States Steel Corporation, 1963 Annual Report, p. 38).
14. W. H. Whyte, Jr., *The Organization Man* (Simon and Schuster, New York, 1956). Whyte relates this subordination is rationalized by ". . . that contemporary body of thought which makes morally legitimate the pressures of society against the individual" (p. 7).
15. ———, *ibid.*
16. On 31 March of this year, Zach Toms, president of Liggett & Myers Tobacco Company, said of the Surgeon General's report: "we think . . . [it] went beyond the limits of the problem as now understood by other qualified scientists." At the same time the president of the American Tobacco Company, Robert B. Walker, dismissed the scientific evidence as ". . . first of all the frustrations of those who are unable to explain certain ailments that have accompanied our lengthening span of life on earth and who see in tobacco a convenient scapegoat." On 14 April, Joseph F. Cullman, III, of Philip Morris, Inc., said that his advisers "do not feel the prime conclusion is justified on the basis of available scientific knowledge and evidence."
17. C. W. Mills, *The Power Elite* (Oxford Univ. Press, New York, 1956).
18. Given the self-destructive character of much unplanned investment, the longer-run conflict is not so clear.

Environment and Man in Arid America

Geologic, biologic, archeologic clues suggest climatic changes in the dry Southwest in the last 15,000 years.

Harold E. Malde

The study of ancient people in the dry Southwest has long commanded the attention of scientists interested in man's response to a changing environment. Although environment is not the only factor controlling man's destiny, its influence is particularly evident in the Southwest, where small climatic changes have noticeably altered the landscape, the plants and animals, and man's way of life. In this survey I indicate only a few of the methods used to gain an understanding of man's past, emphasizing recent contributions and basing the chronology mainly on radiocarbon dating, tree-ring counts, and pottery sequences. The chronology contains numerous gaps and dubious dates, but it is the best framework available. A chronology can also be constructed by correlating local stratigraphic sequences, but such sequences are commonly incomplete and their correlation is still problematic. Moreover, many interesting biogeographic matters and isolated archeologic sites are not yet tied to geologic stratigraphy. In this article stratigraphic names from geologic and archeologic parlance are avoided, except for a few terms in general use.

Several kinds of evidence in the Southwest point to a period of cool and moist conditions, coinciding with the close of the Pleistocene, followed by warmer, drier conditions, and then by a return to a somewhat cooler and wetter climate; but the sequence of environmental change is complicated by climatic fluctuations of lesser magnitude and by differences in the impact of climate on different landscapes.

Earliest Signs of Man

The age of man in the New World has not yet been satisfactorily determined, but there is undoubted evidence in the Southwest that he hunted mammoth and other large animals about 12,000 to 13,000 years ago—when the last Pleistocene glaciers still covered northern North America—using bifacial blades known as Clovis points (*1*). Some archeologists (*2*) recognize a "pre-projectile point" assemblage of less specialized tools (identified as crude scrapers, pebble choppers, and hand axes) more primitive than Clovis points and presumably older. Despite the lack of specific evidence, because of the diversity of man's environmental adaptations in early times it is not unreasonable to assume an age for man in the New World of at least 15,000 years (*3*).

A few radiocarbon samples, supposedly dating man's campfires, suggest even greater age (*4*); but for one reason or another these dates are discounted by most archeologists, though not by all.

Geologic Signs of Environmental Change

Geologic evidence of wetter-colder climate during the late Pleistocene, and the subsequent physiographic changes, comes from the history of mountain glaciation, the rise and fall of pluvial lakes in closed basins, accumulation and dissection of alluvium, and the various effects of wind action (*5*). The position of late-Pleistocene snow line near pluvial Lake Estancia, 100 kilometers southeast of Albuquerque, implies that summer temperature was reduced 5° to 6°C (10° to 12°F) and that annual precipitation increased about 200 millimeters (8 in.) (*6*). Meteorologic study of a Pleistocene lake in Spring Valley, near Ely, Nevada, indicates a probable 30-percent decrease in evaporation, a 200-milli-

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meter increase in precipitation, and a 7°C decrease in summer temperature (*7*). Other details concerning the rise and fall of pluvial lakes in the Great Basin are being worked out, but attempts to calculate the input and loss of salt at these lakes have not yet reckoned with complex problems of geology, hydrology, and past climatic change (*8*). Maps of several ancient soils buried in alpine deposits suggest a changing pattern of climatic zones (*9*). Measurement of alluviation and erosion in arid watersheds shows relations between precipitation, sediment transport, and valley shape that help to explain former stream deposits (*10*). Sand dunes in the plains of western Kansas show reversals of wind direction in conformity with the advance and retreat of continental glaciers (*11*). Finally, geochemical techniques have been used to show that the amounts of manganese, nitrogen, and phosphorous left by animals in cave deposits point to a period of wetter climate that ended some 12,000 years ago (*12*).

Biologic Evidence of Past Environment

The biologic evidence for climatic change in the Southwest, as elsewhere, rests on displacement of biotic zones as recorded by fossils or by disjunct, "relict" species of living plants and animals. Recent reviews of Pleistocene biogeography (*13*) document the growing recognition of the part played by recent climatic change in the distribution of organisms.

Since Eiseley (*14*) pointed out that two land snails, *Pupilla sonorama* and *Gastrocopta ashmuni*, found with artifacts of early hunters at the Lindenmeier site, north of Fort Collins, Colorado imply moist conditions "attendant on receding mountain glaciation," molluscan fossils have received increasing attention in Pleistocene stratigraphy and in archeology (*15*). To account for the moist conditions implied by terrestrial snails in fossil assemblages in upper Pleistocene deposits of the High Plains, for example, shifts of isotherms by several hundred kilometers north to south and large displacements of moisture belts east to west must be assumed. More ecologic studies of modern snail populations are needed (*16*).

The vertebrates of the Southwest include several isolated species, of which only a few have been studied intensively. Hall and Kelson (*17*) have mapped the distribution of 15 endemic species of mammals in the Great Basin that were probably isolated by changes in Pleistocene climate. The southern limits for several Rocky Mountain mammals and reptiles are marked by isolated populations above 2100 meters on desert mountains of southern Arizona (*18*). The shrew, *Sorex milleri*, in mountains of northeastern Mexico, is regarded as a late-Pleistocene remnant of *Sorex cinereus*, which now extends southward in boreal habitats in the mountains of northern New Mexico (*19*). The distributional and variational patterns of southwestern *Microtus* are explained by postulating a pluvial period, followed by a warm, dry interval and then a return to somewhat cooler conditions (*20*). Plethodontid salamanders in the mountains of New Mexico probably became disjunct from Rocky Mountain relatives, because of climatic warming at the close of the Pleistocene (*21*). Similarly, the distribution of iguanid lizards in the Great Basin probably resulted from climatic changes that have occurred since the last pluvial (*22*).

Disjunct distributions that indicate cooler climate during the Pleistocene are also found among insects—especially the butterflies, of which relict arctic and subarctic groups are found at mountain bogs in Colorado (*23*).

It is well known that remains of extinct animals occur in upper-Pleistocene deposits of the Southwest (*24*), but discovery of several boreal animals associated with a Clovis point in Burnet Cave, southern New Mexico, deserves emphasis (*25*). However, the recovery of *Marmota flaviventris* from the cave —a species often cited as an indicator of cold climate—is of doubtful value as evidence of Pleistocene conditions, because *M. flaviventris* is found today in Utah grasslands as low as 1400 meters (*26*).

Some plants of the Southwest also show marked distributional patterns that may reflect colder and wetter conditions during glacial stages of the Pleistocene. Among phytogeographers, the alpine tundra of Colorado is famous, being dominated by a circumboreal flora that includes numerous extraordinary arctic relicts (*27*). The curious disjunct distribution of creosote bush in deserts of North and South America (*28*) and the puzzling taxonomic similarity of other desert plants on opposite sides of the equator suggest past climatic change in tropical zones (*29*).

Pollen records point to many biogeographic details about the former distribution of plants, but accurate interpretation of the fossil pollen requires further knowledge of pollen rain in modern environments (*30*). Looking first at records contemporaneous with the last stage of continental glaciation, we find that scattered sites in southern latitudes yield pollen of trees that now grow at higher altitudes several hundred kilometers farther north. Pollen from deposits 22,500 to 17,000 years old on the southern High Plains, now a region of short-grass prairie, suggests pine woodlands and scattered spruce (*31*), but forest-type soils are lacking; hence it appears that trees probably were not widespread in this region. Spruce pollen dated from 27,000 to 19,000 years old also is abundant in beds of ancient Lake St. Augustin in west-central New Mexico (*32*), a locality now surrounded by pinyon, juniper, and pine. Pollen from pluvial Lake Cochise in southeast Arizona, from 23,000 to 20,000 years old, is dominantly (95 percent) pine but includes some spruce, fir, and Douglas fir; it suggests an environment of pine parkland such as is now found 1400 meters higher on mountains in northeast New Mexico 700 kilometers to the north (*33*). At Searles Lake, California—now a desert basin 1000 meters below the nearest woodland—a pluvial deposit 23,000 to 12,000 years old has relatively abundant pollen of juniper and pine (*34*).

Pollen records from mountain areas in the Southwest during the glacial period, although meager, suggest considerable lowering of the tree line. Sage and spruce pollen in lake sediments dated 19,400 years old, at an altitude of 2700 meters in the Chuska Mountains of northwest New Mexico, are attributed to a tundra environment; this would mean that the tree line was at least 760 meters lower than it is at present (*35*). Similarly, pollen from lakes and bogs in the San Juan Mountains of southwest Colorado indicates a former tree line 670 meters lower than the present one (*36*).

Environment of Early Hunters

The pollen record of the Southwest implies that the climate had already become more dry at the time of the Clovis hunters, from 13,000 to 10,500 years ago. On the southern High Plains, a decline in pollen of pine and spruce, and changes in assemblages of diatoms and mollusks, imply that ponds dried and streams diminished in volume (*37*). Spruce that had reached as far south as the Texas coastal plain disappeared from the pollen record of Texas bogs about 12,000 years ago (*38*). At the same time, pollen representing the Upper Sonoran zone at Rampart Cave in the lower Grand Canyon—a plant community of a type that now grows 600 to 1200 meters higher —disappeared (*12*). At Lehner Ranch in southern Arizona (see Fig. 1), pollen associated with Clovis remains about 12,000 years old suggests an environment resembling present-day grassland (*39*).

Geologic signs of increasing dryness at this time are especially clear at pluvial lakes in the Great Basin. For example, as shown by sedimentary study, water in the Bonneville Basin had evaporated to a state of high salinity by 12,000 years ago (*40*), after a previous stand about 300 meters higher.

Although the climate was becoming drier, water was nevertheless more abundant then than it is now, and Clovis Man found that ponds and streams were favorable places for hunting large animals—particularly the mammoth (*41*). Somewhat later, probably by 8000 years ago, several typically Pleistocene herding animals abruptly died out: elephant, horse, camel, and a large species of bison (*42*). Because the sudden extinction did not extend to most small vertebrates of high reproductive capacity, and because it occurred in a wide variety of environments—from the tropics to northern latitudes—circumstantial evidence points to prehistoric man as a destructive predator. That the extinction was due to purely ecologic causes seems improbable (*43*). However, the deleterious effect of climatic change on breeding habits cannot be ruled out, and the archeologic record so far fails to show that all the extinct animals were exploited as game. Resolution of this question requires more facts, but at present the role of man is one clearly identified factor.

From about 11,000 to perhaps 6500 years ago (the terminal date is poorly determined), big-game hunters other than Clovis Man, using different tools and hunting different animals, appeared on the Great Plains. As judged from remains of their camps and kill sites they were more numerous than the Clovis hunters, although increasingly arid conditions must have made for a hard life. These plains hunters depended mostly on herds of bison for food, but they also ate small game, as shown by scraps found in a few excavated campsites. Grinding tools for the preparation of plant foods appeared for the first time about 10,000 years ago and became increasingly common thereafter (*41*); such culinary objects indicate the beginning of a gathering economy and a more sedentary life.

While the bison hunters roamed the Plains, the climate was becoming drier.

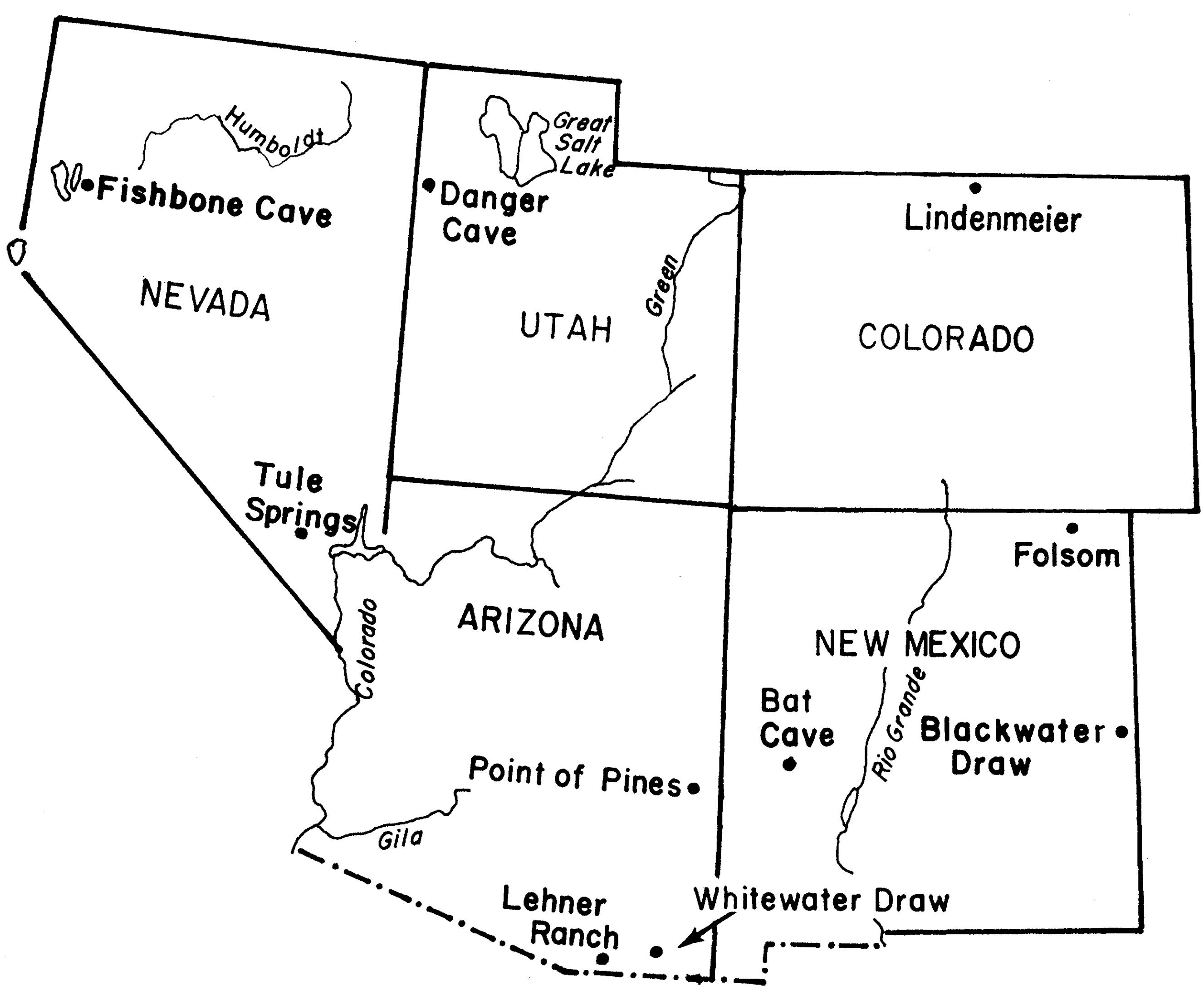

Fig. 1. Index map of archeologic sites.

At first, in such regions as the southern High Plains, ponds were still abundant and supported fresh-water diatoms. Sand dunes of an earlier period were stabilized by vegetation, and cool-climate mollusks found favorable habitats near water. Later, however, the ponds dwindled, fresh-water diatoms were replaced by saline forms, widespread erosion occurred, and presumably vegetation became less dense (*37*). Parallel-flaked points dating from the latter part of this period in eastern Colorado occur in windblown sand, indicative of regional dryness (*44*), but conditions were still rather moist at the Lindenmeier site to the west, near the mountains (*45*). With loss of water supplies, hunting bands may have stayed close to familiar watering places, but travel may have been possible during wetter months, and short journeys between springs during the dry season were perhaps feasible (*46*). In winter, or under stress of increased aridity, people could find shelter in wooded valleys near the foothills (*47*). There is some archeologic evidence that survivors of the big-game hunters migrated northward (*48*), perhaps lured on by better hunting and more plentiful water in the northern plains, but eastward migration also seems likely.

People occupying the Great Basin and the southern deserts at this time were handicapped by even greater aridity and a paucity of big game (*49*). They must have depended for a livelihood on small game and edible plants. Baskets and grinding stones for collecting and preparing plant foods were in use at Danger and Fishbone caves in the Great Basin from about 9000 years ago, and they appeared in southern Arizona at about the same time.

The dry climate of this early period in the Great Basin has been inferred locally from pollen records, as well as from shrinkage of pluvial lakes and from biogeographic considerations already mentioned. Along Whitewater Draw, in southern Arizona, pollen correlated with the earliest Cochise culture (dated about 10,000 to 8000 years ago), like the pollen in earlier deposits with Clovis remains, suggests an environment resembling the present grassland (*50*). The presence of associated oak and hickory charcoal, fresh-water mollusks, and remains of water birds can be explained as evidence of a local riparian habitat within a desert region. At Nevada caves, pollen that overlies deposits yielding a high count of tree pollen dated earlier than 15,000 years ago reflects increasing aridity (*51*). Desert vegetation for the period from 13,500 to 6000 years ago is also implied by pollen from Tule Springs (*52*).

Altithermal Age

Since the pioneer work of Bryan and Antevs on the postglacial history of the Southwest, a climax of aridity from 6000 to about 4500 years ago—dated partly by analogy with European pollen records but also by radiocarbon dating of older and younger deposits—has been widely accepted and only recently disputed (*43*, *53*). Such a period of warm climate is amply demonstrated in the northeastern states and in Europe (*54*) and is identifiable in pollen records from the tropics (*55*), even though the inferred rise in temperature—estimated from the tolerances of modern plants—is only a few degrees. In the Southwest, this interval is usually termed the Altithermal, and, because of evident arroyo cutting, lowered water tables, accumulation of caliche in soils, wind erosion, and dune formation, is commonly believed to have been warm and dry; but recent pollen study casts doubt on this time-worn dogma (*43*), and the assumption that certain geologic features were caused by drought is debatable. Arroyos and wind deflation, for example, are perhaps only a result of climatic shift toward less frequent but occasionally intense rainfall, without overall change in average precipitation (*56*). Such a change in the pattern of rainfall, however, would produce relatively scant vegetation and dry soils subject to erosion. Although prevailing ideas about uniformly dry climate during the Altithermal deserve critical scrutiny, and dates are needed for this period, conspicuous geologic signs characteristic of dry regions are too pervasive and too diverse to be ignored. Our knowledge is incomplete, but my guess is that the Altithermal was at first rather arid and then gradually became wetter.

Citing mainly geologic evidence, Bryan and Antevs (*57*) emphasized physical features that point to a warm and dry middle postglacial period. Local studies supply various details. In the southern Rocky Mountains, glaciers that began to shrink from moraines far down some alpine valleys slightly earlier than 6200 years ago, as estimated from radiocarbon dating, disappeared entirely and probably did not re-form until about 3800 years ago (*58*), at much reduced size. At the Lindenmeier site, a deep arroyo older than 5000 years was cut in deposits that contain artifacts of the early big-game hunters (*45*), and a similar arroyo is found at the famous Folsom site in New Mexico (*59*). An arid period, dating back to between 6300 and 4950 years ago, is expressed at Blackwater Draw on the southern High Plains by a marked disconformity, by accumulation of wind-blown sand, and by growth of gypsum crystals in desiccated lakes (*37*). A period of erosion at Whitewater Draw in southern Arizona had ended by 4500 years ago, as determined by the age of pond clay in an arroyo (*60*). Caliche formation at this time, a hallmark of arid lands, is well known from stratigraphic studies, and its past rate of development can be estimated by radiocarbon analysis (*61*). Hack's (*62*) study of ancient sand dunes of the Hopi country, which relate to this period, is a classic in the annals of geology of the Southwest.

Biogeographic studies mentioned earlier, although still limited to a few plants and animals, support the idea of a postglacial warm period. Some botanical information from peripheral areas is also pertinent. Comparison of the present and past distribution of digger pine (*Pinus sabiniana*) in California suggests that the average winter temperature has risen 5°C since the Pleistocene (*63*). Chaparral in southwest Oregon once extended northward to Puget Sound, a finding which implies a summer rise in temperature of 5°C and a decrease of 230 millimeters in annual precipitation (*64*). Wood peat indicative of warmer-drier climate at bogs in the Northwest dated from 8300 to 3000 years ago is succeeded by sphagnum peat of the present cooler-wetter climate (*65*). In alpine bog deposits of the Colorado Front Range, a warmer period from 8000 to 3000 years ago is inferred from abundant grass pollen and reduced tree pollen (*66*), but pollen records from the San Juan Mountains of Colorado show that the warm period ended about 5000 years ago (*67*).

Archeologic remains from the Altithermal are rather scarce. On the Plains the few artifacts of this age are identified with food collectors belonging to the Archaic culture (*68*). In the Great Basin and in southern Arizona, traces of seed collectors have been found (*49*). Human populations may have dwindled as supplies of game and plant foods decreased, and men looking for water may have followed streams headward, or may have moved from shrinking lakes to higher ground (*69*). This possibility is discussed below. But I can mention two archeologic curiosities that imply necessities of the time: prehistoric wells dug in the southern High Plains (*70*) and storage cists for plant foods found in Nevada caves (*71*).

Despite the predominant view that the Altithermal was arid, Martin (*43*) believes that the climate was actually wetter, at least during summer in southern deserts. His evidence is drawn from flood-plain pollen at two sites in southern Arizona, dated from 5280 to 4120 years ago. The interpretation of pollen from flood plains is beset with unsolved problems (as Martin admits), and assignment of the pollen to the Altithermal is based only on radiocarbon dating, but the pollen clearly shows an increase in moisture indicators (pine, oak, grass, and cattail) as compared with younger beds. Interestingly, a similar increase in tree pollen in the lower sediment of Hackberry Lake, Nebraska, dated at 5040 years ago, also implies a wet period in the generally warm and dry postglacial (*72*). In support of his view that the Altithermal was wet, Martin (*18*) points out that certain lizards, snakes, and rodents in the Sierra Madre of Mexico reach their northern limits as isolated remnants on the lower slopes of the Chiricahua Mountains of Arizona and must have migrated northward along a former corridor of oak-pine woodland. The intervening divides in Sonora now support only desert grassland and scrub, but the woodland required by these animals grows about 300 meters higher. Martin attributes the inferred spreading of woodland to subtropical monsoons during the Altithermal.

Summer wetness in the Southwest during late Altithermal time is also implied by conspicuous soils that formed on landscapes suggestive of earlier aridity. The inferred period of increased moisture (5000 to 4000 years ago) coincides with a time of accelerated soil development on eolian deposits in the plains of eastern Colorado (*44*) and near Denver (*73*). At Blackwater Draw in the southern High Plains, oxidation and jointing of wind-blown sand that overlies pre-Altithermal deposits (*37*) probably indicates soil development. A characteristic soil of this age is also recognized in the La Sal Mountains of Utah and at various Rocky Mountain localities (*9*). Such soil development requires wetness as well as high temperature. Caliche soils that formed in more arid areas are readily explained by postulating additional rainfall (*74*).

Agriculture and Village Life

As the Altithermal drew to a close, relatively wetter and colder conditions returned, and the tempo of human life accelerated, along with evident growth in population. Many arroyos began to fill with alluvium, dry lakes in the northern Great Basin were flooded, sand dunes were overgrown with vegetation, and new glaciers formed in the Sierras and the Rockies.

The archeologic record of the Southwest shows, shortly before 5000 years ago, the first signs of agriculture and, as time went on, increased dependence on plant foods and a progressive adoption of more sedentary ways of life, ultimately resulting in villages attached to farms. Primitive corncobs at Bat Cave, a locality 2100 meters above sea level in west-central New Mexico, are dated 5600 years ago (*75*). Cultivation of corn at this altitude could have been favored by warm climate and summer rain and the subsequent cooler climate actually may have curbed agriculture for a time, because of a short growing season (*76*). Corn does not appear again in the archeologic record of the Southwest until about 4200 years ago at Point of Pines, Arizona, 200 kilometers west of Bat Cave, and at an upland site near Denver (*77*, *78*). Discovery of these hints of early agriculture in uplands of the Southwest reinforces the belief that people moved to higher ground during a period of warm and dry climate.

After this start, cultivation of corn spread over a wide area, especially along tributaries of large rivers, and by the time of Christ it had reached southwestward along the Gila and Salt rivers, eastward to the Rio Grande and the Pecos, and northward into the Colorado Plateau. Corn did not reach the plains of western Kansas until a thousand years ago (probably from the east), although makers of pottery, who depended on native plants, had previously clustered at sites along streams (*79*). Concurrently, squash came into use by sedentary people living along the San Pedro River, Arizona, about 4000 years ago, and beans were added a thousand years later. Thus, a populous economy evolved, based on the familiar triumvirate corn, beans, and squash. The simultaneous rise of agriculture and return of wetter climate, in the Southwest, seems to me more than coincidence. These cultivated plants were presumably imported from northern Mexico, where they had helped sustain a seed-collecting economy dating back several thousand years earlier (*80*).

During the rise of agriculture, which continued into the Christian era, the climate of the Southwest, as indicated by the slow buildup of alluvium, was characterized by intermittent rains interspersed with short intervals of drought and times of cold weather. These vicissitudes of climate, none as severe as earlier changes, brought hardships and induced human migration, but they also evoked remarkable ingenuity. The development of devices for storing and controlling available water is especially noteworthy. The chronologic framework of environmental change during this modern period is founded on a detailed sequence of pottery types first used in the Southwest 2400 years ago, and on variable growth of tree rings, for which a climate-controlled chronology extends back to just before the Christian era (*81*). The tree-ring chronology of climatic change, based on variable growth of very old bristlecone pines, may eventually embrace the past 4000 years (*82*). Because of proximity to modern times, climatic events of this period are, for convenience, referred to the Christian calendar.

As previously mentioned, agriculture was perhaps restrained by a change to a cool climate immediately after the Altithermal, although this was a time of increased moisture. Village farming was established at some sites by the beginning of the Christian era (*83*). Comparatively dry climate about the time of Christ is inferred from beams of pinyon pine in archeological sites now surrounded by ponderosa pine (*84*). Buildup of alluvium continued, however, and by A.D. 550 valleys were being filled rather rapidly. For example, pit houses of this age are found buried 4½ meters deep at Chaco Canyon in northeast New Mexico (*85*), and similar situations are common elsewhere. The beginnings of town life appeared at this time, as shown by construction of pueblos dependent on farms along alluviated valleys. Alluviation ceased by A.D. 900 in some areas but lasted as late as A.D. 1200 in others (*86*). Pueblos built on the alluvial surfaces contain thousands of beams cut from pine forests that presumably grew nearby, although some of these structures are many miles from existing forests. Because of the growth of towns and farms, and the spread of population under a favorable moisture regimen, the period A.D. 700–1200, the culmination of a thousand years of village life, is commonly regarded as the cultural climax of the prehistoric Southwest. However, diminishing alluviation toward the end of this period probably reflects progressively drier conditions, higher temperatures, and consequent privation. Bones of animals from the southern part of the region that migrated northward between A.D. 1000 and 1100 are found in the village middens (*84*), and at this time elaborate techniques for controlling water—such as check dams, floodwater diversion, and irrigation ditches—became widespread (*87*). At Chaco Canyon a channel 5½ meters deep, containing pottery dating from A.D. 1100, was eroded in the early alluvium (*85*); the resultant lowering of the water table must have had a disastrous effect on farming.

After A.D. 1200, or perhaps a little earlier, the inhabitants of large villages in northern uplands of the Southwest began to abandon their villages in favor of lower sites along larger and more dependable streams. At Point of Pines, Arizona, an upland locality with a long record of agriculture, pollen records show that corn declined and disappeared (*77*), suggesting that crops were no longer cultivated. By A.D. 1500, an agricultural population scattered over 600,000 square kilometers had consolidated in an area of 225,000 square kilometers, most of it south of the Mexican border, and the vacant land was not again settled until shortly before historic times (*76*). Within this period, great aridity is indicated in the tree-ring record from A.D. 1276 to 1299, and it has long been thought that regional drought caused crops to fail. However, a wetter climate is suggested by the expansion of coniferous forests between 1300 and 1500 (*84*), and Woodbury argues that skillful farming and the practice of exploiting various modes of water supply would have mitigated crop losses due to drought (*76*). The real cause of the abandonment of northern upland villages may have been a cool climate and a shortened growing season. Possibly these are the conditions indicated by pollen diagrams of flood-plain sediments of Rio Tesuque near Santa Fe for the period A.D. 1100–1400, which show a high proportion of tree pollen (*88*)—but, as I have said, interpretation of flood-plain pollen is still plagued with uncertainties. At the same time, favorable moisture conditions on the plains of Kansas (perhaps fostered by a cool climate) are indicated by the westward migration of creek-bottom agriculture; trees along valleys were cut for houses at places where trees do not now grow (*79*). A drought on the Plains from A.D. 1439 to 1468 is reflected in Nebraska tree rings (*89*), and at about this time villages along streams of the western Plains were abandoned.

Recent Climatic Change

Tree-ring records from Arizona and New Mexico indicate a drought about A.D. 1600 and also the death of many coniferous trees growing at low altitudes (*84*). It seems unlikely that the death of these trees reflects only a deficiency in winter precipitation, because these conifers depend for growth on frequent summer rains (*90*). In the years 1600 to 1800 forests expanded again around small stands of the older trees (those which flourished between 1300 and 1500) that had survived in sheltered habitats; it is a remarkable fact that most conifers in the Southwest are not older than 350 years, but that a few are nearly twice that age (*84*). On the other hand, tree-ring records from Oklahoma indicate rather constant climate on the plains since 1710, although several short droughts are evident (*91*).

The arroyos so common in the Southwest, which began to form about A.D. 1880, are regarded as partly a consequence of overgrazing after the arrival of white men, but contributing climatic causes cannot be discounted. Arroyo-cutting was accompanied in many places by replacement of grasslands with mesquite scrub (*92*), by a lowering of the water table (*93*), and by a deterioration of native fish faunas (*94*). Modern alpine glaciers reached their maximum extent about 1860 and have been retreating since this time (*58*). Lastly, since 1950, many low-altitude trees in the Southwest have died as a consequence of drought.

Conclusion

In arid parts of America man still struggles to satisfy his need for water. He foolishly mines groundwater inherited from the past, and he has only partly learned to manage present-day water supplies, even though the study of man's response to ancient environment gives lessons for evaluating current practices. Conservation practices in vogue a millennium ago for the efficient use of occasional rain would be beneficial now if they were more widely adopted. By seeking to identify and understand past changes in the landscape, modern man might bring his surroundings under better control. There is much to learn. The earliest men and the conditions they faced in the Southwest have not yet been adequately identified, and the affairs of even the big-game hunters are reconstructed from scant evidence. Did they exterminate Pleistocene animals? Or did these animals disappear because of an elusive biologic cause? Was man driven out of some areas by drought during Altithermal time? Or are the prevailing concepts of Altithermal aridity erroneous? Do anomalous distributions of plants and animals map recent changes in climatic patterns? Or is life more tolerant of extremes than uniformitarian ideas assume? From geologic study of former episodes of alluviation, can men learn to make desert streams run again in grassy floodplains? Or is the climate now too great a hindrance? These are a few of the problems that hinge on the study of early man in arid America.

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