CANADIAN BREAKS

A NATURAL AREA SURVEY
Part VII of VIII

DIVISION OF NATURAL RESOURCES AND ENVIRONMENT

The University of Texas at Austin

PHOTO CREDIT

The full-color frontispiece is by photographer Reagan Bradshaw and represents but a small part of the work he recorded in the course of the Canadian Breaks area survey. Transparencies of all his photos of this and the other four areas have been filed with the Parks and Wildlife Commission. Mr. Bradshaw is one of the finest nature photographers of the Southwest. His work on these five sites is sure to increase public awareness of the need to save and protect.

CANADIAN BREAKS

A NATURAL AREA SURVEY
Part VII of VIII

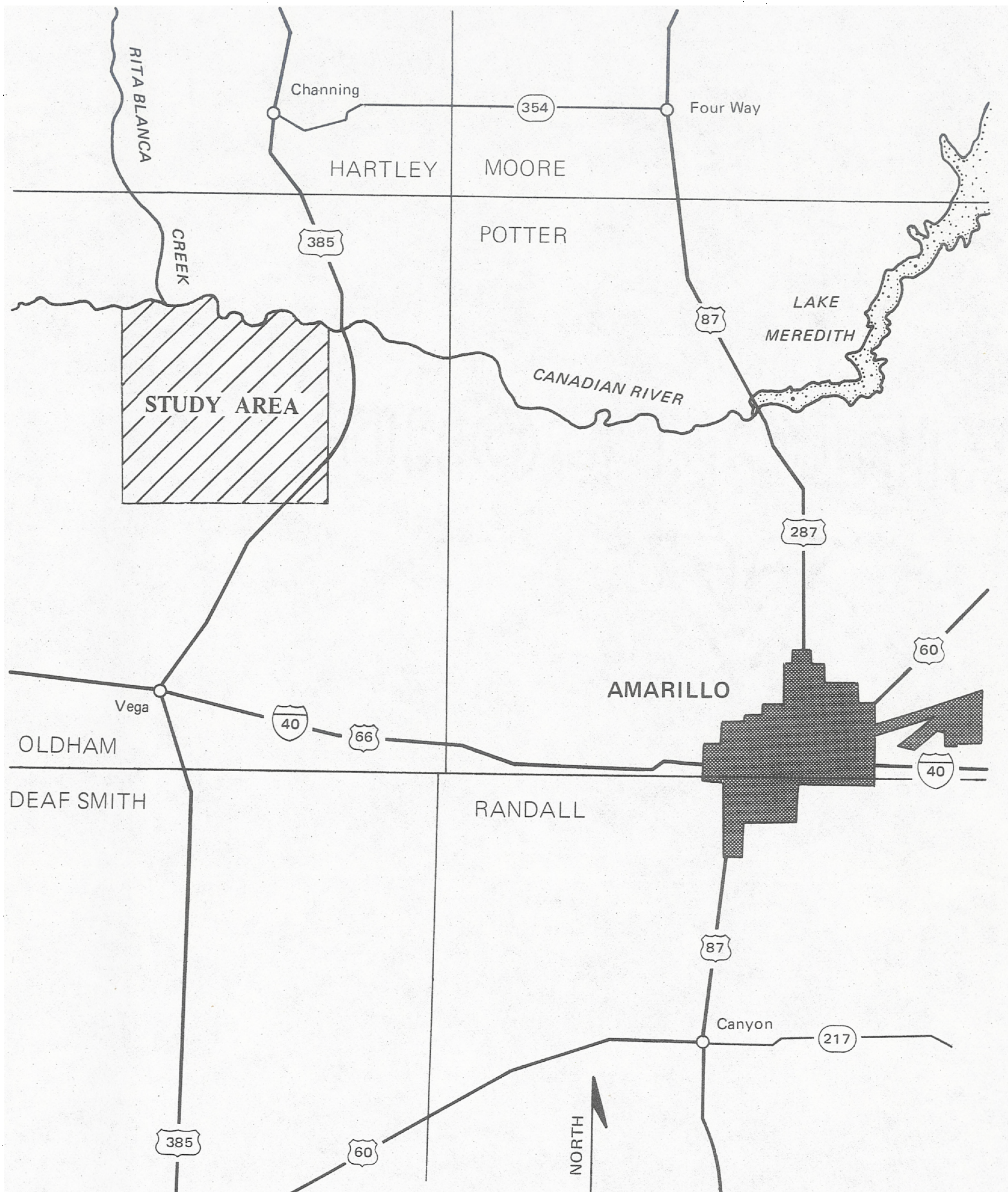
Maps are provided in a separate section.

Prepared for the Texas Parks and Wildlife Department.
Bound separately in 1973 are Part I CAPOTE FALLS, Part II MATAGORDA ISLAND, Part III MOUNT LIVERMORE AND SAWTOOTH MOUNTAIN, and Part IV VICTORIO CANYON. Bound separately in 1975 are Part V BLUE ELBOW SWAMP, Part VII CANADIAN BREAKS, and Part VIII DEVEL'S SINKHOLE AREA – HEADWATERS OF THE NUECES RIVER.

DIVISION OF NATURAL RESOURCES AND ENVIRONMENT

The University of Texas at Austin

1975



LOCATION MAP
FOR
CANADIAN RIVER BREAKS
ALAMOSA CREEK AREA

THE UNIVERSITY OF TEXAS AT AUSTIN
DIVISION OF NATURAL RESOURCES AND ENVIRONMENT
AUSTIN, TEXAS 78712

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May 15, 1975

Texas Parks and Wildlife Commission
Pearce Johnson, Chairman
John H. Reagan Building
Austin, Texas 78701

Dear Mr. Chairman:

The Division of Natural Resources and Environment of The University of Texas at Austin respectfully submits herewith its report, *Canadian Breaks: A Natural Area Survey,* Part VII of VIII, pursuant to the joint request of the Texas Historical Committee, the General Land Office, and the Texas Parks and Wildlife Commission.

Canadian Breaks, like each of the other seven areas – Capote Falls, Part I; Matagorda Island, Part II; Mount Livermore-Sawtooth Mountain, Part III; Victorio Canyon, Part IV; Mount Livermore-Sawtooth Mountain, a supplement to Part III; Blue Elbow Swamp, Part V; Devils River, Part VIII; and Devil's Sinkhole, Part VII – was scientifically and historically surveyed, mapped, and photographed. In addition, current land ownership was recorded and mapped. The project involved the recruitment and direction of a field team of geologists, archaeologists, botanists, zoologists, cartographers, photographers, historians, and landmen.

Texas is a diverse and beautiful land with a rich heritage and abundant natural and scientific wonders that should be preserved for the use and enjoyment of ourselves and of generations yet to come. As your commission pointed out in requesting this survey, the more significant natural areas are disappearing all too rapidly in Texas. It is our hope that the data gathered here will be instrumental in reversing that trend.

Sincerely,

Don Kennard

Don Kennard
Project Director

FOREWORD

The University of Texas at Austin, through The Division of Natural Resources and Environment, conducted this study of five unique and endangered natural areas of Texas as a pilot project to provide basic data for the Governor, the Legislature, and various state agencies in developing a program to protect and enhance these and similar sites for the benefit and enjoyment of ourselves and of future generations.

This is the second Natural Area Survey undertaken by The University of Texas. Previous studies of Capote Falls, Matagorda Island, Mount Livermore and Sawtooth Mountain, and Victorio Canyon were conducted through the Lyndon B. Johnson School of Public Affairs in 1973.

The basic idea for such a program is not new. It is patterned after the National Park Service's Historic American Building Survey (HABS). The HABS program is both an agency continuously studying architecture of historic importance and a notable national collection of documentary drawings, photographs, and written reports which preserve and proclaim the heritage of our man-made environment. HABS was begun in 1933 by architects of the National Park Service with funds from the federal government, and it is now our public record of the building art in America.

This natural area survey project is designed to accomplish basically the same objectives for the recording and preservation of natural sites in Texas. This and subsequent reports will be filed with the Texas Parks and Wildlife Commission.

In Texas there are more than 500 areas of natural, scientific and/or historical significance. Most of these areas may best be preserved through dedicated private ownership; others should be purchased and protected by the state and federal governments. All of them should be systematically recorded, photographed, mapped and scientifically analyzed.

It is our hope that this survey and the establishment of a continuing program will lead to that end.

Don Kennard
Project Director

ACKNOWLEDGEMENTS

Material for this and the other four reports in this series was assembled and edited by Don Kennard. Editorial contributions to the final manuscript were made by Griffin Smith, jr., Attorney and Senior Editor of *Texas Monthly* magazine; Truett Latimer, Executive Director, Texas Historical Commission; Marshall Johnston, PhD., Professor of Botany, The University of Texas at Austin; Dee Ann Story, PhD., Associate Professor of Anthropology and Director of the Anthropological Laboratories, The University of Texas at Austin, and Curtis Tunnell, State Archaeologist.

Color photography was by Reagan Bradshaw. Candy Abshier prepared the layout with the help of Linda Hill, Bill Crim and the staff of the Texas Department of Agriculture. We are indebted to Dr. Keith Arnold, Ross Shipman, and Frances Tisdale of the Division of Natural Resources and Environment, The University of Texas at Austin; Suzanne Winkler, Jeanne Conway, Bob (Rooney) Burnett, Marsha Meredith, and Susan Fieseler for their assistance in handling the multitude of details and arrangements necessary to produce these reports.

It is difficult to acknowledge without omission the time and effort unselfishly given by so many friends of Texas' natural heritage. With a fear that we may have inadvertently missed others, we wish to give special thanks to:

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Dr. Jenny Scholtz, Dr. Jack Hughes, and Mrs. Roberta D. Speer, all of West Texas State University
Stewart Mapping Company
John White, Commissioner of Agriculture

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IMPRESSIONS OF THE CANADIAN BREAKS

Griffin Smith, jr.

Only a geologist could love it. An archaeologist, sifting through its stones to find a weapon that might have ricocheted against a mammoth's skull, can feel excitement for the place; but love? A historian can revere the legions of men who brought their folkways to it and then moved on, leaving it for others; but—panoramic, technicolored—it remains a stage and not an object of affection. A zoologist, a botanist, can search in vain for the extraordinary find, the unexpected living thing that brings a quickening of the pulse; unrewarded, each is left alone with cheerless dry professionalism and feels the disenchantment of a layman. But the geologist, standing in windy solitude, sees something different: a contorted badlands of canyons, buttes, and mesas. Perhaps—depending on his mood and the play of light against the cliffs of multicolored shale—he might even say he loves it.

A snicker would be inappropriate: the geologist is accustomed to fixing his ardor on places that other scientists find devoid of interest, sites whose very barrenness best exposes the uplifts and erosion that made them what they are. The breaks of the Canadian River—a landscape of almost Biblical desolation—suit his purpose admirably. From the level plain of the Llano Estacado northwest of Amarillo they appear first as slight canyons, then as whole eroded valleys lined with vivid colored rock, expanding in scale and majesty as they approach the sandy riverbed. Along the dry arroyos one often finds cut banks composed of 500 or more strata, each perfectly identifiable and distinct even if no more than one-sixteenth of an inch thick, a veritable library of sedimentary history. Higher up, these sandstones give way to several hundred feet of Triassic shales whose wine-hued purples, maroons, and reds are interspersed with white and yellow. Still higher, other sandstones and resistant shales cap the buttes and mesas, leaving grass-topped sentinels to guard the empty valleys.

Few places anywhere belong so completely to the wind. It whines continuously through the canyons at an average velocity of sixteen miles an hour, scattering microscopic red dust over everything and torturing shrubs into stunted parodies of bonsai. The wind is a moody sovereign, intensifying not only the torrid summer temperatures that reach as high as 109°, but also the bitter winters as cold as -18°. It dries the valley floors, leaving salt pans in place of water, and sculpts every ridge and crevice of the rocky walls. There is war here between wind and stone, and the wind is winning.

The sparse vegetation consists primarily of mesquite, bristlegrass, skunkbush, grama, and galleta. Near the bone-dry Canadian River, salt cedars cluster in a dense canopy; on the southern breaks a stand of juniper survives; and along the side canyons, occasional cottonwoods offer protective shade against the beating sun.

It is not a hospitable place for man nor beast. Reptiles like the collared lizard, the checkered whiptail, and the diamondback rattlesnake nevertheless find it congenial, as do coyotes; and birds like Bullock's Oriole regard the cottonwoods as splendid nesting sites. Indeed, the trees may well be the most important zoological aspect of the Breaks, offering valuable shelter that is lacking elsewhere in the Llano Estacado. Otherwise the wildlife is unremarkable, differing little from the Chihuahuan species common to West Texas.

The history of the Canadian River country is as layered as the rocks themselves. Like some constantly recomposing tide, one human society after another has flowed across the plains, leaving behind rich artifacts and richer legends.

The earliest traces suggest that primitive men armed only with atlatls pursued bison, camels, and mammoths here as long ago as 18,000 B.C. Later, and more ingeniously, they drove their quarry into box canyons for the kill, or stampeded the beasts over a convenient precipice.

The region's most impressive prehistoric remains, however, date from the era of the mesa-dwelling Indian farmers who occupied the Breaks from about A.D. 1100 until their civilization was destroyed by drought about 1500. Their architecture and pottery are among the most impressive to be found in Texas. In the Canadian River valley they cultivated pumpkin, maize, beans, and squash with crude stone hoes and other tools, living in communal apartment buildings atop the nearly inaccessible mesas. The finest surviving example of their culture, Landergin Mesa, stands a few miles south of the river. It is almost entirely covered by the remains of a rectangular stone structure comprising numerous rooms; to one side, manos and grinding slabs can still be found. Situated 180 feet above the valley floor and protected by sheer sandstone walls, it offered proximity to farming land, security from marauding enemies, and unobstructed views of distant hunting grounds.

As the climate of the Canadian Breaks grew dryer in the sixteenth century, a new tribe of buffalo hunters–the nomadic Jumanos–infiltrated these abandoned farms. They survived by trading dried meat and hides with their more settled cousins to the west, and it was they whom the Spanish conquistadors first encountered in their futile quest for gold.

Coronado's expedition passed well south of the Breaks, entering Palo Duro Canyon before turning north toward Oklahoma. Not until 1601, when Juan de Oñate followed the north side of the Canadian River searching for the fabled city of Quivera, did European influence arrive. The land was fresher then: "rich in fruits, particularly of infinite varieties of plums, the fruit more numerous than the leaves," Oñate reported to the King of Spain. His men nibbled wild grapes and drank from the many springs that bubbled forth along the Breaks; around them, countless buffalo savored the fine short grass.

To this tranquil country the Apaches soon came, thundering on horseback from the northern plains. By 1650 they had convincingly overthrown the Jumanos and made themselves masters of a territory Spanish in name only. But their domination too was only temporary. From ancestral homes along the Yellowstone River in the northern Rockies, the Comanches poured southward like an equestrian plague, annihilating opposition. By 1725 the land was theirs, though massacres continued as long as straggling Apaches could be found.

A Comanche peace descended upon the Canadian Breaks, not to be broken until 1849 when well-armed convoys of gold-seekers burst through toward California, leaving in their wake disease and slaughtered buffalo. The sullen Indians first traded with, then fought, the interlopers. For a while, amid the distractions of the Civil War, they were successful. It was then, amazingly enough, that Mexican sheep ranchers moved undisturbed into the Breaks, building stone masonry "plazas" and practicing a sly coexistence. The remains of one such plaza can be seen today in a grassy area between Landergin Mesa and the dry riverbed, a weathered heap that once housed an isolated family who unlocked–temporarily–the secret of cooperation with the fierce Comanches.

Their success was fleeting because federal troops finally overcame the Indians, leaving Americans free to descend upon the unspoiled plains where grass, they said, grew tall as wheat. Events moved with kaleidoscopic quickness after Mackenzie destroyed the Comanches' horses at Tule Canyon in 1874. Buffalo hunters like the Moor Brothers came and went by 1879, leaving an eerie silence and a million shaggy corpses. Cattlemen like Goodnight, Pierce, and Loving followed; Pat Garrett and Billy the Kid walked the streets of Tascosa, the jerry-built supply town that sprouted a few miles east of Landergin Mesa. The land, bruised by too many cattle, began to change; grass gave way to gullies; and mesquite seeds, undigested by the grazing herds, sprouted into thickets of thirsty trees that sapped the topsoil dry. In 1886-87, successive drought and polar winter dealt the cattlemen a deadly blow. The Canadian Breaks would never be the same.

By 1887 barbed wire, windmills, and the railroad's arrival outside Tascosa combined to put an end to open range. The great trails, like the Jones and Plummer Trail that crossed the Canadian at Tascosa, were doomed. Even the town itself was passed by, crumbling into ruins while upstart Amarillo prospered.

Later, oilmen came, and ranching accommodated itself to the unromantic reality of feedlots. Less than a hundred years after Mackenzie opened this land to settlement, the raucous pioneer world has been replaced by orderly conservatism. Less than 150 years after white men feared to set foot here, 200,000 Americans occupy the upper Panhandle.

Few, however, venture into the Canadian Breaks, which has distilled into itself the spacious solitude that once spread hundreds of miles beyond its jagged canyons. The many springs are gone, victims of groundwater consumed by distant irrigation. The land is strangled with mesquite, a persistent legacy of overgrazing. The last wave of human civilization to cross the Breaks has scraped them clean; now there is nothing left but the wind and the sculptured rocks.

At night, from the air, the High Plains sparkle with lights, but the Canadian Breaks lie apart:

On the windswept coast of North Africa, near the shabby Libyan town of Tobruk, a stolid windowless building dominates a barren hill. The wreaths inside its bronze doors are gray and withered; only their ribbons are bright. At the four corners of its inner courtyard, the thick walls of somber brown stone are interrupted by iron grillwork, through which one can see . . . nothing but empty desert.

This building is the mausoleum of some 10,000 German soldiers who fought with Rommel and never crossed the Mediterranean again; their bodies are piled within the walls that bear their names. Weeks pass without a visitor. One looks at the tomb and wonders that men should have come so far from home to die, and to such desolation.

On the other side of the world, the Canadian Breaks has that same charnel loneliness: the same dry grit in the air, the same incessant wind speaking in the same low moan. One looks across the Breaks from Landergin Mesa and for a moment the whole human pageant is arrested: a paleo-Indian, arm upraised in vain to block the mammoth's tusk; the mesa-dwelling farmer; shaking the last grains from the scorched maize that nourished his ancestors; the aging Comanche, retelling by firelight the legends that were born in Yellowstone; the bearded Kansas emigré, staring at the frozen carcasses of his cattle and knowing that the ice has killed his dreams as well. Like Tobruk, those who came here called better places home, but their monument is as insubstantial as the red dust that drifts without repose. The pageant has passed across and left behind nothing—except its stones.

The geologist smiles. He knows.

HISTORICAL SURVEY OF THE CANADIAN BREAKS COUNTRY

William A. Ward

The Canadian River, rising in the Raton Pass area of New Mexico, flows south and eastward into the Texas Panhandle, its waters cutting across the vast, treeless prairie of the South Plains known as the Llano Estacado or Staked Plains. In its course eastward across the Panhandle into Oklahoma the Canadian passes through a region whose flat, drab aspect seems an unlikely setting for the varied and often bloody history with which it is associated.

This land, the Llano Estacado, forms one of the most perfect plains regions in the world, extending from the central western part of Texas northward over most of the Panhandle and westward into eastern New Mexico. The area is a giant, irregularly shaped mesa which appears to have been thrust upward out of the surrounding lands and forms a high plateau. The Canadian River forms the northern boundary of the Llano proper, as named during the Spanish period, but the same general type of country extends northward into Canada. The Spanish name Llano Estacado generally is translated as Staked Plain, referring apparently to the fact that on the Llano Estacado it was necessary to stake the horses, there being no trees to which to tie them.[1]

The history of human habitation of this area extends back to the very earliest period of human occupation of North America when the very primitive Pleistocene hunters known as Paleo-Indians stalked such now extinct creatures as the mammoth, mastodon, ground sloth, and giant bison across the grassy plains of the Llano Estacado.

The relics of the earliest of these ancient hunters have been assigned the name Llano complex, with the characteristic artifact being the Clovis point, a long, fluted flint projectile point found from Alaska to the Texas coast. The earliest date for this complex is a tentative 40,000 years ago with the actual age of the carbon sample used exceeding the abilities of the Carbon 14 dating equipment.[2]

The Llano culture was succeeded on the southern High Plains by the Folsom culture, typified by the Folsom point, a technically superior tanged, leaf-shaped fluted point somewhat smaller than the Clovis point. Unlike the Clovis culture which hunted the great elephants, Folsom hunters sought a now extinct form of bison as their chief source of food.[3]

A third hunting culture on the plains was the Plainview culture which also hunted the buffalo. The projectile points used by these people were similar to the Clovis point but not fluted.[4]

In many ways the paleolithic hunters of the plains were similar to the plains tribes of the historic period. Such Indians as the Apaches relied on the buffalo as their staple food, wandering in seasonal rhythms in the path of the herds across the prairie. The historic Indians, however, possessed the bow and arrow, unlike the Paleo-Indians, who had only the atlatl or spear-thrower.

The Paleo-Indian culture waned along with the final withdrawal of the ice sheets and the extinction of many of the hunted animals, such as the mammoth. The relatively few societies or cultures of Paleo-Indians were replaced by the influx of new immigrants, occurring around 5000 B.C., who introduced more advanced techniques of stone technology as well as bone tools.[5]

The new cultures created by this change are referred to as Archaic. They were also hunting and gathering peoples but with more advanced and varied types of tools and domesticated animals such as the dog. The use of the bow and arrow was introduced about the time of Christ, supplanting or at least supplementing the use of the spear-thrower.[6]

These Archaic hunters established a mode of life based around the hunting of the buffalo which remained largely unchanged to historic times, with one major exception—the introduction of the horse. By the eighteenth century the Plains tribes had become mounted hunters and would shortly evolve into one of the world's finest cavalries. The forerunners of the Lipan Apaches or Plains Apaches probably were among the originators of much of the plains culture which was followed by many western tribes during the eighteenth and nineteenth centuries.[7]

In addition to the nomadic hunters another and far more sophisticated group of Indians settled along the Canadian River, becoming one of the great enigmas of Texas prehistory. They were a highly advanced people commonly called the Canadian River Puebloans and identified by archaeologists as the Antelope Creek focus. These people seem to have migrated into the area about A.D. 1100. They appear to have been a hybrid culture, being a mixture of Plains and Pueblo. They apparently originated in the Republican River area of Nebraska and filtered south, assuming aspects of the more advanced Pueblo culture as they migrated. They were settled farmers, planting mostly maize and beans and living in community apartment dwellings as did Pueblos. Their architecture, however, was distinctly different in that instead of building walls in horizontal courses of sun-dried bricks, they embedded flat stones vertically in the dirt in two parallel rows and heaped rubble in between. Sometime about the year A.D. 1400 they abandoned their communities and disappeared, possibly because of severe drought in the area at this time.[8]

The Archaic hunters of the plains, however, had not disappeared but had continued to range across the plains in pursuit of the buffalo, much as they had for thousands of years. The contact they made with the slowly migrating Pueblo peoples eventually altered their way of life with a new culture evolving, one which was an adaptation of both societies to the harsh environment of the region and developing into what is called the Jumano culture. The Jumanos ranged all over West Texas from the Rio Grande to the Concho and as far north as the Canadian River. A portion of the Jumano bands settled into an agricultural Pueblo-type existence, living in multistoried adobe-brick houses. The rest of the Jumanos remained a nomadic hunting people who continued to roam the plains in search of buffalo, bringing the hides and dried meat to trade with the settled Jumanos. It was these settled Jumanos that Cabeza de Vaca referred to as the "cow nation" because of the abundance of buffalo hides and dried meat. According to sixteenth-century Spanish sources, the nomadic Jumanos dominated the country surrounding the upper Red and Canadian Rivers, a position, however, they were soon to lose to the Apaches.[9]

The first European contact with this area was as a result of the tale told by Cabeza de Vaca to the viceregal court in Mexico City in 1536 about a fabulous golden city somewhere to the northwest of his own travels. This story created an immediate sensation and demand that an expedition be launched in search of the city. The viceroy, Antonio de Mendoza, prudently decided to send a reconnaissance party to determine the strength and exact location of the city of gold before he ordered a full expedition. Mendoza selected for this mission Father Marcos de Niza, a Franciscan monk, and as his guide, Estavan, the Negro companion of de Vaca, as well as a few friendly Indians. In 1539 the Marcos party went north into eastern Arizona where Estavan was murdered by Indians, resulting in the hasty return to Mexico by Father Marcos. He did not come back, however, to disappoint the viceroy and the many noble young Spaniards eager for conquest. Instead he related an elaborate tale of having seen the fabled city from a distant hill, whose name, he had been told by an Indian, was Cibola. The walls were of gold, the streets of silver, and the gates studded with precious jewels. He had learned also that there were six other such cities, all greater in wealth than Mexico City. This tale told by Father Marcos paralleled a medieval legend current in Spain and Portugal at that time of the land of the Seven Cities, one of which was Cibola. All were reputed to be of fantastic wealth. Father Marcos transposed, it seems, a European legend into an American reality.[10]

This tale was adequate to what the Spaniards' enthusiam, and a great expedition was organized, consisting of over a thousand men, fifteen hundred horses, a few priests, and scores of camp followers. To lead this great company the viceroy selected Francisco Vasquez de Coronado, one of the higher nobility who had accompanied him from Spain. The expedition departed on February 23, 1540 and headed north toward Pueblo country, reaching the pueblo of Hawikuh on the present border of Arizona and New Mexico which they believed to be Cibola. After a short skirmish the city was taken, with the disappointing discovery that the Cibola of reality was far from that described by Father Marcos. Very unwisely, Marcos had joined the expedition and was sent back to Mexico in disgrace.[11]

Not yet disillusioned, Coronado divided his force, sending two groups west and one group east. The group traveling west discovered the Grand Canyon and the head of the Gulf of California; the group moving to the east located the Pueblo villages on the Rio Grande in New Mexico. Winter quarters were made at the Pueblo of Tiguex on the Rio Grande where the Spanish were approached by an Indian of the plains whom they called Turk because of his headdress and who offered to lead them to another land called Quivera which was incredibly rich in gold and lay beyond the plains to the northeast.[12]

Seeming not to have learned a great deal from his previous experience, Coronado followed the Indian into Texas in the spring of 1541, crossing the Staked Plains and angling north where he descended into the Palo Duro Canyon near Amarillo. With a small detachment Coronado traveled north from the canyon to the Canadian River which he followed into Oklahoma, continuing northward to Kansas and the Arkansas River. Here the Turk proudly showed them Quivera, which turned out to be a series of Indian villages with straw houses near small fields where primitive agriculture was practiced. In disappointment and disillusionment, Coronado returned to New Mexico, but not before he had the Turk throttled. A destitute and very dispirited expedition returned to

Mexico in 1542. The viceroy, Coronado, and a large number of nobles had lost their fortunes in search of the fabled cities of the north.[13]

Some fifty years later another expedition set out in search of Quivera, this one led by Juan de Oñate, commissioned by the viceroy in 1598 to establish a permanent settlement on the Rio Grande. Oñate crossed the Rio Grande at El Paso del Norte, passing through the area of present-day El Paso and following the Rio Grande to an Indian village near present-day Santa Fe where he made his headquarters. Oñate, however, was more interested in gold than settlement and led several expeditions into the unknown regions. On one of these expeditions again in search of Quivera, in 1601, he crossed the Staked Plains of the Texas Panhandle and followed a course parallel to the Canadian River. His march east toward Oklahoma took him through the center of the Apache nation. Upon reaching the vicinity of what is now Oklahoma, he turned north and went as far as the Arkansas River and again found only very poor Indians who lived in a community of several villages which were called Quivera collectively. He then returned with his small force to New Mexico.[14]

For the fifty years following the Oñate expedition the Jumano hunters remained firmly in control of the hunting grounds of the Staked Plains. They then slowly began to lose their hold to the steadily increasing Apaches, who were beginning to flood onto the plains on their newly acquired horses, pushing the Jumano and all others out of the way. It was the Apaches Coronado called the Querechos on his march across the High Plains. The Querechos apparently were the ancestral people of the Jicarillas, Lipan, and Kiowa Apache as well as the prototype for the mounted Indians of the historic period.[15]

These southern plains people were the earliest Indians to begin using horses, an adaptation which made them far more successful as hunters and also turned them into a formidable enemy for the Spanish. The plains Apaches (who were related linguistically to the Athapaskan speakers of the northwest) are called eastern Apaches to distinguish them from the western Apaches of Arizona and New Mexico.[16]

The Spanish attitude toward the Apaches was made very clear, when in 1724 the viceroy ordered Brigadier Pedro de Rivera y Villalon to inspect the northern frontier and advise him of what was necessary to reduce government expenditure while maintaining a strong Spanish presence. One of Rivera's suggestions was that a war of suppression be waged against the Apache Indians who were devastating the frontier. This suggestion was not carried out, however, as it was beyond the resources of the Spanish. It was also not apparent to them that the reason for the intensified pressure on the South Texas Spanish settlements by Apaches was because of the pressure the Apaches were themselves experiencing in the north as a new plains people pushed south into Texas.[17]

These new people were the Comanches, a Shoshone-speaking nation that had lived for generations along the Yellowstone and Platte Rivers in the foothills of the Rockies. At the beginning of the eighteenth century they acquired horses and almost simultaneously became the terror of the plains. In a few decades they had swept south, driving the other tribes before them and creating for themselves complete reign over the South Plains from the Arkansas River to the Rio Grande and from the mountains of New Mexico to the hills of Central Texas. The Pawnee, Wichita, Waco, and other tribes were forced eastward into present-day Texas and Oklahoma. The Utes and Piutes were forced into the mountains of Colorado and northern New Mexico. The Apache nation was sundered with the tribes being driven into northern Mexico and southern Texas. There remained, virtually alone among all the tribes previously hunting on the south Plains, the Kiowa, who had made a loose alliance with the Comanches.[18]

The losses among the Apaches during this period were extremely high, with several of the bands being wiped out and the others scattered. In one legendary battle of 1725 fought on the Red River in the Texas Panhandle the Apaches lost a seven-day battle to the Comanches. After this defeat, the Apaches never again confronted the Comanches but yielded to them their ancient hunting grounds.[19]

The Jicarillos took refuge among the Pueblos, while the other Apaches scattered over the plains. Some, including the Kiowa Apaches, were absorbed by the more powerful Kiowa nation. Others were forced farther south into Texas and Mexico to become the very savage Lipans. By the nineteenth century these surviving elements had produced three somewhat varying tribal cultures: the Jicarillas, becoming Puebloan; the Kiowa Apaches, maintaining their plains identity; and the Lipans, adapting to their changed environment and becoming no longer strictly plains Indians.[20]

At their height there were more than a dozen Comanche bands occupying the newly won hunting grounds. The largest and best known band was the Panatekas or Honey Eaters, the southernmost band who had led the advance onto the southern plains. Another band, the Antelopes or Quahadi, drifted south about the same time and settled onto the Llano Estacado, becoming one of the fiercest of the Comanche bands which constantly raided the Texas frontier. They also were the last to surrender to U.S. domination.[21]

Relations between the Spanish and the northern Comanches of the Staked Plains stabilized in the following one hundred years, with only very infrequent incursions into this area by the Spanish. The relationship with the southern Comanches, however, was one of constant harassment. The northern Comanches were unaffected, for the most part, by the shifting situation to the south as the Spanish empire collapsed and the Mexican republic was born, to be followed by the arrival of Anglo settlers and revolution in Texas. They continued to follow the buffalo across the Staked Plains, and except for sporadic raiding, remained detached from the events to the south.

In 1838 a group of northern Comanches carried out a raid in north Texas against the new Anglo settlement of Parker's Fort and captured Parker's nine-year-old daughter Cynthia Ann, who was taken back to the Canadian River country and raised as a Comanche. She married a chief, Peta Nocona, and had two sons, Pecos and Quanah Parker, the latter becoming the great war chief of the Comanches. On one occasion a trader offered to buy her freedom, but she declined the offer, saying she was happy and had no desire to return to her parents. In 1860 she and her two-year-old daughter, Prairie Flower, were captured. She was claimed by Isaac Parker, her uncle, but never became reconciled to her new life. After trying to escape several times, she died in 1864 at the age of thirty-six.[22]

It was not until the discovery of gold in California in 1849 that the position of the northern Comanche began to change, as thousands of gold seekers flooded west, principally through El Paso. One party, led by Captain Randolf Marcy, followed the Canadian River across the Texas Panhandle. Because the gold seekers traveled in large, well-armed groups, the Comanche refrained from attacking them, choosing to go to their camps to trade instead. There they became infected with diseases and within six months many northern bands were wiped out as epidemics raged through their villages.[23] Gold fever also brought about another discovery. It made it possible for the white man to learn that the Staked Plains were not impossible to cross, and shortly the far-flung wilderness began to attract settlers. As the whites moved onto the prairie, they began to pressure the Comanches the same way the Comanches had the Apaches two hundred years.[24]

The Comanches began to loose ground in other ways as well. The buffalos, their prime source of food and clothing, began to dwindle in number as the result of intensive hunting by whites. The Comanches were also driven from many of the better waterholes by white ranchers, causing their lifestyle to deteriorate rapidly.[25]

In 1849 and again in the early 1850's a series of forts was built to protect the expanding frontier. The later ones, such as Fort Belknap and McKavett, placed heavy pressure on the northern Comanches who were beginning to carry out raids against the settlers on the plains. In 1858, a punitive expedition of some 200 Rangers was sent out by the Texas state government to engage a band of northern Comanches on the Canadian River and decisively defeated them, halting for a time this raiding from the northwest.[26]

The outbreak of the Civil War in 1861 put the Comanches in the advantageous position wherein neither the North nor the South wanted to wage war against them, and as a result they began to increase their raiding activities with a vengeance as they swept into West Texas. Throughout the war thousands of head of cattle were lost and scores of farms and ranches burned. This activity was brought to a head in November of 1864 when a major battle took place between federal troops under Colonel Kit Carson and a large encampment of Comanches and Kiowas at Adobe Walls on the Canadian River.[27]

Adobe Walls had been a trading post which was built in 1843 by one William Bent, but was later abandoned because of Indian hostility and had fallen into ruin, becoming a well-known landmark on the South Canadian River. Kit Carson, a famous mountain man, fur trapper, and guide, was commanding the First Cavalry, New Mexico Volunteers, when he was commanded in 1864 to lead an expedition against the winter quarters of the Comanche and Kiowa Indians, believed to be somewhere on the south side of the Canadian River. This engagement become one of the most successful hit and run raids ever made against a large part of plains Indians. Encamped in several villages along the breaks of the river were some three to seven thousand Indians. With two mountain howitzers Carson and a force of infantry and cavalry numbering fewer than 400 attacked one of the Comanche villages and then retreated into the ruins of Adobe Walls where they forted up and held off successive attacks of Indians, primarily by breaking up the Indian charges with the howitzers. The following morning Carson retreated after burning a Kiowa village and killing scores of Indians. The Comanches were so stunned by this action that they sued the Confederates for peace in February of 1865 to avoid fighting on two fronts.[28]

Immediately following the war, the western frontier of Texas was ravaged as never before by Comanche and Kiowa raids, with hundreds of people killed or captured and tens of thousands of head of cattle stolen. In October 1867, federal agents were at last able to get the Kiowa and Comanche Indians to sign the Medicine Lodge Creek Treaty which established a three-million-acre reservation in southwest Oklahoma and promised annuities or supplies for the Indians. The treaty did not end the raiding on the plains, however, because the government showed no hurry to provide the promised supplies, and also because many of the Comanches and Kiowas had no interest in reservation life, preferring their nomadic existence on the plains. They were also unable to carry on their lucrative traffic of selling looted goods to the Comancheros if they stayed on the reservation.[29]

The Comancheros were whites and Mexicans who traded with the Comanches, carrying on their business in the canyons on the eastern edge of the Llano Estacado, with the leading Comanchero trail going along the Canadian River. Among the Canadian Breaks the Comancheros would meet war bands of Comanches and Kiowas and trade them guns and trinkets for stolen horses and cattle. The Comanchero traffic did not end until the near extermination of the buffalo and subsequent ruin of plains Indian life.[30]

In 1867 and 1868 the War Department reestablished a line of defense in Texas with the older posts being reoccupied and several new ones built. The posts were manned for the most part by inexperienced soldiers, most of them Negroes called "buffalo soldiers." Despite these efforts there was very little abatement of raids because the forts were too far apart to provide real protection.[31]

In 1871 Generals William T. Sherman and Randolf Marcy were almost killed during an inspection of the Texas frontier in an ambush laid for them by Kiowas in a skirmish known as the Salt Creek Massacre. A Kiowa chief named Santana led a band of 150 Kiowas from their Oklahoma reservation into West Texas where they fell upon a wagon train and killed and scalped the teamsters. Sherman, who was inspecting frontier posts and was accompanied by Marcy, had passed the ambush with a small contingent only a little ahead of the wagons, but was not attacked because the Indians thought Sherman would be with the main wagon train. When Sherman found out how close he had come to being scalped, he had Santana and two other chiefs, who had returned to the reservation, arrested, returned to Texas, and tried for murder. As one of his last official acts, Governor Davis of Texas paroled them. This action enraged Sherman, who wrote Davis, ". . .if they are to take scalps, I hope yours is the first. . ."[32] Very shortly Santana was again leading raids into Texas and was again captured and imprisoned in Huntsville where he committed suicide in 1878.[33]

It was Sherman's near scalping that produced an unconditional war against the plains Indians to bring them under control. To this end Colonel Ranald S. Mackenzie was put in command of the Fourth Cavalry and charged with carrying out this policy. In 1871 he led a force of 600 men into the heart of the Comanche stronghold in the canyons of the Llano Estacado. For almost a year the Indians eluded him until a captured Comanchero pointed out the main Indian trails on the High Plains, on one of which he surprised a large Comanche village on the north fork of the Red River and killed twenty-six Indians. These punitive attacks reduced Comanche raiding in 1873.[34]

The last major campaign against the Indians in Texas was undertaken in 1874. The Comanches and Kiowas were advised that the deadline for entering the reservation was August of 1874. The army then moved out onto the Staked Plains in a five-pronged campaign to mop up the recalcitrant diehards. One column went south from Fort Dodge, Kansas along the eastern edge of the Texas Panhandle; another went east from Fort Union, New Mexico; a third was sent west from Fort Sill, Oklahoma; a fourth rode northwest from Fort Griffin; and a fifth column, composed of the Fourth Cavalry under Colonel Mackenzie, rode out from Fort Concho and up the eastern escarpment of the High Plains. There were some three thousand soldiers employed in this operation which easily snared the remaining Indians. Only one significant skirmish occurred when Mackenzie's troopers, guided by a Comanchero, surprised an encampment of Comanches led by Quanah Parker in Palo Duro Canyon and scattered them after a brief fight. He also captured their 1500 head of horses which he ordered to be shot, thus throwing the Indians helplessly afoot. They were then rounded up and taken to the reservation. This operation netted all except a few hundred of the hostile Indians, and by the summer of 1875 all but an estimated 50 or so had straggled dejectedly into the reservation. In this operation the Comanche and Kiowa menace which had existed for 150 years to the settlements in Texas was finally broken, as the Comanche nation's long domain of the prairies was finally ended.[35]

The army was not the only element responsible for the defeat of the plains Indians. A handfull of buffalo hunters with their .50 calibre Sharps rifles steadily depleted the Indian source of food, leaving them no recourse but to go on the reservations. There were at this time, two great buffalo herds roaming the prairies, one of which grazed on the northern plains and the other on the southern plains. The slaughter of these two herds did not begin in earnest, however, until after the Civil War when the transcontinental Union Pacific Railroad was being built and employed hunters to provide the laborers with fresh meat. Soon the value of buffalo hides encouraged the hunters to kill, not for the meat but for the hides alone. Very shortly bands of professional hunters spread down into the Staked Plains and began ravishing the southern herd of buffalo.[36]

Among the first of the hunters were Bob and Jim Cator, who entered the northern Panhandle in 1872, and the Moor brothers who began hunting the breaks of the Canadian River in 1873, followed by George Causey, who hunted in the Palo Duro Canyon. The Moors were so successful that scores of hunters were attracted to the Panhandle. In 1874 a large hunting expedition was financed by businessmen in Dodge City, an expedition which included such youthful hunters as Billy Dixon and Bat Masterson. The hunters established their camp near the ruins of Adobe Walls, giving their tent camp that name. Shortly, a small community began to grow with the building of several stores and a saloon. The little settlement was short lived, however, because in June of 1874 a force of 700 Comanches and Kiowas swarmed down on it, beginning the Second Battle of Adobe Walls.[37]

On the Oklahoma reservation late 1873 a young Comanche warrior named Ishatai, or Coyote Droppings, had a dream in which he claimed to have communed with the Great Spirit. When to told his village of this, they were awe-striken. The desperate situation the Comanches were in caused them to grasp at the prospect of a messiah, and with this purpose they rejected their chief and installed Ishatai in his place. Messengers very quickly carried word of his vision to the other bands, and they soon were also convinced that only by following Ishatai could they regain their former glory.[38]

During the following spring Ishatai had another vision which told him that if all the Comanches would gather for a Sun Dance, they would be told how to regain their power. In May of 1874, for the first time in the history of the tribe, the Comanche gathered together, joined by Kiowas and Kiowa Apaches. There, after a period of dancing, Ishatai told them that if they took to the warpath in one massive raid, they could drive all the whites out of the land of the Comanche, known as the Comancheria. After that was done, the buffalo would return in even greater numbers, and all would be right again. On hearing this, the people worked themselves into a frenzy, and some 700 warriors led by Quanah Parker mounted their ponies and rode off to begin this war of extermination, and their first target was the little camp of buffalo hunters on the Canadian River near the ruins of Adobe Walls.[39]

Trapped inside the few buildings were twenty-eight men, mostly buffalo hunters, and one woman. At daybreak on June 24, 1874 the Indians launched a mass attack which was beaten off by the heavy, long-range .50 calibre buffalo guns which were capable of blowing off an arm. Repeatedly that day and for the following two days the Comanches attempted to storm the buildings but failed, losing scores of warriors with the loss of only four whites. It was then that the fight degenerated into a final two-day siege, with the Indians withdrawing out of gunshot range but keeping the town under constant watch. It was during this siege that Billy Dixon made his famous record shot when he killed an Indian on horseback nearly a mile away.[40] The realization that a handful of white hunters had repulsed a powerful Comanche warband was a terrible blow to the pride of Quanah Parker and the Comanches. Badly disillusioned and furious at Ishatai for misleading them, they broke off the siege on the fifth day and rode away. The little company of whites had by that time also increased to nearly a hundred, as buffalo hunters came riding in from all directions to help.[41]

Many of the Indians returned to the reservation, but Quanah Parker rallied many to stay with him and continue to struggle. In the following weeks he conducted a hit and run war, taking refuge finally in the steep-sided Palo Duro Canyon. It was there that Colonel Mackenzie found him and his band and destroyed his camp. Parker managed to escape with a small remnant of his band, but by the following spring—starving and in rags—they came back to the reservation, ending (for the most part) the Comanche threat on the prairies.[42]

During the next four years the great buffalo hunt continued, with frequent skirmishes between the hunters and small bands of Indians, the last significant one occurring in Yellow Horse Draw near Lubbock in 1877. By 1879 the big hunt had ended. The buffalo had become almost extinct. It was this disappearance of the buffalo that made possible the containment of the Indians on the reservations. It also opened the Great Plains to the cattle industry, as cattle were not able to compete for grass with the larger buffalo.[43]

After the containment of the Indians and the slaughter of the buffalo, ranchers immediately pushed into the West Texas area. These early ranchers were called free rangers because they used the free grass of the public lands. Some of the earliest ranchers to move onto the newly acquired public domain were Charles Goodnight, former buffalo hunters J. W. Moor and Jim Cator, Abel H. "Shanghai" Pierce, and Oliver Loving. Free-grass ranching quickly spread from Texas into New Mexico and then into other western states. By the end of the trail-driving era, ranchers operating in the Texas style on free grass stretched all of the way into Saskatchewan and Alberta.[44]

When the land in the public domain was put on the market, most of the free rangers acquired title to as much of their former pastureland as they could. The state's policy of granting five-year grass leases on the land set aside for the permanent school fund at a few cents an acre provided the incentive for vast influx of out-of-state investment from the east and England. By 1885 over half of the land and cattle in West Texas was controlled by out-of-state cattle companies, many of which were British. Hundreds of ranches, ranging from a few sections to thousands of acres, were established at this time. Some of the more famous spreads of the Llano Estacado were the J A, the Matado, and the XIT.[45]

The J A Ranch was started by Charles Goodnight with assistance from an investor named John Adair. Goodnight purchased a herd and drove it into Palo Duro Canyon in 1875, utilizing the steep canyon walls to contain the cattle and thereby avoiding the need for line camps and line riders to keep the stock from straying except at the mouth of the canyon. Goodnight quickly became the epitome of a Texas cattle baron, and when the ranch was divided between Goodnight and Adair's widow twelve years later, the spread consisted of some 700,000 acres, 40,000 head of cattle, hundreds of miles of fences and roads, and fifty houses.[46]

Goodnight, who had leased vast acres of public lands, became the champion of the other ranchers in what was known as the Panhandle Grass Lease Case, in which the cattlemen lost the right to renew their five-year leases. Goodnight loaded a wheelbarrow with money and pushed it from an Austin bank to the General Land Office, demanding that the State renew his lease. He made national news again when he established what he called a "Winchester Quarantine" on his ranch to keep out trail drives infected with the Texas fever, the quarantine to be enforced with Winchester rifles. In 1890 Goodnight sold his half of the ranch and spent the rest of his life operating a small ranch at Goodnight, Texas, dying in 1929.[47]

The Matador Ranch was perhaps the greatest ranching operation in Texas or American history. In 1878 a free ranger operating out of a buffalo hunter's dugout in Motley County was bought out by A. M. Britton and H. H. Campbell, who formed the Matador Cattle Company. In 1882 they in turn were bought out by a Scottish firm which formed the Matador Land and Cattle Company of Dundee, Scotland. From 1882 to 1952 the Scottish firm operated the ranch, never failing to pay its stock dividend. It was the only ranching concern in the state to have survived the multiple perils of panic, drought, and depression without benefit of oil revenue or land speculation. At its height at the turn of the century the company maintained five pastures: 300,000 acres leased in Carson County, 200,000 purchased from the XIT Ranch on the Canadian River, 500,000 acres leased on the Sioux reservation in North Dakota, and 150,000 acres in Saskatchewan. The main office of the ranch was at Trinidad, Colorado. In 1952 the ranch was sold to an American syndicate, Lazard Brothers.[48]

The XIT Ranch was the largest contiguous spread in North America, containing some 3,250,000 acres and extending along the western boundary of the Panhandle for over 150 miles. The ranch brand supposedly represented the ten counties included in the ranch, i.e., X for ten, followed by I (in), and T(exas). The origin of the XIT and its 3,250,000 acres came about as a result of the grant of this land by the State of Texas to the Capitol Syndicate, the firm which built the capitol building in Austin. The legislature lacked sufficient funds to build the structure and decided instead to use lands in the public domain to entice a builder. For this purpose 3,000,000 acres of land were authorized for this purpose in 1876. No action was taken, however, until the old capitol was gutted by fire in 1881. A contract was then awarded to Mattheas Schnell of Illinois, who agreed to accept land in lieu of money, with his plan being to realize his profit later upon the sale of the land. Schnell turned to Chicago bankers for his financing and transferred to them three-fourths interest in the project. The bankers then organized themselves as the Capitol Syndicate and began construction of the capitol in 1883.[49]

A long series of frustrating and costly delays followed, involving a construction change from the use of limestone to granite, a prolonged labor dispute over the use of Scottish stone masons, and a disagreement over the type of roof to be used. The syndicate did not want to use copper for the roof because the Texas heat would make it expand and then leak, but Attorney General Hogg insisted that the roof be sheathed with copper. In May of 1888 the building was dedicated, but unfortunately it rained and predictably the roof leaked, and as a result the State refused to accept the building. The syndicate protested this action as being unfair, stating that they had already warned that the use of copper would cause this result. The State, however, refused to accept the building until it was reroofed with slate. The venture had proven so costly by this time that the syndicate had to sell bonds in England through a London firm called the Captiol Freehold Land and Investment Company which took a lien on the land to be transferred to the Capitol Syndicate. In the end, the total cost of the building, not including interest, slightly exceeded $3,000,000. The syndicate, in effect, had paid approximately $1.00 per acre for land selling at no more than 50 cents an acre. Unable to sell the land except at a loss, the syndicate embarked on a large-scale ranching operation to recover its money, which it continued for nearly a decade before beginning to sell the land.[50]

Most of the land was sold in very large tracts to other ranchers, but some of it was broken into smaller tracts for sale to settlers as the frontier moved west. The Capitol Syndicate thus became one of the biggest promoters of settlement of the Llano Estacado. Before its breakup, the operation of the ranch was enormous. It has some 6,000 miles of fence and hundreds of windmills and had become famous for ordering its supplies by the boxcar load.[51]

The cattle of these great ranches were moved to market and other grazing areas over a multitude of cattle trails, with the beginning in 1866 of a steady northward movement of some ten million cattle and one million stock horses, requiring 40,000 cowboys to effect their movement.[52]

The major trails used in the region of the Canadian River were the Western Trail and the Jones and Plummer Trail. The Western Trail was the principal route for Texas cattle going to northern ranges and Dodge City after 1876. One route of this trail went through Collingsworth, Wheeler, and Hemphill Counties, crossing the Canadian River at the present town of Canadian. It then turned north, merging with the other trails before reaching Dodge City.[53]

The Jones and Plummer Trail began as a route used by buffalo hunters and freighters carrying buffalo hides to Dodge City. It later went through Tascosa when a trading post was built there. By the 1870's it was used to move cattle to Dodge City until 1885 when the Kansas quarantine law of that year diverted Texas herds around that state. After 1885 the trail was shifted to Colorado and Montana.[54]

A smaller trail in this area was the Chisum Trail to Tascosa. This trail brought cattle from John Chisum's ranch near Portales, New Mexico to Tascosa where the herds struck the Jones and Plummer Trail to Dodge City. Another trail from Fort Sumner, New Mexico to Tascosa was also called the Chisum Trail.[55]

Tascosa, in northeastern Oldham County, and located on a ford of the Canadian River, was one of the major junctions on cattle drives north during the 1870's and 1880's, as well as the main shipping and supply point for ranches in the area, such as the XIT. At this time it was called the Cowboy Capital of the Plains and developed a very quick reputation for violence. Such personalities as Billy the Kid and Pat Garrett frequented it as it was one of the few towns in that region. In 1887 the Fort Worth and Denver City Railroad built a line across the county some two miles for Tascosa and the town was then virtually abandoned as business moved to the railroad line.[56]

At the time the Fort Worth and Denver City was being built through this region, a construction crew established a tent camp in Potter County which was dubbed Rag Town. It was shortly combined with the small settlement of Oneida to become the town of Amarillo, named after a nearby lake. By 1890 Amarillo was one of the largest cattle shipping points in the world, with later development based around oil refining and oil shipping.[57]

In 1883 a serious labor dispute broke out in the Tascosa area when the Cowboy Strike was fomented, and continuing to one degree or another for over a year. In March of 1883 some 325 cowboys from seven ranches went on strike for better wages. The organizer of the strike was a certain Tom Harris, who was himself a small rancher and not a hired man. He organized a meeting with some of the cowboys in a dugout near Tascosa where it was agreed they should strike for $50.00 a month. They also demanded, at his instigation, that small herd owners be allowed to run their cattle on the ranch, which expressed the anger of small ranchers who were being shut out of the spring roundup by the large companies. The strike was broken up finally by lack of money, the death of Harris, and the intercession of the Texas Rangers.[58]

In the mid-1880's there began a steady movement of settlers and farmers onto the plains. Their progress westward after the end of the Indian troubles had been hampered by the aridity of the area as well as the problem created by free-grazing stock. These problems were shortly alleviated by the development of windmills to pump underground water to the surface, barbed wire fences to contain the cattle, and dry-farming techniques to compensate for insufficient moisture. With these developments, the line of settlement steadily moved across the prairie until by the turn of the century the Texas frontier was gone.[59]

Two major problems which faced the cattlemen and homesteaders at this time were those of fence cutting and cattle rustling. The enclosure of the grazing land with the introduction of barbed wire in 1881 brought an end to the open range by 1890. There developed as a result, however, a series of clashes between free-grass, landless cattlemen and those cattlemen who had leased their land from the public domain and had begun fencing off their leased areas. The farmers were affected also, because in some cases the ranches would completely enclose the homestead of a settler as well as block access to rivers and watering places, public roads, and even schools and churches. This process was also carried on by the new settlers who would file on a piece of public land which had the only waterhole for miles around and fence it off. The result of such activity was a rash of fence cutting in the mid-1880's which prompted a special session of the legislature to enact legislation against this practice after an estimated twenty million dollars in financial loss had been incurred by fence cutting. It was, therefore, made a felony to carry wire cutters on one's person, which proved to be an almost unenforceable statute and one which is still state law. Laws were also enacted, however, which provided that no one could be denied entry or exit from his property, and gates were required every three miles.[60]

A problem even more serious concerned the level of cattle rustling and brand changing. The cattlemen formed organizations to hire their own brand inspectors, and a few of the larger outfits hired small, private armies to patrol the range. The XIT ranch had such a massive problem that it hired ex-Ranger Ira Aten and some of his cohorts to patrol against rustlers.[61]

By the late 1880's the ranges had become greatly overstocked, and the ranchers had overinvested in fencing, wells, and windmills to such an extent that their margin of profit was very narrow. A severe drought in 1886, followed by a severe winter and then a sharp drop in cattle prices in 1887, brought the cattle industry of the Canadian Breaks to near ruin. Countless ranchers went bankrupt, and scores of big ranches were broken up. Those who survived began to adapt their operations to the closed range where they thinned their herds and upgraded their stock by importing purebred bulls. By reducing their herd size to a more realistic average of one steer to twenty acres and planting feedcrops for winter forage, they were able to recuperate and strengthen their chances of survival during future difficult times.[62]

By the late 1880's the railroads had also cut through the area with direct rail service to Fort Worth and its great stockyards, the Fort Worth and Denver City line having completed a line across the Panhandle by 1887. This brought to an end the era of the great cattle drives north.[63]

The panic of 1893 shook the cattlemen hard again, with a few more ranches going under. But following this, the industry stabilized. By the turn of the century most of the ranches had been reduced to a size that could be handled by a single family, the average ranch being about six to ten sections of land. There remained however—as today—several large ranches which, with their vast reserves, have been able to survive droughts and depressions, most of them profiting enormously from the later discovery of oil.[64]

One of the largest oil and gas discoveries in the area was made in 1916 by Charles N. Gould near Amarillo and later called the Panhandle Field. Continued exploration disclosed the tremendous extent of the field which had an average width of twenty miles, broadening to over forty miles in the north, and stretching for 115 miles. This field became the largest single producing gas field in the world, and its northeast flank became a significant oil producer. By 1927 two other fields were producing in the area, the South Pampa Field and Borger Field, providing a total Panhandle production of forty million barrels of oil a year, which has continued to the present, declining to some thirty million barrels by 1950.[65]

The Borger Field was developed by A. P. Borger, who built the town of Borger in March of 1926 on the South Canadian River. The lure of oil plus elaborate advertising brought in some 45,000 people within eight months. Very shortly a boom town developed with boom shacks lining a three-mile-long main street. At the end of the boom in 1929 the Rangers and local police were used to rid the town of most of the boomers.[66]

During the depression the situation in the Panhandle became little short of desperate as widespread droughts cut into production. A number of ranches had by this time been subdivided and sold to farmers on the installment purchase basis. The depression, along with dust bowl conditions, however, ruined most of these farmers. Two land companies in the area tried very hard to help the farmers by not foreclosing on the farms unless they were abandoned. One large ranch, the Spade Ranch, even remitted interest payments one year to help the farmers.[67]

With the end of the depression and World War II, the region began to recover. Following the war the Panhandle continued to diversify with new industries based around oil and gas, such as petrochemicals and synthetic rubber. Near Borger the largest pumping station in the world was built to pump natural gas west to Denver and east to Indianapolis, and at Amarillo a helium extraction plant was built which for a number of years was the sole producer of commercial helium in the world.[68]

It is seen, therefore, that this region of flat, treeless expanse and seemingly infinite prairie, cut open by the jagged, eroded breaks or canyons of the Canadian River, has been the arena for some of the most colorful and dramatic events in Texas history: It has been witness to the age of the mastadon and Folsom hunters; the Spanish Conquistadors driven by their greedy vision of golden cities waiting to be plundered; the tragic and total destruction of the proud Plains

Indians and their nomadic lifestyle; the very turbulent and colorful age of the frontier with its gunfighters and cattle barons; and finally the large, complex centers of concrete built from the wealth obtained by extracting from beneath the earth the viscous, foul-smelling residue of ancient sealife, these cities' twentieth-century towers of stell and glass rising impetuously over a land whose soil has long been stained with the blood of ancient tragedies and long-forgotten triumphs.

FOOTNOTES

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25. Ibid., p. 116.
26. Conner, p. 169.
27. Ibid., p. 241.
28. Ibid., p. 243.
29. Ibid., p. 244.
30. *Texas Handbook,* p. 386.
31. Conner, p. 244.
32. Ibid., p. 245.
33. Ibid.
34. Ibid., p. 246.
35. Ibid., pp. 246-247.
36. Ibid., pp. 247-248.
37. Ibid., p. 248.
38. Place, p. 126.
39. Ibid., p. 126.
40. Ibid., p. 127.
41. Conner, p. 248.
42. Place, p. 128.
43. Conner, p. 248.
44. Ibid., pp. 254-255.
45. Ibid., p. 255.

46. Ibid., p. 250.

47. Ibid., p. 256.

48. Ibid.

49. Ibid., p. 257.

50. Ibid., pp. 294-296.

51. Ibid., p. 257.

52. *Texas Handbook*, p. 316.

53. Ibid., p. 886.

54. Ibid., p. 928.

55. Ibid., p. 343.

56. Ibid., p. 708.

57. Ibid., p. 39.

58. Ibid., p. 429.

59. Conner, p. 260.

60. Ibid., p. 263.

61. Ibid.

62. Ibid., pp. 265-266.

63. Ibid., p. 266.

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65. *Texas Handbook*, p. 331.

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SOIL ASSOCIATIONS OF ALAMOSA CREEK

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INTRODUCTION

The soils of the study are in two distinct kinds of topography. The southern part is a smooth, nearly level to gently sloping tableland known as the High Plains. The mean elevation above sea level is about 4,000 feet. Bordering the High Plains on the north is the Rolling Plains which is known locally as the "Canadian Breaks." This area is well dissected by local streams and much is steep, rough, and broken. The elevation at the northern end of the study is about 3,200 feet above sea level.

The soils of the High Plains have developed in an eolian mantle under a native short grass cover. The soils of the Rolling Plains have formed in parent materials from several sources. Some have formed on colluvial footslopes below the High Plains, while others have developed in reworked redbed materials.

Much geologic erosion is evident in the steep, broken areas. The soils in these areas are very shallow and in some instances the raw shale, siltstone, gravel or sandstone is exposed.

There are eleven soil associations in the study area of Alamosa Creek from its beginning on High Plains to its confluence with the Canadian River. These are given on the General Soil Map of the Alamosa Creek which is figure 1. The numbers of each association correspond to numbers of the areas in figure 1.

SOIL ASSOCIATIONS OF ALAMOSA CREEK

1. Pullman Association
2. Estacado – Posey – Berda Association
3. Potter Association
4. Mobeetie – Acuff – Amarillo Association
5. Bippus – Spur Association
6. Tascosa Association
7. Knoco – Glenrio – Badland Association
8. Quay – Montoya Association
9. Burson – Stony rough broken Association
10. Quay – San Jon – Latom Association
11. Clairemont – Mangum Association

A. NEARLY LEVEL TO GENTLY SLOPING SOILS OF THE HIGH PLAINS

1. Pullman association–Deep, well drained, very slowly permeable, noncalcareous, loamy soils that have clayey subsoils.

This association occupies an almost featureless plain dotted with numerous circular basins that collect runoff water from heavy rains and form intermittent lakes, or playas.

Pullman soils are on nearly level to gently sloping broad plains and comprise about 75 percent of the association. The remaining 25 percent is made up of Estacado, Posey, and Randall soils.

Estacado and Posey soils occupy the sideslopes of the basins, and Randall soils occupy the floor of the basins.

The Pullman soils have a dark brown, neutral, surface layer about 6 inches thick. The subsoil, to a depth of 38 inches is a brown, mildly alkaline, clay. The next 14 inches is a reddish brown moderately alkaline, clay loam. The lower part, extending to a depth of 78 inches is a pink, moderately alkaline, silty clay loam, that contains about 50 percent calcium carbonate.

This association is used primarily for cropland for which it is well suited. It is both dry-farmed and irrigated. The principal crops grown are grain sorghum and wheat. A few small areas are used as rangeland which support a dense stand of short grasses such as blue grama and buffalograss. These soils are well suited to use for rangeland and wildlife. Natural fertility of these soils is high. The surface layers of these soils are fairly easy to work with hand tools.

B. NEARLY LEVEL TO STEEP SOILS OF THE ROLLING PLAINS

2. Estacado-Posey-Berda association–Deep, well drained, moderately permeable, calcareous, loamy soils that have loamy subsoils.

This association occupies nearly level to moderately sloping slopes above, and to some extent below, the caprock escarpment.

Estacado and Posey soils are on nearly level to gently sloping plains and have formed in eolian mate-

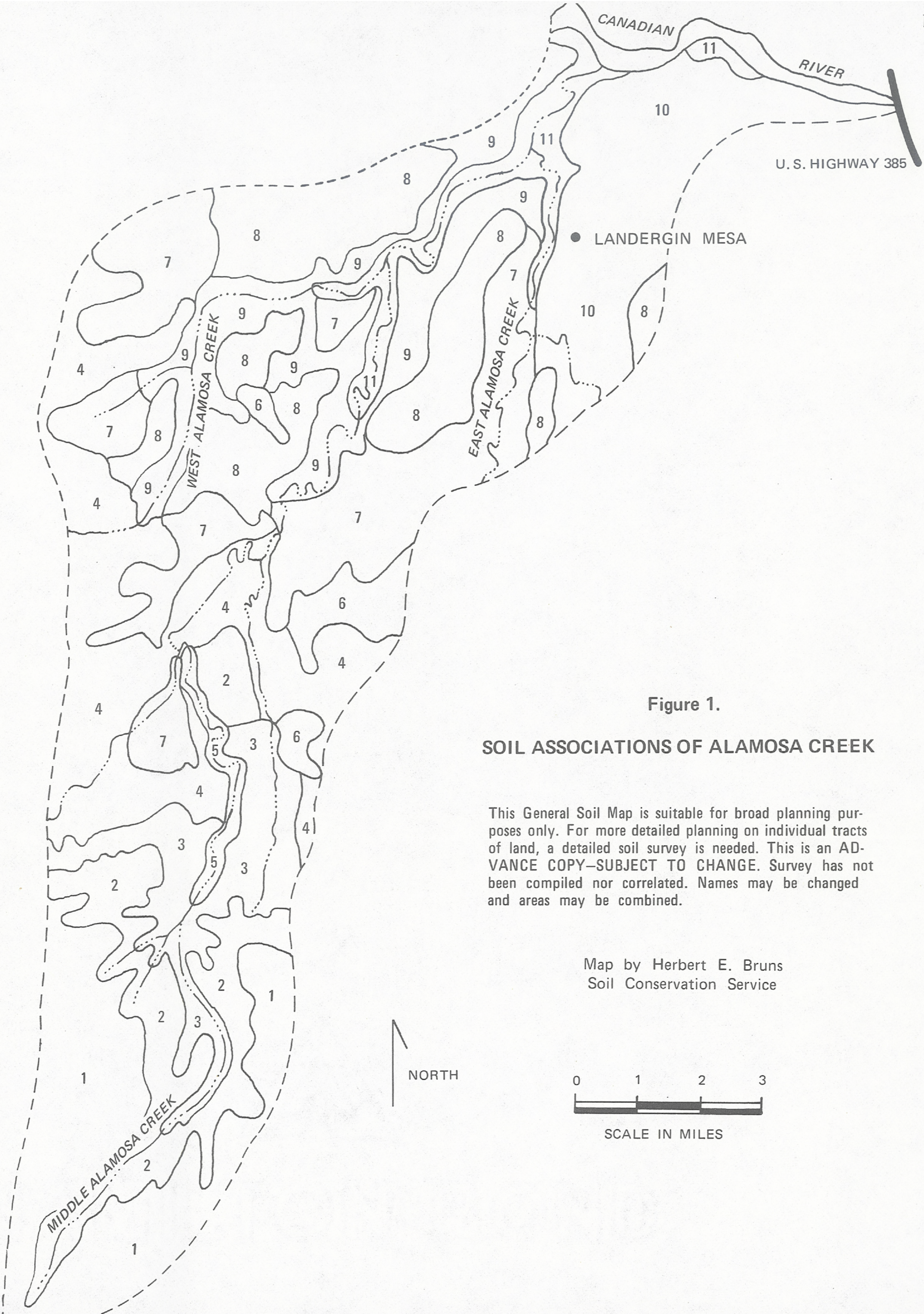

Figure 1.

SOIL ASSOCIATIONS OF ALAMOSA CREEK

This General Soil Map is suitable for broad planning purposes only. For more detailed planning on individual tracts of land, a detailed soil survey is needed. This is an ADVANCE COPY—SUBJECT TO CHANGE. Survey has not been compiled nor correlated. Names may be changed and areas may be combined.

Map by Herbert E. Bruns
Soil Conservation Service

rials. Berda soils are formed in colluvial materials on moderately sloping to steep footslopes. The Estacado soils make up 40 percent of the association. The surface layer is very dark grayish-brown calcareous clay loam about 12 inches thick. Below this is a layer of brown calcareous clay loam about 18 inches thick. The next layer is reddish-yellow calcareous clay loam about 20 inches thick. The next layer is pink calcareous clay loam about 12 inches thick. This is underlain by a layer of brown calcareous clay loam to about 80 inches that is reddish-yellow in the lower part. Posey soils make up 25 percent of the area. The surface layer is reddish-brown calcareous clay loam about 9 inches thick. Below this is a layer of yellowish-red calcareous clay loam about 12 inches thick. The next layer is light reddish-brown calcareous clay loam about 18 inches thick. This is underlain to about 80 inches by yellowish-red calcareous clay loam. The Berda soils make up about 20 percent of the association. The surface layer is calcareous brown loam, about 7 inches thick. The next layers over 70 inches thick, are calcareous reddish-brown clay loam. The remaining 15 percent is Olton, Acuff, Tulia, and Mansker soils.

This association is used for rangeland and wildlife for which it is well suited. These soils support a dense stand of mostly short grasses of blue grama and buffalograss with traces of sideoats grama, wild alfalfa, yucca, and broomweed. Natural fertility of these soils is moderate to high. The surface layers of these soils are fairly easy to work with hand tools.

3. Potter association—Very shallow, well drained, moderately permeable, calcareous, loamy soil, over thick caliche beds.

This association occupies the gently sloping to steep area along the "caprock" escarpment.

The soil areas are adjacent to the High Plains and are characterized by caliche outcrops.

Potter soils comprise about 60 percent of the association. The remaining 40 percent is made up of Mobeetie, Berda, Posey, and Tulia soils. Mobeetie and Berda soils are on the lower slopes, below the "caprock." Posey and Tulia soils occupy the higher areas.

Potter soils have grayish brown, calcareous, gravelly loamy surface layers about 9 inches thick. The underlying material to a depth of 30 inches is weakly cemented platy caliche which is 60 to 80 percent calcium carbonate.

This association is used primarily for wildlife and range. These soils are poorly suited for rangeland. The native vegetation consists of sparse stands of short and mid-grasses such as sideoats grama, little bluestem, blue grama, and hairy grama. This association is poorly suited for openland wildlife. These soils have no potential for cultivation.

4. Mobeetie-Acuff-Amarillo association—Deep, well drained, moderately rapid and moderately permeable, calcareous and noncalcareous loamy soils that have loamy subsoils.

This association occupies gently sloping to moderately sloping plains.

Mobeetie soils are colluvial soils derived from moderately sandy calcareous sediments of reworked Ogallala formation and eolian mantle admixed. The Acuff and Amarillo soils are on the more stable landscape of the upper Rolling Plains.

The Mobeetie soils make up about 35 percent of the association. The surface layer is grayish brown, calcareous brown fine sandy loam about 9 inches thick. The next layer is calcareous brown fine sandy loam about 16 inches thick. Below this, to a depth of about 80 inches, is calcareous light brown fine sandy loam. The Acuff soils make up about 20 percent of the area. The surface layer is dark brown neutral sandy clay loam about 10 inches thick. The next layer is reddish-brown neutral clay loam about 16 inches thick. This is underlain, to a depth of about 80 inches by pink calcareous clay loam, the lower part of which is yellowish-red in color. The Amarillo soils make up about 15 percent of the association. The surface layer is brown, mildly alkaline fine sandy loam about 8 inches thick. The next layer is dark brown, mildly alkaline sandy clay loam about 10 inches thick. The next layer is reddish-brown, mildly alkaline sandy clay loam about 8 inches thick. The next layer is yellowish-red, moderately alkaline to calcareous in lower part sandy clay loam about 19 inches thick. The next layer is pink calcareous clay loam about 20 inches thick. This is underlain by yellowish-red calcareous clay loam to 80 inches. The remaining 30 percent is made up of Veal, Berda, Posey and Olton soils which are intermingled at random in the association.

This association is used for rangeland for which it is well suited. These soils support a dense stand of short and mid-grasses. The predominant vegetation is blue grama, buffalograss, little bluestem, sand sagebrush and species of yucca with a light overstory of mesquite. The soils in this association are well suited for openland wildlife. Natural fertility of these soils is moderate to high. The surface layers of these soils are fairly easy to work with hand tools.

5. Bippus-Spur association—Deep, well drained, moderately permeable, calcareous, loamy soils that have loamy subsoils.

This association occupies nearly level to moderately sloping floodplains in the upper Rolling Plains.

Bippus and Spur soils are alluvial soils formed in loamy materials along streams.

The Bippus soils make up 50 percent of the association. Bippus soils have a surface layer of dark grayish-brown clay loam about 23 inches thick. The next layer, about 36 inches thick, is brown clay loam. The underlying material, to a depth of 83 inches, is brown clay loam. Spur soils make up 35 percent of the association. Spur soils have a surface layer of calcareous, dark grayish-brown clay loam about 19 inches thick. There are 2 inches of recently deposited, brown clay loam on the surface, and brown layers are within this layer. The layer beneath the surface layer is calcareous, brown clay loam about 29 inches thick. The underlying material, to a depth of about 80 inches, is brown sandy clay loam.

The remaining 15 percent of the association is mainly made up of the channel that is riverwash, a miscellaneous land type.

This association is used for rangeland for which it is well suited. The soils support a dense stand of mostly short grasses of blue grama and buffalograss. The soils in this association are well suited for openland wildlife. Natural fertility of these soils is high. The surface layers of these soils are fairly easy to work with hand tools.

6. Tascosa association—Shallow, well drained, moderately permeable, calcareous, very gravelly loamy soils that are over thick gravel beds.

This association occupies moderately sloping to steep hills. The Tascosa soils make up about 85 percent of the association. The surface layer is a dark grayish-brown calcareous very gravelly loam about 10 inches thick. The next layer, about 18 inches thick, is pale brown calcareous very gravelly loam. This is underlain by very pale brown calcareous very gravelly loam, to a depth of 60 inches. Below 10 inches, these soils have 40 to 80 percent gravel. The remaining 15 percent of these soils are Acuff soils on some hilltops and Bippus and Berda soils in the lower valleys between the hills.

This association is used for rangeland for which it is suited. These soils support moderate stands of predominantly short grasses of black grama, hairy grama, blue grama with lesser amounts of little bluestem and sideoats grama. There are some catclaw and yucca, and a few mesquite. These soils are generally poorly suited for wildlife. These soils do not have a potential for cultivation.

7. Knoco-Glenrio-Badland association—Very shallow to shallow, well drained, very slowly permeable, calcareous, clayey soils over clayey shales and barren shale badlands.

This association occupies gently sloping, geologically eroding surfaces that are cut by many gullies.

Knoco soils make up about 35 percent of the area. The surface layer is reddish-brown calcareous clay about 8 inches thick. This is underlain by reddish-yellow calcareous clayey shale that extends to 60 inches. Glenrio soils make up about 25 percent of the area. The surface layer is reddish brown calcareous clay about 6 inches thick. The next layer is reddish yellow calcareous clay about 14 inches thick. This is underlain to 60 inches by reddish-yellow calcareous clayey shale. About 40 percent of this association is barren clayey shales with some gravel on the surface.

This association is used for rangeland and wildlife, for which it is poorly suited. These soils have a sparse stand of galleta and sideoats grama with a few scrubby mesquite, redberry juniper and some cactus. Wildlife and rangeland are the only potential uses for the soils of this association. These soils have no potential for cultivation.

8. Quay-Montoya association—Moderately deep, well drained, moderately to slowly permeable, calcareous, loamy and clayey soils that have loamy and clayey subsoils.

This association occupies nearly level to gently sloping plains in association with redbed materials.

Quay soils make up about 80 percent of this association. The surface layer is reddish-brown calcareous loam about 9 inches thick. The next layer is reddish-brown calcareous clay loam about 15 inches thick. This is underlain by reddish-brown calcareous clay loam that has weak structure. Montoya soils make up about 15 percent of the area. The surface layer is reddish-brown calcareous silty clay about 8 inches thick. The next layer is reddish-brown clay about 15 inches thick. This is underlain to a depth of 60 inches by reddish-brown calcareous silty clay. About 5 percent of this association is steeper or more rolling very shallow to moderately deep soils on small hills or in small drains.

This association is used for rangeland for which it is well suited. These soils support a dense stand of mostly short grasses of blue grama, buffalograss, galleta and alkali sacton. There is scattered mesquite on the Quay soils. Wildlife in this association is the openland type for which these soils are generally well suited. Natural fertility of these soils is moderate to high. The surface layers of these soils are somewhat difficult to fairly easy to work with hand tools.

9. Burson-Stony rough broken land association—Very shallow, excessively drained, moderately permeable, calcareous loamy soils and stony, rough, broken land.

This association occupies steep slopes that have barren stony, rough, broken land that includes shales, sandstones, raw clays and siltstones. This association characterizes the entire Rolling Plains area as the "Canadian Breaks."

Burson soils make up about 45 percent of this association. The surface layer is yellowish-red calcareous clay loam about 3 inches thick. This is underlain by red calcareous sandy shale to about 60 inches. About 55 percent of this association is steep outcrops of ledges or stones of sandstone, clay or shales, or else less sloping areas of badlands of similar materials.

This association is used for rangeland and wildlife. It is poorly suited for these uses. This association has a sparse cover of sideoats grama, hairy grama, little bluestem, tridens, threeawn, black grama and redberry juniper shrubs. Natural fertility is very low. Runoff is high.

10. Quay-San Jon-Latom association—Moderately deep to very shallow, well drained, moderately to slowly permeable, calcareous, loamy soils that have loamy subsoils unless they are shallow.

This association occupies gently sloping to steep valleys in the lower Rolling Plains, and it includes a number of mesas and large sandstone ledge areas.

Quay soils make up 35 percent of this association. The surface layer is reddish-brown calcareous loam about 9 inches thick. The next layer is reddish-brown calcareous clay loam about 15 inches thick. This is underlain by reddish-brown calcareous clay loam that has a weak structure. San Jon soils make up about 20 percent of the association. The surface layer is reddish-brown calcareous loam about 8 inches thick. The next layer is gravelly to not gravelly calcareous light reddish-brown clay loam about 9 inches thick. The next 9 inches are red calcareous silty clay loam. This is underlain by red fragmental shale. Latom soils make up about 20 percent of the association, and they occupy the surfaces in the sandstone ledge areas. The surface layer is brown calcareous fine sandy loam about 8 inches thick. This is underlain by very pale brown calcareous sandstone to 60 inches.

This association is used as rangeland for which it is generally well suited. It grows short grasses predominantly of blue grama, sideoats grama, some buffalograss and galleta grass. There are some redberry juniper scrubs and mesquites. Wildlife in this association is both openland and brushland types for which these soils are generally suited or well suited. The Quay soils have moderate natural fertility. The surface layer of Quay soils are fairly easy to work with hand tools.

11. Clairemont-Mangum association—Deep, well drained, moderately to very slowly permeable, calcareous, loamy to clayey soils with loamy to clayey subsoils.

This association occupies the floodplains in the lower Rolling Plains about the Canadian River. The Clairemont soils make up about 45 percent of the association. The surface layer is light reddish-brown calcareous clay loam about 7 inches thick. This is underlain by light reddish-brown calcareous clay loam that had bedding planes and extends to 80 inches. The Mangum soils make up about 15 percent of these areas. The surface layer is brown calcareous clay about 12 inches thick. The next layer is brown calcareous clay with bedding planes about 8 inches thick. This is underlain by brown light clay with bedding planes extending to a depth of about 60 inches. About 40 percent of the association is made up of Lincoln soils, a sandy alluvial soil, eroded Mangum or Clairemont soils, or riverwash which is usually barren. Most of the riverwash is in entrenched stream beds.

This association is used as rangeland for which it is well suited. These soils support a dense stand of blue grama, buffalograss, galleta grass, alkali sacton, and inland saltgrass. There are also numerous cottonwood trees, mesquite brush and some salt cedar. This association is a fair to good openland and brushland wildlife area. Clairemont has a moderate natural fertility. The surface layer of Clairemont is fairly easy to work with hand tools.

GEOLOGIC ENVIRONMENT OF THE ALAMOSA CREEK DRAINAGE

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INTRODUCTION

This report has been prepared for the Natural Areas Survey, Division of Natural Resources and Environment, the University of Texas at Austin. It is intended to be used by both geologists and non-geologists and at the same time to provide a resource document on the geology of the area. There is some conflict in this charge, as the details of the stratigraphy (the formation, composition, sequence, and in particular correlation of stratified rocks from area to area) of both the Triassic and Cenzoic sediments in the study area are complicated and not adequately known. Limited field work was done in June of 1973 with the Natural Areas Survey field team. I spent only a few days in the field, and although some original work was done for this, most has been drawn from the past work of others. Where at all possible I have attempted to reduce technical jargon to a minimum, but this has not been possible when directly quoting findings and writings of others. Non-geologists will find the *Glossary of Geology* (Gary *et al.,* 1972) a useful reference.

PHYSIOGRAPHY AND CLIMATE

The Alamosa Creek drainage is on the south side of the Canadian River approximately 35 miles northwest of Amarillo in the area known locally as the Canadian Breaks. To the west and south the Llano Estacado is a remnant of one of the flattest surfaces in the world. The name means "staked plains" and supposedly derives from the habit of earlier travelers who drove stakes into the ground for reference points on the nearly featureless plain. This surface is part of the Southern High Plains section of the Great Plains physiographic province, slopes eastward at a rate of approximately 10 feet per mile, has a mean elevation of about 4000 feet above sea level in the study area, has no well-developed drainage, and is dotted by hundreds of shallow depressions.

The eastward-flowing Canadian River has incised a valley 800 feet below the level of this surface, creating the rough broken area called the "breaks" and exposing colorful shales and sandstones of Triassic age. The sandstones are more resistant to erosion and local cap mesas, buttes, cuestas, and canyon rims.

The climate of the area is classified as a *steppe* region (BSH) in the Koppen-Geiger system (Reeves, 1972) and is characterized by low annual humidity, low annual precipitation, high winds, hot summers, and frigid winters. Mean relative humidity in July and January is about 50 percent. Temperature and rainfall records for the last ten years are summarized in tables 1 and 2. Records have been accumulated at Amarillo continuously since 1905 and probably are fairly characteristic of the study area. In 1960 the accumulated data showed that Amarillo had a mean annual precipitation of 20.12 inches, but inspection of the yearly records shows that this is highly variable and unevenly distributed throughout the year. A maximum of nearly 40 inches was recorded in 1923, and a minimum of little less than 10 inches was recorded in 1956 and 1970 (Anonymous, 1960, p. 6). The mean annual temperature of approximately 57 degrees F. is also misleading, as Vega, the Oldham County seat, has recorded a maximum of 109 degrees F. and a minimum of 18 degrees below zero (Kitchen *et al.,* 1972, p. 8). Kitchen *et al.,* 1972, p. 9 remark:

> The average wind velocity for the county is sixteen miles per hour. The major windy period occurs from February through May. There are very few other places in the United States, except on the seashore or on mountain tops, where the wind blows harder and more continuously.

The high summer temperatures and high winds compound the effect of low rainfall. The average effective rainfall (that portion which remains available for infiltration and plant use after surface runoff) for the Canadian River basin for the period 1940-1957 was calculated to be 19.2 inches, while the average gross evaporation rate for the same period was more than three times as great, 73.9 inches (Anonymous, 1960, p. 6). Some of the runoff is held in the local closed depressions on the Llano Estacado, but recharge experiments indicate that 60 to 65 percent of the water impounded in them is lost to the atmosphere by evaporation (Anonymous, 1960, p. 5).

ROCK UNITS

The rocks exposed in the Alamosa Creek drainage are Triassic, Tertiary, and Quaternary in age (fig. 1), and unconformably overlie rocks of Permian age.

Permian Rocks

A fairly thick section of Permian rocks underlies the study area but is not exposed at the surface. Gould

TABLE I

Temperature Data for the Canadian Breaks Area
Degrees Fahrenheit

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Avg.
1964													
Vega	35.7	30.7	41.6	54.6	65.9	72.3	79.7	75.4	67.2	57.7	44.6	36.8	55.2
Boys Ranch	––	––	––	––	––	––	82.7	80.3	69.3	61.9	49.4	40.3	––
Amarillo	37.2	32.1	44.8	57.9	68.9	76.5	81.9	77.2	69.6	60.6	47.5	39.1	57.9
Tascosa	––	––	––	––	––	––	––	––	––	––	––	––	––
1965													
Vega	39.0	34.7	35.1	56.3	64.6	70.1	76.2	73.2	65.4	57.9	50.4	40.4	55.3
Boys Ranch	43.1	40.4	41.4	63.0	––	73.5	––	78.2	69.2	60.3	55.1	––	––
Amarillo	41.0	37.6	38.4	59.4	66.9	72.1	78.6	67.9	68.5	59.5	52.5	42.9	57.9
1966													
Vega	28.8	30.9	47.3	53.9	62.5	71.2	80.0	70.7	66.7	53.9	48.6	32.9	54.0
Boys Ranch	30.3	––	––	––	64.8	76.1	85.3	74.3	69.6	57.3	50.1	36.3	––
Amarillo	27.8	34.1	50.0	54.4	66.0	74.2	82.9	73.5	68.5	57.5	51.6	35.5	56.4
1967													
Vega	37.6	37.1	50.2	57.4	60.0	70.0	73.1	71.5	64.5	58.5	43.4	31.9	54.0
Amarillo	40.7	40.6	53.4	60.6	63.4	73.7	77.2	75.0	68.3	60.9	46.6	35.4	58.0
Channing	––	––	––	––	63.0	71.3	75.6	73.4	66.3	58.8	45.4	33.4	––
1968													
Vega	34.2	35.5	44.9	50.6	59.1	71.9	73.4	72.9	65.7	58.6	43.6	35.5	53.8
Amarillo	38.3	38.0	48.7	55.3	63.4	74.9	77.0	77.0	69.1	62.1	45.4	36.9	57.0
Channing	36.3	37.9	46.7	55.2	60.7	73.7	76.8	75.7	69.3	60.0	44.5	35.2	56.0
1969													
Vega	39.8	39.0	36.4	55.4	64.0	69.3	78.8	77.2	67.8	51.8	44.6	38.7	55.2
Amarillo	41.4	40.4	38.8	59.9	67.2	72.8	82.6	80.2	71.1	54.5	46.7	38.4	57.8
Channing	39.5	39.3	37.4	57.5	65.1	69.8	80.3	78.2	68.8	52.9	45.1	41.3	56.3
1970													
Vega	31.5	41.9	39.9	51.7	65.4	71.5	76.6	76.8	66.8	51.6	44.3	41.4	55.0
Amarillo	33.2	43.2	41.7	56.0	68.8	74.5	80.7	79.1	70.9	54.0	46.6	43.4	57.7
Channing	32.9	42.2	41.7	53.3	66.6	72.8	78.7	78.5	69.5	––	44.4	41.8	––
1971													
Vega	36.0	35.5	44.5	53.6	61.5	74.6	75.8	70.7	64.8	56.1	46.9	37.7	54.7
Amarillo	37.8	38.8	48.3	55.7	64.9	75.9	76.9	72.2	67.1	57.2	45.6	37.6	56.5
Channing	35.6	37.1	45.4	55.8	64.0	76.0	76.8	72.5	––	58.2	46.9	38.5	––
1972													
Vega	35.7	40.5	51.2	58.1	62.7	73.5	73.9	72.6	67.0	56.6	36.7	33.2	55.1
Amarillo	35.7	40.9	51.7	59.5	63.2	73.6	74.5	73.9	69.2	57.9	36.9	32.9	55.8
Channing	36.8	41.1	52.4	59.3	64.6	74.2	74.1	73.1	67.4	58.0	36.6	32.6	55.9
1973													
Vega	31.3	36.7	44.1	47.5	60.3	71.5	75.3	75.5	66.1	59.7	48.6	37.0	54.5
Amarillo	33.4	39.5	47.1	50.3	62.9	75.1	78.1	78.8	68.7	62.0	50.8	38.6	57.1
Channing	32.3	38.1	45.1	48.8	60.9	72.1	76.6	77.1	66.7	59.5	48.4	36.9	55.2
1974													
Vega	33.3	40.2	51.0	56.0	68.8								
Amarillo	35.0	42.2	53.1	60.2	71.5								
Channing	––	43.8	54.3	58.8	71.1								

TABLE II

Precipitation Data for the Canadian Breaks Area
Inches per Month

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1964													
Vega	T	1.62	.02	T	2.35	1.91	1.03	3.00	2.68	.28	3.00	.74	16.93
Boys Ranch	—	—	—	—	—	—	1.15	2.69	2.69	.10	1.65	.14	—
Amarillo	T	1.37	.03	T	1.69	1.90	.94	5.69	3.95	.08	1.53	.79	17.97
1965													
Vega	.24	.93	1.49	.27	.99	12.26	1.05	3.64	.82	2.85	T	.53	25.08
Boys Ranch	.05	.15	.30	.26	1.32	9.88	.45	1.32	.62	1.76	.00	.45	16.56
Amarillo	.55	.47	.72	.23	1.88	10.73	1.54	1.71	.79	1.02	.07	.38	20.09
Tascosa	.06	.34	.58	.24	1.54	9.68	1.60	2.14	2.32	2.07	.00	.87	21.44
1966													
Vega	.77	.59	T	.14	.61	2.34	3.81	3.82	1.95	.06	.03	.03	14.15
Boys Ranch	.27	.36	.00	.06	.00	1.83	3.77	5.51	.14	.13	.00	.12	12.19
Amarillo	.43	.69	.01	.87	.19	4.62	1.37	3.77	2.40	.29	.08	.19	14.91
Tascosa	.35	.24	.00	.05	.32	2.18	3.86	4.36	.17	.15	.00	T	11.68
1967													
Vega	.03	.82	.09	1.82	.98	3.30	5.10	1.32	1.12	.43	.57	1.07	16.65
Amarillo	T	.15	.42	1.95	1.40	2.55	3.70	1.81	2.47	1.61	.28	.51	16.85
Channing	—	—	—	—	3.33	8.67	1.71	1.74	.33	.10	.14	.38	—
Tascosa	.04	.19	T	1.34	1.79	4.67	2.50	2.30	.68	.09	.15	.56	14.31
1968													
Vega	2.47	.75	1.31	1.91	4.08	1.49	3.04	3.13	.15	.47	.50	.26	19.56
Channing	1.18	.56	.26	.73	3.61	2.27	1.36	1.65	.22	2.25	.77	.04	14.90
Amarillo	2.33	.73	.45	.93	2.84	1.68	2.96	3.35	.62	.90	.92	.26	17.97
Tascosa	1.26	.49	.37	1.13	3.13	1.91	4.82	2.03	.08	1.96	.69	.09	17.86
1969													
Vega	T	.82	.77	.86	4.29	3.20	2.78	2.26	3.35	2.71	.44	.38	21.86
Amarillo	.02	.50	1.15	.30	2.93	4.09	2.55	4.51	2.77	2.56	.34	.83	22.55
Channing	.00	.95	1.36	.43	4.91	3.48	2.73	2.81	4.26	2.52	.49	.35	24.29
Tascosa	T	1.22	1.37	.44	4.71	3.78	3.42	4.45	3.79	2.40	.74	.35	26.67
1970													
Vega	.07	.06	1.10	1.51	.37	2.17	1.05	1.37	1.68	1.39	.27	T	11.04
Amarillo	.02	.02	2.10	1.33	.23	1.54	1.39	1.27	.34	1.06	.26	T	9.56
Channing	.00	.00	.70	1.93	.57	1.49	1.51	2.30	1.15	1.10	.22	.00	10.97
Tascosa	T	.00	.76	2.03	.86	2.93	2.77	2.48	1.10	1.39	.25	.00	14.57
1971													
Vega	.20	1.06	.17	.68	.94	1.18	3.11	2.20	4.34	1.72	3.53	.36	19.49
Amarillo	.10	1.65	.10	.77	.91	4.17	1.75	3.33	4.70	2.59	2.08	.89	23.04
Channing	.13	.94	.06	1.05	1.12	1.86	4.51	1.68	1.88	2.07	1.91	.60	17.81
Tascosa	.35	.83	T	.94	.97	.94	5.41	2.05	2.86	2.48	1.91	.52	19.26
1972													
Vega	.21	.12	T	T	2.13	1.15	2.90	2.00	2.85	2.33	1.25	.26	15.20
Amarillo	.21	.11	.11	.03	2.81	3.87	2.59	1.73	.71	1.66	1.19	.32	15.34
Channing	.06	.13	.12	.00	1.32	2.64	7.82	4.02	3.07	1.69	2.25	.22	23.34
Tascosa	.02	.50	.05	T	2.71	4.20	6.44	1.45	3.17	3.17	1.57	.34	23.62
1973													
Vega	.37	.43	3.20	2.46	2.14	.96	2.97	1.28	.75	.72	.07	.88	16.23
Amarillo	.56	.42	3.99	1.88	1.43	.84	4.08	2.31	1.22	1.05	.10	.17	18.05
Channing	.33	.47	3.16	2.09	.93	1.45	1.85	2.32	1.28	.51	.25	.25	14.89
Tascosa	.32	.29	3.60	2.20	.82	1.54	5.23	2.59	.99	.55	.11	.57	18.81
1974													
Vega	.23	.43	.79	.08	1.79								
Amarillo	.33	.24	.60	.04	4.06								
Channing	—	.10	.84	.15	.81								
Tascosa	.21	T	1.02	.02	2.52								

(1906, 1907) named these rocks the Quartermaster Formation. They are mostly gypsiferous terra-cotta sandstones capped by a massive 10-foot bed of dolomite, referred to by Gould as the Alabates lentil of the Quartermaster Formation. Where the Alabates dolomite is locally silicified, it usually has a distinct and banded appearance. The primitive Plains Indians manufactured projectile points out of this Alabates "flint" and traded it extensively across much of the Southwest (see the archaeology section in this report). The Alabates dolomite crops out a few miles east of the study area.

Triassic Rocks

The Triassic rocks exposed in the Alamosa Creek drainage are composed of a lower shale unit several hundred feet thick, a middle sandstone unit a few tens of feet thick, and an upper shale unit several hundred feet thick (fig. 1). The problems involved in the naming and correlation of the Triassic section is discussed later, and in this report I am referring to the lower shale unit as the Tecovas Formation, the middle sandstone unit as the Trujillo Formation, and the upper shale as the Chinle Formation.

Both the base and the top of the Triassic section are erosional unconformities. A few miles west of the study area, in the Vat Camp quadrangle, post-Triassic erosion removed the section completely. There the Pliocene Ogallala Formation rests directly on the Alabates dolomite (Finch, 1971).

Tecovas Formation

The prominent series of sandstones capping the numerous buttes and the canyon wall along the Alamosa Creek drainage in the middle of the study area form an obvious stratigraphic marker of at least local significance. The beds below those resistant sandstones appear to correspond to the beds Gould defined (1907, p. 20-29) as the Tecovas Formation on Tecovas Creek in Potter County, a few miles east of the study area. Along lower Alamosa Creek and near the Canadian River, several hundred feet of variegated white, yellow, purple, and maroon sandy shale and dark red shale are exposed beneath the overlying prominent sandstones (fig. 1). The top of the Tecovas Formation is marked by an orange shale and an underlying light-colored (in many places white), soft sugary sandstone. This sandstone crops out in the valley below Landergin Mesa where it contains numerous mortar holes created by early human usage and appears to correlate with the bed described by Gould as "Rock City" on the L-S Ranch south of Tascosa.

Trujillo Formation

The previously mentioned prominent sandstones and interbedded shales form a unit a few tens of feet thick cropping out in the northern half of the study area. This unit is more resistant than the surrounding shales and forms the "middle breaks," capping Landergin Mesa and the canyon walls of Middle and West Alamosa Creeks. These sandstones were defined as the Trujillo Formation by Gould (1907) from exposures along Trujillo Creek in western Oldham County.

Several closely spaced and lens-shaped sandstone bodies make up the bulk of the Trujillo Formation exposed in the Alamosa Creek area (figs. 2 and 3).

Chinle Formation

A sequence of brightly-colored shales and sandy shales overlie the sandstone ledges of the Trujillo Formation in the Alamosa Creek area. I refer to this sequence as the Chinle Formation in this report. It is several hundred feet thick and is composed primarily of red-brown mudstone and sandy mudstone and contains local sandstone beds. It crops out in an east-west band across the study area north of the flat High Plains surface capped by the Ogallala Formation and south of the Trujillo sandstone caprock along Alamosa Creek. It is exposed throughout the southern part of the Mansfield Ranch and the northern part of the Green Ranch. Typical exposures occur in the area known as the "Cedar Brakes."

TERTIARY ROCKS

Ogallala Formation

The High Plains caprock is a caliche-cemented sequence of gravel, sand, silt, and clay called the Ogallala Formation. It is easily recognized by its general buff color and by its thick caprock of caliche and forms the resistant caprock in the southern part of the study area on Tom Green's ranch (fig. 4). A good summary discussion has been written by Reeves (1972):

> The Ogallala Formation (Darton, 1905), form a massive piedmont alluvial plain on the east side of the southern Rocky Mountains and extends from southern South Dakota to southeastern New Mexico. Throughout the 800-mile north-south extent, as well as from west to east, the Ogallala Formation consists predominantly of fluvial gravel, sand, silt, and clay. Minor quantities of betonitic clay, buried soil, chert lentils, and volcanic ash also occur in the Ogallala (Frye, 1970) section, but generally only in the northern parts of the depositional area.
>
> The original easternmost extent of the Ogallala Formation is unknown. Outliers occur in Dickens, Scurry, Fisher, and Nolan Counties, Texas, but Menzer and Slaughter (1970) found evidence of Ogallala gravel as far east as Dallas County, Texas, suggesting that the Ogallala

Generalized Geologic Section of the Rocks Exposed along Alamosa Creek

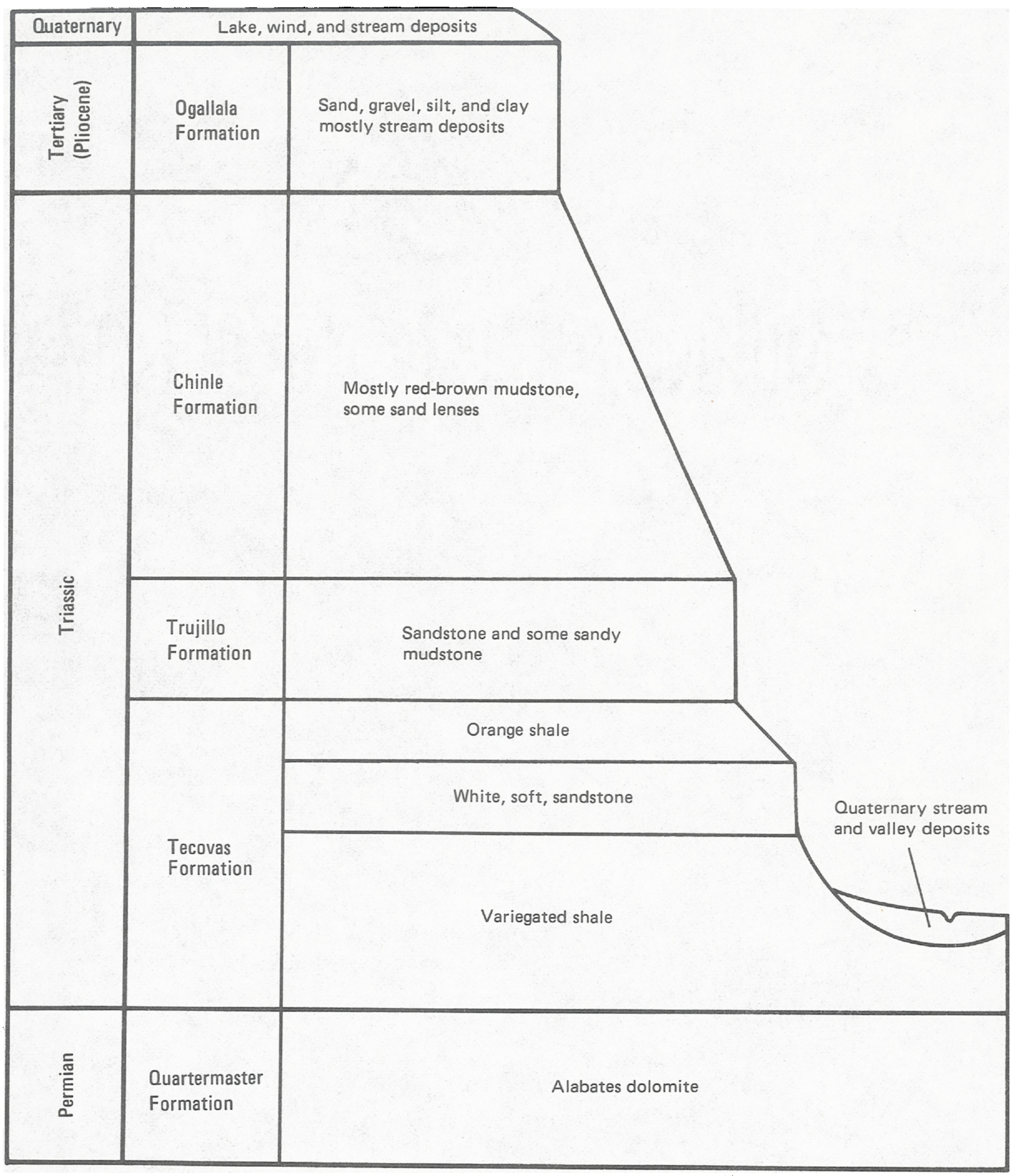

FIGURE 1

alluvial deposits once formed a "gangplank" type ramp (as presently found in Wyoming-Nebraska) across Texas. This was originally suggested by Plummer (1932).

Thickness of the Ogallala Formation ranges from a feather edge to more than 500 feet, the thickest wedge trending eastwest through Parmer and Castro Counties, southeast through Hale County and the southwestern corner of Floyd County, and southeast through Crosby County, Texas. However, small narrow channels with thick Ogallala clastics controlled by relief on the post-Cretaceous unconformity exist in many areas. In eastern New Mexico the Ogallala is usually thinner than in West Texas, typical thickness being from 75 to 225 feet around Lovington (Ash, 1963), 100 to 200 feet in the Causey-Lingo area (Cooper, 1960), and up to 350 feet north of Maljamar (Ash, 1963). Along the escarpment from Taiban Mesa east to Ragland, the San Jon area, and into Deaf Smith County, Texas, the Ogallala is commonly less than 100 feet thick. On the plains the areas where the Ogallala section is thin or absent correspond to topographic highs on the post-Cretaceous unconformity.

The Ogallala is defined and recognized by the U.S. Geological Survey (Keroher and others, 1966) as a formation, but recognizable units in the Ogallala have been termed formations, members, and floral zones (Frye, 1970). In 1949 Evans and Meade informally elevated the Ogallala Formation to group status by proposing division of the section into the Couth Formation and the overlying Bridwell Formation from studies along the eastern escarpment in Crosby County, Texas. Frye and Leonard (1957), however, concluded that recognizable rock-stratigraphic units in the Ogallala section in a 225-mile north-south traverse along the eastern escarpment, exist only on a local scale and thus considered the Ogallala a formation with no recognizable members. To date no regional attempt has been made to trace the suggested Couch and Bridwell "formations" from their type locality westward in the dip direction, principally due to the absence of outcrops.

In Nebraska the Ogallala Formation contains three identifiable floral zones, the basal Valentine overlain by the Ash Hollow, the Sidney gravels, and the Kimball (Johnson, 1935; Lugn, 1938 and 1939), but distribution is not uniform to the south. The lower Valentine zone apparently does not exist south of Floyd County, Texas (Frye and Leonard, 1964) but the overlying Ash Hollow and Kimball zones have been identified by Frye and Leonard (1964) from various localities in West Texas. Unfortunately, correlation of these zones has not been extended to the western escarpment in eastern New Mexico. In Kansas and Nebraska the Ogallala Formation can also be correlated on the basis of volcanic ash zones, lithology, the topmost pisolitic limestone and by topography at the base of the section (Frye and Leonard, 1959), but such methods have met with little success in West Texas and southeastern New Mexico. Age of the Ogallala, which ranges from late Miocene to Pliocene, has been based mainly on several vertebrate faunas (Frye, 1970).

Evans' (1949) Couch Formation consists of ". . . .well-sorted calcareous sand and gravel. . . ." which is deep brown to dark red, subangular to angular, well-sorted and massive bedded. The gravel, which may or may not be present, consists of quartzite and jasper cobbles in a clean quartz sand matrix, often with water-worn Cretaceous shells. The overlying Bridwell Formation (Evans, 1949) consists of unconsolidated, fine-grained, reddish sand, silt and clay with sporadic gravel; thus a color contrast often marks the contact in the type area.

As classically envisioned (Fenneman, 1931; Plummer, 1932) the Ogallala section was spread over the plains as a vast fan of alluvial debris from the central and southern Rocky Mountains, but Frye, Leonard, and Swineford (1956) found evidence that the Ogallala represented mainly valley alluviation. In central-eastern New Mexico the Ogallala section consists, in many areas, of coarse-grained fluvial sand and gravel but in southeastern New Mexico, where Ogallala section is "within sight" of the mountains, the section consists mainly of fine-grained calcareous sand and silt, the only fluvial-appearing sands and gravels being a basal section measuring 5 to 10 feet thick. The predominance of fine-grained sand and silt and the absence of fluvial sand and gravel indicates that there were no eastward-flowing Pliocene streams south of the San Juan Mesa area after earlymost Ogallala time.

The widespread basal Ogallala gravel is typical of regional piedmont-type deposits, but a great part of the Ogallala Formation, even in the Lubbock, Texas area, consists of a great thickness of overlying fine-grained, brownish to reddish calcareous sand and silt (loess?) especially in the upper part. The coarse gravel at San Juan Mesa and north of Tolar indicates high discharge rates during all of the time represented by the section, thus if these sections correlate with the entire Ogallala depositional period in other areas, the regional change from basal gravel to eolian debris must have been caused by a change in source area.

As a working hypothesis, I proposed that during uppermost Miocene time, when lower Ogallala gravel was being deposited, an ancient Pecos Valley (as originally suggested by Bretz and Horberg, 1949) developed by solution-subsidence. Its extension northward progressively pirated the streams which were flowing eastward off the low Sacramento Mountains onto the southern part of the Llano Estacado. Thus, most of the Ogallala south of the San Juan Mesa region consists mainly of indurated eolian sheet sand and finer debris deflated from this ancient Pecos Valley whereas in the northwestern part of the Llano Estacado the Portales River continued to deposit mainly fluvial deposits. The Triassic high from about Maljamar southeast to U.S. 180 (and actually running northwest of Maljamar for at least 20 miles), shown by Nicholson and Clebsch (1961), Ash (1963) and Cronin (1969), was covered by lowermost Ogallala gravel, and thus was not high enough to interfere with Ogallala deposition and act as a local drainage drive. The high is also indicated by Ogallala outliers south of Maljamar and west of Jal which also show an

FIGURE 2
Trujillo sandstones capping the south wall of West Alamosa Creek. Note more than one resistant bed in the background. The slopes below the resistant beds expose the Tecovas Formation. Photograph by Dwight Deal.

eolian sand-silt lithology.

As the ancient Pecos Valley developed by solution-subsidence it was contemporaneously filled with several hundred feet of fluvial, eolian and sheetwash debris, a unit which Lang (1938) termed the Gatuna Formation. The Gatuna Formation was named for a section of terrestial sand, silt, and gravel at Gatuna Canyon in Eddy County. It has been mistaken in the Pecos Valley where similar appearing Triassic and Permian red beds also occur. Illustrative of the confusion which can arise between these similar appearing red bed sequences is the mapping of Pierce Canyon southeast of Carlsbad, New Mexico and east of the Pecos River. Pierce Canyon was given by Lang (1935) as the type section for the Pierce Canyon red beds and the area was mapped as Permian by Dane and Bachman (1958). Vine's (1963) work in the Nash Draw area considered the Pierce Canyon red beds to be of either Triassic or Permian age, thus it was startling to find, when mapping Pierce Canyon, that the outcrops were of Gatuna strata. Kelley (1971, p. 24) also noted this.

Age of the Gatuna Formation is unknown. Lang (1938) thought Gatuna sediments, which obviously represent fill in the Pecos Valley after maximum development, were deposited in post-High Plains time, but Kelley (1971) suggests that Gatuna, based on lithology and induration, may be of pre-Ogallala age. However, on the basis of minimal stratigraphic evidence, I suspect the Gatuna Formation represents an ancient Pecos Valley fill contemporary with the post-basal gravel part of the Ogallala Formation on the Llano Estacado.

Accurate dating of the Gatuna will have to wait on a paleontologic evidence; however, age of the Gatuna Formation in relation to the Portales Valley, to the southern High Plains and to the Ogallala Formation may be clarified by stratigraphic studies now underway north of Roswell and in the Fort Sumner and Taiban areas. As discussed in the section "The Pecos and Portales Valleys" (p. 27), interception of the Portales River supposedly occurred during Kansan time, thus if the Gatuna Formation is of pre-Pleistocene age it should be limited to that part of the Pecos depression south of the Fort Sumner-Taiban area. If, however, the Gatuna Formation is of Pleistocene age, outcrops should occur upstream from the Fort Sumner-Taiban area. Kelley (1971) mapped the northernmost outcrop of Gatuna in T. 6 S., R. 26 E. just south of Bosque Draw and approximately 60 miles south of Fort Sumner. To date I have been unable to find any Gatuna north of the preceding location.

Fairly extensive vertebrate fossil collections have been made from the Ogallala Formation, although we recovered no specimens from the study area. Schultz (1972) summarized what is known:

> During the Pliocene, streams flowing eastward out of the Rocky Mountains deposited the silts, sands, and gravels of the Ogallala Formation. . . . At times, environmental conditions favored the burial and preservation of vertebrates in lakes, ponds, channels, sinkholes, and on flood plains. Erosion has not exposed these fossiliferous units in many areas. The great abundance and variety of Lower and Middle Pliocene horses, camels, mastodons, rhinoceroses, deer, and carnivores which have been found in certain parts of the Texas Panhandle prompted Wood and others (1941) to designate these areas and their faunas as the basis for the Clarendonian (Lower Pliocene) and Hemphillian (Middle Pliocene) mammalian ages of North America. These, along with the other mammalian ages of the Tertiary, are generally defined on the basis of the first and last appearances and joint associations of certain characteristic mammalian genera.
>
> The term Clarendonian is derived from the town of Clarendon in Donley County, Texas. North of Clarendon, the Salt Fork of the Red River flows through Permian rocks. Along the divides north of the river are exposures of Pliocene strata where fossils belonging to the Clarendon fauna are found. The earliest discoveries were made by Cope and Cummins in the early 1890's. Cope referred the sediments and their contained fossils to the "Loup Fork" because of their resemblance to the "Loup Fork" of Nebraska. Gidley (1903) referred to these strata as the "Clarendon beds" but the name has not found general application. The fossil-bearing beds are now recognized as being a facies of the Ogallala Formation. Unfortunately, no comprehensive study or description of the Lower Pliocene Clarendon fauna has ever appeared in print although single species have been described in short papers or in larger publications dealing with certain taxonomic groups. In addition, papers on other Lower Pliocene faunas have from time to time made reference to fossils from the Clarendon fauna. At the present time, more than 30 fossil sites are known from the area north of the Salt Fork. No detailed biostratigraphic analysis has been done on these sites and no individual site has ever been chosen as the basis for a "type" Clarendon fauna. The large number of fossil sites makes it quite probable that they may represent slightly different ages and horizons. Careful biostratigraphic studies are needed to demonstrate these relationships.
>
> Starting about 10 miles north of Clarendon, the fossil sites occur along a belt which extends eastward for about 15 miles along the divides north of the Salt Fork. In the western part of this belt, the fossils occur encased in a hard concretionary matrix or free in a greenish-gray clay whereas farther east they occur mainly in coarse-grained ferruginous sand of fluvial origin or encased in ferruginous sandstone concretions in sinkhole deposits developed in Permian redbeds. They clays probably represent accumulations in oxbow lakes and flood-plain ponds where animals came to drink, but the coarser sands are fluvial deposits of a stream or streams which trended in an easterly direction. The sink holes developed as a result of subsurface solution of evaporite minerals and resultant collapse of overlying sediments.
>
> Since the first fossil collections were made for the Texas Geological Survey by Prof. Cope in 1892, many other institutions have worked in the area including the American Museum of Natural History and the Frick Laboratories of New York, the University of California,

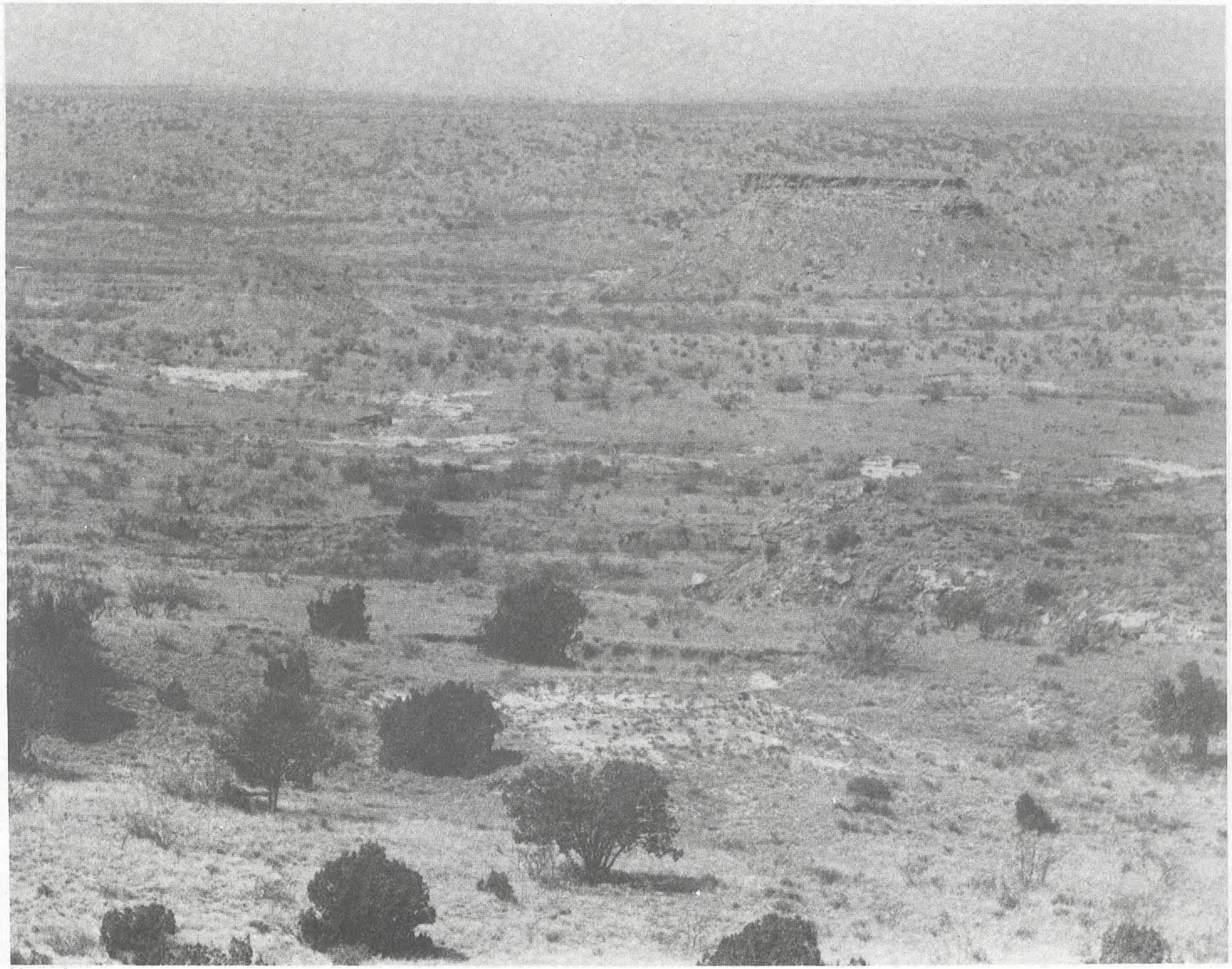

FIGURE 3
Landergin Mesa and the Ranch Creek valley viewed from the east. The resistant sandstones of the Trujillo Formation cap the mesa. Note two resistant units exposed on the right end of the mesa. Photograph by Dwight Deal.

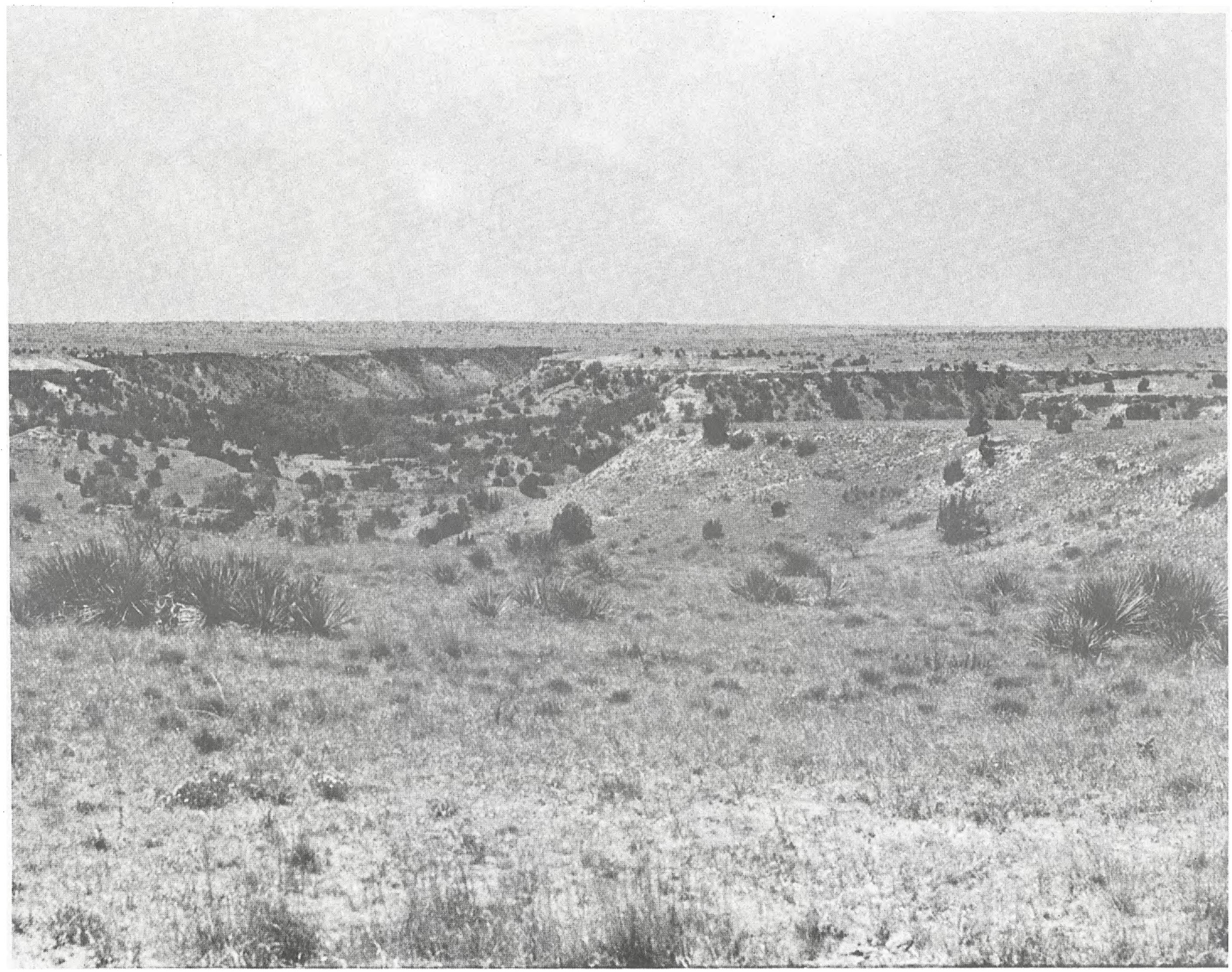

FIGURE 4
View southwest toward the head of Middle Alamosa Creek on Green Ranch. The High Plains surface forms the skyline, and the Ogallala Formation froms the resistant caprock over soft mudstones of the Chinle Formation. Photograph by Dwight Deal.

and West Texas State University. A number of new mammalian species have been described. The fauna is an impressive one consisting for the most part of various kinds of horses but including also a variety of camels, deer, and carnivores as well as representatives of the rhinoceros, peccary, oreodont, and mastodon groups. Many forms are represented by complete skulls, jaws, and, in the case of sinkhole deposits, complete skeletons. The horses range in size from the tiny goat-sized *Calippus* up to the pony-sized *Pliohippus.* Three-toed horses are represented by grazers such as *Neohipparion* and *Pseudhipparion* and by the last of the browsing horses, *Hypohippus.* Camels include large and small species of *Procamelus* and a giraffe-necked form called *Aepycamelus.* Among the deer is an unusual form called *Synthetoceras tricornatus* which possessed a pair of horns above the eyes and a third horn which extended forward from the nose and then forked into two branches like a slingshot. Carnivores, while not abundant, are, nevertheless, varied. Dogs include large bear-like forms (*Ischyrocyon*), large heavy-jawed bone-eaters (*Aelurodon*), and terrier-sized forms like *Tomarctus.* Mustelids and saber-toothed cats are among the rarer carnivores. *Teleoceras* is a rather common, short-legged, barrel-chested rhinoceros, whereas the oreodonts, so common in Nebraska and South Dakota during Oligocene time, and here represented by one of the last surviving genera, *Ustatochoerus.* Among the lower vertebrates, remains of large tortoises are frequently encountered and alligator scutes have been found occasionally.

The Hemphillian Age is based on an assemblage of Middle Pliocene mammals from a quarry located in Hemphill County, Texas, about 8 miles northeast of Miami. This locality on the Coffee Ranch was first discovered by two oil company geologists while engaged in a reconnaissance of the county in 1928. The first significant fossil collections were made by the University of California a few years later. According to Dalquest (1969, p. 2) the fossils at this site accumulated in a seasonal lake or bog of moderate but unknown area. The lacustrine sediments, a facies of the Ogallala Formation, are now exposed in a 20-foot vertical section for a distance of about 300 feet along a tributary of Red Deer Creek. Most of the fossils have been found in the greenish sand and sandy clay at the base of the section. These include well-preserved skulls and jaws of *Osteoborus,* a bone-eating dog; a nearly complete skeleton of *Machairodus,* a saber-toothed cat; four different kinds of horses; large and small camels; deer; peccary; antilocaprid; rhinoceros; and an assortment of rarer carnivores. The fauna is more advanced than the Clarendon fauna as evidenced from a comparison of the horses and other taxa. A paleoecological study of the fauna by Shotwell (1955) suggests that the proximal community at the Hemphill site lived in a grassland habitat on the basis of the large number of herbivores present.

Overlying the main fossil beds at the Hemphill quarry is a thick bed of volcanic ash which preserves the tracks of birds and mammals along certain bedding planes. The absolute age and the source of the ash have not been determined but the ash fell in sufficient quantities to completely fill the lake basin and to seal off the fossil beds below.

In some of the tributary canyons of the Red River such as Palo Duro and Cita Canyons, located about 20 miles south of Amarillo, faunas of a Late Hemphillian or Late Middle Pliocene age have been found. By this time, rhinoceroses were nearly extinct in North America and other lineages were evolving new genera. Climates were changing too. During most of the earlier Pliocene, climatic conditions were subhumid and subtropical as evidenced by remains of large tortoises and alligators in some of the faunas. At the close of Hemphillian time, conditions became more arid and extensive development of caliche occurred in the upper part of the Ogallala Formation. During subsequent Blancan time, there was a return to moist conditions. Basins developed in which the early Pleistocene Blanco Formation and the middle Pleistocene Tule Formation accumulated.

QUATERNARY SEDIMENTS

Sediments of Quaternary age cap the surface of the High Plains, forming a very complex sequence of lake, wind, and stream deposits which has been described by Reeves (1972, p. 110-112). Other deposits of Quaternary age fill the stream and river valleys in the study area and veneer slopes (fig. 5).

A very complex sequence occurs along the Canadian River and its tributaries, and some very outstanding fossil localities occur just north of the study area (Schultz, personal communication, June, 1974). We noted several vertebrate fossil locations in the study area. An elephant tooth (mammoth) and other bone fragments occur in the west bank of Middle Alamosa Creek, approximately 1½ miles due east of Bradley Tank (fig. 6). The location is a few yards south of archaeological site 41 OL 28 and was shown to us by the ranch owner, Tom Green. A number of bison bones crop out along Middle Alamosa Creek slightly less than two miles due south of the elephant bonesite. The bison site was visited by the archaeological team (Marmaduke and Whitsett) who reported finding bones for several hundred feet along the creek. A third site was found in the southwest bank of Middle Alamosa Creek, 600 feet southwest of the East Prong windmill on the Mansfield Ranch (fig. 5). The bones at that site were neither identified nor collected and are too small to be either adult elephant or bison.

Schultz (1972) has summarized what is known about the Quaternary vertebrate fauna of the southern High Plains:

> The type locality for the Blancan Mammalian Age (Late Pliocene—early Pleistocene) of Wood and others

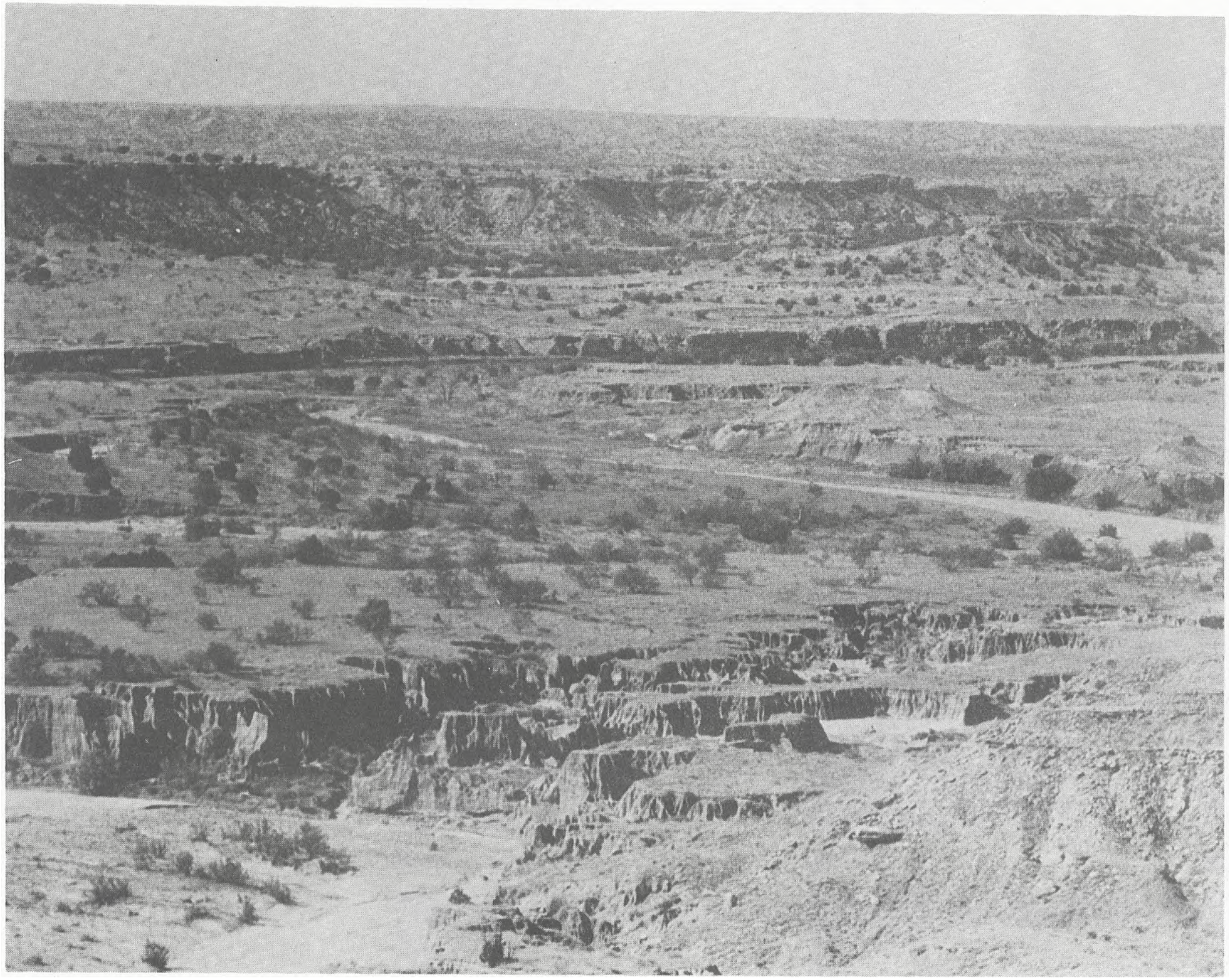

FIGURE 5

A thick sequence of Quaternary valley-fill sediments are found in the drainages in the study area. This view is toward the south from the south end of Battleship Mesa, just northwest of the East Prong windmill on Middle Alamosa Creek. Vertebrate fossils occur in the bluff above the bend in the creek in the lower left corner of this photograph. The caprock in the background is the Trujillo Formation, and the Cedar Brakes (developed on the Chinle Formation) form the distant skyline. Photograph by Dwight Deal.

FIGURE 6
Sequence of Pleistocene sediments exposed along the west bank of Middle Alamosa Creek, approximately 1½ miles due east of Bradley Tank on Tom Green Ranch. An elephant (mammoth) tooth was found at this location. Photograph by Dwight Deal.

(1941) is about 40 miles northeast of Lubbock, Texas. According to Evans and Meade (1945), the Blanco Formation is a localized basin accumulation and is predominantly of lacustrine origin although a fluviatile origin has been advocated by Gidley (1903), Matthew (1924), and by Frye and Leonard (1957). The best exposures of these white beds occur for a distance of 2 or 3 miles along the upper walls of White River Canyon (Blanco Canyon) and along Crawfish Draw which enters it from the west. In this region, the Blanco beds unconformably overlie the reddish-brown sand and clay of the middle Pliocene Bridwell Formation (locally defined equivalent of part of the Ogallala Formation). They are in turn overlain by widespread aeolian sands, silts, and caliche of middle or late Quaternary age.

Evans and Meade (1945) state that "the Blanco beds consist mainly of well-bedded light gray calcareous sands and clays with some fresh-water limestones, tufa, diatomite, and coarse gravels. The finer-grained materials make up the main body of the deposits but grade marginally to coarser sand and gravel." In an outcrop distance of about 1.5 miles, Evans and Meade recognized from 10 to 12 traceable beds and noted a range in thickness of 56 to 74 feet for the formation.

Disagreement exists as to the environment in which the Blanco Formation was deposited. In 1900 and 1901, Gidley made a large fossil collection for the American Museum of Natural History and concluded (1903) that the beds were of limited extent and represented a valley deposit of an aggrading stream. He wrote that "the occasional beds of diatomaceous earth are easily accounted for by supposing that there were in this ancient valley occasional ponds filled with clear water enduring for various periods of time, partially or totally isolated from the stream that ran through the valley." Matthew (1924) also considered the Blanco to be a stream valley deposit but thought that the light-colored fossil-bearing strata were a channel facies which interfingered with the bordering reddish-brown Pliocene sand and clay which he took to be a flood plain facies of the Blanco. He wrote "the Blanco beds were deposited in a broad and shallow slowly aggrading stream valley with a slow-flowing, probably intermittent stream of about the type of the present Blanco Creek. The valley would be partly occupied then as now by abandoned stream channels forming ponds and muckholes. . . ."

Evans and Meade (1945, p. 492) believed the Blanco beds "to be lacustrine deposits laid down in broad shallow basins rather than deposits of a large stream valley." Their evidence consists of the fact that the coarser clastics are indigenous pebbles of caliche caprock occurring along the margins of the basin, the excellent stratification persistent over much of the exposed area, the presence of diatomite, bentonitic clay, and fresh-water limestone, and the absence of any connecting filled valley segment between the two main areas of Blanco bed exposures. Their summary of the geologic history of the region consists of the following stages or steps: (1) development of a caliche caprock on the plains surface during an arid interval near the end of Pliocene time, (2) development of a basin or basins to a depth of 60 or 70 feet during an arid interval—perhaps due to deflation, (3) occupation of these basins by lakes and filling of these lakes with lacustrine sediment of the Blanco Formation during a wet period (viz. Nebraskan), (4) deposition of wind-blown silt and volcanic ash during a subsequent arid interval to complete the filling of the basins to the level of the present plains surface.

Frye and Leonard (1957, pp. 20-21) have argued against Evans and Meade's interpretation of the environmental history of the Blanco citing as evidence the significant absence of aquatic mollusks and certain types of vertebrate fossils such as fish and amphibians—all of which should have been present had a large permanent lake existed under humid climatic conditions for any period of time. They state that "all the known facts . . . point to alluviation by streams of very low gradient flowing across a semiarid terrain."

Since the Blanco Formation disconformably overlies deposists of middle Pliocene age and is disconformably overlain by aeolian silts and sands, the age of the Blanco fauna is based mainly upon the evidence of fossil vertebrates. Included are such short-range genera as *Borophagus* (bone-eating dog), *Titanotylopus* (large camel), and *Plesippus* (zebrine horse) which are known only from the Blancan. There are present, in addition, longer range genera such as *Camelops* (camel), *Tanupolama* (llama), and *Platygonus* (peccary), which first appear in the Blancan but survive through most or all of the Pleistocene. The fauna also includes surviving genera typical of the Pliocene such as *Nannippus* (3-toed horse) and *Rhynchotherium* (mastodon) which did not survive the Blancan. The presence of Pliocene genera in early collections from the Blanco appears to be responsible for the original assignment of a Pliocene age to the fauna by Gidley, Matthew, and others. The typical Pleistocene genera in the fauna were not recognized until later. A number of forms were added to the faunal list by Meade (1945) who assigned an early Pleistocene age on the basis of faunal composition. This, together with the evidence that the deposits were formed in a humid climate which would likely correspond with a glacial stage, indicated, in the opinion of Evans and Meade, that the Blanco beds are of Nebraskan age. Others have argued for an Aftonian or a pre-Nebraskan age.

Although opinions still differ on the precise age, the climatic conditions, and the depositional environment, new contributions to our knowledge of the Blanco Formation and its fauna are being made. It is now known, for example, that the volcanic ash which overlies the Blanco horizon matches petrographically the rhyolite air-fall tephra (Guaje Pumice bed) that underlies ash flows of the Bandelier Tuff in the Jemez Mountains of northern New Mexico. The Guaje has been K/Ar dated at about 1.4 million years (Izett and Wilcox, 1972, p. 384). Furthermore, paleomagnetic studies are presently being carried out to determine if magnetic reversals of the earth's field are recorded in the rocks here.

The Blanco fauna is an extremely interesting one and it has had a long history of study. Over the years a number of institutions have made collections and many new species have been described. Most of the fossils consist of disarticulated specimens although in a few cases articulated skeletons have been found in the white clay including those of *Plesippus*, the zebrine horse, collected by Matthew and Simpson in 1924 for the American Museum. At one locality Meade collected the remains of about 18 individuals of a large camel, *Titanotylopus.* Although no articulated skeletons were found, there were several articulated skulls and jaws and a number of articulated leg bones. According to Meade, these fossils may represent a herd of camels which ventured into the shallow waters of the ancient lake and were trapped or overcome by carnivores at the edge of the water. Other significant discoveries include the skull and jaws of a large jaguar, *Felis palaeoonca,* and the carapace of a large glyptodont.

Basins similar to that at the Blanco site occur elsewhere in the southern High Plains. In Cita Canyon, southeast of Amarillo, excavations by W.P.A. crews in the late 1930's produced an exceptionally large Blancan fauna, the Cita Canyon fauna, which includes horses, camels, deer, peccary, bone-eating dogs, coyote, saber-toothed cats, puma, ground sloth, glyptodonts, and turtles. Unusual finds include two teeth of an early ursid (bear) and the lower jaw of the only genus of hyena known to have been native to North America.

Basins of middle Pleistocene age are also present in the region. One of the largest of these is the Tule Basin between Tulia and Silverton, Texas. Here the gray clay and sandy silt of the Tule Formation have nearly filled the basin to the level of the High Plains surface. Fossils have been collected from the Tule Formation since the days of Cope and Cummins. One of the best known sites is at the head of Rock Creek, a tributary of Tule Canyon. The Rock Creek fauna has produced new species of turtle, camel, and horse as well as numerous remains of ground sloth. Of great significance is the occurrence of the horse, *Equus scotti.* Since its discovery by Gidley in 1900, about 20, more or less, articulated skeletons have been removed from one quarry and are now in the collections of Yale University, the American Museum, the Smithsonian, and West Texas State University.

The recent trend in vertebrate paleonotology has been the collection of microvertebrates through screen-washing techniques. A number of microfaunas of middle and late Pleistocene age have been found in the southern High Plains. One of the best known of these is the Cudahy fauna which is known from localities in Nebraska, Iowa, Kansas, and north Texas. The fauna includes an abundance and variety of rodents which indicate cool, wet climatic conditions. At present, the fauna is assigned to the Late Kansan glacial stage. Overlying the Cudahy faunal horizon at some of the fossil sites is a layer of volcanic ash which is about 600,000 years old (Pearlette Type O). The source area for this ash fall in Yellowstone Park. Within the last two years this author has located several good Cudahy fauna sites in the Texas Panhandle which have produced a large number of fossils.

The possibilities for further paleontological study in the southern High Plains are unlimited and there is a great need for additional work to be done in the Triassic and Pliocene and especially in the Pleistocene.

PROBLEMS OF TRIASSIC STRATIGRAPHY

Roberta Speer (1972), a student at West Texas State University, wrote a paper on the Triassic stratigraphy of the Llano Estacado area as part of one of her class projects. It was a carefully researched paper and the remainder of this section is largely rewritten from it. The basic problem in correlating the rock types and rock names in the Canadian River-Llano Estacado area is compounded both by the occurrence of exposures that cannot be physically traced from one area to another and by the fact that some of the units seem to change their characteristics quite rapidly in lateral directions.

HISTORY OF GEOLOGIC INVESTIGATIONS

The earliest geologic work in the Texas Panhandle is reported to have been done by George P. Shumard, a geologist with the Marcy expedition of 1852. In 1853-1854, Lieutenant A. W. Whipple of the Topographical Engineer Corps of the United States Army commanded an exploratory expedition from Fort Smith, Arkansas to the Pacific Ocean. Jules Marcou, official geologist for the party, contributed information on Panhandle geology (Marcou, 1856). W. F. Cummins (1889) published a paper in the First Annual Report of the Geological Survey of Texas, describing the Triassic beds near Dockum in Dickens County, which he named the Dockum Group. The three following Annual Reports contained additional information acquired by Cummins.

W. F. Drake made a trip completely encircling the southern High Plains and in 1891 published the first comprehensive report of the Texas Triassic. His party followed the eastern escarpment north from Big Spring to the Canadian River, from there traveled west to near Tucumcari, New Mexico, then south along the Pecos River, and finally east to San Angelo. He divided the Dockum Group as follows: ". . . a lower bed of sandy clay which is 0 to 150 feet thick; a central bed or beds of sandstone, conglomerate, and some sandy clay, which is from 0 to 235 feet thick, and an upper bed of sandy clay and some sandstone, which is from 0 to 300 feet thick." In a separate paper accompanying Drake's report, E. D. Cope (1891) analyzed the vertebrate paleontologic finds in the Dockum and confirmed the age of the deposits as Triassic.

The 21st Annual Report of the United States Geological Survey contains an extensive article in which W. D. Johnson discussed the topography and geology of the High Plains. The work of C. N. Gould, who studied the geology of Sherman, Moore, Potter, Randall, Dalham, Hartley, Oldham, and Deaf Smith Counties was published as Water Supply Papers No. 154 and 191 by the U.S. Geological Survey in 1906 and 1907. Gould measured exposures in Palo Duro Canyon and along the Canadian River valley and then subdivided the Triassic into two formations on the basis of differing lithologies. The lower clay and shale member was named the Tecovas, the upper sandstone and shale the Trujillo. Both names derive from creeks draining into the Canadian between Amarillo, Texas and the New Mexico line.

These formations, averaging 150 to 300 feet in thickness, were described as follows (Gould, 1906): The lower Tecovas "...consists largely of shales, it is divided lithologically into two parts ... the lower more or less sandy shale of various colors, with maroon, lavender, yellow, and white predominating, and the upper or dark red or magenta shale." The upper Trujillo "...consists of several ledges of massive, more or less cross-bedded sandstone and conglomerate with interbedded red and gray shales."

Gould's type locality for the upper sandstone unit of the Triassic is in western Oldham County, adjacent to New Mexico. He said, "...most of the red beds of the region are Triassic in age, both the Tecovas and Trujillo formation being well exposed along the river and in places as far back as the edge of the High Plains. Along the creeks red and gray and yellow sandstones are conspicuous. Near the mouth of Trujillo Creek the variegated shales of the Tecovas formation are represented by a ledge of soft yellow and red sandstone containing fossil wood."

Gould's description of the Trujillo includes the following remarks:

> It consists of several ledges of massive more or less cross-bedded sandstone and conglomerate with interbedded red and gray shale. In most sections there are three well-defined ledges, although there may be as many as five. Along Palo Duro Canyon and in the Canadian River valley a persistent ledge of massive sandstone occurs near the middle of the Triassic beds. It is mostly fine-grained and massive, occasionally cross-bedded and conglomeratic. It is usually gray or brown in color and in the valley of the Canadian River has an average thickness of about 25 feet. The Trujillo forms conspicuous ledges and is a convenient horizon for reference, especially where synclines have carried other beds, notably the Alibates dolomite, beneath the surface. Separated from the lower sandstone by a bed of red or gray shales 15 to 60 feet thick is a sandstone and conglomerate ledge designated as the middle sandstone. It is generally coarse-grained and cross-bedded, with an average thickness of 10 feet. The upper sandstone is not exposed along the Canadian River valley.

Darton named the Santa Rosa Sandstone in 1921, at which time both identity of Triassic beds and correlations to the west and east were imperfectly understood. He states that:

> ...the strata overlying the Chupadera formation consist of 800 feet or more of red shales and sandstones representing the Dockum group, including near the bottom a resistant massive sandstone which is prominent in the mesas of Guadalupe County and along the Pecos River at Santa Rosa. This sandstone appears to occur at about the horizon of the Shinarump conglomerate, but no definite is possible, and I here propose for it, tentatively, at least, the name Santa Rosa sandstone. Darton notes that in the Pecos Valley region in Eddy and Chaves Counties the overlying series is several hundred feet thick and its outcrop extends from the east bank of the Pecos River to the edge of the Staked Plains.

Patton (1923) furnished detailed descriptions of the geology of Potter County just east of Oldham County. His report included mechanical analyses of the sandstones and chemical analyses of the shales in the Dockum group. He describes the Tecovas Formation as consisting of

> ...various colored shales and soft gray unconsolidated sandstone. This sandstone is a series of lenses, not a stratum, having a maximum thickness of 35 to 40 feet at the mouths of Bonita and Pedrosa Creeks. The Tecovas formation exhibits great local variation in thickness but averages about 200 feet in Potter County. The Trujillo formation is 25 to 75 feet thick and consists of three to five ledges of sandstone with interbedded shale. In most of Potter County only one ledge is represented, and between the west wall of East Amarillo Creek and West Amarillo Creek it is absent. The sandstone is micaceous and sometimes conglomeratic. Siliceous pebbles, bone fragments and minute particles of limestone are present. Silicified wood is present in considerable amounts in both the Tecovas and Trujillo formation.

H. W. Hoots (1925) provided lithological data on the Triassic beds of the extreme Southern Plains region and noted differences between the Gould and Drake descriptions of sections and those he observed in the southern Triassic deposits. He states that the Dockum in its southern areas near the Edwards Plateau, is exposed along the southeast edge of the Llano Estacado in Borden, Scurry, Howard, and Mitchell Counties. Sediments vary in thickness from 300 to 450 feet and consist largely of dark red clay with interbedded layers of gray cross-bedded sandstone and coarse sandstone conglomerate. The sandstone is invariably micaceous, having bedding planes lined with small flakes. Variegated shales are not found anywhere in the region. Hoots states:

> It may be said, therefore, that the Dockum Group in this region is divisible into two more or less distinct forma-

> tions—a lower one with a maximum thickness of 275 feet characterized by red clay and numerous beds of massive gray cross-bedded sandstone and an upper one with a maximum thickness of 175 feet or more and consisting almost entirely of red clay. The lower formation includes the basal sandstones exposed in and near Colorado City, Mitchell County, in addition to Drake's "lower beds of sandy clay" and his "central bed or beds of sandstone" exposed near Iatan. The upper formation is approximately equivalent to Drake's "upper bed of sandy clay and some sandstone."

With some exceptions, Hoots states, these two units hold for the major portion of the area.

> In the Pecos, west of the Llano Estacado and east of the Guadalupe, the lower micaceous cross-bedded sandstone is not so abundant. Sandstone is fairly common near the base and top; however, it is red not gray and is well cemented. Resistant red sandstone at the top of the bluff, which laterally changes to gray, is easily the most conspicuous stratum seen within the red beds of southeastern New Mexico, and it is unusually persistent. The sandstone series in eastern Eddy, Loving, and Ward Counties, which has been described above may be the equivalent of Darton's Santa Rosa sandstone of Guadalupe County, New Mexico. It is considered to occur at or very near the base of the Dockum of Eddy and Chaves Counties; the (overlying) series is several hundred feet thick and its outcrop extends from the east bank of the Pecos River to the edge of the Staked Plains.

Adams (1929) provided detailed analyses of Triassic depositional conditions as well as specifics of stratigraphy from the eastern part of the extreme southern High Plains westward into eastern New Mexico. He remarks that sandstones generally are more common and generally poorly cemented in the lower part of the Triassic beds. "The sandstones in the lower sandy part of the Dockum seem to form fairly continuous beds. Those in the upper part are evidently discontinuous lenses. In eastern New Mexico these upper sand lenses are much more extensive than in Texas."

The main shale beds occur in the upper part of the Dockum but it is common in lower parts also. Beds of nearly pure shale ranging from 600 to 1200 feet overlie the sandstones in the central and western parts of the area.

In recent subsurface work of this area two formations can be recognized on the basis of lithology: a lower sandstone with an average thickness of 350 feet, maximum thickness 600 feet and an upper shale about 1200 feet thick. The shale member has minor amounts of sandstone, limestone, and conglomerate and occupies the stratigraphic position of the Chinle.

Well samples show that the lower sandstone correlated northward is the Santa Rosa sandstone of north central New Mexico. Only the Santa Rosa is present at the south and east margins of the Triassic area. This is true in Pecos, Crockett, Irion, Sterling, Mitchell, Scurry, Fisher, Nolan, and Coke Counties. Camp Springs, Quito, Dripping Springs, Barstow, and Taylor are names that apply to some sandstone locally. The beds to which they apply cannot be recognized over large areas, and this is predictable in view of the lensing nature of terrestrial deposits.

L. H. Sellards *et al.* (1932) discussed Texas geology at length. From the data available to them, Sellards *et al.* described and correlated the proposed units of eastern New Mexico and the southern, central, and northern Panhandle. He also summarized information on deposition, lithology, and paleontology for the Dockum Group. Sidwell (1945) made mineral and physical analyses of Triassic sediments collected from the eastern fringe of the High Plains to Santa Rosa, New Mexico. J. B. Reedside and others (1957) collaborated on a correlation of Triassic sediments of North America based on fossils.

Green (1954) worked on the Triassic beds exposed in Garza, Crosby, Dickens, Motley, Floyd, Briscoe, Armstrong, Randall, Potter, and Oldham Counties. He stated that the two-fold division of the Triassic Dockum in the northern part of the eastern escarpment of the Llano Estacado gives way to three units beginning in Crosby County. With regard to nomenclature, Green states that "The general practice or tendency in recent literature, especially in stratigraphic nomenclature dealing with the Permian Basin section in West Texas and southeast New Mexico is to substitute the name Santa Rosa for the term Trujillo, and although the former name has been found to be preoccupied, it will probably continue in popular usage."

Green reports variegated shales comparable to the Tecovas type section occurring at his Silverton section number 12 but not at his Silverton section number 2 or in Tule Canyon, both of which lie between his section 12 and Palo Duro Canyon. He also notes numerous other stratigraphic variations observable southward along the eastern scarp of the Llano Estacado. One such is observable at Lingos Falls where the Trujillo Formation rests directly on Permain Rocks.

Green, speaking of the Trujillo Formation, states that "There is only one massive sandstone in the Canadian River, Briscoe, and Motley County outcrops where the thickness of the two formations is less than Randall County exposures when two or more sandstone ledges occur; and two, the Trujillo or its probable equivalent becomes more conglomeratic going southeast from Oldham County to Crosby and Garza Counties."

In Crosby County the Trujillo Formation is represented by a single sandstone about 20 feet thick which, in extreme southeast Crosby County, becomes a 10-foot-thick coarse sediment resting directly on the folded and truncated Permian deposits. At Calgary, ten miles away, this same bed is 18 feet thick and is underlain by more than 120 feet of clay and shale referred to as the Tecovas Formation. Green refers to red beds that overlie the Tecovas and Trujillo, but possess the same lithology as the latter, as Chinle but notes differences between them and the Chinle of east central New Mexico.

McKee and others (1959) published a U.S. Geological Survey report, with maps, on the Triassic System of the United States. Spiegel (1972) comments on that report:

> Geologists have tried to classify the complex assemblage of rocks into a few idealized widespread units on the basis of local studies. The regional study of the Triassic by McKee and others (1959) unfortunately was based primarily on subsurface data in the Canadian River valley. Because it disregarded the excellent key outcrops along the river, that study is of little value for local details seen in the Canadian River area. The McKee report does provide useful data concerning regional thickness trends and lithologic variations.

The Texas Board of Water Engineers bulletin number 6107 published in 1961 includes a summary of Triassic geology and discusses the use of the Dockum Group as an aquifer in the southern part of the High Plains.

B. E. Fink (1963) reports on ground-water geology in the northern part of the southern High Plains and correlates the Santa Rosa and Trujillo sandstones, using well logs as the major source of data.

Berkstresser and Mourant (1966) have mapped the underground Triassic of Quay County, New Mexico, west of Oldham County on the basis of numerous water well logs. They drew three profile lines through the county: a diagonal southwest-northeast line across the entire county and two north northwest-south southeast lines that divide the county approximately into equal parts. Berkstresser's sections indicate that the Santa Rosa rises steadily along the southwest-northeast line, outcrops at the Canadian River, then dips underground again as it continues northeast into Texas. The more southerly of the northwest-southeast lines shows the Santa Rosa dipping approximately another 1000 feet below its normal subsurface level toward the north and west, then rising slightly before entering San Miguel County to the northwest. The more northerly profile line shows the Santa Rosa rising steadily to the northwest, cropping out at the Canadian River about two miles east of Logan, New Mexico, then dipping gently downward again under Harding County.

Berkstresser describes the Santa Rosa as consisting of "...interbedded layers of clay, shale, and conglomerate. The sandstone strata typically are gray, although some are red or brown. They are fine to coarse-grained, thin-bedded to massive and locally cross bedded. The sandstone contains small amounts of fossil wood and bone. . . . The clay and shale layers are reddish orange, maroon, dark red, or variegated. . . ." About 140 feet of Santa Rosa is exposed in the valley of the Canadian River one mile south of Logan. The log of oil-test well 13.34:9.333 indicates that the Santa Rosa is 375 feet thick; it may be as much as 450 feet thick near the Canadian River. The water table in the Santa Rosa aquifer slopes toward the Canadian River and its tributaries, which are discharge areas. Overlying the sand member are shales and siltstones of the Chinle Formation.

Spiegel (1969) spent one week walking along the Canadian River and states that:

> The massive sandstone (Logan sandstone) incised deeply by the Canadian River was traced downstream for 40 miles from sec. 19, T13N, R33E, in Quay County to the type locality of the Trujillo Formation in adjacent Oldham County, Texas. Friable white-to-buff sandstone and interbedded red mudstone, observed locally at the base of the bluffs of the Canadian River in R35E and R36E of Quay County and in samples for two drill holes at Dunes dam site, sec. 2 T13N R35E, are correlated with the Tecovas formation of Potter County, Texas. . . . Excellent outcrops in the river bluffs show both intraformational and post-Trujillo subsistence, due to solution of underlying Permian rocks. Red sandstone and mudstone of the Chinle Formation conformably overlies the Trujillo Formation on the west flank of an anticline which carries the top of the Trujillo Formation below the Canadian River westward from sec. 20 T13N R33E, between Ute Dam and the mouth of Ute Creek. . . . Scattered exposures of the Tecovas are present upstream, at the base of the Trujillo bluffs in the Canadian River canyon to within 1½ miles (airline) of Logan. . . . Al Clebsch . . . mapped the Santa Rosa in Guadalupe County in connection with a U.S.G.S. ground-water study. . . . He has also seen the Tecovas in the Quay Oldham area and believes there is lithologic similarity with the lower Santa Rosa near Puerto de Luna, south of Santa Rosa.

Spiegel has recently completed a geologic map of the Canadian River area from near Logan, New Mexico to sec. 2, T13N, R35E, eight miles west of the Oldham-Quay County Line.

CURRENT STATUS OF THE STRATIGRAPHIC PROBLEMS

In the early 1970s three things were happening: Zane Spiegel, a geologist for the state of New Mexico, continued to try to work out the relationships of the "Logan sandstone" exposed at the Ute Dam site; G. K. Eifler was compiling a regional geologic map of the Tucumcari AMS sheet as part of the Texas Bureau of Economic Geology Geologic Atlas series; and Warren Finch was studying the Triassic rocks of the area as part of a uranium project for the U.S. Geological Survey. These men conferred in the field on March 22 and 23, 1971.

Finch (1971) summarizes the problem:

Published maps in the area show the Triassic as follows: On the New Mexico Geologic Map (Dane and Bachman, 1965, 1:500,000), the Santa Rosa Sandstone is shown along the Canadian River from Ute Creek eastward to within one mile of the border. A band of Chinle Formation is shown wholly separated from the Santa Rosa by Quaternary cover south of the River. The geologic map of Quay County (Berkstresser and Mourant, 1966, scale 1 in = 3 mi) shows a similar distribution of Santa Rosa, except it is extended to the State line; the Chinle is shown to directly overlie the Santa Rosa without intervening Quaternary cover. On the Texas Geologic Map (1932, 1:500,000) the Dockum Group is shown as a wide outcrop at the state line extending from the River southward to the approximate position of the upper contact of the Chinle shown on the New Mexico map.

The Santa Rosa Sandstone was named by Darton (1922) for sandstone and conglomerate beds that crop out along the Pecos River at Santa Rosa about 70 miles west-southwest of Ute Reservoir. The closest beds to Ute Reservoir mapped as Santa Rosa are upstream about 40 miles at Conchos Reservoir. Westward from Conchos, the State geologic map shows a continuous outcrop of Santa Rosa to the type locality. (My field studies substantiate this mapping.) The lithology and bedding characteristics of the Santa Rosa at Conchos Reservoir are very similar to those of the sandstone mapped as Santa Rosa at Ute Reservoir. Furthermore, the sequence of beds above the Santa Rosa, namely, lower shale and middle sandstone members of the Chinle, is the same at Conchos and Ute Reservoirs.

Gould (1907, p. 22) in his paper on the western part of the Texas Panhandle subdivided the *whole* of the Triassic into "two well-differentiated formations." At the base are varicolored shales called the Tecovas Formation and at the top are beds composed of three to five ledges of massive more-or-less crossbedded sandstone and conglomerate separated by red shales called the Trujillo Formation. The type locality of the Tecovas is at the head of Tecovas Creek in Potter County, where the shale rests on the Alibates dolomite lentil but its upper contact with the Trujillo is not present. The type locality for the Trujillo is about 45 miles to the west apparently near the mouth of Trujillo Creek, which is about 10 miles east of the Texas-New Mexico border. In the Trujillo Creek drainage, as will be discussed in more detail below, the Triassic is not well-differentiated into two formations. No one has been able to locate THE type locality. The nearest place where both the Trujillo and Tecovas are well exposed, sandwiched between Permian and Ogallala, in the same outcrop is at the head of Palo Duro Canyon, about 25 miles southeast of Tecovas Creek.

Spiegel (1969), based on 1:16,000 scale mapping along the Canadian River in 1957, traced the Santa Rosa from the dam at Ute Reservoir to the "type locality" of the Trujillo. Sandstone and mudstone that crops out locally below the Santa Rosa and intersected in drill holes at the Dunes Dam site, sec. 2, T. 13 N., R. 35 E. are correlated with the Tecovas. He thus correlates the combined section of Trujillo and Tecovas with the Santa Rosa along the Pecos River at Santa Rosa, N. Mex. On the basis of priority of the names of Trujillo and Tecovas, he proposes that those names replace Santa Rosa in Quay County.

After the field conference, Finch

. . .spent two days that week, chiefly in the Bravo Dome area—Moser Ranch, Boise, Signal Springs, Signal Springs SE, Trujillo Camp, and Vat Camp quadrangles. I found that as one approaches the crest of Bravo Dome—in the lower part of Trujillo Creek and its tributaries (the reported type locality of the Trujillo)—the stratigraphy becomes very complex: the Tecovas shales thin and thicken greatly in short distances and are absent in places; intraformational unconformities show reworked Tecovas shale, probably at the base of the Trujillo; in several places the Santa Rosa equivalent interfingers with Tecovas shale; beds traceable with the lower shale member of the Chinle are irregularly distributed throughout the quads named above, beds traceable with the middle sandstone member of the Chinle lie with both erosional and angular unconformity on the Santa Rosa equivalent. The complex relations indicate uplift of the Bravo Dome and local subsidence during Triassic sedimentation. Thus, at the type locality of the Trujillo, the stratigraphy is not simple layer-cake geology. No wonder the type locality of the Trujillo is not recoverable. It leads me to question the validity of the name Trujillo.

The study of the Triassic stratigraphy is further complicated by beds of Ogallala that cut out entirely the Triassic on the east flank of Bravo Dome, where at the river in Vat Camp quadrangle the Ogallala rests directly on Alibates Dolomite. This irregular band of Ogallala is several miles wide and questions are what happens to the Santa Rosa equivalent and various members of the Chinle where the Triassic emerges on the east side.

Spiegel (1972) summarizes his view of the stratigraphic problems as follows:

Disagreement among geologists as to the nomenclature to be used for Triassic units is due to a combination of factors: difficulty of access to many of the good outcrops in the Canadian River, Trujillo Creek, and Bravo Dome, the discontinuity of outcrops across the Tucumcari basin, the great area of discontinuous exposures, the sparsity of good subsurface data, numerous and rapid facies changes, and the presence of the New Mexico-Texas state line.

Due to unfortunate provincialism, Gould's terminology of Tecovas and Trujillo for the complete Triassic section in Texas was not followed in New Mexico. The term Santa Rosa was extended erroneously from outcrops in the Pecos Valley into the Conchos Dam area by Griggs and Hendrickson (1951), and Dane and Bachman (1965), and to the Logan area by Berkstresser and Mourant (1966), and Dane and Bachman (1965). The writer has noted the following arguments against identification of the sandstones exposed at Conchos Dam and Logan as "Santa Rosa."

(1) The Santa Rosa in the Pecos Valley locally contains a basal mudstone section resembling some lithologies of Gould's Tecovas (Clebsch, 1957, oral comm.).

(2) The Chinle in the area north and east of Santa Rosa, (Dinwiddie, 1967); and elsewhere in north-central New Mexico has been noted to contain a persistent middle sandstone member. This and other less persistent sandstones, particularly in the lower member of the Chinle (Spiegel, 1957a; State Engineer Office, 1961) can be mistaken for sandstones lower in the Triassic section (Santa Rosa) when the stratigraphic position cannot be verified independently, such as by Permian outcrops, well samples, and cores. Clebsch (in Dinwiddie, 1967) has correctly mapped sandstones in northeastern Guadalupe County as Chinle. Griggs and Hendrickson (1951, p. 27) have generally correctly described the extent of the middle sandstone of the Chinle in San Miguel County, but mapped sandstones in the middle Chinle as Santa Rosa. However, they expressed some doubts (p. 26) as to the validity of the assignment of the sandstones at Conchas to the Santa Rosa. The presence of sandstones in shallow drill holes in lower Chinle beds near Ute dam site (State Engineer Office, 1961) was confirmed by an excellent outcrop created during excavation for the north abutment of the spillway of Ute Dam.

(3) Deep drill-hile data at Dunes and Ute Dam sites (Bechtel, 1962 a, b; 1963) indicated the presence of Tecovas lithologies below the Logan Sandstone, and Tecovas-like outcrops are observable at the base of sandstone bluffs at a number of locations down-river from Logan. These outcrops are characterized by red mudstone and a friable white sandstone similar to outcrops on the west flank of Bravo dome, where they were identified by Gould (1907) as Tecovas.

(4) The gentle westward dip of the rocks west of Ute Creek carries the top of the Chinle down nearly to the Canadian River at the west edge of the Tucumcari 2-degree quadrangle (Section 4, T. 13 N., R. 30 E.), and although the dip reverses upstream, only the upper third to half of the Chinle is exposed in the Conchas area to the west. The limited thickness of the Triassic section exposed below Jurassic rocks northeast of Conchas Dam is further evidence that the "canyon sandstone" beds at Conchas Dam are not Santa Rosa, but local sandstone in the upper to middle part of the Chinle. Dam-site tests holes show that sandstone and red mudstone extend to at least 240 feet below river level at Conchas Dam (Crosby, 1940). Some of these deeper beds (see well log 2) could be equivalents of the upper part of the Santa Rosa or, more likely, the Santa Rosa could be even deeper than 240 feet below Conchas Dam.

(5) Well Log 3, from a 1946 oil test (Waggoner & Wharton, Upton No. 1) in the northwest corner of Sec. 25, T. 18 N., R. 26 E., at elevation 4,875 feet (well 5 in Wanek's list of wells) near the top of a sandstone mapped by Wanek (1962) as "middle sandstone member of the Chinle," indicates a 120-foot section of predominantly hard sandstone at a depth of 681 to 801 feet, underlain by a 144-foot section of sandy shale, in turn underlain by anhydrite. These sections are interpreted herein to be, respectively, Trujillo Formation (restricted), Tecovas Formation, and the upper Quartermaster or Bernal Formation.

If the log of this well were added to Wanek's measured section No. 4 in his graphic correlation it would appear more logical to correlate the thick sandstone at the base of Wanek's measured Section No. 5 with the middle sandstone member of the Chinle rather than with the Santa Rosa.

The key to the problem lies in the structure and lithology in the Canadian River Canyon just below Conchas Dam, and in deeper subsurface information near Conchas Dam. Is there a sufficient reversal of dip to carry the top of the Logan Sandstone, from an estimated depth below the river of more than 1,000 feet in the axis of the Tucumcari basin (east of the mouth of Atarque Creek) up to the top of Conchas Dam? Or does the thick mudstone facies of the upper Chinle in Quay County, northeastern Guadalupe County (Clebsch, in Dinwiddie, 1967), and southern Harding County interfinger with units of sandstone of the upper Chinle in east-central San Miguel County? A short walk downstream from Conchas Dam along the right bank of the Canadian River is sufficient to determine that (a) the structure is not favorable to the outcrop of the Logan at Conchas Dam, and (b) that the "canyon sandstone formation" at Conchas Dam thins eastward and interfingers with mudstone.

In the writer's 1957 reconnaissance tracing of the Logan Sandstone eastward to Trujillo Creek in Oldham County, Texas, it was noted that the sandstone section of the mapped area (Spiegel, 1957 a, b) split into three sandstone units separated by red mudstones, and that the section was equivalent to sandstone in the lower part of Gould's Trujillo Formation. Therefore the name Trujillo Formation was applied to the Logan, since Trujillo had considerable precedence over "Santa Rosa." Further reconnaissance in 1971, in part with W. I. Finch, confirmed the extension of the Logan Sandstone facies into the lower part of Gould's Trujillo Formation at Trujillo Creek, with the top of the uppermost massive sandstone crossing Trujillo Creek at the state line about two miles north of Glenrio. The overlying typical sequence of lower shale, middle sandstone, and upper shale members of the Chinle were traced eastward from eastern San Miguel County across the southern part of the Tucumcari 2-degree quadrangle independently by Spiegel and Finch in 1971. The sandstone at Logan is not continuously exposed westward between Logan and bonafide Santa Rosa outcrops in the Pecos Valley.

The solution, essentially as proposed by Trauger in a memorandum of November 4, 1971, and concurred in by the writer, is to redefine Gould's Trujillo Formation to include only the lower sandstones north of Glenrio (equivalents of the Logan Sandstone) and to assign the upper beds of Gould's Trujillo to the Chinle.

The Santa Rosa in the Pecos Valley probably is equivalent to the combined section of Tecovas and Gould's lower sandstones of the Trujillo, but the sandstone members of the Santa Rosa may not be physically continuous into the Logan Sandstone and are definitely not equivalent to the "canyon sandstone" at Conchas, or the sandstones at Sabinoso dome.

As a result of these discussions, I have decided to use the terminology shown in figue 1, dividing the Triassic sediments exposed in the Alamosa Creek drainage into three units: 1) a lower mudstone, the Tecovas formation; 2) the middle sandstone ledges of the Trujillo formation; and 3) the upper mudstones of the Chinle formation.

TRIASSIC PALEONTOLOGY

Cope (1893) published early reports of the vertebrate paleontology of the Dockum Group. Case later added to the work in a series of reports beginning in 1914. Paleontological correlation of Triassic sediments along the eastern escarpment of the Llano Estacado in Garza, Crosby, Dickens, Motley, Floyd, Briscoe, Armstrong, Randall, Potter, and Oldham Counties were supplied by Green (1954). He made detailed descriptions of fish, amphibian, and reptilian remains, most of which appear to have come from Tecovas horizons, although one "lower Chinle" strata is mentioned. He uses the term "Dockum Group" in comparing Texas Triassic fauna with those of other regions.

Buettneria is the dominant amphibian genus found in the Dockum Group, having been identified from locations in several counties. It appears that there are no invertebrate fossils in the Texas Triassic that have correlative values, for the one genus represented, *Unio,* is both scarce and poorly preserved. Triassic floral remains are scanty and are most frequently present in the form of fossil wood, which is discussed comprehensively by Stagner (1941). He states that "While the Upper Dockum is contemporaneous with the Chinle, the Lower Dockum is older." Green (1954) notes that the statement is unqualified because no mention is made of what part of the Dockum produced the fossil plants.

Reeside and others (1957) summarized the fossil evidence of the Texas Triassic as part of a major correlative effort concerned with continental Triassic sediments.

WATER RESOURCES

Introduction

The ground-water and surface-water resources of the area have been summarized by Anonymous (1960), Alexander (1961), Fink (1963), and Kunze and Lee (1968). Water flowing in the Canadian River valley tends to be fairly high in dissolved solids and range from hard to very hard. Ground water in the Ogallala Formation generally is of good quality, but that produced from the Triassic rocks underlying most of the study area is highly variable in quality. We noticed great variations in the water quality, taste, and odor found at various windmills: some was of good quality, but most was fairly high in dissolved solids, and some had a very disagreeable odor, taste, or color.

There is enough water of good quality in the area to allow for the present land use of ranching and hunting. There is also enough to allow for limited development, as evidenced by Cal Farley's Boys Ranch.

Surface Water

Surface-water resources are summarized by Kunze and Lee (1968) as follows:

> The quality of water in streams of the Canadian River basin, Texas, is controlled by the geology, streamflow pattern and characteristics, and in some areas by man's activities. Most of the streams drain rocks of the Ogallala Formation of Tertiary age and Dockum Group of Triassic age and generally contain water of good quality, with dissolved-solids concentrations less than 250 ppm (parts per million). However, the 12,700 square miles of the basin in the semiarid Texas Panhandle receives an average of only 19 inches of rainfall per year, of which less than 1 inch leaves the State as runoff. The surface-water supply of the basin is very limited, with most of the streams dry many days during the year.
>
> The water in the Canadian River, as it enters Texas from New Mexico, contains more than 500 ppm dissolved solids; as the river flows across the Texas Panhandle, the dissolved-solids content progressively increases. The meager flows of streams with water of good quality from Ogallala and Dockum rocks are not sufficient to dilute natural saline inflows from Permian rocks and inflows of oil-field brines and municipal wastes. Most surface waters in the basin range from hard to very hard. Calcium, sodium, magnesium, and bicarbonate are the principal dissolved constituents in most streams.
>
> Lake Meredith, completed in 1965, is the only major surface-water supply in the basin except for Lake Rita Blanca which is used solely for recreation. Water from Lake Meredith will be used to supplement ground water for municipal and industrial purposes. Water impounded in this lake, although usable for public supply, is very hard and does not meet U.S. Public Health Service standards for dissolved-solids concentrations. During extended dry periods, the dissolved solids may approach 1,000 ppm. There are no plans to use Lake Meredith water or any other surface supply in the basin for irrigation. Any surface-water source to supplement the

ground water presently used for irrigation would probably have to be imported to the basin.

Ground Water

Ogallala Aquifer

The Ogallala Formation is the principal source of water for the High Plains, furnishing nearly all the municipal, industrial, and irrigation water used in that area. This aquifer is recharged by precipitation in eastern New Mexico, and the ground water moves generally eastward under the Llano Estacado. Present withdrawals of water from this aquifer are many times the recharge rate, and the water that has been stored in the Ogallala Formation for many thousands of years has been depleted almost completely. Prior to this extensive withdrawal, natural discharge occurred at many places along the eastern edge of the Llano Estacado, at the base of the Ogallala caprock. Most of these springs have now dried up. Some water is naturally lost from the aquifer to underlying Triassic and Permian aquifers. The water in the aquifer is of high quality but probably does not provide a major water resource in the study area.

Quaternary Aquifers

Unconsolidated valley fill along Alamosa Creek and the Canadian River are aquifers of local significance. A large quantity of ground water occurs beneath the terraces and bed of the Canadian River, but the chemical quality of that water is the same as that reported for the Canadian River. Small amounts of water of higher quality occur in the shallow aquifers along Alamosa Creek, locally supplying small amounts of good quality water for stock use. The water in these aquifers, because it is shallow and unconfined, is more susceptible to contamination than that in other aquifers in the area. These aquifers are locally significant in the study area.

Triassic Aquifers

Much of the water produced from Triassic Rocks is too high in dissolved solids to be usable, even for stock use. The Trujillo Formation, however, does produce water of fairly good quality. Fink (1963) discusses the quality of the water in the Triassic rocks south of the Canadian River but uses the name "Santa Rosa Sandstone" to refer to the body of rocks I call the Trujillo Formation in this report. Fink's discussion follows:

> Analyses of water from Triassic wells are given in table 3. These water analyses are of samples from wells used for irrigation, municipal, stock, and domestic supplies. The standards used for evaluating the chemical quality of the water differ depending upon the proposed use.
>
> Water used for municipal and domestic supply is produced from wells PC, TW, IO, and the City of Canyon wells. Fluoride is the one constituent in the water from the City of Canyon wells that exceeds the standard limits recommended by the U.S. Public Health Service for drinking water used by carriers in interstate commerce. The total hardness as $CaCo_3$ in the water from the City of Canyon wells is not higher than 67 ppm (parts per million) which is considered to be soft water. The water of maximum hardness given in the table is from the Palo Duro Club well which is 156 ppm. This water is considered moderately hard.
>
> Well IO is a domestic well drawing water from a sand zone in the Chinle Formation. The water from this well is slightly higher in most mineral constituents than water from the Santa Rosa Sandstone. Well FA-1 is a stock well about 3 miles south of well IO. This stock well is drawing water from a sand zone in the Chinle Formation. The similarity of the water from well FA-1 and well IO can be seen by comparing the analyses in table 3. The water from the Chinle sand zone appears to be generally poorer in quality than the water in the Santa Rosa Sandstone.
>
> The most objectionable constituent in the water in relation to irrigation is the sodium percentage. Sodium percentage is calculated by adding the equivalents per million of the positive ions (calcium, magnesium, and sodium), and dividing this total into the equivalent per million of sodium. This gives the percentage of sodium to all the positive ions in the water sample.
>
> Water from O-1 has a sodium percentage of 96. This water has been used seven years to irrigate a soil classified by the U.S. Soil Conservation Service as a pullman silty clay loam. The writer observed the crops produced on this land during the years 1960-1963. The crops appeared to be of excellent quality and compared favorably with crops grown on neighboring land, irrigated with water from the Ogallala Formation.
>
> Water from the City of Canyon wells was used to irrigate lawns and shrubs in the city for 28 years. The writer interviewed several city residents and former city officials in an effort to learn of any detrimental effects the water may have had on the soil. The results were that no change in plant growth had been noticed and the present condition of plants in the City of Canyon appears to be excellent.

Triassic sediments underlie most of the study area and are a major source for ground water in the study area.

Permian Aquifers

Some water resources occur in the Permian rocks that underlie the entire area, but the water in them is so highly mineralized that it is essentially unusable for domestic or stock use (Alexander, 1961, p. 10).

ACKNOWLEDGEMENTS

This report could not have been compiled in the time available had it not been for the assistance of

TABLE III – Chemical Analyses of Water Produced from Wells in Triassic Rocks
(Parts Per Million Except Specific Cond., pH, & Percent Sodium)
(from Fink, 1963)

Well No.	Owner	Depth of Well (ft)	Date of Collection	Silica (SiO_2)	Iron (Fe)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (C1)	Fluoride (F)	Nitrate (NO_3)	Dissolved Solids	Total Hardness as ($CaCO_3$)	% Na	Specific Conductance (Micromhos at 25° C)	pH	Analyzed by 1/
CASTRO COUNTY																			
FA-1	Frank Annen	472	1955	2.4	0.2	9	27	392	354	302	227			1347	132	87		7.9	D
DEAF SMITH COUNTY																			
0-1	V.J. Owens	767	9-5-56	12	.43	4.4	2.2	275	472	177	37	1.4	0.4	775	20	96	1,190	8.6	A
			11-25-56						472		39				20		1,190	8.2	A
			5-58						475		39				22		1,210	8.0	A
JF	J.H. Fish	860	10-30-53	11	.12	5.0	1.9	298	460	226	50	1.2	.0	834	20	97	1,300	8.2	A
	W.G. Russell	803	10-30-62		.04	8.0	2.0	120		150	89	1.3			100	93		8.2	E
IO	Ira Ott	396	3-10-58	9.6		12	4.7	441	435	302	222	3.2	.0	1220	50	95	1,980	8.4	A
A-2	Wilburn Axe	1023	4-15-63		.05	12.0	3.2	114		180	90	1.3						8.3	E
OLDHAM COUNTY																			
M-3	Malcolm Moser	271	6-7 38			104	52	58	433	214	14	0.2		655	472				G
Boise	Rock Island RR	240	3-31-38			43	22	66	323	61	9	0.7		360	199				G
RANDALL COUNTY																			
TW	Mrs. T.J. Wagner, Jr.	521	6-2-58		2.3	1	1	269		160	36			596	8	98		9.0	F
C-1	City of Canyon	488	6-11-36			9	6		352		25	2.5			43		659	8.3	A
			6-20			7.6	5.8				18	2.5			43		659	8.3	A
C-3	City of Canyon	504	9-12-56		.14	8	4	151	349	35	22	2.4	.4	414	36	90		8.3	B
			8-28-57		.02	6	4	144	342	31	20	2.6	.4	450	33	95	750	8.0	B
C-4	City of Canyon	567	8-28 57		.24	6	6	150	344	36	24	2.8	.4	471	35	89	785	8.0	B
C-5	City of Canyon	550	8-25-56			24	26	328	366	71	360	1.0			164	81			B
			8-28-57		.02	8	8	163	343	32	70	2.6	.4	553	54	87	922	7.9	B
C-6	City of Canyon	570	9-14-53			10	10.5	150	353	74	20	1.4	1.0	459	67	83		8.4	B
C-7	City of Canyon	562	10-23-53		.14	8	9	136	348	36	21	2.2	.4		57	84		7.7	B
			8-28-57		.02	9	9	120	332	27	17	2.6	.4		58	81		7.9	B
1,2, 3,4	City of Canyon (Composite)		12-4-47	11	.05	7.7	5.8	135	341	29	17	2.2	.5	390	43	87		8.0	A
PC	Palo Duro Club	504	5-15-61	12	.05	25.6	22.3	80.8	353.8	23.1	12			542	156	53	595	7.4	C

A – U. S. G. S., Austin, Texas
B – Texas State Department of Health
C – Curtis Laboratories, Houston, Texas
D – Texas A&M College
E – Deaf Smith County Research Lab.
F – Western Filter Co., Denver, Colorado

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A VEGETATIONAL STUDY OF THE CANADIAN RIVER BREAKS

Samuel Sikes and Jackie Smith

INTRODUCTION

The Canadian Breaks is an area dissected by severe erosion channels and invaded by mesquite. It may be delineated into three major plant association. The largest, a mesquite-grassland, extends from the breakdown of the High Plains into creek channels to the margin of the Canadian River. At a point approximately 300 meters from the main streambed of the river, mesquites are immediately replaced by salt cedars, and grasses found with mesquites intermingle with salt cedar-resistant species for a short distance before being totally replaced by them, forming the second association.

Stands of juniper are randomly interspersed within the mesquite grassland and are the dominant member of the third major plant association.

Several minor associations found within the research area are discussed at the end of the major association in which they are found.

Besides delineating plant associations, the objectives of this study were to compose a list of plant species present and measure effective ground cover.

METHODS

Collections were made of all species that were flowering or could be identified by vegetative characters, unless immediate field recognition could be made. In that case a list was made of all species identified and not collected, and that list is incorporated into the final species list (table VI).

Ground cover was determined, using four quadrat transects and one line transect. The first method consisted of one-tenth meter plots every ten meters along a straight-line 100-meter tape. Each plot was examined for species, number of each, and percent coverage. This procedure was continued at ten-meter intervals until one or no new species appeared within a transect line. Utilizing the data thus gathered, raw and relative frequency, density, and dominance were calculated. A line transect was used where trees formed a major portion of ground cover, preventing multiple parallel lines. The 100-meter tape was placed in a straight line, and all trees or shrubs above and below the tape were counted, as well as the linear area each covered. From this information, density and dominance were tabulated.

Unless otherwise indicated in the discussion, only those areas which appeared typical of a major plant association were chosen for transects.

Vegetation maps were made, using aerial photographs.

All formal nomenclature and some common names were taken from Correll and Johnston (1970), and the remaining common names were from Gould (1969).

DISCUSSION

Mesquite-Grassland Association

Four transects were chosen in the mesquite grassland to check coverage and species range of grasses. In all but one, a different grass was dominant, although the major grasses were represented in almost every transect.

The first transect was a mesquite (*Prosopis glandulosa*)-Galleta (*Hilaria jamesii*) association on a high mesa immediately west of Ranch Creek (fig. 1). Very few species were noted; were conditions more favorable, however, more annual species would have been present. Within the 300-square-meter transect area only two species of grass were found: Galleta and fluffgrass (*Erioneuron pulchellum*) (table I). Occasional pricklypear (*Opuntia* sp.) and cholla (*Opuntia imbricata*) were present but were so scattered they did not appear in the transect line. The soil-holding capabilities on the transect area were great as evidenced by a lack of severe erosion channels which was surprising, considering the low total coverage (41.82%).

The second transect area, a mesquite-bristlegrass (*Setaria leucopila*) association was on an alluvial plain just above Ranch Creek (fig. 2). Its proximity to a permanent water supply (ca. one-half mile) and a slightly moist subsurface made it an ideal grazing area for wildlife and livestock. Grazing, however, had removed only flowering spikes and a small amount of vegetative material, not markedly affecting ground cover. The dominant grass in the association occupied 40.64% of the total vegetation, and all the grasses together composed 80.08% of the total (table II). The dominant shrub, mesquite, represented only 7.17% of the ground cover.

This transect locality is from time to time inundated by high water from overflow of the nearby creek (as are most of the lower alluvia in the breaks), but it is hardly affected by runoff, as indicated by the absence of bare washes within the immediate transect area. Unlike many other alluvia along creeks, grasses like bristlegrass, bermudagrass (*Cynodon dactylon*), fluffgrass, and others are present in sufficient amounts to impede runoff, thereby reducing erosion. In areas devoid or deficient in these grasses, erosion has produced deep, narrow washes that tend to undercut adjacent stabilized surfaces that would normally hinder topsoil loss (fig. 3). An alluvium of this latter type was noted directly across Ranch Creek from transect number two. Such areas are indicated by a high percentage of mesquite as well as a reduced grass cover; circumstances which are precipitated by natural conditions, overgrazing, or a combination of both.

The third transect was chosen in a partially gullied alluvium below the crest of a mesa near the Canadian River. The transect information showed a ground cover of 56.83%, with hairy grama (*Bouteloua hirsuta*) comprising 27.27% of the total ground cover (table III). Yucca (*Yucca* sp.) comprised 25.22% of the vegetation, making it the dominant shrub of the transect area. Scrub mesquite was in the immediate area but was too sparse to influence the ground cover and did not fall along transect lines. Many areas nearer the headwaters of the research area (i.e., southern end) are similar to this Yucca-hairy grama association but tend to have a greater abundance of mesquite. Apparently, areas which contain more sand in the topsoil have a higher yield of yuccas and as the clay content increases, mesquites and other shrubs replace them as dominants.

A fourth transect was chosen in the mesquite grassland as a comparison of grass dominance and cover with transect one (fig. 4). Ground cover was 44.62% (2.8% greater than transect one), with hairy grama composing 73.13% of the total vegetation (table IV). The location, a mesa comparable in many respects to the area of transect one, differed in being uneven rather than flat. Grasses totaled 79.11%, while shrubs made up only 7.01% of the cover, as compared to 85.22% grasses and 3.96% shrubs in transect one. Transect number one had a small number of species represented, while a variety of species was present in transect four. Even though conditions appeared equal, a great variation was noted for the two transects. Indeed, this diversity exemplifies the typical character of the complete research area, making the accurate circumscription of specific associations impractical if not impossible within the limited time available.

Throughout the mesquite grassland, skunkbush (*Rhus aromatica*) has replaced mesquite along steep mesa slopes, forming a narrow band that often completely encircles the mesas. Hackberry (*Celtis reticulata*) is often found in these areas but is rare elsewhere. Grasses are few, hence rain runoff is rapidly weathering soil from the roots of many of the shrubs.

Large cottonwoods (*Populus deltoides*) are concentrated in moist areas along streambeds. These clumps of trees produce cool, shady spots utilized extensively by cattle, resulting in a paucity of grasses in the immediate area. The greatest concentration of cottonwoods observed was along both sides of Ranch Creek. These formed a broken line of shade near the creek from the upper drainage almost to the Canadian River. Since most grasses were removed directly under the trees, it was difficult to determine what should have been the second member of the association. However, bermuda grass seemed to have the greatest resilience to grazing pressure. This association is an exceedingly important one in terms of wildlife. Not only is the shade used by mammals, but the branches serve as nesting areas for many birds.

The beds of creeks having seepage and standing water support swordleaf grass (*Scirpus americanus*), other grass, and many annual and perennial herbs as well as seedlings of cottonwood and skunkbush. As with most streambeds, vegetation is only temporary—that is, until the next heavy rain when all but the most hardy are washed away.

Juniper-Hairy Grama Association

In scattered localities throughout the research area and also in a thin strip in the southern sector, there are isolated populations of juniper (*Juniperus scopulorum*) (fig. 5). The dominant grass is commonly hairy grama, although there are many other grasses in abundance such as barnyardgrass (*Echinochloa cruzgalli*), alkali sacaton (*Sporobolis airoides*), saltgrass (*Distichlis spicata*), sideoats grama (*Bouteloua curtipendula*), and fluffgrass. A line transect was chosen in the largest population of juniper to determine density and cover represented by the trees and shrubs (fig. 6). Juniper composed 85.26% of the total cover and represented 69.23% of all trees and shrubs, while the second most frequent, grape (*Vitis acerifolia*), accounted for only 6.32% of the total cover and 15.39% of individuals (table V). Within the ill-defined boundaries of the "cedar brakes," many annual species such as plains fleabane (*Erigeron modestus*), flax (*Linum alatum*), broomweed (*Xanthocephalum* sp.), vernonia (*Vernonia* sp.), and sunflowers (*Helianthus annus, H. petiolaris*) are common. No species seems to be unique to this association, however, not even junipers, which may be found intermittently throughout the mesquite grassland.

Salt Cedar-Dropseed Association

Quite moist soil bordering the Canadian River contains heavy concentrations of salt cedar (*Tamarix gallica*) in several distinct, parallel bands within 300 meters of the riverbed. Indeed, so dense is the canopy that in many places everything else is excluded. These dense strips alternate with concentrations of dropseed. Clumps of this grass, some three meters across, are mixed with barnyardgrss, rabbitfoot polypogon (*Polypogon monospeliensis*), western wheatgrass (*Agropyron smithii*), and tumble windmillgrass (*Chloris verticillata*) growing beside and intermingling with them. Occasional cottonwoods were present on the edge of the grass bands. Few other species seemed able to compete with the dominants of this association. Consequently, only after reaching the margin of this association were a variety of species found. Clumps of dropseed extend beyond the salt cedar border into adjoining mesquite, forming an admixture of grasses from the salt cedar and mesquite associations.

CONCLUSIONS

The overall measured ground cover (46.28%) does not indicate an ideal grazing situation, nor does it enhance the possibility of erosion stabilization. Although grass is *relatively* plentiful, it appears to be failing as a major erosion deterrent. Botanically, the area is neither exciting nor unique in any respect. Even the diversity observed in the field is only a diversity of minor association dominants, not a variety of widely different or unusual species. Were the land within the research area to be utilized by the public on a large scale, considerable care would be necessary to prevent further destruction of valuable ground cover and procedures implemented to reclaim or improve land that is already deteriorating.

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TABLE I

	RF_i	RF_{ii}	RD_i	RC	RD_{ii}
GRASSES					
Hilaria jamesii	27	90.00	77.98	31.16	74.51
Erioneuron pulchellum	11	36.67	18.80	8.66	20.71
HERBS					
Euphorbia geyeri	1	3.33	.46	.17	.41
Kallstroemia paryiflora	1	3.33	.46	.17	.41
SHRUBS					
Prosopis glandulosa	5	16.67	2.29	1.66	3.96

Total Coverage: 41.82% Total Individuals: 218

TABLE II

	RF_i	RF_{ii}	RD_i	RC	RD_{ii}
GRASSES					
Sectaria leucopila	18	60.00	29.00	17.00	40.64
Hilaria jamesii	13	43.33	41.13	11.34	27.11
Erioneuron pulchellum	4	13.33	13.42	4.50	10.76
Bouteloua curtipendula	1	3.33	4.33	1.33	3.18
Cynodon dactylon	1	3.33	2.60	1.00	2.39
HERBS					
Xanthocephalum sp.	5	16.67	3.03	2.33	5.57
Euphorbia lata	4	13.33	3.90	.83	1.98
Solanum elaeagnifolium	2	6.67	.87	.83	.79
SHRUBS					
Prosopis glandulosa	3	10.00	1.30	3.00	7.17
Opuntia leptocaulis	1	3.33	.43	.17	.41

Total Coverage: 41.83% Total Individuals: 231

TABLE III

	RFi	RFii	RDi	RC	RDii
GRASSES					
Bouteloua hirsuta	14	46.67	42.08	15.50	27.27
Erioneuron pulchellum	15	50.00	29.50	14.00	24.63
Panicum obtusum	5	16.67	12.56	5.66	9.96
Aristida glauca	2	6.67	1.09	1.66	2.92
HERBS					
Zinnia grandiflora	3	10.0	1.64	.50	.88
Thelesperma megapotamicum	1	3.3	.55	.17	.30
Solanum elaeagnifolium	1	3.3	.55	.17	.30
Sphaeralcea coccinea	1	3.3	.55	.17	.30
Eurorbia geyeri	1	3.3	.55	.17	.30
SHRUBS					
Yucca sp.	9	30.00	8.20	14.33	25.22
Rhus aromatica	2	6.67	1.09	3.50	6.16
Mimosa biuncifera	2	6.67	1.09	.83	1.46
Opuntia imbricata	1	3.30	.55	.17	.30

Total Coverage: 56.83% Total Individuals: 183

TABLE IV

	RFi	RFii	RDi	RC	RDii
GRASSES					
Bouteloua hirsuta	37	92.5	80.33	32.63	73.13
B. curtipendula	1	2.5	2.09	1.50	3.36
Distichlis spicata	2	5.0	1.67	1.00	2.24
Agropyron smithii	2	5.0	.84	.25	.56
HERBS					
Xanthocephalum sp.	2	5.0	.84	1.25	2.80
Desmanthus virgatus	1	2.5	.42	.25	.56
Penstemon albidus	1	2.5	.42	.25	.56
Machaeranthera australis	2	5.0	.84	.25	.56
Dalea aurea	1	2.5	.42	.12	.27
Petalostemum tenuifolium	1	2.5	.42	.12	.27
Euphorbia geyeri	2	5.0	.84	.38	.85
Unidentified	3	7.5	7.11	1.87	4.19
SHRUBS					
Prosopis glandulosa	3	7.5	1.26	1.63	3.65
Opuntia sp. (2)	3	7.5	1.25	1.87	4.19
Mimosa biuncifera	1	2.5	.42	.25	.56
Yucca sp.	1	2.5	.42	.75	1.68

Total Coverage: 44.62% Total Individuals: 239

TABLE V

	Raw Cov.	Rel. Cov.	Rel. Den.
Juniperus scopulorum	40.5	85.26	69.23
Vitis acerifolia	3.0	6.32	15.39
Rhus aromatica	2.0	4.21	7.69
Mimosa biuncifera	2.0	4.21	7.69

Total Coverage: 47.5% Total Individuals: 26

RF_i – Raw Frequency: Number of quadrats in which species occurred.

RF_{ii} – Relative Frequency: $\frac{RF_i}{\text{Total number of quadrats}}$

RD_i – Relative Density: $\frac{\text{Total individuals of species}}{\text{Total individuals of all species}}$

RC – Raw Cover: $\frac{\text{Total area covered by species}}{\text{Total area sampled}}$

RD_{ii} – Relative Dominance: $\frac{\text{Area covered by species}}{\text{Area covered by all species}}$

FIGURE 1
Transect Number 1. Typical Mesquite Grassland on a Mesa West of Ranch Creek.

FIGURE 2
Transect Number 2. A Mesquite Grassland on a Creek-Border Alluvium. Note Cottonwoods Along the Creek.

FIGURE 3
An Eroded Lowland Alluvium. Note the Density of Mesquite Shrubs and Steep-Banked Gully.

FIGURE 4
Transect Number 4. Note Small Junipers on Right hand Concentration of Yuccas.

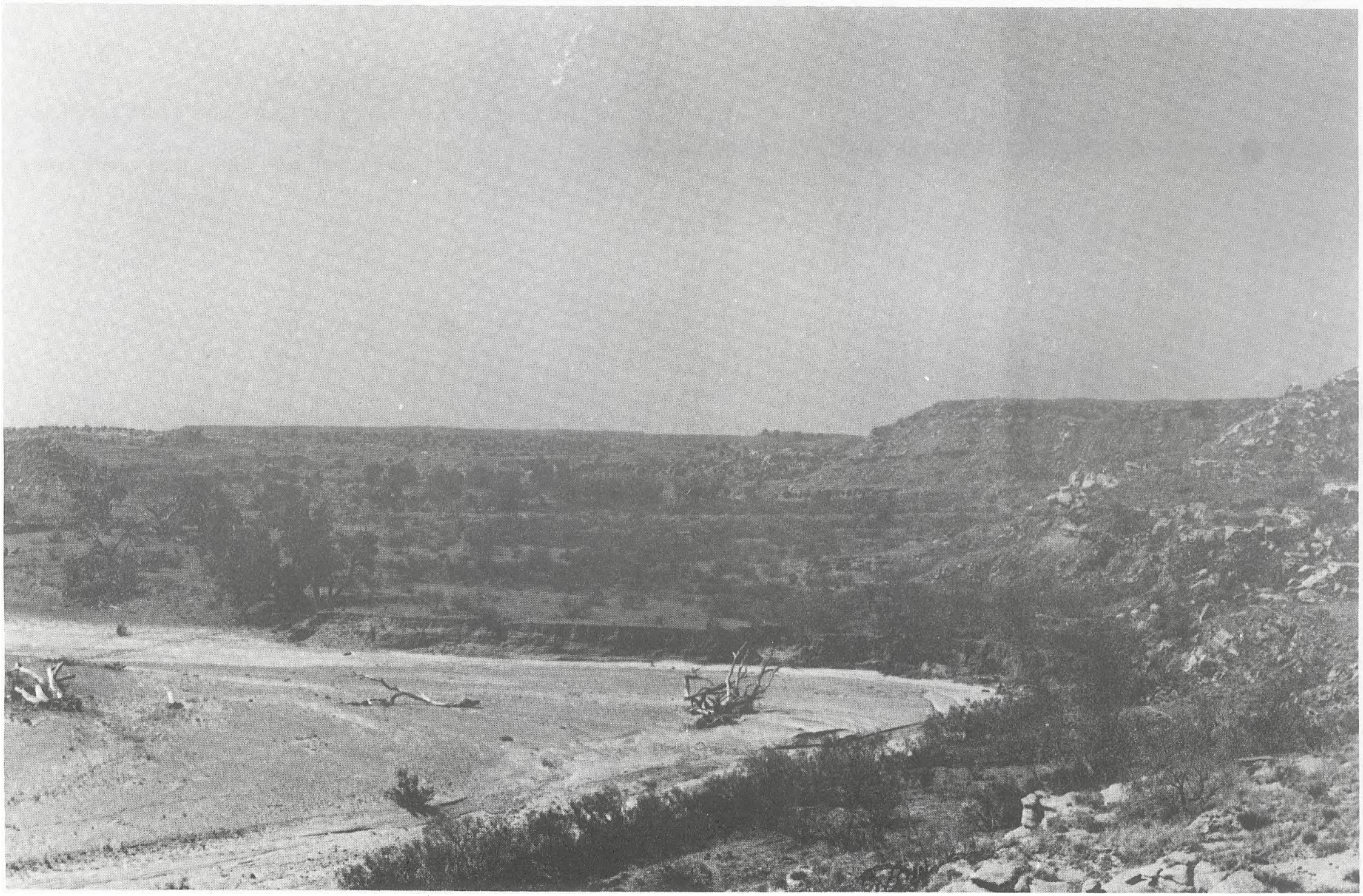

FIGURE 5
Small Population of Junipers along the Alamosa Drainage. Junipers may be seen throughout the field of view.

FIGURE 6
Line Transect 1. "Cedar Breaks" in the Southern Portion of the Research Area.

TABLE VI – PLANT LIST

SPECIES	COMMON NAME
Amaranthacese	Amaranth Family
Tidestromia lanuginosa (Nutt.) Standl.	Woolly tidestromia
Apocynaceae	Dogbane Family
Apocynum sibiricum Jacq.	Prairie dogbane
Asclepiadaceae	Milkweed Family
Asclepias arenaria Torr.	Sand milkweed
A. oenotheroides Cham. & Schlect.	Milkweed
A. subverticillata (Gray) Vail	Poison milkweed
A. viridiflora Raf.	Green antelopehorn
Sarcostemma torreyi (Gray) Woods.	Soft twinevine
Boraginaceae	Borage Family
Heliotropium convolvulaceum (Nutt.) Gray	Bindweed heliotrope
Cactaceae	Cactus Family
Opuntia imbricata (Haw.) DC.	Cholla
O. leptocaulis DC.	Tasajilla
O. sp.	Pricklypear
Carophyllaceae	Pink Family
Paronychia jamesii T. & G.	James nailwort
Chenopodiaceae	Goosefoot Family
Salsola kali L.	Tumbleweed
Commelinaceae	Spiderwort Family
Tradescantia occidentalis (Britt.) Smyth	Hairyflower spiderwort
Compositae	Sunflower Family
Artemisia sp.	Sagebrush
Berlandiera lyrata Benth.	Lyreleaf greeneyes
Cirsium ochrocentrum Gray	Yellowspine thistle
Echinacea atrorubens Nutt.	Purple coneflower
Engelmannia pinnatifida Nutt.	Englemann daisy
Erigeron modestum Gray	Plains fleabane
Gaillardia pinnatifida Torr.	Slender gaillardia
G. pulchella Fouq.	Indian blanket
Helianthus annus L.	Common sunflower
H. ciliaris DC.	Blueweed
H. petiolaris Nutt.	Prairie sunflower
Heterotheca horrida (Rydb.) Harms	Goldaster
Hymenopappus tenuifolius Oyrsg.	Chalkhill woollywhite
Hymenoxys odorata DC.	Western bitterweed
H. scaposa (DC.) Parker	Plains tetraneuris
Machaeranthera australis (Greene) Shinners	
Melampodium leucanthum T. & G.	Plains blackfoot
Palafoxia sphacelata (Torr.) Cory	Rayed palafoxia
Parthenium sp.	
Psilostrophe villosa Rydb.	Hairy paperflower
Senecio longilobus Benth.	Threadleaf groundsel
Stephanomeria pauciflora (Torr.) A. Nels.	Desert skeletonplant
Thelesperma megapotamicum (Spreng.) O. Ktze.	Greenthread
Vernonia sp.	Vernonia
Xanthium spinosum L.	Spiny cocklebur
Xanthocephalum sp.	Broomweed
Zinnia grandiflora Nutt.	Plains zinnia

Convolvulaceae	Morningglory Family
Convolvulus equitans Benth.	Bindweed
Ipomea leptophylla Torr.	Bush morningglory
Cucurbitaceae	Gourd Family
Cucurbita foetidissima H.B.K.	Buffalo gourd
Cupressaceae	Cypress Family
Juniperus scopulorum Sarg.	Rocky mountain juniper
Cyperaceae	Sedge Family
Eleocharis rostellata (Torr.) Torr.	Beaked spikesedge
Scirpus americana Pers.	Swordgrass
Ephedraceae	Ephedra Family
Ephedra sp.	Mormon tea
Euphorbiaceae	Spurge Family
Argythamnia mercurialiana (Nutt.) Muell. Arg.	Tall wildmercury
Croton pottsii (Kl.) Muell. Arg.	Leatherweed
C. texensis (Kl.) Muell. Arg.	Texas croton
Euphorbia geyeri Engelm.	Geyer euphorbia
E. lata Engelm.	Hoary euphorbia
E. marginata Pursh	Snow-on-the-mountain
Gramineae	Grass Family
Agropyron smithii Rydb.	Western wheatgrass
Aristida glauca (Nees) Walp.	Blue three-awn
Bothriochloa springfieldii (Gould) Parodi	Springfield bluestem
Bouteloua curtipendula (Michx.) Torr.	Sideoats grama
B. hirsuta Lag.	Hairy grama
Chloris verticillata Nutt.	Tumble windmillgrass
Cynodon dactylon (L.) Pers.	Bermudagrass
Distichlis spicata (L.) Greene var. *stricta* (Torr.) Beetle	Saltgrass
Echinochloa cruzgalli (L.) Beauv.	Barnyardgrass
Erioneuron pulchellum (H.B.K.) Tateoka	Fluffgrass
Hilaria jamesii (Torr.) Benth.	Galleta
Panicum obtusum H.B.K.	Vine mesquite
Phragmites communis Trin.	Common reed
Polypogon monospeliensis (L.) Desf.	Rabbitfoot polypogon
Setaria leucopila (Scribn. & Merr.) K. Schum.	Bristlegrass
Sporobolis airoides (Torr.) Torr.	Alkali sacaton
Krameriaceae	Ratany Family
Krameria lanceolata Torr.	Trailing ratany
Labiatae	Mint Family
Hedeoma drummondii Benth.	Drummond hedeoma
Teucrium laciniatum Torr.	Germander
Leguminosae	Legume Family
Astragalus racemosus Pursh	Creamy loco
Caesalpinia jamesii (T. & G.) Fisher	James rushpea
Dalea aurea Nutt.	Golden dalea
D. formosa Torr.	Featherplume
D. lasiathera Gray	Purple dalea
Desmanthus virgatus (L.) Willd.	Bundleflower
Glycyrrhiza lepidota Pursh	American licorice
Hoffmanseggia glauca (Ort.) Eifert	Rushpea
Melilotus albus Lam.	White sweetclover
Mimosa biuncifera Benth.	Catclaw mimosa

Petalostemum candidum (Willd.) Michx.	White prairieclover
P. tenuifolium Gray	Slimleaf prairieclover
Prosopis glandulosa Torr.	Honey mesquite
Psoralea lanceolata Pursh	Lemon scurfpea
Schrankia uncinata Willd.	Catclaw sensitivebriar
Strophostyles leiosperma (T. & G.) Piper	Slickseed wildbean
Liliaceae	Lily Family
Yucca sp.	Yucca
Linaceae	Flax Family
Linum alatum (Small) Winkl.	Flax
Loasaceae	Stickleaf Family
Mentzelia oligosperma Sims	Chickenthief
M. reverchonii (Urban & Gilg.) Thomps. & Zavortink	Mentzelia
Malvaceae	Mallow Family
Sphaeralcea coccinea (Pursh) Rydb.	Scarlet globemallow
Martyniaceae	Unicorn-Plant Family
Proboscidea louisianica (Mill.) Thell.	Common devil's claw
Nyctaginaceae	Four-O'Clock Family
Allionia incarnata L.	Trailing allionia
Mirabilis linearis (Pursh) Heimerl.	Linearleaf four-o'clock
Onagraceae	Evening Primrose Family
Calylophus drummondianus Spach.	Drummond primrose
Gaura villosa Torr. var. *vilosa*	Hairy gaura
Oenothera missouriensis Sims	Gray sundrope
Stenosiphon linifolius (Nutt.) Heynh.	Falsegaura
Polygalaceae	Milkwort Family
Polygala alba Nutt.	White milkwort
Polygonaceae	Knotweed Family
Eriogonum longifolium Nutt.	Longleaf wildbuckwheat
Rumex crispus L.	Curly dock
Scrophulariaceae	Figwort Family
Penstemon albidus Nutt.	White penstemon
P. ambiguus Torr.	Gilia penstemon
Solanaceae	Potato Family
Chamaesaracha conoides (Dun.) Britt.	False nightshade
C. cf. *villosa* Rydb.	False nightshade
Solanum elaeagnifolium Cav.	Silverleaf nightshade
S. rostratum Dun.	Buffalo bur
Salicaceae	Willow Family
Populus deltoides Marsh.	Eastern cottonwood
Tamaricaceae	Tamarisk Family
Tamarix gallica L.	Salt cedar
Typhaceae	Cattail Family
Typha latifolia L.	Common cattail
Ulmaceae	Elm Family
Celtis laevigata Willd.	Sugar hackberry
C. reticulata Torr.	Netleaf hackberry
Vitaceae	Grape Family
Vitis acerifolia Raf.	Bush grape
Zygophyllacea	Caltrop Family
Kallstroemia parviflora Nort.	Warty caltrop
Tribulus terrestris L.	Goathead

A PRELIMINARY SURVEY OF THE VERTEBRATE FAUNA OF THE UPPER CANADIAN BREAKS AREA

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Ten days, from June 19 through June 29, were spent on the John Mansfield Ranch in an attempt to adequately sample and analyze the vertebrate fauna of the Canadian Breaks area. In addition to our own observations and data, we spent one day examining the records of the vertebrate collection at Texas Tech University. Thanks are extended to Hugh Genoways, Robert Baker, John Mecham, Steve Williams, and others who helped so much with the Tech records.

The study area is located in the Kansan Biotic Province of Dice (1943) and Blair (1950). The Canadian River here has cut deeply into the plains, effectively separating the high plains of the northern part of Texas and Oklahoma from those of the southern high plains. At the same time the river and its drainages have formed canyons and slopes unlike most of the typical Kansan landscape.

The vertebrate fauna of the Kansan Biotic Province reflects the transitional position of this province between a western and an eastern fauna. Only three species of mammals and one species of snake are restricted to the Kansan Biotic Province. As a whole, the vertebrate fauna of the Mansfield Ranch closely resembles a Chihuahuan fauna, with only one species of lizard, one species of snake, four species of birds, and three species of mammals occurring there that do not occur in the Chihuahuan Biotic Province. All amphibians and turtles found on the Mansfield Ranch also occur in the Chihuahuan Biotic Province.

The broad valley formed by the Canadian River and its narrower canyon tributaries have created a corridor whereby vertebrates adapted to more mesic environments are found to interdigitate with species characteristic of the drier high plains. Exposed beds of sandstone and other rocks also provide a unique habitat for animals not commonly found on the high plains.

The fauna of the study area did not appear to be as diverse as the diversity of habitats might suggest. Only birds (Class Aves) occurred as a heterogenous mixture of species within the various habitats. However, the short duration of the survey, the size of the study area, the fact of a prolonged drought with unusually hot weather and high winds, and the natural seasonality of animals themselves were restrictions to the survey. Many more amphibians might have been observed had it rained heavily while we were in the field. Certainly the list of birds could be more than doubled if fall, winter, and spring surveys could be conducted. Out list of birds represents only the summer resident birds, as no bird records could be located elsewhere. Numerous species of ducks, geese, and charadriiform birds are known to occur there during other seasons, yet only the killdeer and a small flock of unidentified ducks (probably shovelers) were observed during the study period.

There are few records available from other collections on Oldham County. The Museum at Texas Tech contained no bird records, a few records of mammals, but was very helpful with some amphibian and reptile records. Vertebrate records from nearby Randall County, particularly from Palo Duro Canyon, were common. The similarity of topography and geologic history of Palo Duro Canyon and the Canadian Breaks and the geographic proximity of the two areas suggest a similarity of faunal assemblages. Therefore, where a species is not recorded from Oldham County, but is known to occur in Palo Duro Canyon, it is cited as a probable for the study site.

The list of vertebrates, by class, recorded from the study site or adjacent areas of Oldham County will be followed by a discussion of those considered unique or that have some significant biological problem associated with them. The discussion will also emphasize ecological and environmental considerations within each class of vertebrates. All records cited preceded by TT represent Texas Tech collection records. Numbers preceded by SRSU are in the Sul Ross Vertebrate Collection.

AMPHIBIANS OF THE CANADIAN BREAKS AREA, OLDHAM COUNTY, TEXAS

CLASS AMPHIBIA

Order Caudata – Salamanders
Family Ambystomatidae .... *Ambystoma tigrinum marvortium* – Barred Tiger Salamander

Order Anura – Frogs and Toads
Family Pelobatidae .... *Scaphiopus couchi* – Couch's Spadefoot
S. hammondi – Western Spadefoot
S. bombifrons – Plains Spadefoot
Family Bufonidae .... *Bufo punctatus* – Red-spotted Toad
B. cognatus – Great Plains Toad
B. woodhousei – Rocky Mountain Toad
Family Ranidae .... *Rana blairi* – Plains Leopard Frog

Discussion–Only four species of amphibians were recorded during our survey of the Mansfield Ranch. This can be attributed to the extreme dryness and very hot days. The Canadian River was completely dry throughout its course in the study area, and Ranch and Alamosa Creeks contained only a few isolated pot-holes of water. Barred Tiger Salamanders, both the neotenic form (axolot) and metamorphosed adults, were common in stock tanks into which windmills were pumping water. These same ponds also supported large populations of the recently described Plains Leopard Frog (Mecham, *et al.*, 1973). The Plains Leopard Frog is one of a number of cryptic species of the large Leopard Frog (*Rana pipiens*) complex.

A steady but light rain fell during early morning hours of June 22. On the night of June 22 numerous Great Plains Toads were seen on the ranch roads and about camp. A single specimen of Couch's Spadefoot was collected.

Relevant amphibian specimens in the Texas Tech collection are: Rocky Mountain Toad (*Bufo woodhousei*), TT 1917 from 2.2 mi S Tascosa, and TT 1915 from 7.7 mi N Tascosa, and TT 1933 from 2 mi S Channing. Red Spotted Toad (*Bufo punctatus*), TT 1922 from 20 mi N Adrian, Oldham County; Plains Spadefoot (*Scaphiopus bombifrons*) TT 1936 from 11.2 mi S Channing, Oldham County; and the Western Spadefoot (*S. hammondi*) TT 1953 from neighboring Deaf Smith County, north Hereford.

REPTILES OF THE CANADIAN BREAKS AREA, OLDHAM COUNTY

CLASS REPTILIA

Order Chelonia – Turtles
Family Kinosternidae .... *Kinosternon flavescens* – Yellow Musk Turtle
Family Emydidae .... *Pseudemys scripta* – Pond Slider
Terrapene ornata – Ornate Box Turtle

Order Squamata – Lizards and Snakes
Family Teiidae .... *Cnemidophorus sexlineatus* – Six-lined Racerunner
C. tesselatus – Checkered Whiptail
Family Scincidae .... *Eumeces obsoletus* – Great Plains Skink
Family Iguanidae .... *Phrynosoma cornutum* – Texas Horned Lizard
P. modestum – Round-tailed Horned Lizard
Sceloporus undulatus – Southern Prairie Lizard
Crotaphytus collaris – Collared Lizard
Uta stansburiana – Side-blotched Lizard
Holbrookia maculata – Lesser Earless Lizard
Family Leptotyphlopidae .... *Leptotyphlops dulcis dissecta* – New Mexico Blind Snake
Family Colubridae .... *Pituophis melanoleucus sayi* – Bull Snake
Lampropeltis getulus splendida – Sonoran Kingsnake
Elaphe guttata emoryi – Emory's Rat Snake
Arizona elegans – Glossy Snake
Thamnophis marcianus – Checkered Garter Snake
Natrix erythrogaster – Blotched Water Snake
Diadophis punctatus – Ringneck Snake
Masticophis flagellum – Western Coachwhip
Heterodon nasicus – Hognose Snake
Tropidoclonium lineatum – Lined Snake
Rhinocheilus lecontei – Longnosed Snake
Tantilla nigriceps – Plains Black-headed Snake
Hypsiglena torquata – Night Snake
Sonora episcopa – Ground Snake
Family Viperidae .... *Crotalus atrox* – Western Diamondback
C. viridis – Prairie Rattler

Discussion—The same ecological factors affecting amphibian distribution and activity fairly well apply to turtles also. A single Ornate Box Turtle (SRSU 3386) was found above the caprock 1 mile north of our camp. The Yellow Musk Turtle and the Pond Slider are represented only by shells found in and around dried-up earthern tanks. The prolonged drought of 1974 apparently has been disastrous to turtle populations. A Pond Slider in the Texas Tech Collection (TT 2880) is from "4.8 mi NE Tascosa, Oldham County."

The Spiny Softshell Turtle (*Trionyx spinifer*) occurs in neighboring Randall County (TT 576). The ephemeral nature of the Canadian River and its tributaries in Oldham County probably precludes this aquatic species from the study area.

Collared Lizards were the most commonly encountered reptile on the Mansfield Ranch. This species was found both above and below the caprock. Individuals could be seen almost any time of the day basking on rocky outcrops, on fallen trees, or just in open spaces among the grass. The Checkered Whiptail was a close second in occurrence. This beautiful whiptail is one of the more interesting faunal features of the area.

The Checkered Whiptail (*Cnemidophorus tesselatus*) is one of the few recognized parthenogenetic species of vertebrate. Parthenogenesis refers to its mode of reproduction which allows eggs to develop without benefit of sperm. As no sperm is involved, the male Y chromosome cannot be incorporated into the developing offspring; thus all offspring are a carbon copy of the mother, and all female. Parthenogenesis leads to an all-female species. Many interesting biological problems exist with this group of lizards. Zweifel (1965) did an analysis of variation among *Cnemidophorus tesselatus*-like populations and assigned the one occurring the Panhandle area of Texas to his pattern class C. Thus the Checkered Whiptail of the Mansfield Ranch should be referred to as *Cnemidophorus tesselatus* C. (fig. 1).

Checkered Whiptails are common on rocky slopes, grassy flats, and mesquite arroyos below the caprock. It generally drops out above the cap and is replaced by the Six-lined Racerunner (*C. sexlineatus*) in the rolling to flat grasslands found there. Both species were found along the Canadian River, but the Six-lined Racerunner was not common there. Southern Prairie Lizards were most often found on the trunks of the large cottonwood trees that bordered all drainages.

Our failure to find any individuals of the Lesser Earless Lizard (*Holbrookia maculata*) is difficult to explain. The habitat was ideal, and the species is known to occur across the Great Plains. A series of specimens in the Texas Tech Museum (TT 1927, 2832, 2850) are from Oldham County near Adrian. Another series of 29 specimens (TT 1909) are from 43 mi WNW Hereford, Deaf Smith County. The species almost certainly occurs on the Mansfield Ranch, but climatic conditions possibly caused a state of estivation among some reptilian species at the time of our field work.

No specimens of the Great Plains Skink or of the Side-blotched Lizard were collected, but these two species should be included in the herpetofauna of the Mansfield Ranch. The Museum at Texas Tech has 68 specimens of the Side-blotched Lizard (TT 233, 261,266,267, and others) and a Greak Plains Skink (TT 281) from Palo Duro Canyon, Randall County.

The most common snake of the Mansfield Ranch study site was the Diamond-back Rattlesnake. This venemous snake was seen throughout the ranch but was most common along the rocky rims of the buttes and arroyos. The Prairie Rattlesnake (*Crotalus viridis*) was seen only one time, and that was a specimen (SRSU 3383) killed by John Graves when he ran over the snake with his truck while coming to our camp. The Prairie Rattlesnake generally is found above the caprock.

Except for the Diamond-back, snakes, like the lizards and amphibians, were not active or common during our study of the Mansfield Ranch area. We were told by local residents that this was not always the case. Bullsnakes, Western Coachwhips, and Speckled Kingsnakes have been reported as common. Even water snakes (*Natrix*) were said to be common during wet years.

All species of snakes reported here are to be expected in the kind of habitat represented on the Mansfield Ranch, with one exception. The Lined Snake (*Tropidoclonium lineatum*) is common in the Dallas-Ft. Worth area, but becomes more scarce to the west. A Texas Tech specimen (TT 1900) is from Hartley County, .5 mi S of Channing. This locality is less than 10 miles from the study area. Stebbins (1966) shows several isolated populations of *Tropidoclonium* in the Texas Panhandle, northeastern New Mexico, and western Oklahoma. These small isolated populations illustrate an eastern species penetrating arid environments by moving up mesic corridors created by the drainage systems of the Panhandle Plains. A single specimen of the Night Snake (*Hypsiglena torquata*) was collected from beneath a cottonwood log near the Canadian River (SRSU 3380). Texas Tech has a specimen (TT 1899) from 18.3 mi S Channing, Oldham County. This unusual little snake is a characteristic form of the Chihuahuan herpetofauna but has been recorded from scattered localities in the Texas Panhandle.

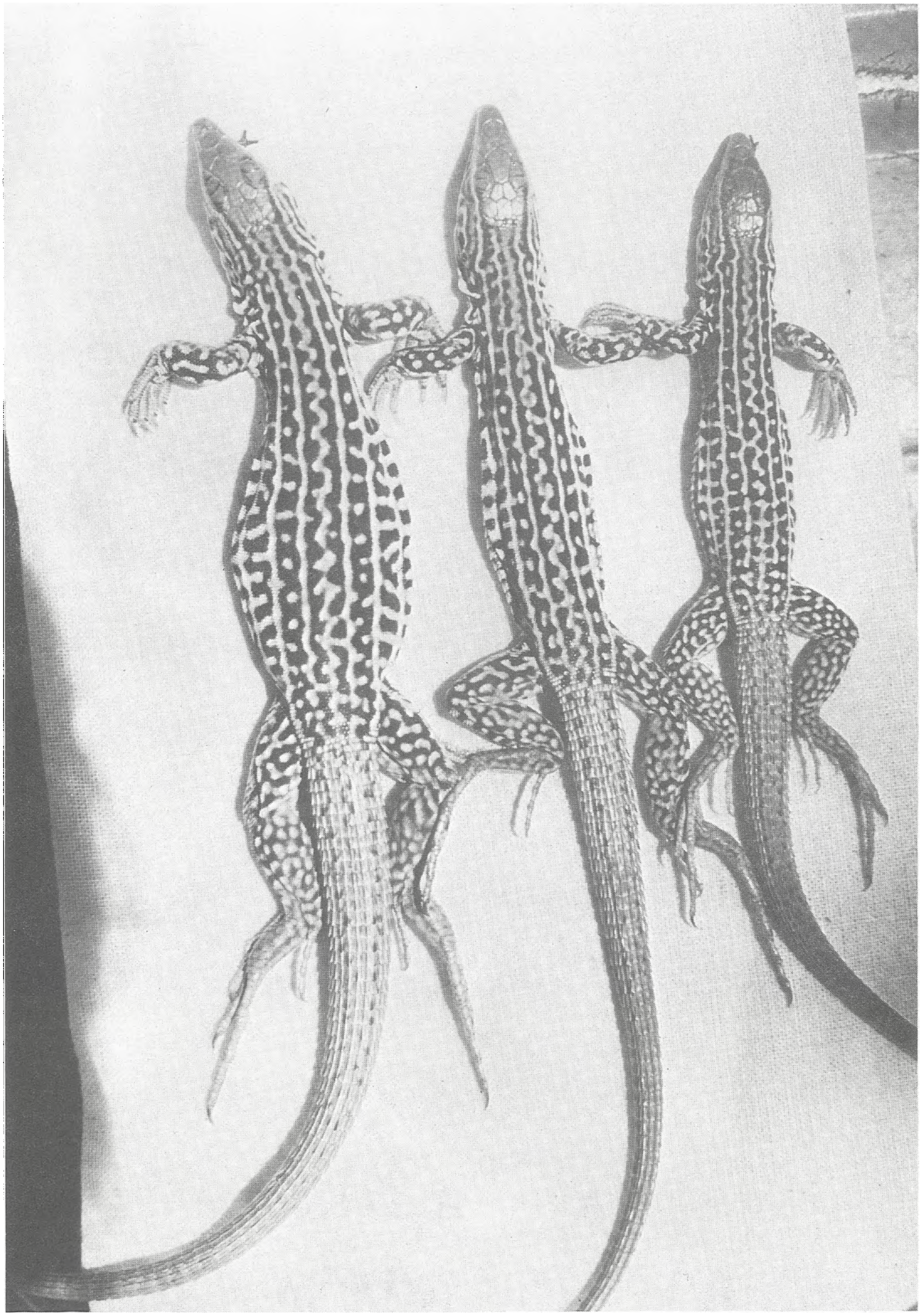

FIGURE 1
Cnemidophorus tesselatus **C, the unisexual whiptail from the Canadian Breaks Area.**

A single specimen of the New Mexico Blind Snake from Randall County, Palo Duro Canyon, is in the Texas Tech collection (TT 1818). Other species in the Tech collection, but not seen by us in the field, are: Glossy Snake (*Arizona elegans*) TT 1503 from 3.8 mi SE Tascosa, Oldham County; Sonoran Kingsnake (*Lampropeltis getulus splendida*) TT 295 from Randall County, 1 mi N Canyon; Hognose Snake (*Heterodon nasicus*) TT 2852 from 14 mi N Adrian, Oldham County; Western Coachwhip (*Masticophis flagellum*) TT 1513 from Tascosa, TT 1919 from 10.8 mi N Vega, and TT 2849 from 28 mi N Adrian, Oldham County; Emory's Rat Snake (*Elaphe guttata emoryi*) TT 294 from 2 mi W Canyon, Randall County.

BIRDS OF THE CANADIAN BREAKS AREA, OLDHAM COUNTY

CLASS AVES

Order Falconiformes	
Family Cathartidae	*Cathartes aura* – Turkey Vulture
Family Accipitridae	*Buteo jamaicensis* – Red-tailed Hawk
	B. swainsoni – Swainson's Hawk
	Ictinia misisippiensis – Mississippi Kite
Family Falconidae	*Falco sparverius* – Kestrel
Order Galliformes	
Family Phasianidae	*Callipepla squamata* – Scaled Quail
Family Meleagrididae	*Meleagris gallopavo* – Wild Turkey
Order Charadriiformes	
Family Charadriidae	*Charadrius vociferus* – Killdeer
Order Columbiformes	
Family Columbidae	*Zenaida macrorura* – Mourning Dove
Order Cuculiformes	
Family Cuculidae	*Coccyzus americanus* – Yellow-billed Cuckoo
	Geococcyx californicus – Roadrunner
Order Caprimulgiformes	
Family Caprimulgidae	*Chordeiles minor* – Common Nighthawk
Order Piciformes	
Family Picidae	*Colaptes auratus cafer* – Red-shafted Flicker
	Centurus carolinus – Red-bellied Woodpecker
	Melanerpes erythrocephalus – Red-headed Woodpecker
	Dendrocopos scalaris – Ladder-backed Woodpecker
Order Passeriformes	
Family Tyrannidae	*Tyrannus verticalis* – Western Kingbird
	Muscivora forficata – Scissor-tailed Flycatcher
	Myiarchus cinerascens – Ash-throated Flycatcher
Family Alaudidae	*Eremophila alpestris* – Horned Lark
Family Hirundinidae	*Petrochelidon pyrrhonota* – Cliff Swallow
Family Corvidae	*Corvus cryptoleucus* – White-necked Raven
Family Troglodytidae	*Salpinctes obsoletus* – Rock Wren
	Thryomanes bewickii – Bewick's Wren
Family Mimidae	*Mimus polyglottos* – Mockingbird
	Toxostoma curvirostre – Curve-billed Thrasher
Family Laniidae	*Lanius ludovicianus* – Loggerhead Shrike
Family Icteridae	*Sturnella neglecta* – Western Meadowlark
	Icterus galbula bullockii – Bullock's Oriole
	Molothrus ater – Brown-headed Cowbird
	Agelaius phoeniceus – Red-winged Blackbird
Family Fringillidae	*Chondestes grammacus* – Lark Sparrow
	Aimophila cassinii – Cassin's Sparrow
	Amphispiza bilineata – Black-throated Sparrow
	Spizella pusilla – Field Sparrow

Discussion—The summer resident birds of the Canadian Breaks generally are the kinds one would expect in a prairie habitat. Large cottonwood trees are found along the drainages, and the valley of the Canadian River itself is covered with dense mottes of cottonwoods. These trees provide nesting sites and roosts for a number of bird species not normally encountered on the Panhandle Plains (fig. 2). Also, there are the sometimes dense stands of "cedars" (*Juniperus*) found along some drainages and slopes which are especially characteristic of the Cedar Brakes area, that provide a variety of nesting habitat.

We were surprised to find Red-headed Woodpeckers and Mississippi Kites common among the cottonwoods along Ranch Creek and the Canadian River and indications that both these species nest there. Mississippi Kites were seen pursuing Red-headed Woodpeckers, Flickers, and Mourning Doves but were not seen to catch any. The activity appeared to be more harassment than serious attempts to secure food.

Bullock's Orioles were the most commonly seen nesting bird among the cottonwoods throughout the study area. Four pairs of Bullock's Orioles used the cottonwood tree that shaded our camp for nesting. Numerous Bullock's Oriole nests were seen among the large cottonwoods in the Cedar Breaks area.

Large stick nests characteristic of a number of hawks were also seen in the Cedar Brakes area. A Red-tailed Hawk nest was observed near our camp from which a young Red-tail fledged during our stay. Nesting birds observed among the large cottonwoods were Bullock's Orioles, Western Kingbirds, Mississippi Kites, Red-tailed Hawks, Red-bellied Woodpeckers, Red-shafted Flickers, and Scissor-tailed Flycatchers. Birds observed nesting in the Cedar Breaks area were Ash-throated Flycatchers, Kestrels, Ladder-backed Woodpeckers, Mourning Doves, Mockingbirds, Field Sparrows, and Yellow-billed Cuckoos. Birds observed in nesting behavior in open grasslands were Cassin's Sparrow, Lark Sparrow, and Horned Larks. A number of species were observed in nesting behavior, or nests were seen among mesquite-hackberry thickets, especially those around semi-permanent stock ponds. These include Mockingbirds, Red-winged Blackbirds, Ash-throated Flycatchers, Ladder-backed Woodpeckers, Mourning Dove, Curve-billed Thrashers, and Black-throated Sparrows. The nest of a Scaled Quail was found beneath a large cottonwood log near the Canadian River, and the nest of a Killdeer was located on a sandbar in Ranch Creek.

It appears that a variety of birds have found suitable nesting habitat on the Mansfield Ranch. Additional surveys conducted in the fall and spring months would show a much richer avifauna for the area. Numerous species of water fowl and shore birds probably would be found there in the fall when the Canadian River and its tributaries contain water. The Cedar Brakes undoubtedly serve as a welcome respite for numerous species of warblers, vireos, and other passeriform birds during the spring migration. It is our impression that the area's major biological function is that of a bird sanctuary within a region largely devoid of a diversity of habitats for birds.

Wild Turkeys have been introduced into the area and are quite successful. Some turkeys are taken by hunters yearly. The Wild Turkeys seemed to prefer the areas along the Canadian River and the lower ends of Ranch and Alamosa Creeks.

MAMMALS OF THE CANADIAN BREAKS AREA, OLDHAM COUNTY

CLASS MAMMALIA

Order Marsupialia	
Family Didelphidae	*Didelphis marsupialis* – Opossum
Order Chiroptera	
Family Vespertilionidae	*Antrozous pallidus* – Pallid Cave Bat
	Pipestrellus hesperus – Canyon Bat
Order Rodentia	
Family Sciuridae	*Spermophillus tridecemlineatus* – Thirteen-lined Ground Squirrel
Family Geomyidae	*Pappogeomys castanops* – Chestnut-faced Pocket Gopher
Family Heteromyidae	*Dipodomys ordi* – Ord's Kangaroo Rat
	Perognathus hispidus – Hispid Pocket Mouse
	P. merriami – Merriam's Pocket Mouse
Family Cricetidae	*Peromyscus maniculatus* – Deer Mouse
	P. difficilis – Juniper Mouse
	P. truei comanche – Comanche Deer Mouse
	Neotoma albigula – White-throated Woodrat
	Onychomys leucogaster – Short-tailed Grasshopper Mouse

FIGURE 2
Riparian Association near the Canadian River. Birds found nesting here included the Mississippi Kite, Red Headed Woodpecker, and Bullock's Oriole.

Order Lagomorpha
Family Leporidae .... *Lepus californicus* – Black-tailed Jackrabbit
Sylvilagus auduboni – Desert Cottontail

Order Carnivora
Family Mustelidae .... *Taxidea taxus* – Badger
Family Procyonidae .... *Procyon lotor* – Raccoon
Family Canidae .... *Canis latrans* – Coyote
Vulpes velox – Swift Fox
Family Felidae .... *Lynx rufus* – Bobcat

Order Artiodactyla
Family Antilocapridae .... *Antilocapra americanus* – Pronghorn
Family Cervidae .... *Odocoileus hemionus* – Mule Deer

Discussion–The mammalian fauna of the Kansan Biotic Province is somewhat depauperate compared to most of the other natural Biotic Provinces. The diversity of rodent species found elsewhere was not evident on the Mansfield Ranch, nor were those present found in great numbers. This too could be a result of adverse climatic conditions during the first half of 1974. Our data indicate the Deer Mouse (*Peromyscus maniculatus*) to be one of the most common and ubiquitous mammals in the study area. These little mice were trapped among rocks, in the grasslands, in sandy open areas, and among logs and debris along the stream beds.

Ord's Kangaroo Rats were readily seen at night while driving the ranch roads through sandy areas. A single specimen of the Hispid Pocket Mouse was collected one night in the same habitat observed to have numerous Ord's Kangaroo Rats.

Evidence of Pocket Gophers was everywhere. Three specimens were collected, and all three proved to be Chestnut-faced Pocket Gophers. One was trapped in red clay beds where the soil was extremely hard and tight, while the other two came from soft, friable sand substrate.

The most visible mammals were rabbits. Desert Cottontails appeared to greatly outnumber Black-tailed Jackrabbits in all habitats.

Bats were often seen and heard near camp and around ponds. A Pallid Cave Bat (SRSU 1495) and a Canyon Bat (SRSU 1496) were netted over a small pond near a windmill. The study area does not offer a great deal of bat habitat and actually may not have a diverse bat fauna. The Hoary Bat (*Lasiurus cinereus*) should occur here but was not taken or observed.

Carnivores were represented by the Coyote, Badger, Raccoon, Swift Fox, and the Bobcat. Coyotes were numerous and could be seen during early morning and late afternoon hours and could be heard every night. A coyote den was located about 180 yards from our camp site.

The Badger is recorded on the basis of a skull found by the archeological team near the Canadian River. Raccoon tracks were seen in the mud of Big Halfway Tank.

Mule Deer were introduced successfully onto the Mansfield Ranch in the early 1950s and today are hunted during the Panhandle deer season. A shed antler was found on Alamosa Creek.

Pronghorns once roamed the entire Panhandle but are now found only in isolated places there. Mr. Estes stated that Pronghorns are more numerous on the north side of the Canadian River, but a few individuals could be found to the south of the river. We saw none during our stay, but they are listed here on the basis of Mr. Estes' statement.

W. B. Davis (1960) cites two mammalian species from Oldham County that were not observed in the field by us. However, on the basis of Davis' authority we include the Opossum and Swift Fox from the Canadian Breaks area. Davis also cites the Bobcat from southern Hartley County, and on the basis it also is included.

The Museum at Texas Tech had a Thirteen-lined Ground Squirrel (TT 7052) from Moore County, a *Perognathus merriami* (TT 7049) from 4.5 mi S Canadian River on US 87, Potter County; two White-throated Woodrats (TT 4750, 8594) from Randall County; a specimen of *Peromyscus truei comanche* (TT 4893) from Randall County; and three *Peromyscus difficilis* (TT 8399-8401) from Randall County.

The Tech records of *Peromyscus difficilis* and *P. truei comanche* are especially interesting. These mice are generally confined to Texas along the eastern caprock. *Peromyscus difficilis* recently has been reported to also occur in the Guadalupe Mountains of western Texas (Diersing and Hoffmeister, 1974). *Peromyscus comanche* has been recognized as a distinct species (Blair, 1943; Tamsitt, 1960). Later Hoffmeister and la Torre (1960) regarded *P. comanche* to be a subspecies of *P. difficilis.* Recently Schmidly (1973) presented evidence to show *comanche* is more closely allied to *truei* than to *difficilis.* The name *Peromyscus* *truei comanche* is a relatively new combination for this taxon in Texas.

Schmidly (1973) gave the known range of both *Peromyscus difficilis* and *P. truei comanche* as occurring in Texas along the "rocky, cedar covered slopes along the Break of the Plains in western Texas." He cites specimens of *P. truei comanche* as coming from only two counties in Texas, Randall and Briscoe. The geographical proximity of these two counties to Oldham County, and the similarity of habitat along the Canadian Breaks with that in Randall and Briscoe counties, raises the distinct possibility that both *P. difficilis* and *P. truei comanche* also occur within the present study area. These unique mice should be looked for along the Cedar Brakes on the Mansfield Ranch. If *P. truei comanche* does indeed occur on the Mansfield Ranch, it represents the only localized endemic form of vertebrate occurring on the study area.

Our thanks go to Mr. John Graves of Vega who did so much in making our stay on the Mansfield Ranch so pleasant. Mr. Graves always provided help when problems arose. Also, thanks to Mr. and Mrs. John Estes, owners of the Mansfield Ranch, for their great cooperation and as a source of historical documentation of some faunal elements. Special thanks to the other team members for all their help and cooperation. Such a task of recording so many vertebrates in such a short period of time would be impossible without observations and clues brought in by all the members of the team.

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RECONNAISSANCE AND ARCHAEOLOGICAL STUDIES IN THE CANADIAN RIVER VALLEY

William S. Marmaduke with Hayden Whitsett

INTRODUCTION

The Great Plains of North America have fired the imagination of the world for nearly a century and a half; first with its immense herds of bison and its free-roaming, proud Indians, a people capable of fierce and equal battle with invading immigrants, and later with a prodigious agricultural potential that stunned sensibilities with repeated surplus harvests in a world where most of the inhabitants are poorly or uncertainly fed in even the best of times. Despite its vivid history and productive potential, however, the Plains are essentially a hard environment where grasses dominate, wind is constant, and water uncertain. From east to west, the dryness of the Plains increases, and the size and luxuriance of the vegetation diminishes. The western portion of this land, the High Plains, is a semiarid environment where grasses are short and capable of periodic enforced dormancy. These High Plains stretch from Pine Ridge, just south of the Black Hills, to northwest Texas where they either break sharply over the crests of the Llano Estacado, or gradate and merge into the xerophytic savannah of west central Texas.

The Canadian River in the Texas Panhandle is one of only four major water courses that completely traverse the High Plains. In former times, the moisture provided by the river and the numerous springs exposed by the river's erosive force created an "oasis" or "haven" for many forms of plant and animal life that were unsuited to the harsh, wind-swept flatness of the High Plains. This hospitality made the wildly eroded valley, or "breaks," unique. Today, there is little of this uniqueness left. In our desire to be well fed, a human aspiration of considerable antiquity, the river's flow has been dammed, the groundwater pumped up, and the flora decimated by livestock grazing practices. Today the "breaks" appear harsh and forbidding, but still possess unbridled beauty.

The goal of the Natural Area Study is to describe the singularity of our natural heritage in the "breaks" of the Canadian River, to recognize the changes that have occurred in it, to measure what is left of it, and to provide a useful commentary for the conservative management of this fragile resource irrespective of the nature of its ownership. The focus of this particular report is on the human use of the river valley in times past. Human beings form an integral part of any biophysical system around them, and the remains and refuse of long-departed peoples stand as a testament to the dynamic nature of those systems and of man himself. As a participant in a rather especial ecology operating on the High Plains, man found, as other life forms did, the river valleys to be a unique combination of exploitable resources. Hence, the watercourses were a locus of activity for the primitive plainsman and formed a large portion of the particular ecology in which he functioned. Consequently, this report will describe the nature of human occupancy in the valley in terms of its temporal, spatial, and ecosystemic depth, using data derived from the previous investigations of other archaeologists, from historical observations, and from an archaeological reconnaissance performed by the authors in a selected part of the valley.

The portion of the Canadian River valley selected for field study is in Oldham County, west of Amarillo near the Texas-New Mexico border. The authors limited themselves to a single drainage area, Alamosa Creek, and that part of the south bank of the Canadian River that flanks the mouth of Alamosa Creek. In terms of land ownership, the authors confined their investigations to the Mansfield Ranch, owned by Mr. and Mrs. Jack Estes, and the ranch immediately south owned by Mr. Tom Green. These ranches are south of the Canadian River, east of U.S. Route 385, north of Interstate Route 40, and west of Longitude 102° 31'.

THEORETICAL CONSIDERATIONS

The authors have attempted to conduct this study as the first stage in the multistage fieldwork design postulated by Redman (1973). The requirements of this stage, with some modification by the authors, are

We wish to thank Dr. Jack Hughes of the Panhandle Plains Historical Museum in Canyon, and Dr. Dee Ann Story of the Texas Archeological Research Laboratory in Austin, for all of the aid which they freely gave us, and for their frank criticisms of our work; the final responsibility for all that follows, however, rests with us.

a general field reconnaissance, an organization of background cultural data, and a recognition of the ecological dynamics of the study area.

A general reconnaissance is site location and evaluation without the limitations of a strict sampling design. The purpose is to provide indications of cultural trends that in turn become the basis for a statistically valid sampling design. It helps define the statistical universe. Collections made on discovered sites are limited to those items that give a reasonably clear indication of age and cultural affiliation, the rationale being that later stages of the research program will collect the surface in a controlled fashion.

The organization of background cultural data is an obvious omission in Redman's design. The background data in this study come from two areas: previous investigations and historic sources. The inclusion of these materials serves to bolster the available working data derived from the general reconnaissance, possibly filling gaps and certainly increasing the perspective of spatial, cultural, and temporal variation.

Paleoecological study is included by Redman in the primary stage because it outlines the dynamics of the natural forces in an area and thus allows the recognition of connections between natural forces and cultural trends. This in turn has predictive value in succeeding stages of research and is necessary to the systematic explanation of culture process and lifeways.

The ideal of Redman's approach was only approximated in this study. The general reconnaissance was performed not merely to "see what was there" but was directed through a nonstatistical, subjective design; practical limitations of time and budget forced the authors to arrive at a plan for giving a rather large area a reasonably complete coverage. Statistical methods demand more time in defining the universe than was practical in this study, and indeed they are reserved by Redman for the later stages of fieldwork.

Primary paleoecological data were unavailable. Under Redman's model, biologists and geologists would be employed to that specific task. Unfortunately, such aid could not be obtained, forcing the authors to rely on the few regional studies available, historical sources, and materials recovered from archaeological investigations.

Having previously declared the intent to describe the human occupations of the Canadian River valley within the framework of a total natural system, the theoretical basis for doing so requires explanation. A crucial assumption for archaeologists is that the material goods or artifacts, the refuse left by defunct peoples, represent the patterned behavior of the makers and users. This assumption enables the prehistorian to place artifacts which purport to display time and affinity. Carried further, these constructions are amenable to statistical testing under the laws of probability. But taken alone, the assumption is quite narrow, having buried within it the bias that humans and their culture exist quite apart from the rest of nature, interacting with it in a dyadic fashion as one essentially closed system having external connections for purposes of life maintenance with another closed system.

The alternative consideration is afforded by Lewis (1974), who observes ". . . that patterned behavior is one part of *a* system." Rather than looking at patterned behavior, antique culture, as a closed system, the implication is that culture is merely a subsystem of an encompassing biophysical system. Culture still is separable from the rest of the biophysical system if the requirements of the investigation force it. But the separation properly should be viewed as an artificial one of closely interacting subsystems possessing multiple articulatory positions along their respective frameworks. In essence, neither constructed subsystem is closed, and a full understanding of one demands a careful exposition of the other.

The holistic approach to the reconstruction of lifeways, culture history, and culture process, the aims of archaeology outlined by Binford (1968:8), has been embraced by archaeologists in what is termed the "ecological approach." As practiced, there is a wide variation in attitude and cant amongst prehistorians that has been described by Trigger (1971) as falling into two distinct orientations. The first is the deterministic approach as exemplified by Meggers, Evans, and Estrada (1964) and by numerous Marxist practitioners. Crudely put, the method of the deterministic approach is to resolve all questions of history and process to the interaction of technology and nonhuman ecology. All other attendant systems that can be identified are passed off as dependent on and predictable from the synthesis of these primary factors.

The second, the "open" system, is more fluid. There is the recognition that cultures are multifaceted and essentially open when considered in separation from the rest of the local ecology. An explanation of the culture, therefore, necessitates that all possible connections must be scrutinized fully for their interactive effects. This in turn requires some examination of the connections between nonculture subsystems. Simply put, until the total environment and the linkages between the culture and that environment are considered, the mechanics of process and the factors of history cannot be fully known. An *a priori* identification of key features as characterize the deterministic view would, under an "open" theoretical framework, result in a lie or, at best, a half-truth. Thus the authors feel most at home with an "open systems theory" and will attempt to utilize it in discussing the work in the Canadian River valley.

The authors have repeatedly made the distinction of culture and noncultural spheres. A better division would be into culture and biophysical systems in the sense that culture refers to the remains or peoples under study, while biophysical refers to all else. This is the arbitrary separation made by Lewis (1974) on the basis of Clarke's (1968) recognition of five components of the biophysical environment: flora, fauna, geology, climate, and socio-cultural interactions. It seems to the authors, however, more convenient to discuss the first four as the "natural environment," leaving the last as something to be considered in conjunction with the culture under study. Socio-cultural interactions are often best observed from their effects, since their mechanics may be the most poorly understood of all the biophysical components.

The Natural Environment

For detailed, competent analysis of the present-day natural constitution of the Canadian River valley, the reader is referred to the pertinent reports contained elsewhere in this volume. The authors do not intend to duplicate the work of other, more qualified specialists, but merely to identify and organize the features of the natural environment that have pertinence to the understanding of the human ecology of the area.

Geology

> In traversing 250 leagues, [another] mountain range was not seen, nor a hill, nor a hillock which was three times as high as a man. Several lakes were found at intervals; they were round as plates, a stone's throw or more across, some fresh, some salt... The country is like a bowl, so that when a man sits down the horizon surrounds him all around at the distance of a musket shot.—Casteñeda, chronicler of Coronado, 1540. (Winship, 1904)

The High Plains of the Texas Panhandle are composed of a suite of layered Pliocene and Pleistocene age sediments. The Plains surface itself is a mantle of Recent loessial silts and sands which rest atop the upper Pleistocene sands and clays of the Panhandle formation. At its lower margin, the Panhandle formation contacts a strata of partially indurated Pliocene gravels, the Ogallala formation, which in turn rest unconformably on the Dockum group, a series of interspersed sand and mud beds of upper Triassic Age. In the eastern portion of the Panhandle, however, the Dockum group is absent and the Ogallala formation sits directly on top of the Permian Quartermaster formation which elsewhere is buried beneath the Triassic sediments.

The Ogallala and Panhandle formations were deposited in a series of merging alluvial fans extending eastward from the Sangre de Cristo and Sierra Grande uplifts in New Mexico (Sellards, *et al.*, 1938). Rivers carrying sediments into the area were captured later by the Pecos River headwaters, effectively cutting off the deposition on the then broad alluvial piedmont. The Canadian River, however, was not captured and continued to flow across the area; but a decrease in the quantity of rainfall in New Mexico, or another uplifting episode in the Rockies, or possibly a lowering of the Gulf of Mexico altered the river's dynamic action from deposition to erosion, causing it to entrench itself in a deep, broad valley. Since the initial deposition of the Panhandle formation, wind, during periodic episodes of dryness, became an important depositional agent, sorting and moving finer sediments from the river valleys onto the uplands.

The sand and gravel layer beneath the Panhandle formation, called the Ogallala formation, has been hardened by the deposition of calcium carbonate materials such that it is quite resistant to erosion. This hard layer forms a "caprock" and protects the western High Plains surface from the lateral erosion of the river. Additionally, the Ogallala is an important aquifer on the High Plains, and its exposed edges along the river valleys must have provided some dependable springs and moist areas in times past.

The resistance of the Ogallala formation to erosion causes a peculiar drainage phenomenon on the Plains surfaces. Excess water, having no established drainages system to carry it away, pools in low areas to form small, ephemeral, sinking lakes called playas. These lakes are reserviors of moisture on the surface of the otherwise near-arid plain and support a more luxuriant plant and animal life on their shores. When the plains were the home of Pleistocene and recent megafauna, the playas served as watering localities. As a result, the remains of these animals are often found in playa lake sediments.

The Dockum group below the Ogallala is by contrast less well known. W. S. Adkins (Sellards, *et al.*, 1938) supposed the source of the Dockum sediments to be a land mass to the north or northwest with some material provided from Permian deposits (location unclear). In the Canadian River valley the Dockum is described as composed of two formations. The lower Tecovas formation consists of several vari-colored shale/mud layers: white, grey, or lavender at the bottom, maroon in the middle, light yellow to sulphur yellow at the top. Above the Tecovas lies the Trujillo formation formed by one to five sandstone ledges of varying hardness with interbedded red and grey shales. In actual appearance, the Tecovas and Trujillo formations are considerably more complex, possessing local sand lenses and conglomeratic inclusions.

The exposed Triassic red beds in the Canadian River valley were providers of spring water and moisture away from the river channel itself, but on a nonregional basis. Sand lenses and ancient stream beds are the dominant source of well water in the area today, and their outcrop—where properly situated—form the spring locations deep in the valley.

A third suite of sediments present in the river valley are Quaternary and Recent in age. Primarily complexly stratified series of fluvial/pluvial muds and gravels, these units are roughly correlative to Wisconsin age ice advances. The Pleistocene sediments are sometimes difficult to separate from later valley alluviation and are not obviously contiguous over broad areas. Their unconsolidated mud and gravel lithology cause their erosional characteristics to be similar to some of the associated Triassic sediments.

The combination of hardened caprock and soft substrata cause the peculiar topographic relief that characterizes the "breaks." The valley edges, in most places, are abrupt. The caprock is prominently exposed at the top of the valley walls and the underlying, easily weathered Triassic strata slope precipitously downward from it. In only a few places is the descent into the valley gentle. Where erosion has cut behind a particularly resistant portion of caprock, flat-topped remnants stand in front of the valley edges.

Deeper in the valley, the more resistant sand layers in the Trujillo formation provide enough overlying support to cause what could be considered a second set of "breaks" or canyonlike slopes topped by relatively flat land. The sand layers of the Trujillo, however, are softer than the Ogallala caprock and large masses of wind-sculpted sandstone are not uncommon. Again, back-cutting around resistant areas causes numerous mesas.

Below the second "breaks," local hard sand areas provide the necessary support for the development of a badlands topography characterized by convoluted mud hills and small pedestal-like prominences.

Generally, the valley floors are flat and deeply cut by water action into vertically banked channels. The floor fill is composed of material from adjacent and upstream slopes. Soils developed on the floors are classified as inceptisols or aridisols. Upon examination, the deeply cut stream walls often reveal several buried soil profiles.

The Dockum exposed in the valley was a primary source of lithic raw materials. Occurring as nodules or extensive lenses in a mudstone matrix is a varicolored jasper with reasonably good working qualities and undeniable aesthetic appeal. The general recognition feature of this material, called Tecovas jasper locally, is a lustrous brown or caramel color which occurs within a white and purple streaked field. A secondary lithic resource in the Dockum is quartzite which often lies exposed as cobbles on erosional surfaces within the valley; the larger specimens may be remnants of the vanished Ogallala gravels which used to lay above, while some of the smaller ones come from localized concentrations in the Dockum itself. On many of the archaeological sites visited, tools fabricated of quartzite were observed. Often these were the larger, less well worked items such as large bifaces ("knives," "choppers," "scrapers" ?), milling stones, and hammerstones, although one site, 41 OL 21, did produce two small, finely flaked projectile points of quartzite. Additionally, pieces of pottery often had a crushed quartz temper, and many hearth concentrations were lined with quartzite cobbles which served to limit the fire and possibly to aid the cooking of food (boiling stones).

In portions of the valley to the east and west of the study area the underlying Permian strata, the Quartermaster formation, is exposed. The units of the Quartermaster are described as "well bedded red sand and sandy and gypsiferous shales" (Sellards, *et al.*, 1938:180). The Upper unit, however, is a dolomite layer (Alibates) that helps support the Canadian river bluffs north and northest of Amarillo. Portions of this dolomite have become agatized and the resulting material is a fine-grained, flinty stone with bands of white, purple, and red color running through it. Alibates agate was valued by aboriginal plainsmen as a raw material for the production of all classes of stone tools featuring a cutting edge, and it has a wide temporal and spatial distribution throughout the region.

The erosional characteristics of the Quartermaster formation are approximately similar to those of the Dockum formation despite some lithologic differences.

Climate

The unique environment that characterized the Plains is due in large part to its weather. Summers are hot, occassionally with severe storms and drying wind, while winters can be hard with freezing temperatures present from October to mid-April. The river valley provides protection in places, however, thus mitigating some of the extremity.

Perhaps the most easily noticed climatological feature of the High Plains is incessant wind. The mean annual wind velocity at Amarillo is 16.1 knots

(Orton, 1964). The wind blows out of southerly directions (between southwest and southeast on a compass rose) 70 percent of the time in summer. In contrast, wind direction in winter is 50 percent south to west and 28 percent north northeast to west. Only one percent of the days are considered calm (Arbingast, *et al.,* 1973). One extreme feature worth noting is the quality of the south southwest and southwest summer winds. Moving at relatively high velocity, this air has a phenomenally high temperature and low humidity, making it a restraining factor in both dry-land farming and human work capacity.

The mean annual temperature in the Canadian river area is between 54° and 58°F with a cooling gradient from southeast to northwest. In the study area the mean is 57° (Arbingast, *et al.,* 1973). The average maximum temperature during the summer months is over 90°, and this—coupled with the heated, swift southerly winds—gives the area an evaportion rate of nearly 60 inches per year. During the drought years of 1950-1956 this factor was well over 70 inches (Arbingast, *et al.,* 1973). The winter average minimum temperature is below freezing from November to March, with the mean date of the first frost on 1 November and of the last frost on 15 April (Arbingast, *et al.,* 1973). The average winter maximum temperature is between 48° and 58° (Orton, 1963).

The mean annual relative humidity on the Texas High Plains is 65% to 75% at 6 a.m. and 35% to 45% at 6 p.m. (Arbingast, *et al.,* 1973).

The average annual rainfall at Amarillo is 19.67 inches (Orton, 1964) and ranges from over 20 inches in the valley in Hutchinson County eastward, to 16-18 inches in central Oldham County, and less than 16 inches on the Texas-New Mexico border to the west (Arbingast, *et al.,* 1973). But averages are deceiving, and a clearer understanding of precipitation levels can be gained by examining the pattern of rainfall over time and space. In the area of Amarillo, over 3 inches of rain falls in May, over 2 inches in June, July, and August, over 1 inch in April, September, and October (averages of years 1931 and 1960) (Orton, 1964). Over 10 inches of the 19-inch average falls during the growing season. Coverage can be so fickle, however, that an excellent rain year may be a few miles removed from a debilitating drought. Moreover, the whole years amount may fall on only 2 or 3 occassions, simply running off a soil which cannot absorb it quickly enough.

Climate on the High Plains is not unchanging. Ample evidence exists to demonstrate major, long-term shifts, as well as minor periodic variation. The depth of alluvium in valley floors and the exposed profiles of buried soils indicate substantial alternation of relatively wet and dry climates: the soils represent relative dry periods while the burying materials indicate relative wetness. Presumably, today's weather patterns, causing erosion and some soil formation rather than deposition in the valley floors, are characteristic of drier periods.

Broad climatological patterns can be recognized from geologic phenomena. The Pleistocene sediments in the river valley display silty alluvium, gravelly stream channels, and lacrustine muds, all pointing to a much wetter climate than today over a large span of time. After the termination of the Pleistocene epoch, 8500 B.C. (Hopkins, 1959), the cool climate of the Plains waned (Antev's anathermal) into a period marked by conditions much hotter than the present (Antev's altithermal). The exact nature of the altithermal period is not agreed upon. Most researchers accept that the period was hotter than present, but whether this temperature rise was accompanied by increased dryness is unsettled. Malde's (1964) study supports the conclusion that the Plains were much drier than today, while Aschmann (1958) and Martin (1963) claim that the altithermal was a time of environmental change featuring violent thunderstorm activity rather than slow, even precipitation. Regardless of the possible specificities embodied in the various interpretations, Jennings (1968) points out that the broad concept of an altithermal has never been satisfactorily useful in archaeological interpretation, because its effects on human populations, living at different times and possessing different adaptive histories, cannot be predicted absolutely.

Following the altithermal, climatic conditions became much as they are today. But the range of variation in the climate serves as a tempering feature for our conceptions of past climatological conditions.

Within the last 1000 years there is evidence for small-scale periodic, if somewhat uneven, variations in climate. Thick loessial deposits which mantle relatively recent sites in the central Great Plains (Wedel, 1941) attest to a habitable period that was ended by drought around A.D. 1250. Faunal studies on bone materials recovered from archaeological sites in the Canadian River valley point to a reasonably moist climate from A.D. 1250 to A.D. 1300, followed by progressive drying (Duffield, 1970). Many of these archaeological sites presently are covered with a layer of loess, which adds strength to that argument. In historic times, the experiences of the late nineteenth century—when more than a million Anglo-American farmers were forced from the Plains (Wedel, 1961)—and of the 1930s dust bowl attest to the occasional problems that the Plains climate has caused man. In contrast, the opposite variation is demonstrated by piles of grain on small town streets when the elements have been beneficent and the harvest strains modern storage capacities.

Flora

> The grass grows tall around [playa] lakes; away from them it is very short, a span or less. There are no groves of trees except at the rivers, which flow at the bottom of some ravines where the trees grow so thick that they were not noticed until one was right on the edge of them. —Casteñeda, chronicler of Coronado, 1540, (Winship, 1904).

For archaeological reconstruction of Plains lifeways, studies of the present floral composition are of little use. Agricultural practices, cattle raising and irrigation, have extensively altered plant life in the Texas Panhandle from the scene viewed by Casteñeda in 1540. Much of this change has occurred in the last one hundred years, some even within the memory of people who are not really old.

The study area examined by the authors can be characterized briefly as a grass land, dominated by short-statured species, supporting substantial growths of mesquite and cholla cactus. Where erosion is actively attacking the land surface, grasses tend to occur as clumps separated by expanses of bare soil. Some juniper growth is also prominent in steep canyons and dissected badlands. The mesquite and cholla cactus vary in their density, thick enough in some localities to inhibit cross-country foot travel.

The land was not always so rugged. Essentially, the mesquite and cholla cactus are usurpers in the valley. Their seeds are spread by cattle which consume the relatively nutritious seed pod but pass the seeds themselves in their feces. Mr. Jack Estes, owner of the Mansfield Ranch, related that photographs made on the ranch prior to the Second World War show less than one-third of the present mesquite-cholla growth. This is comprehensible if one remembers that Americans' present passion for beef began only thirty-odd years ago, thus making the era 1940 to present—despite cinematic and literary romanticization of the nineteenth century—the true cattle boom years. This unprecedented demand for meat, for meat at a low price, encouraged the intensive use of the land for livestock. The result is a basic alteration of the flora.

Irrigation has played a part in the conversion of the breaks particularly. Because the Ogallala caprock, the principle aquifer in the area, is so hardened by the deposition of carbonates, it has an exceedingly low recharge capacity on its upper surface. Coupled with the imbalance between pricipitation and evaporation rates, the low recharge means that water pumped out of the aquifer is not replaced, and the lowered water table ceases to provide discharge at spring locations on the caprock edge, depriving the flora there of its sustaining moisture and probably drying most of the upper drainage stream channels. The Triassic sediments are similarly affected, and local ranchers claim that more than 90 percent of the springs in the valley have ceased to flow in the last fifty years.

The decision to dam the Canadian River in New Mexico has taken its toll also. The river in Oldham County is dry except for periods of locally heavy rainfall or when water is released from upstream reservoirs. The slight amounts of water that do get to the river are removed by evaporation rather than flushing through the drainage system. As a result, the river sands are covered in many places by salt pans, and the channelside vegetation is predominantly salt cedar and salt grasses. But less than one hundred years ago the rancher Charles Goodnight related that grass in the valley was as dense and high as cultivated stands of wheat. The grass was in such abundance and luxuriance that ranchers mowed it for hay (Archambeau, 1963). Spanish (Winship, 1904; Hammond and Rey, 1953) and American (Abert, 1941) explorers in the Canadian River valley reported stands of plum trees and growths of fruit which Casteñeda described as rivaling the best "prunes" and grapes of Spain (Winship, 1904).

Farther back, during the Pleistocene periods of increased wetness, the High Plains probably were grasslands, featuring lusher growths than are found today. Pollen studies indicate a possible savannah of mixed tall grass-shrub-tree vegetation (Wendorf and Hester, 1962; Martin, 1963). Since the end of the Pleistocene, however, the High Plains area was much the same as it was in historic times.

ZONATION

Lathel Duffield (1970) provides a useful and partially correct definition of the Canadian River valley biotic zones. Each defines a peculiar environment possessing somewhat differing inorganic resources and subsequent floral association. Since no palynological studies are available, reconstructions of the former characteristics of each zone are based on historical observation as well as information from other Plains river valleys.

Grassland—Plains

This zone consists of the flat Plains surface above the river valley and the large flat surfaces in the river valley that are either significantly higher than the drainage channels or substantially removed from possible moisture sources. The surface vegetation is almost entirely Buffalo grass and Grama grass, except around the functional playa lakes where higher moisture levels support growths of taller grass species. The short grasses of this zone are hardy life forms capable of both rapid growth on receipt of moisture and long periods of dormancy. Additionally, these grasses have the phenomenal ability to "cure" on the stand (without cutting) during the winter months. What mesquite was present around the Canadian River valley in former times was confined to a narrow belt of the Grassland-Plains zone immediately adjacent to the valley edges (Abert, 1941).

Edge Breaks

Areas defined as edge breaks are the upper drainages of tributary streams, the caprock edge and adjacent slopes, and intravalley areas of extensively broken topography. They do not include the banks of active stream channels. The edge breaks near the caprock have a higher moisture level than the Plains. The lowered ground level affords some protection from drying summer winds on the south side of the river and frigid winter blasts on the north side, while the attendant differences in sunlight regimes vary evaporation rates and snow accumulations. The assumption must be made that this differential protection instigated some floral differences between the north edge breaks and the south edge breaks.

The vegetation of the edge breaks is described by Duffield as "Eastern Woodland" (1970) which is somewhat a misnomer. The Spanish and American observers characterized the edge breaks flora as quite thick but did not attempt a description of varieties beyond the economic plums and grapes. The others were likely juniper, oak, persimmon (rare), chokecherries (rare), and buffalo berries. Exposed ground supported growths of short grasses with localized concentrations of long-stemmed bunch grasses, bear grass, sagebrush, gourd, and unicorn plant.

Moist–Aquatic

This zone incorporates the bottoms, banks, and adjacent bottom lands of the Canadian River and its active tributaries. Moisture levels were high from proximity to the drainage water.

The moist-aquatic zone was the most fecund of all, supporting stands of cottonwood, elm, hackberry, willow, ash, wild china, persimmon, oak, plum, buttonwood, and possibly box elder. The underbrush contained chokecherries, grape, buffalo berries, and, rarely, currants. Much of the bottomland was covered by the dense growths of tall grasses, while the aquatic area immediately adjacent to the channel banks featured cattails, arrowhead, and other similar plants.

Economic Wild Plants

Few of the Grassland-Plains plants were of primary economic usage. The short grasses nourished the important herds of bison and antelope, and grass seeds may have been used as a food (41 HC 31-John Keller, personal communication). Wedel (1961) identifies the Indian Turnip (*Psoralea esculenta*) and the Wild Onion as exploitable upland food vegetables, but documentation of these plants in the Texas Panhandle is lacking. Wedel also suggests that several Grassland-Plains plants were valued by primitive Plains dwellers for medicinal or magical purposes but does not provide identifications or specific usages.

In contrast, edge breaks and moist-aquatic zones provided much.

> The land was . . . rich in fruits, particularly of infinite varieties of plums, as different in flavor and quality as the ones that are cultivated in well tended gardens of our own country. Their quality was such that even if eaten in large quantities no one felt any bad effects. The trees were small and the fruit more numerous than the leaves. In more than one hundred and fifty leagues hardly a day passed that we failed to find groves of them, or grapevines, which, even when found in remote places, produced sweet and tasty grapes. –Don Juan de Oñate to the King of Spain, 1601, (Hammond and Rey, 1953).

Hackberries, chokecherries, buffalo berries, yucca cacti, various forbs, acorns, and onion were also available in season. Groundnuts (*Apios tuberosa*) and ground beans (*Falcata comosa*) are generally listed as other lowland vegetables, but again the authors are unable to confirm their occurrence in the Texas Panhandle.

If the box elder was present formerly, it may have been a frequently exploited resource. Ethnographic information from other Plains locations indicate that the sap of the box elder, when boiled, produces a pleasing sugar syrup (Wedel, 1961).

Aside from food, the moderately timbered valley provided building materials in the form of "poles" and brush, as well as fuel, fiber, and hardwood for use in aboriginal technologies.

AGRICULTURE POTENTIAL

Agriculturalists today use the Canadian River area in the following fashion: the "breaks," encompassing the edge breaks, intravalley grasslands, and moist-aquatic zones are livestock grazing areas; the plains of the Grassland-Plains zone also are used for some livestock grazing but are primarily farmland for cotton and grains. Modern use of the grasslands for vegetal crops, however, depends on the use of steel plows, for the sod is unyielding to lesser force.

Primitive farming is practicable only in the valley itself, where alluvial soils are easily turned with a digging stick and soil moisture more persistent. There are two opinions on suitable locations for primitive farming. One argues that soil moisture would be most regular along stream channels and the land surrounding springs. The other view, offered by a soil surveyor, points out that the channelside soils have a poor fertility and that portions of the valley floor near hillslopes are more fertile and actually retain more moisture.

Corn requires an eight-inch rainfall during its growing season, a figure that is achieved in the Canadian River valley (see Climate). As a form of insurance against the vicissitudes of High Plains precipitation patterns, primitive horticulturalists may have selected a variety of soil environments, hoping that one would match the growing season qualities in such a way as to provide a sustaining harvest.

Fauna

As with the flora of the High Plains, the fauna of the Canadian River valley has undergone changes. The causes are partly natural and partly historical. The loss of the Pleistocene megafauna probably was natural, although the mechanism is unknown. Other more recent losses can be laid partly to the previously outlined floral alterations. Finally, the large bison population that so awed early visitors to the Plains was decimated for economic and military purposes:

> [White Buffalo Hunters] are destroying the Indians' commissary; and it is well-known fact that an army losing its base of supplies is placed at a great disadvantage. Send them powder and lead, if you will; but for the sake of lasting peace, let them kill, skin and sell until the buffaloes are exterminated. Then your prairies can be covered with speckled cattle, and the festive cowboy, who follows the hunter as a second forerunner of advanced civilization. –Gen. Philip Sheridan before the Texas House and Senate, 1875 (Cook, 1907:113).
> (Note–This speech has not been authenticated, but it represents the dominant thinking of the military leaders in that age.)

In discussing the previous faunal resources of the Plains, this study will have to depend on historical observations and archaeological recoveries.

Late Pleistocene Fauna

According to A. S. Romer (1966), the basic difference between the late Pleistocene and Recent faunas is the number and kinds of mammals.

> There are presumably no living types which were not also present in the Pleistocene, but many forms then present are not extinct. These were mainly mammals of large or more than average size (p. 346).

The extinct forms recovered from archaeological sites include the mammoth, large, long-horned bison (*Bison antiquis, Bison occidentalis*), camel, tapir, brocket or extinct antelope, sloth, dire wolf, and horse. The mammoth and large bison occur generally in archaeological strata laid during cool, wet climate regimes, with the large bison showing some ability to survive drying changes. The others are found in both wet and dry situations but faced extinction by the last advance of Wisconsinan ice.

Recent Fauna

> The buffalo ... are large like the cattle of Castile. They have humps like camels. From the middle of their body to the front they resemble lions because of their long hair. Their haunches are like those of a priest's fat mules, and their tails like pigs' tails, hairless to the tip, which has bristles. The animals are very fat and their meat tasty.
>
> There are vast numbers of these cattle on the prairies where they graze. We saw them only at good watering places and on the plains where there is fine short grass. [We] were unable to corral these animals but killed more than a thousand. –From the testimony of Marcelo de Espinosa before the Val Verde Inquiry, July 28, 1601 (Hammond and Rey, 1953).

When one thinks of Indians living on the Plains, the first image is of the bison and of red men happily gorging themselves on effortlessly gotten prime red meat. In truth, the bison were not so easily taken, or so readily available. Bison are usually docile creatures. But when aroused, they prove to be quicker, more agile, and much faster than their physical appearance suggests (Roe, 1951). Historic Indians told many stories of braves who lost their lives in the hunt and relate that prior to the acquisition of the horse, bison hunting was a difficult and dangerous undertaking (Flannery, 1953). Moreover, bison were not migratory creatures but aimless wanderers within a range with less than 200 miles of seasonal variation (Roe, 1951). Finally, there is doubt that bison populations were as large as popularly conceived: a huge herd in the fall of the year generally meant no buffalo in other areas for a considerable distance.

For hunting peoples, this meant that a strict dependence on the bison as a singular source of proteins was not feasible. Moreover, other animal products found a ready utility in all phases of aboriginal technology. Hides provided the raw material for clothing and shelter, and sinews became strong, elastic cordage for bindings and bowstrings. Bones were obtained to serve as durable tools, as well as decorative artwork. The feathers of many birds were valued for their beauty and their supposed magical powers, while the bird itself may have been regarded as unfit for human consumption. The total faunal resource of the area becomes, then, an important factor in life on the Plains.

The animals of the Canadian River valley cannot be organized into gross zones, as the plants can, without doing violence to the facts. Each species of animal found there frequents a particular microenvironment which it describes for itself and which may not coincide exactly with the habits of any other species. And while some animals occur only in a narrowly defined area, other animals, such as carnivores and large herbivores, are likely to be found almost anywhere in the valley. Moreover, there are certain requirements for life that are common to nearly all animals: specifically there is the need for water which draws most animals, at one time or another, into contact with a zone of moisture and, hence, moist-aquatic plants.

Rather than duplicating the efforts of zoologists, whose report is found elsewhere in this volume, it might be pertinent here to simply list the Recent fauna which has been recovered from archaeological sites in the valley (from Duffield, 1970). It should be recognized, however, that not all of these animals may have gotten into the sites as a result of human activity; animals, like all other living things, do die occasionally without the intervention of man into the process, and an archaeological site is as good a location for this as any other. Most of the following animals probably did expire from an unfortunate encounter with prehistoric plainsmen, but the information necessary to determine those that may not have is not available in the published literature.

Mammals: Bison, Antelope, Mule Deer, White-tailed Deer, California Jack Rabbit, Eastern Cottontail Rabbit, Desert Cottontail Rabbit, Raccoon, Muskrat, Coyote, Swift Fox, Badger, Spotted Skunk, Striped Skunk, Bobcat, Prairie Dog, Prairie Vole, Kit Fox, Eastern Mole, Plains Pocket Gopher, Chestnut-faced Pocket Gopher, Hispid Cotton Rat, Ord Kangaroo Rat, Grey Wood Rat, White-throated Wood Rat, Mexican Wood Rat, Hispid Pocket Mouse, Baird Pocket Mouse, White-footed Mouse, Short-tailed Shrew, Big Brown Bat.

Birds: Turkey Vulture, Red-tailed Hawk, Sharp-tailed Grouse, Bald Eagle, Sparrow Hawk, Mourning Dove, Great Horned Owl, Burrowing Owl, Short-eared Owl, White-necked Raven, Brown Thrasher, Robin, Trumpeter Swan, Whistling Swan, Canada Goose, White-fronted Goose, Mallard, Gadwall, American Pintail, Green-winged Teal, Blue-winged Teal, American Widgeon, Shovelor, Redhead, Ring-necked Duck, Ruddy Duck, Canvasback, American Coot, American Woodcock.

Reptiles: Snapping Turtle, Yellow Mud Turtle, Box Turtle, Western Painted Turtle, Red-eared Turtle, Spiny Soft-shelled Turtle, Spineless Soft-shelled Turtle, Horned Toad, numerous snakes.

Amphibians: Unidentified frogs.

Fish: Catfish (*Ictalurus* sp.), Freshwater Drum, unidentified minnows.

Domesticates

Animal domestication in the western hemisphere lagged behind the achievements of the eastern. While turkeys and dogs were kept in the pueblos of New Mexico, there appears to be only one domestic animal in the prehistory of the Canadian River valley: *Canis familiaris*, the dog. Remains of these animals are found archaeologically in the Canadian River valley, but it is the early Spanish explorers who add flesh to the picture:

> To carry this [tent], the poles to set it up, and a knapsack of meat and their *pinole*, or maize, the Indians use a medium-sized shaggy dog, which is their substitute for mules. They drive great trains of them. Each, girt round its breast and haunches, and carrying a load of flour of at least one hundred pounds, travels as fast as his master. It is a sight worth seeing and very laughable to see them travelling, the ends of poles dragging on the ground, nearly all of them snarling in their encounters, travelling one after another on their journey. In order to load then the Indian women seize [the dogs'] heads between their knees and thus load them or adjust the load, which is seldom required because they travel along at a steady gait as if they had been trained by means of reins. –Don Juan de Oñate, 1601, of Indians encountered in the Canadian River area (Hammond and Rey, 1953).

Of the general appearance of these dogs, only a few further comments can be offered:

> . . . not much larger than water spaniels. . . –Capt. Juan de Ortega, 1601 (Hammond and Rey, 1953).

> . . . much smaller than Mastiffs. –Marcelo de Espinosa 1601 (Hammond and Rey, 1953).

> Most . . . are white, others have black spots. –Capt. Juan de Ortega, 1601 (Hammond and Rey, 1953).

Just when primitive Americans accomplished the domestication of the dog (or was it possibly the reverse?) is unsettled. The remains of dogs are found in the Abejas Phase (3400 B.C.-2300 B.C.) of the Tehuacan Valley in Mexico (MacNeish, 1964) but appear somewhat later in the midwestern U.S. in the Three Mile component (2500 B.C.-2000 B.C.?) of the Eva site (Lewis and Lewis, 1961).

CULTURE CHRONOLOGY

The previous work of other archaeologists has identified a set of distinctive cultural entities on the Texas High Plains. As temporal units, they cover an impressive span of time, but as cultural units their contiguity is uncertain. The authors discuss this chronology here in order to recognize the previous investigations on the High Plains and to organize a tentative framework for the presentation of our own.

The Paleo-Indian Stage

The earliest demonstrably authentic cultural remains on the High Plains have been variously titled Paleo-Indian, Paleo-American, Early American

Hunter, Upper Lithic, and Big Game Hunter. The last appellation identifies the accepted diagnostic feature of the stage: the association of tool-using humans with the late pleistocene megafauna. There are some tantalizing hints and conjectures that the human occupation of the New World may have begun as long ago as 35,000 B.C. (see Haynes, 1969 for a brief discussion of this). Most of the evidence for man before 10,000 B.C., however, is either questionable (not meeting the minimum standards of archaeological proof) or not yet published. In any event, no sites beyond the 10,000 B.C. date have been claimed for the Texas Panhandle and this paper will be limited to a discussion of those cultures succeeding it.

Three separable "cultures" have been identified from chronological, cultural, and faunal evidence.

The Llano Culture

Named by E. H. Sellards (1952), the Llano culture is the earliest within the Paleo-Indian stage. The characteristics of the culture which are considered "fingerprints" are large lanceolate projectile points (Clovis points) approximately 3 to 6 inches in length and one-fourth as wide as long, showing one or more short flakes removed from the basal faces toward the tip, and the association of these projectile points with the remains of mammoths.

The Llano culture was defined from excavations at Blackwater Draw near Clovis, New Mexico (Sellards, 1952) where Clovis points and other less characteristics tools were found with the remains of mammoth, horse, camel, and extinct bison, all sealed in a discrete geologic stratum. Other sites on or near the Texas High Plains that have yielded Llano cultural remains are Miami in Roberts County, Texas (Sellards, 1938); McLean in Throckmorton County, Texas (Ray, 1942); Lubbock Lake in Lubbock County, Texas; and Domebo in Oklahoma and (Leonhardy, 1966).

Most Llano sites are the remains of hunting activities involving the mammoth; their geologic contexts indicate a bog, marsh, or playa lake environment. Whether this represents a distinctive hunting strategy is undecided, but Jennings (1968) lists the possibilities as (1) a deliberate technique, (2) the result of previously wounded and feverish animals seeking water, or (3) an opportunistic kill of an incidentally discovered, mired animal.

Of the nature of Llano life, Jennings (1968) likens it to the lifeways of the Yahgan or Ona of South America: few material possessions, some cooperative and some lone hunting, no permanent camps. The emphasis on mammoth as a game animal may not have been as intense as the few sites known seem to indicate. From ethnographic information available for the African Bushman, as well as the Ona and Yahgan, a picture of a people living off gathered vegetal foods as well as an eclectic assortment of game can be constructed. As Jennings points out, few historically observed hunters concentrated on a single species of animal to the near exclusion of others.

The absolute dating of the Llano culture is imprecise. C. V. Haynes (1964), using a long series of radiocarbon dates, argues that the Llano culture was a short-lived phenomenon from 9500 B.C. to 9000 B.C.

The Folsom Culture

The Folsom culture takes its name from its first indisputable discovery: the Folsom site near Folsom, New Mexico (Roberts, 1935). The characteristic tool of the Folsom culture is a lanceolate point, smaller than the Clovis point, showing finely pressure-flaked edges and a long flake removed from each face practically from the base of the tip. These points usually are associated with the remains of *Bison antiquis*. Generally accepted as authentic Folsom sites on or near the Texas High Plains are the Lipscomb quarries in Lipscomb County, Texas (Schultz, 1943); Lubbock Lake in Lubbock County, Texas; Scharbauer in Midland County, Texas (Wendorf, Krieger, and Albritton, 1955); and Blackwater Draw in New Mexico (Sellards, 1952).

As with the Llano culture before it, the Folsom sites, save one, are "kill sites." They do, however, reveal changes in lifeway: the exploitation of the large extinct bison, probably a shift tied to an ecological alteration from Llano to Folsom times; the "surround kill" where animals were either trapped or driven into a *cul-de-sac* and then dispatched; and the "jump" or "fall" in which large numbers of animals were stampeded over a precipice or bit of rough ground where they were killed or injured by falling and then finished off by hunters. The best known living site for the Folsom culture, Lindenmeier in Colorado (Roberts, 1936) does not offer any indication that the Folsom lifeway differed much from that of the Llano culture (Jennings, 1968), aside from a more cooperative hunting effort suggested by the hunting technique.

The age of the Folsom culture is somewhat better known than that of the Llano. The excavations at Blackwater Draw established a relative age, when Folsom materials were recovered from a stratum above and well separated from the Llano materials. Absolute radiometric dates from Lubbock Lake, Lindenmeier, Blackwater Draw, and Hell Gap (Wyoming) establish the temporal limits at 9000 B.C. to 7000 B.C. (Haynes, 1964).

Plano Culture

Following the Folsom culture was a time of increased diversity in artifact form. The removal of large flakes from the faces of projectile points ceased, although the general lanceolate form was retained. The period seems to have been a time of changing economy as well; some Plano culture sites have the remains of the large extinct bison while others yield the modern *Bison bison*. In addition, more small game remains are found.

The Plano culture also points to a greater and more diverse population with not one but many sizes and shapes of projectile points in sites stretching from Canada into Mexico. Names such as Angostura, Lerma, Meserve, Plainview, and Scottsbluff refer to distinctive and different projectile point designs. There may be some chronological significance in this diversity as Krieger (1964) suggests, but its nature or order does not seem to be well understood.

Plano culture sites are more numerous on the Plains than those of either Folsom or Llano. Those in the immediate vicinity of the Texas High Plains include Plainview in Hale County, Texas (Sellards, 1947); Lone Wolf Creek in Mitchell County, Texas (Suhm, Krieger, and Jelks, 1954); Milnesand in New Mexico (Sellards, 1955); San Jon in New Mexico (Roberts, 1942); and Blackwater Draw in New Mexico (Hester, 1973). Many other documented sites exist in Texas along with a substantial number of surface or random finds of diagnostic artifacts, but those above seem to be the more important sites in the area being discussed.

Along with the population increase, the Plano culture hunting patterns bespeak the cooperative, planned efforts of larger social groups. This—coupled with the uncovering of living sites such as Red Smoke (Davis, 1953) and Lime Creek (Davis, 1952) in Nebraska, Levi (Alexander, 1963), Damp Cave (Epstein, 1962), and Devil's Mouth (Johnson, 1964) in Texas—indicates a more settled, perhaps territorialized existence in which group competition may have become a factor of life.

The relative dating of the Plano culture, like that of Folsom, was proven through stratigraphy at Blackwater Draw (Sellards, 1952). Since then, absolute radiometric dates have been obtained that define a range from 9800 + 500 or approximately 7850 B.C. at Plainview (Kelley, 1964) to approximately 5400 B.C. from Zone IV at Levi Rockshelter (Alexander, 1963).

THE ARCHAIC STAGE

The Archaic stage on the Texas High Plains is poorly understood. Jack Hughes (1955) states that there are many sites of Archaic peoples in the Texas Panhandle, but they have been sorely neglected by archaeologists. Recent excavations of Archaic materials in Palo Duro Canyon by the Smithsonian Institution and at Lubbock Lake by the Texas Tech Museum may greatly expand our understanding of the Archaic lifeway on the Plains.

One site, Little Sunday, is available in the literature (Hughes, 1955). The cultural material recovered featured projectile points of the *Ellis, Refugio, Lange,* and *Palmillas* designs (Suhm and Jelks, 1962), a variety of scrapers, some gravers, Clear-Fork gouges, triangular knives, "key shaped drills," blades, manos, and ovally ground metates. Also recovered were heat-fractured cobbles which Hughes interpreted as boiling stones, some conch shell, and fragments of *Bison bison* bone. Most of the lithic material was of local origin, but from diverse locations, indicating a resident population that was mobile within its own area.

Hughes assigned a date of 2000 B.C.-A.D. 1000 to the Archaic manifestation represented in the Little Sunday site. A radiocarbon date from the Archaic unit at Blackwater Draw was 4950 + 150 (3000 B.C.) (Kelley, 1964), indicating that the High Plains Archaic may have been a long-lived phenomenon. Wedel (1961) cites the dearth of Archaic material and the lack of absolute dates on Archaic material older than circa 2500 B.C. as evidence of an altithermal depopulation between 4500 B.C., around the lower limit of the Plano culture, and 2500 B.C. From this, Wedel sees drought or aridity as the terminating factor for the Paleo-Indian stage and the instigator of the Archaic lifeway. He supports this contention by pointing to the diverse nature of faunal remains in the Signal Butte site in Nebraska (Strong, 1935) and describing it as the refuse of a people drawing harder on a diminished resource base. To some extent, Wedel may be correct. Comparing the faunas represented in the Llano, Folsom, Plano, and Archaic cultures, a trend favoring animals able to survive in a less moist environment can be discerned. But the Archaic on the Plains *is* poorly investigated, as Hughes indicated, and further inquiry may reveal that the "altithermal" meant only an economic change for already established peoples rather than a wholesale extinction of peoples or abandonment of the area.

THE FORMATIVE STAGE

As it is generally given, the Formative stage is characterized by the combination of agriculture and ceramics (Willey and Phillips, 1958). Ford (1969) points out, however, that the concept of a formative culture or stage tends to be bound less by a universal cultural evolvement than by the needs of local chronology. Two reasons were given for this view. First, ceramic history showed Ford that coastal hunting and gathering peoples developed or obtained ceramic technologies before their horticultural brethren. Second, peoples in Mesoamerica who appeared to be well on their way to the first food-producing economies in the New World were aceramic until the practice of agriculture was firmly a part of the subsistence strategem. The concept of a Formative stage does help, however, because the Paleo-Indian and Archaic stages in almost all parts of the New World represented a long period of stable adaption. On the Plains, it is true that shifts occurred in animals being exploited, hunting methods, and tool design. Yet the basic style of life remained. What replaces this Archaic lifeway is a period of innovation and transition displaying a new weapons technology, a new storage or container industry that exposed peoples to plastic arts, and an expanded concept of food resources with the ability to instigate and control plant growth. When compared to the Archaic life style, the Formative appears as a heady time.

Plains Woodland

In 1962 Jack T. Hughes published a report on the excavation of a ceramic-bearing site in the Lake Creek drainage in Hutchinson County, Texas. The materials recovered from a discretely sealed geologic stratum included sherds of a poor quality, limestone-tempered, fabric-impressed pottery, and of a hard, compact, feldspar-tempered grey-brown plainware. The former sherds were quite thick, and their curvature indicated a large vessel with a pointed base. A single rim sherd showed a gradually contracting neck area with a thinned and "slightly everted" lip. This technology and design is very characteristic of ceramics on the eastern plains that occur in "Plains Woodland sites" which represent the immigration of Mississippi Valley peoples or the diffusion of their culture onto the tall-grass prairies. The identification was clinched by the lithic remains. Projectile points were predominantly corner-notched varieties, a few tending to be larger than is normally considered feasible for arrow hafting. Like the ceramics, these projectile points are quite similar to those found in Plains Woodland sites in Nebraska and Kansas.

The brownware, on the other hand, appears to have come from the Jornado branch Mogollon of the Middle Pecos River valley. Age assignments based on dendrochronological studies indicate that this particular brownware was in vogue from A.D. 900 to A.D. 1300, thus providing a date range for the Lake Creek site in general. Radiocarbon dates, however, taken from other Jornada brownware sites consistently place them earlier than A.D. 900 (Jack Hughes, personal communication).

Plains Woodland occupations in Kansas, Nebraska, Iowa, and South Dakota have afforded radiocarbon dates ranging from 1872 B.C. to A.D. 828 but clustering in the area of 122 B.C. to A.D. 828 (Wedel, 1961). There is a welter of separate foci: Stearns Creek, Loseke Creek, Valley, Keith. All feature the poor quality, bullet-shaped pottery and corner-notched points. Settlement patterns seem to have been low density, small residential groupings. Both the Stearns Creek and Loseke Creek foci have produced domesticated plant remains (Wedel, 1959).

In his incomparable synthesis of Plains archaeology, *Prehistoric Man on the Great Plains,* Wedel indicates the presence of early, eastern-style sites on the High Plains. Two observations were offered about them: they have been relatively uninvestigated, and they probably represent some seasonal use by people living farther east. The materials from Lake Creek do not entirely fit this interpretation. The lithic artifacts are entirely of local materials. A seasonal use presumably would show local material use also, but some trace of "home" materials should also be present. From the descriptions given by Hughes, the authors tend to agree that Lake Creek represents a people more or less ensconced in the Canadain River valley.

The similarities in dating between the Plains Woodland of the eastern Plains and the Lake Creek site are provocative, but the data available from the Woodland occupation in the Canadian River valley are too sparse to permit definitive conclusions or hypotheses.

Panhandle Aspect (Plains Villager)

Investigation into the Panhandle Aspect began early, spurred by stone masonry ruins that held promises of relationship to the cultures of the Southwest. A. F. Bandelier, along with other early students of southwestern culture, is said to have reported on the ruins in the Canadian River valley (Holden, 1929). In 1917 a field assistant of Warren V. Moorehead surveyed approximately thirty "ruins." Two years later, a survey performed by C. B. Franklin recorded seventy sites. In 1920 Moorehead conducted his own survey and reported many of the sites that have found their way into print: Wolf Creek, Cottonwood Creek, Tar Box Creek, Antelope Creek, Dixon Creek, and Landergin Ranch (which the authors suspect means Landergin Mesa). How much overlap or duplication occurred in the course of these surveys could not be determined easily. Excavations commenced in the valley with a site along Wolf Creek (Eyerly, 1907), followed by sites on Tar Box Creek (Holden, 1929), Antelope Creek (Holden, 1930), Saddleback Mesa (BTK ruins) (Holden, 1933), and Coetas Creek (Studer, 1934). During the depression years, numerous sites were excavated by the W.P.A. (Duffield, 1970), and lately salvage excavations were conducted in the Sanford Reservoir (Duffield, 1964). The title Panhandle Aspect was applied by A. D.

Krieger (1946) to all sites in the Canadian River valley that displayed what has been termed by many as "typical Plains culture." Within the broad definition, Krieger identified an "Antelope Creek Focus" primarily on an architectural basis: walls built with two rows of edge-set stone slabs filled with rubble enclosing contiguous square or rectangular rooms. Somewhat later, V. Watson (1950) submitted the "Optima Focus" for inclusion in the Panhandle Aspect. The Optima Focus purported to define the Oklahoma incidence of the Panhandle Aspect and was also dependent of architecture: noncontiguous square structures with walls constructed of a single set of stone walls constructed of a single set of stone slabs cemented with adobe. A careful reading of the literature and discussions with workers familiar with Canadian River valley archaeology, however, show the Antelope Creek and Optima Foci to be artificial and useless.

Panhandle Aspect Architecture

A scheme or ordered strategy of house construction in the Panhandle Aspect appears beyond the powers of discernment as yet. Holden's excavations along Antelope Creek (A-C ruin) (1930) revealed the "classic" construction method described by Krieger, along with two other methods: adobe with a rock core and horizontally laid slabs cemented with adobe. Most of the rooms at Holden's site were rectangular and had interior post molds. A small number, however, were oval in outline. The Saddleback Mesa site (Holden, 1933) possessed walls of edge-set slab, horizontally laid slabs, or a combination of the two. House shapes were squared, rectangular, oval, circular, crescentic, L-shaped, or simply irregular in a substantial contiguous-roomed structure. Finally, Studer's (1934) excavations along Coetas Creek revealed a contiguous, square-roomed structure built of horizontally laid slabs, surrounded by noncontinguous, circulr structures with edge-set slab construction. Clearly, Krieger's identification of a Focus based on architecture involved a misunderstanding of the archaeology, of an improper use of McKern's (1939) taxonomic system.

If the reader is now quite confused about Panhandle Aspect architecture, a small addition of relatively recent data should serve as the denouement. Three sites were excavated in the floodpool of Sanford Reservoir in Hutchinson County by L. F. Duffield (1964). Each had noncontiguous houses. The Conner site was composed of oval and circular houses with walls of edge-set stone slabs. At the Medford Ranch site, the houses were square or rectangular and had horizontally laid stone walls. Finally, the Spring Canyon site had rectangular and small oval houses built by setting stone slabs on edge for the interior surface and horizontally for the exterior surface! If that is not enough variety, the Medford Ranch houses had central post molds while the other two sites did not.

The architectural remains of the Panhandle Aspect, then, defy the abilities of the archaeologist. At present, no worker knowledgeable in the field has been able to adequately explain the observed variation. There may be some chronological, functional, or spatial significance to the disparate construction techniques, but it may well take a more acute analysis than has been generally performed if the significance is to be discovered.

Panhandle Aspect Ceramics

The potters of the Panhandle Aspect held very closely to one particular design that has been titled *Borger Cordmarked* (Suhm, Krieger, and Jelks, 1954). Vessels are in a jar form with globular to slightly elongated bodies and rims, set at an angle with the body curvature, tending to be slightly constricting, out-turned, or simply vertical. Size and proportionality are quite variable, as is the thickness of the vessel walls.

Vessel outer surfaces are covered by cordmarks that usually are made in a parallel fashion without overlap, but gridlike decoration occurs fairly often. These cord impressions vary in terms of impression depth and cord size. Interior surfaces are generally smoothed.

The paste of *Borger Cordmarked* vessels is black, brown, grey, olive, orange, or tan in color. Tempering materials are usually sand, crushed quartz, and mica, often occurring together as a complex. Bone tempering is said to occur in the eastern Panhandle (Suhm and Jelks, 1962), but this pottery may not be of the Panhandle Aspect.

Ceramics from the Anasazi peoples in New Mexico often are found in Panhandle Aspect sites. Their number is not statistically large in comparison with the *Borger Cordmarked,* but their dates, associated through dendrochronology, are important indicators of the age of the Panhandle Aspect. A list of Puebloan ceramics recovered from Panhandle Aspect sites was compiled by Martha Crabb (1967): Chupadero Black-on-White, A.D. 1200-1600; Agua Fria Glaze-on-Red, A.D. 1325-1425; Cienguilla Glaze-on-Yellow, A.D. 1375-1450; Galisteo Black-on-White, A.D. 1300-1325; Heshotauthla Polychrome, A.D. 1275-1375; Kuaua Glaze-Polychrome, ca. A.D. 1450; Kowina Black-on-White, A.D. 1200-1400; Largo Glaze-on-Yellow, ca. A.D. 1425; Rowe Red-on-White, ca. A.D. 1350; Santa Fe Black-on-White, A.D. 1225-1350; Wiyo Black-on-White, A.D. 1300-1400.

Panhandle Aspect Lithics

The stone tool designs in the Panhandle Aspect are as unvarying as the ceramic tradition. Projectile points are small, thin, and triangular with or without notches in the sides and base. In Texas, many refer to the notched forms as *Harrell* points and the unnotched specimens as *Fresno* points. Workers in Oklahoma have further divided the form into *Harrell* points with side and basal notches and *Washita* with side notches only or when a millimetric shift in the placement of side notches on the basally notched forms occur (Bell, 1958). Unfortunately for all workers thus engaged, no kind of complementary distribution for the sixteen possible combinations of notchings has yet been discovered. The technology is rather widespread on the Plains in conjunction with ceramic-producing peoples, and it occurs as far east as Cahokia (Baerreis, 1954). The authors will use only the *Harrell* and *Fresno* names, and then only as descriptive terms.

The other lithic tools frequently found in Panhandle Aspect sites are diamond- and oval-shaped knives, T-shaped drills, unifacial side and snubnose scrapers, utilized flakes, oblong manos, longitudinally ground metates, and stone elbow pipes. As a whole, the assemblage is not much different than what is found elsewhere on the Plains in Formative times.

Panhandle Aspect Bone and Shell

Implements of bone are usually hoes and squash knives made from bison scapulae, tips of bison tibia for digging sticks, hide-working tools, awls, and needles. Duffield (1970) noted that bone-tip digging sticks seem to be more popular in the Panhandle Aspect than bison scapula hoes, marking a distinction between the horticultural people of the central plains and those of the Canadian River valley.

Mussel is often found in Panhandle Aspect sites in the form of whole valves, fragments, pendants, and beads. Occasionally, small nicks are found unevenly spaced along the edges of whole valves, or the edges show a smoothed polish. Will and Hyde (1917) noted the Pawnees often used shell to cut corn kernels from the cob. By analogy, this may have been the use of the shell in the Canadian River valley, probably after the mussel had been consumed.

Agriculture

The remains of several domesticated plants have been recovered from Panhandle Aspect sites. Duffield (1964) recovered the charred kernels of a popcorn or small flint variety of maize which he called "South Plains-Pima-Papago-Basketmaker." Pumpkin, bean, and squash seeds were found by Green in the area (1967). That agricultural activities had a substantial place in the lifeway of the Panhandle Aspect peoples is seen in the relative abundance of scapular hoes and bone-tipped digging sticks.

Social Organization

Krieger (1946) argued that the combination of stone masonry, a seemingly southwestern idea, and plainslike lithics, pottery, bone, and shell material represented a patrilineal/patrilocal social organization. The reasoning behind his thesis was that Panhandle Aspect men acquired some of their wives from the Pueblos of New Mexico. Housebuilding there was a woman's task, and the women carried their skill and possibly the prerogative of housebuilding with them. Since potterymaking is also a woman's task, Krieger's argument would seem to be weakened, but he anticipated that question, stating that the ceramic tradition of the Panhandle Aspect would be passed by the female members of the man's family to the new wife. The social pressures of this female group could have been such, according to Krieger, that a rigid confirmity was maintained.

An alternative reconstruction is argued by Duffield (1970), who sees the Panhandle Aspect as matrilineal because of the homogeneous ceramic tradition. Furthermore, the diversity of house construction would be the result of matrilocality, assuming housebuilding to be a male task, since the continual flow of new males into the local family group would be constantly introducing outside ideas.

In each of these, the authors see the seeds of philosophical disaster. If—as Krieger says—housebuilding were a female activity, why would not the husband's female relatives force standards of construction on the newcomers in the same way they presumably ensured the traditionality of their ceramics? And why would the ceramic tradition be so stringently enforced? The presence of southwestern trade wares in Panhandle Aspect sites indicates that colorful, highly decorated ceramics were valued.

Duffield's hypothesis is similarly untenable. The bonding effect of a matrilineage operates only within the lineage. What holds the ceramic tradition in such a tight grasp on an extra-lineage basis? Why do not such strictures operate for construction practices? Ostensibly, the male products of a matrilineage are imbued with some sense of lineal conformity as well as the females. For the present, the authors do not feel that either of the reconstructions of kinship is satisfactory.

Dating

The dating of the Panhandle Aspect has generally relied on the presence of Puebloan "trade" ceramics. The Panhandle Aspect was believed originally to be an early manifestation of the southwestern cultures of New Mexico and Arizona. This belief was based on construction similarities with some early Puebloan dwellings. Holden's excavations on Saddleback Mesa, however, produced ceramics from New Mexico which were reliably dated around A.D. 1400. In reading Holden's writing about the discovery (1933), one cannot help but detect a thin air of disappointment. Other excavations recovered enough Puebloan ceramics to place the lifespan of the Panhandle Aspect to A.D. 1300-A.D. 1450. Subsequent dating efforts, using radiocarbon (Baerreis and Bryson, 1966), revised the range to A.D. 1250-A.D. 1450, but within their dates were three which were earlier (A.D. 1080 from Palisades Shelter, A.D. 1180 from the Alibates run, A.D. 1150 from the Coetas Creek Ruin). Added to a radiocarbon date from the Currie Ruin (A.D. 1120), there seems to be evidence for the assignment of an A.D. 1100-A.D. 1450 date range.

Culture History

Several hypotheses have been offered to explain the origin of the Panhandle Aspect as well as the causes of its termination. Baerreis and Bryson (1966), using a long series of radiocarbon dates, managed to link the time sequences for the Upper Republican cultures and the Panhandle Aspect. Using Wedel's (1941) proof of drying conditions on the Central Plains and their own postulation for the southern Plains (1965), the argument was developed that Upper Republican peoples around A.D. 1200-A.D. 1250, fleeing debilitating drought conditions in Nebraska and Kansas, penetrated the Canadian River area where conditions were considerably more moist than today. There, using stone for their lodges instead of timber, they flourished until A.D. 1450 when a slow drying trend finally forced them away again. This hypothesis is supported by Duffield (1970), who argues on faunal evidence that the era A.D. 1250-A.D. 1300 was relatively wet, while A.D. 1300-A.D. 1450 saw a progressive drying trend that turned into prolonged drought around A.D. 1450. Tree-ring analysis from the north central Plains shows that the late fifteenth century was a time of extreme dryness (Weakly, 1954; Will, 1946), and the deposition of eolian soil upon many Panhandle Aspect sites tends to confirm it.

There are problems, however, with Baerreis and Bryson's hypothesis. The authors find their conclusions concerning the termination of the Panhandle Aspect tenable, but the proposed origins ignore too much evidence. If the Upper Republican peoples had fled the central Plains in a fairly precipitous fashion (as Baerreis and Bryson suggest in answer to the criticism that there are no intermediate sites between the areas), the ceramic traditions of each area should "match up" somewhere. Unfortunately, they do not. Furthermore, there are plausible antecedents for the Panhandle Aspect ceramic tradition in the still little-investigated Woodland occupation represented by the Lake Creek site.

A hypothesis that seems more credible to the authors is that the Canadian River valley may have been receiving new ideas, either from the contact of Woodland and Puebloan peoples with a resident Archaic population, or in the form of some small-scale Woodland immigration at an age much earlier than the terminus of the Upper Republican culture. The date range represented by the Lake Creek site indicates possible non-Archaic population earlier than A.D. 900. The ceramics of this population were allied to eastern traditions, but the presence of Puebloan ceramics proves some kind of social intercourse with the cultures of the Southwest. In this intersection of influence, the Panhandle Aspect may have seen its genesis. The variation of architectural design throughout the life of the Aspect can then be ascribed to continuing contact with eastern Plains and southwestern peoples. The authors offer no more proof aside from these observations but do believe they form a set of pregnant queries to be tested.

THE LATE PREHISTORIC/HISTORIC AGE

Little is found in the archaeological record to suggest what kind of human habitation, if any, followed the disappearance of the Panhandle Aspect. The first European incursion of the Texas Panhandle occurred in A.D. 1541, leaving just ninety years between the demise of the Panhandle Aspect and the beginning of written history. If the extensions of Will's (1946) and Weakly's (1943) data to the southern Plains (Krieger, 1946) are valid, the drought that ended the Panhandle Aspect may have persisted as late as A.D. 1518. Such an extension is disputed (Baerris and Bryson, 1965) with good reason. Yet, a drought did occur, the Panhandle Aspect did cease as a recognizeable culture unit, and the void was filled by a people whose lifestyle was less sedentary. Possibly these peoples forced out the older population during a period of hard times when the old population was economically less competitive, perhaps the new assimilated the old, or the latecomers may have simply inherited the area by a superior adaptation to the climatic events.

In 1541 Juan Vasquez de Coronado, after giving the Indians of the settled Pueblos a good dose of Spanish military and ecclesiastical culture, set out from the Rio Grande valley in New Mexico. He and his group of pious freebooters were bound for a fabled city called "Quivira" that they had been assured by their tiring Pueblo hosts lay somewhere to the northeast in the swallowing vastness of the Plains. Juan Vasquez journeyed all that summer, crossing the Texas Panhandle (there is some reason to believe that his Indian quides helped him recross and recross) until early fall found him in southern Kansas, and the advent of winter forced a flight back to the settlements of New Mexico.

During the travels in the Panhandle of Texas, the expedition met two groups of Indians: "Querechos" and "Teyas."

> [these] people follow the cows, hunting them and tanning the skins...
>
> They have better figures, are better warriors, and are more feared [than the Pueblo dwellers]. They travel like the Arabs, with their tents and troops of dogs. . . . These people eat raw flesh and drink blood. They do not eat human flesh. They are a kind people and not cruel. They are faithful friends. They are able to make themselves very well understood by means of signs.
>
> [The Teyas] are very intelligent; the women are well made and modest. They cover their whole body. [The men] wear shoes and buskins made of tanned skin. The women wear cloaks over their small under-petticoats, with sleeves gathered up at the shoulders, all of skin, and some wear something like little sanbennitos [a poncho-like affair] with a fringe, which reached half-way down the thigh over the petticoat.
>
> [We] found an Indian girl here [amongst the Teyas] who was as white as a Castilian lady, except she had her chin painted like of Moorish woman. In general they all painted themselves in this way here, and they decorated their eyes. –Casteñeda, chronicler of Coronado, 1541 (Winship, 1904).

The Querechos were encountered on the High Plains somewhere near the Texas-New Mexico boundary, probably east of Tucumcari, accepting Bolton's (1949) reconstructed itinerary. The Spaniards met the Teyas in the canyon areas along the eastern periphery of the High Plains. Differences between the two groups seemed to be minimal, with the exception that the Teyas either painted or tatooed themselves in some distinctive fashion. There was also the assertion that they were "enemies of each other" (Casteñeda, in Winship, 1904). Jaramillo (one of Coronado's officers) reported that the name "Querecho" was supplied by Pueblo informants. The origin of "Teyas" was probably similar, and use of two different names indicates that the Pueblo peoples saw a distinction. Exactly what that distinction was remains a mystery: both groups were engaged in identical economic pursuits when encountered by the Spanish, and both spoke with the Spaniards and their Indian guides using sign language. While most investigators feel that at least one of them was Athapascan, specific identification with later groups has been only speculative. Both groups were inhabiting areas that were known to be controlled later by Athapascans. Accordingly, two possibilities are offered. First, the Querechos were Athapascan by virtue of their location, and the Teyas were Jumanos (Bolton, 1949), or Wichita, or even Caddos. When Coronado's group met the Teyas, they discovered an elderly Indian who could recall meeting Cabeza de Vaca some years earlier, a recollection that indicated a rather southerly range into south, central, or east Texas. The second possibility is that both groups were Athapascan: Querechos belonging to what was later known as Jicarilla Apaches and the Teyas to Faraones Apaches. Hostility between Jicarilla and Faraones Apaches was well documented in the late seventeenth century (Thomas, 1935), and each occupied approximately the same areas where Coronado reported meeting Querechos and Teyas.

Both the later Jicarillas and the Faraones practiced some horticulture on a marginal scale, but their true economic advantage lay in the prodigious quantities of bison found on the plains. Both groups carried on a lively trade in meat, tallow, and hides with the Pueblos. The failure of the Coronado records to mention any agricultural activity in connection with the Querechos and Teyas may be due to the timing of the expedition. The historic Jicarillas used the late spring and summer for bison hunting on the Plains east of their settled areas.

Juan Vasquez's failure to find treasure for the taking dampened the enthusiasm of the Spanish "culture bearers" for further explorations in New Mexico and Texas. Once a reasonable time had passed and memories grew short, a host of Spanish "gentlemen" again rose to the task. The next attempt of consequence was made by Don Juan de Oñate, son of a moderately wealthy Zacatecas family. In 1599, after commandeering a suitable Pueblo for his operations base in New Mexico, Oñate dispatched his *Sargento Mayor,* Vincente de Zaldivar, to the Plains east of the New Mexico Sierras for the purpose of announcing the majesty of the Spanish king and his divinity, and to catch some buffalo for domestication experiments. On this occasion the Spaniards described the Indians they met as being both Querechos and Vaqueros (since they depended so heavily on the bison for sustenance). But later, in 1601, when Oñate himself led an attempt to find fabled Quivira, all of the Indians from the Sangre de Cristos Mountains to central Oklahoma were referred to as "Apaches." And when the Spaniards encountered other Indian groups in central Oklahoma, who were similarly nomadic, the name "Apache" was not applied, and the testimony of Baltasar Martinez before the Val Verde inquiry indicates that the distinction was linguistic (Hammond and Rey, 1954:841). Evidently, the Spanish had become aware enough of Indian languages that they were able to distinguish cultural units on that basis. The evidence for the Athapascan occupation of the Canadian River valley by 1601 is, then, fairly reliable.

There are a few more pertinent facts about the early footbound Apache lifeway. Baltasar Martinez testified that the largest Apache group numbered about one hundred persons, and that was unusually large (Hammond and Rey, 1953:839). Martinez and Oñate both reported the custom of greeting a stranger with a palm of the hand open towards the sun which was then turned to face the newcomer. A latecoming man of cloth, Alonso de Benevides (1630), recorded the customs of cutting off an adulterous woman's nose and ears and corporal punishment of children. And the bison-roping Vincente de Zaldivar explained that the Apaches often traveled to the Picuries and Taos Pueblos where they "... sold meat, skins, fat, tallow, and salt in exchange for cotton blankets, pottery, maize, and some green turquoise." (Hammond and Rey, 1953:400)

The failure of Oñate's search for easy wealth marked the end of large-scale Spanish efforts on the Plains until the late seventeenth century. Prior to the Pueblo revolts in 1680, the Spanish authorities in New Mexico were primarily concerned with consolidating their colonial, and personal, hold on the Rio Grande valley and its inhabitants. The revolt interrupted these efforts and involved Spaniards again with the Indians of the Plains.

Upon breaking the back of the Pueblo revolt in 1680, the Spanish authorities learned that many groups of the offending Puebloans had fled onto the Plains to the northeast and east, seeking shelter from Spanish retribution amongst the Apaches. Lamentably, many of these Puebloans were enslaved by the Apaches. The Spaniards desired the return of these people for three compelling reasons: their church could not abide *formal* slavery, to die apostate was the worst fate of a human, and the Spanish landowners desperately needed the free labor.

In accomplishing their task of returning runaways, the Spanish discovered the inroads being made on the eastern Plains by the French. Various Apache groups complained that eastern Plains tribes, possessing French guns, were conducting raids far onto the High Plains. In 1695, French-aided Indians attacked and destroyed a large Jicarilla settlement in northeast New Mexico. More French-Indian raids against the Apaches occurred in 1706, 1714, and 1719. To complicate matters, Spanish records reveal that on a number of occasions the Jicarillas in New Mexico requested Spanish protection from the Canadian River Faraones (Thomas, 1935). In an attempt to meet the French problem, the Spaniards embarked on a paternalistic Indian policy designed to keep the Apaches at peace with each other, while presenting a unified front to the French and their Indian allies.

The buffer zone of Apache Indians collapsed completely, however, with the appearance of the Comanche. In 1705, a Captain Serna reported the first instance of Comanche predation. By 1719, Spanish authorities were driving hard to prevent the complete retreat of their Apache allies from the Plains, but in 1724 there was a disastrous attack on "La Jicarilla" which resulted in its total abandonment by the survivors. The Spanish sought to stem the Comanche and French tide through aggressive military action, and this intercession probably prevented a complete sweep of the Plains early in the eighteenth century. It is clear, however, that by the mid-1700s, the Plains Apache lifeway was completely altered. Many were killed in the wars or incorporated into the Comanche structure (mostly women and children). Spanish records imply that the attrition suffered by the Apaches was staggering. What remained of the Faraones of the Canadian River valley either moved southward off of the Plains to become what was later known as the Lipan Apache, or they sought a new association with the Kiowa as the historic Kiowa Apache. There is no record of their retreating into New Mexico.

There are many reasons for the Comanche success. The French apparently kept them well supplied with firearms while Spanish policy steadfastly refused to provide guns to the Apache. But that was not the sole reason: Comanches also carried out successful raids on eastern Plains Indians, the Spanish, and occasionally the French, all of whom possessed guns. Perhaps a more important contribution to the Comanche success was their own organization, tactics, and philosophy of war. Most reports of Comanche war parties describe rather large, well disciplined groups, in contrast to the small, individualist bands of the Apache. In addition, the Comanches had become accomplished horsemen at an early date, allowing them to reserve the time and method of contact for themselves by traveling great distances to surprise their enemies on the enemies' home range. Finally, the Apache viewed war as a method of acquiring material goods. How many people they killed was often immaterial. By contrast, the early Comanche efforts appear to have been oriented toward the acquisition of victory itself, and a victorious engagement was usually pursued until the enemy was substantially destroyed, with the exception of women and children who were viewed as booty. The Spanish saw chilling evidence of this warfare style in 1776 during their pursuit of a band of marauding Sierra Blanca Apaches. After following the Apaches from central New Mexico to the High Plains, the Spanish caught up with their quarry near the Canadian River valley in the Texas Panhandle. Unfortunately, the Apaches had only moments before come in contact with a Comanche war party. The scene is vividly etched in the Spaniards' report of blood-spattered tents and still warm, some quivering, bodies of 300 Apaches (Thomas, 1932). No one was left alive.

The Comanches were the last aboriginal occupants of the Canadian River valley. Betraying their Great Basin Shoshonean origin, the Comanche never attained the social integration or cosmological richness of the other Plains tribes, preferring rather to live in autonomous bands ranging in size from single families to several hundred souls. Band composition was extremely fluid, and there is no record of tribal aggregation prior to 1874 when white pressure forced them into messianic worship. The Comanches had no marriage regulations other than a close blood relative restriction, no clans, no police, no residence rules, and precious few pan-tribal societies (perhaps some medicine societies, nother more) (Wallace and Hoebel, 1952).

The Comanche groups managed to keep up a near perpetual state of war with Spanish, Mexican, Texas, and American settlers surrounding the High Plains. In 1875, however, they were finally removed by military force from their historic homeland and placed under military supervision in Oklahoma. The last Comanche group to go, the Antelopes or *Quahadis,* was considered the fiercest, and their home range was the Canadian River valley.

Before the removal of the Comanche, there were other cultural influences felt in the area. Kiowas and Kiowa-Apaches occasionally visited as did Mexican traders (the Comancheros), some of whom were ruthless, others merely pathetic (Abert, 1941). After the Civil War, the Canadian River valley received an influx of Mexican sheep ranchers (Pastores), attracted by the abundant grass in the area. The Mexicans established a number of "Plazas" or stone-masonry complexes that served as a dwelling of a family and as trading locations for the visits of traders who bought the rancher's product. The "Plazas" also were the social centers of their areas. How the Mexicans survived in the Comanche home range is not well understood, but to some extent there must have been an element of "live and let live." The Mexicans apparently left the Indians and their bison alone, and the Indians reciprocated. It is also possible that the Indians found the closely located trading locations, where, in all probability, no "class" of goods was refused a capable buyer, to be distinctly advantageous.

In 1875, the year of the final Comanche removal, the large Anglo-American cattle ranches began forming. Their history continues to the present, although the larger ranches have since been fragmented into smaller units.

FIELD RESEARCH

The authors were limited by their budget to ten days of actual field work, part of which was spent in consultation with professional archaeologists who were familiar with the archaeology of the Texas Panhandle. Consequently, an intensive survey of the entire Alamosa Creek was impossible. The authors, then, decided to examine only three portions of the Alamosa drainage: the mouth area along the Canadian River, mid-valley along Ranch Creek, Middle Alamosa Creek, West Alamosa Creek, and a portion of the caprock escarpment near the head of Middle Alamosa Creek. The selection of these areas was, to some extent, highly arbitrary and not related to any scheme of probability statistics. Such research designs demand a familiarity with the ecological factors operating in the valley that was impossible to gain in a mere ten days. The authors feel, however, that the sample obtained is a reasonably good one.

Some of the sites described in this report are outside the self-imposed limits. These are sites that were shown to the authors by helpful residents or sites that had been recorded previously by the Panhandle-Plains Historical Museum and West Texas State University.

THE SITES

Forty-nine archaeological sites and 3 bone localities were examined during this reconnaissance. Of these none were of the Paleo-Indian period although the fossil bone localities may prove after some further erosion to be sites of such antiquarian human activities. Only a single Archaic-age site was found and no sites were observed which could be attributed to the Formative Plains Woodland peoples. The Late Prehistoric/Historic age was represented in two sites, one Indian and one Mexican-American in origin. The bulk of the identifiable sites, 15 in number, belong to the Formative Panhandle Aspect. Sadly, the sites for which no cultural identification could be made on the basis of a surface examination far outnumber (31) all others.

These sites represent social and chronological units as well as a distinct segment of their biophysical system. The differentiation of botanical zones provided by Duffield (1970) is descriptively useful, yet too abstract and generalized to be of much use in explaining the locations and patterns of particular archaeological sites within the valley. For our purposes a more complex and definitive division of the valley is needed, one less applicable to the Canadian River valley as a whole and more tailored to the peculiarities of the study area itself.

The Alamosa Creek drainage can be divided on a topographic and biological basis into 8 areas:

1. **The Caprock Edge**—This is the portion of the Plains upland surface which is immediately adjacent to the eroded river valley. The exposed Ogallala formation juts out above steep slopes, forming a level, graveled ledge from which one can view a large part of the valley below. A ribbon of juniper trees outlines the precipice and sets it apart from the flat sea of grass behind.

2. **The Caprock Slopes**—In most places the slopes are quite sharp, but often there are long ridges standing out which stretch down into the valley bottoms with a much gentler gradiant sometimes marked by localized level ground along their crest. Most of the caprock slopes are covered with sparse grasses, junipers, and xerophytes such as yucca and cactus. Formerly, these slopes may have had small areas of wetness where water-bearing rock was exposed, and around these locations a more salubrious collection of plants may have flourished.

3. **Tributary Headwater Valleys**—Below the caprock escarpment the major tributaries to the Canadian begin. Their valleys are narrow comparatively but possess ample amounts of habitable ground in bottoms of rolling hillocks of resistent stone and seperated by alluvial/colluvial terrace deposits which slope easily downward towards the deep, earthen-walled stream channels of dry gravel. The principal vegetation in these areas today consists of grasses, juniper, cottonwood, and mesquite; in the past, prior to the extensive ground water removal, the channels probably were wetter and more heavily vegetated with tall grasses and deciduous trees. Also, there may not have been as much down-cutting of the channels themselves since the ground cover on the slopes upstream was probably thicker than today.

4. **The Intermediate Area**—The canyonlike headwater valleys open downstream onto an area of relative levelness which in some places resembles a softly rolling prairie. Like the plains above, these surfaces are the result of a broad supporting stratum of rock underlying a cover of bedded muds and eolian earth. Unlike the plains, the support is not uniform everywhere, nor is it quite as impervious to erosion. In many places where the support has been breached, or simply is not present, the ground has been dissected into a jumble of low, sharp hills, as in the cedar breaks, or into convoluted knife ridges and incised canyons of a badlands. The flatter places are grasslands dotted with clumps of mesquite and cholla cactus; previously there were probably just grasses growing there. The hills of the cedar breaks are, and probably were, the home of dense growths of not cedars but junipers, which are confused for cedars everywhere they occur in Texas. Cottonwoods stand along the stream channels and at old spring locations.

5. **Lower Tributary Highlands**—About 1067 meters above sea level the intermediate "prairies" break off into broad, deep canyons whose bottoms are little more than 100 meters higher than the Canadian River bottoms still many kilometers away. The bordering highlands of these canyons, however, are the preserved remnants of the intermediate area which may extend as long, flat-topped ridges nearly to the Canadian itself. The tops of these ridges are vegetated much the same as the intermediate areas.

6. **Lower Tributary Valleys**—The bottoms of these valleys are either gently rolling to flat, grassy, alluvial surfaces or heavily dissected badlands practically devoid of vegetation. The growth of mesquite is considerable in these valleys, punctuated by occasional large cottonwoods near the edges of the channels. Formerly, there was almost certainly less mesquite and more phreatophytes.

7. **The Canadian River Highlands**—High above the floodplain of the Canadian are remnants of higher geologic strata standing as large mesas or as the tip ends of the lower tributary valley highlands. Their tops are mostly grasslands, and on some of the large mesas, which are difficult for cattle to climb, a nearly pristine grassland with few mesquites and with luxuriant grasses may be preserved.

8. **The Canadian River Floodplain**—This is, of course the flat, flood-scoured bottom of the Canadian River valley. The river is remarkably shallow today—that is when there is water in it—and it is a mature watercourse meandering sinously through its valley. The inside of each curve in the river is a low terrace formed by point-bar deposition supporting heavier growths of grass and cottonwoods than elsewhere, but also more given over to salt grasses and dense thickets of tamarisk (salt cedar). In times past there was probably a greater variety of deciduous plants than is present today.

Using the division given above, we may proceed to describe the sites in terms of there occurrence in these areas. The reader, however, should not confuse the number of sites reported here for each area for a statement of the relative densities of archaeological resources in different parts of the creek drainage, or sites reported here may be a reflection of the time allotted to fieldwork in various portions of the valley (ten days for over 400 square kilometers) as well as the authors' relative inexperience in this part of Texas.

Sites on the Caprock Edge

41 OL 25

Location: On the top of a long caprock prominence east of and overlooking the headwater valley of the Middle Alamosa Creek.

Description: A single definite circular structure of edge-set slabs and several possible square structures. The circular structure is two to three meters in diameter. Other cultural material is exposed only in areas of animal activity. Total site area is an oval estimated at 50 by 100 meters.

Material Collected: *Harrell* (1) and *Fresno* (2) projectile points (Tecovas), utilized and nonutilized flakes (Alibates–1, Tecovas–1, Obsidian–4), a "pear"-shaped uniface (Tecovas), three sherds of angular quartz-tempered *Borger Cordmarked* pottery, nearly whole mussel shell (*Lampsilis anodontoldes*) with one end cut out crescentically, the other finely cut with six evenly spaced notches.

Cultural Affiliation: Panhandle Aspect

41 OL 37

Location: On top of a caprock escarpment projection facing a small side wash to Middle Alamosa Creek in its headwater area.

Description: A hearth area of burned calcareous stone built adjacent to the edge of the escarpment. A sparse scatter of lithic debitage is associated.

Material Collected: None

Cultural Affiliation: Unknown

41 OL 38

Location: On top of a caprock escarpment projection adjacent to 41 OL 37 to the northwest.

Description: Same as 41 OL 37.

Material Collected: None

Cultural Affiliation: Unknown

Sites on the Caprock Slopes

41 OL 26

Location: On a long, sloping ridge extending north and down from the caprock escarpment on the east side of Middle Alamosa Creek in its headwater area. A ranch trail cuts the site.

Description: Abundant cultural materials are exposed in the road cut and in small areas of edge erosion. The ridgetop is covered by a 30-centimeter layer of eolian soil. A small low mound on the east side of the road cut may conceal a structure, but no distinct evidence was observable. The total site area is an ill-defined ellipse measuring 50 by 100 meters.

Material Collected: Projectile points of *Harrell*–1, and *Fresno*–1 design (Alibates); a grey sherd of *Borger Cordmarked* with angular quartz temper.

Cultural Affiliation: Panhandle Aspect

41 OL 29

Location: Along the north edge of the gently sloping flatland .8 kilometer below a large free-standing mesa on the west side of Middle Alamosa Creek towards its headwater area.

Description: Massive flakes, large core-stones, and hammer-stone of quartzite resting on the surface of the flatland just next to its edge where it breaks off into a massively eroded bàdland. Many of the flakes were next to a core-stone of similar materials.

Material Collected: None

Cultural Affiliation: Unknown

41 OL 30

Location: In a saddle area between the caprock escarpment and a large, free-standing mesa on the west side of Middle Alamosa Creek near its headwater area.

Description: A 100-square-meter area of burned calcareous stone and sparse lithic debitage. The ground surface below is a calcareous gravel.

Material Collected: None

Cultural Affiliation: Unknown

41 OL 39

Location: On a relatively flat area on a long spur ridge extending gently eastward from the caprock edge to the valley floor in the headwater area of Middle Alamosa Creek. The site is approximately halfway between the caprock and valley floor in altitude and 50 meters eastward from the caprock escarpment. A ranch trail cuts the site.

Description: Lithic materials with some burned calcareous rock and ashy soil are exposed by the removal of an eolian soil cap. The site is an ellipsoidal area 10 meters wide and 50 meters long with the major axis coinciding with the direction of the ridge.

Material Collected: *Ellis* projectile point (Alibates), unidentifiable thinned biface fragment (Tecovas), and two uniface fragments (Tecovas).

Cultural Affiliation: Archaic Stage.

Sites in the Tributary Headwater Valleys

41 OL 27 (Panhandle-Plains Historical Museum No. A814)

Location: on a small hillock on long, gentle ridge west of Middle Alamosa Creek in its headwater area.

The site location is 18 meters above the stream channel and enclosed on three sides by a channel loop. A ranch trail cuts the site.

Description: Abundant lithic and ceramic materials cover the summit and slopes of the hillock. Where the road has cut into the slope, a lense of dark soil with charcoal is exposed.

Material Collected: A *Fresno* projectile point (white flint), a trapezoidal thinned biface fragment (Alibates), a possible fragment of an *Ellis* projectile point (brown, lucent flint), and eighteen sherds of *Borger Cordmarked* pottery with angular quartz temper.

Cultural Affiliation: Panhandle Aspect, with possibly an Archaic representation.

41 OL 28 (Panhandle-Plains Historical Museum No. A813)

Location: On a hilltop at the end of a low, gentle ridge extending north from the broad slopes below the caprock escarpment west of Middle Alamosa Creek. The hill is nearly surrounded by a meandering loop of the creek and is just above bone locality B.

Description: The hilltop is broad and flat with occasional shallow erosion channels scaring the surface and small erosion "steps" being cut into the edges. Lithic and ceramic materials are exposed in the erosion areas only. No evidence of structures was observed. Site area is estimated at 5000 square meters.

Material Collected: Projectil points of side notched *Harrell*–1 (black quartzite) and *Fresno*–2 (Alibates, red quartzite) design, a utilized flake (Tecovas), 20 sherds of *Borger Cordmarked* pottery with two sherds showing a quartz-mica temper and the others large angular quartz temper.

Cultural Affiliation: Panhandle Aspect

41 OL 33

Location: On the end slope of a low ridge west of Middle Alamosa Creek in its headwater area; the ridge slopes down from the caprock escarpment and is partially truncated by the stream channel.

Description: Burned calcareous stone, lithic, and ceramic material is eroding from a cover of eolian soil atop a blue mudstone. Where the ridge ends, there is a sandstone ledge above a 4.5-to-6-meter sheer drop into the stream channel. Cultural material previously eroded has become concentrated on this ledge in quantity.

Material Collected: Eight sherds of *Borger Cordmarked* pottery with angular quartz temper.

Cultural Affiliation: Panhandle Aspect

41 OL 34

Location: The site is in approximately the same position and circumstance as 41 OL 33 but is .6 kilometer upstream.

Description: The ridge end is a gentle slope terminating in a 30-centimeter cut bank. Sparse amounts of lithic debitage and burned calcareous stone are exposed in the bank and strewn down to the channel bank edge.

Material Collected: A *Fresno* projectile point (blue-purple banded flint).

Cultural Affiliation: The Fresno projectile point is indicative of no particular archaeological culture, save the Formative Stage and Late Prehistoric time in general.

41 OL 35

Location: The site is in approximately the same position and circumstance as 41 OL 33 and 41 OL 34 and is .9 kilometer upstream from 41 OL 33.

Description: The end slope of the ridge is gentle with small erosional areas scattered about its face. Sparse lithic materials and burned calcareous stone are eroding from a level about 26 centimeters below the surface of an eolian soil cover. The site is 100 meters from the stream channel.

Material Collected: A small *Fresno* projectile point (Alibates), a high-backed uniface (Tecovas), and a bladelike uniface (Tecovas).

Cultural Affiliation: Formative Stage in general.

41 OL 36

Location: On a small gravel hill in the west valley of Middle Alamosa Creek in the headwater area. Site is 160 meters upridge of 41 OL 35.

Description: Several eroding hearths composed of burned calcareous stone cover a 10 by 10 meter square area on the hilltop. The hearths are still relatively concentrated. Surrounding the hearths is a moderate scatter of lithic debitage.

Material Collected: A small, rounded triangular projectile point (purple flint), a utilized flake (Tecovas), a large-angle uniface fragment (grey quartzite), and a single sherd of plain brown pottery with an angular quartz and iron pyrite temper. The sherd has a portion of a drill hole on one of its edges.

Cultural Affiliation: The projectile point is similar to the *Fresno* design, but the triangular points common to the Panhandle Aspect generally possess sharper corners. Some of the Woodland projectile points (Hughes, 1961) are similar to the one found on this site, but such an assignment would be weak on the basis of this single equivocal specimen. The sherd probably is of a long-lived Puebloan pottery that could have occurred in either Woodland, Panhandle Aspect, or later times.

Sites in the Intermediate Area

41 OL 21

Location: On a hilltop in the juniper-covered badlands known as the "Cedar Brakes." A ranch trail cuts the crest of the hill.

Description: The hill summit is a one-meter-deep circular cap of eolian soil. Lithic, ceramic, and abundant bone materials are exposed at the soil cap edges and in the road cut. The hilltop commands a good view of the surrounding valley uplands and is approximately 100 meters west of a tributary channel flowing north into Middle Alamosa Creek.

Material Collected: Ten projectile points: side-notched *Harrell*–1 (Alibates), *Fresno*–6 (Alibates–4, quartzite–2), *Alba*–2 (Jasper, quartzite), and Aspen leaf-shaped–1 (Tecovas); a large thinned biface fragment (quartzite); a blade with a modified edge (brown quartzite); a sinuous edge biface (Alibates); and two sherds of *Borger Cordmarked* pottery with an angular quartz temper.

Cultural Affiliation: Panhandle Aspect

41 OL 31 (Panhandle-Plains Historical Museum No. A812)

Location: On a hilltop on the east side of Ledger Creek on the east side of Middle Alamosa Creek approximately 2.7 kilometers downstream from Billy's Creek Windmill.

Description: The hilltop is capped by an eolian soil. From the eroding edges, substantial amounts of lithic debris are exposed. On the west side of the hill, overlooking a dry spring in the creek below, are two stone-lined pits of about one-meter diameter. The stones are flat slabs set in a pavement fashion in the bottom and on edge, slanting outwards slightly (75°-85°), on the sides. One pit is completely exposed and has but a small amount of side still intact. The other is complete and partially buried.

Some of the site has been excavated.

Materials Collected: None

Cultural Affiliation: While stone-lined pits occur in Archaic-age sites in the Panhandle, the lack of other, supporting materials in this site causes us to be leary of such an assignation.

Bone Locality B

Location: In a steeply cut west bank of the Middle Alamosa Creek near the headwater area, approximately 2.8 kilometers downstream from Locality A.

Description: A single mammoth tooth is eroding from wall approximately 9 to 12 meters above the channel floor. Matrix is the gravely caliche mud of an old stream channel.

Material Collected: None

Bone Locality C

Location: West cut bank of Middle Alamosa Creek channel directly south of Battleship Mesa and west of the "east prong windmill."

Description: Bone is exposed approximately 2 meters above channel floor in a fill of red mud alluvium.

Material Collected: None

Sites on the Lower Tributary Highlands

41 OL 19

Location: On the flat ridge top overlooking the junction of Billy's Creek and Ranch Creek. The ridge sits between the creeks, faces the combined drainage channel, and is nearly 24 meters above the stream channel.

Description: Lithics, ceramics, and abundant bone are exposed in the back dirt of roden burrows. Exposed materials are densest near the edge facing the stream junction. Several flat gravel platforms exist below this edge, and a very thin scatter of cultural materials was observed on the surfaces of each.

Material Collected: A median thinned biface fragment (Alibates), a large, thick flake with a worked edge showing "chopping" wear (black quartzite), a utilized flake (Tecovas), a grey sherd of *Borger Cordmarked* pottery with angular quartz temper, and a burned fragment of bison (?) long bone.

Cultural Affiliation: Panhandle Aspect

41 OL 22

Location: On the edge of a promontory ridge of intravalley highland overlooking a portion of the mid-valley of Middle Alamosa Creek. Directly above and across the creek from Espendiza Windmill.

Description: Lithic, bone, and ceramic materials are exposed by rodent burrowing and edge erosion on a small platform extending from the side of the main promontory ridge. The soil is a light tan, floury, eolian silt. No structures were observed, but the eolian soil cap may be as much as a meter deep. The site area is an oval 10 meters wide and 25 meters long.

Material Collected: A *Fresno* projectile point (quartzite), large triangular unifaces (2) with steeply flaked edges (Tecovas), a small, heavily worked circular uniface (Alibates), a small, thinned biface fragment (Alibates), and a small rim-sherd of black-on-red Rio Grande glazeware (Agua Fria Glaze-on-Red, A.D. 1325-1425).

Cultural Affiliation: Panhandle Aspect

41 OL 23

Location: On the top at the south end of a large, free-standing mesa on the west side of Middle

Alamosa Creek in the mid-valley area. The site is just above 41 OL 24.

Description: Four large flakes of Tecovas flint were found lying on the side slope of a thick eolian soil cap on the top of the mesa. No other materials could be observed anywhere on the mesa. While it is large, the mesa is elongated and narrow rather than evenly proportioned.

Material Collected: None

Cultural Affiliation: Unknown

41 OL 40

Location: On edge of an east-draining highland wash that breaks over a caprock of Trujillo sandstone into the mid-section of West Alamosa Creek.

Description: A deflating, gentle slope where abundant cobbles and pebbles are exposed, with scattered large flakes, and lithic tools.

Material Collected: A fragment of alternate edge beveled biface (Tecovas), a fragmentary *Fresno* projectile point (Alibates), a bladelike, steep-edged uniface (Alibates).

Cultural Affiliation: Probably Panhandle Aspect

41 OL 49

Location: On the top edge of the highland east of Middle Alamosa Creek in its mid-valley approximately 1.9 kilometers grid northeast of Battleship Mesa and 1 kilometer grid northwest of North Cactus Windmill.

Description: The head of a side draw of Middle Alamosa Creek is eroding the highland topsoil and exposing a 15-centimeter layer of burned rock and lithic debitage that is in turn covered by a 15-centimeter layer of sterile eolian soil.

Material Collected: Two flakes of a porcelainlike siliceous stone.

Cultural Affiliation: Unknown

Sites in the Lower Tributary Valleys

41 OL 9

Location: The second erosional bench on the west bank of Ranch Creek approximately .8 kilometer upstream from the cottonwood grove below Landergin Mesa.

Description: The west side of Ranch Creek is a gentle slope into the stream channel. There are several erosional benches of less than 30 centimeters cut into the slope and parallel to the stream channel. The site is a sparse scatter of lithic debitage eroding from the second bench above the stream channel.

Material Collected: None

Cultural Affiliation: Unknown

41 OL 10

Location: The second erosional bench on the west bank on Ranch Creek approximately .8 kilometer upstream from the cottonwood grove below Landergin Mesa and 30 meters upstream from 41 OL 9.

Description: Lithic debitage is eroding from the face of the bench but not from the ground surface above. A longitudinally ground slab metate and a large, heavy biface were observed.

Material Collected: None

Cultural Affiliation: Longitudinally ground slab metates have been recovered from Archaic, Woodland, and Panhandle Aspect sites.

41 OL 11

Location: The second erosional bench on the west bank of Ranch Creek directly across from the cottonwood grove below Landergin Mesa.

Description: Lithic debitage eroding from the face of the bench but not from the surface above it.

Material Collected: None

Cultural Affiliation: Unknown

41 OL 12

Location: The second erosional bench on the west bank of Ranch Creek approximately 300 meters upstream from the cottonwood grove below Landergin Mesa.

Description: Lithic debitage eroding from the face of the bench but not from the surface above it.

Material Collected: None

Cultural Affiliation: Unknown

41 OL 13

Location: The second erosional bench on the west bank of Ranch Creek, just upstream across a tributary draw from 41 OL 13.

Description: Lithic material washing from the face of the bench. No materials can be observed on the surface above the bench.

Material Collected: None

Cultural Affiliation: Unknown

41 OL 14

Location: The second erosional bench on the west bank of Ranch Creek, approximately 640 meters upstream from the cottonwood grove below Landergin Mesa.

Description: Lithic debitage is being eroded from the face of the bench. No materials were observed on the surface above.

Material Collected: None

Cultural Affiliation: Unknown

41 OL 15

Location: On the east top of an eastward-sloping, free-standing sandstone mass approximately 560 meters grid northwest of Landergin Mesa. A ranch trail touches the east margin of the site.

Description: Numerous mortar holes have been cut into the relatively soft, flat sandstone surface. Most holes are filled with eolian soil and support a growth of grass.

Material Collected: None

Cultural Affiliation: Unknown

41 OL 16

Location: On the east side of Ranch Creek valley at the base of some low escarpments at the south edge of the valley mouth of a west-flowing tributary stream approximately .8 kilometer north of the cottonwood grove below Landergin Mesa.

Description: The site appears to be a surface phenomenon at the base of a sandstone outcrop. The only cultural material observed was collected.

Material Collected: A sherd of *Borger Cordmarked* pottery with a temper of fine sand and angular quartz and an obsidian fragment.

Cultural Affiliation: Panhandle Aspect

41 OL 17

Location: On the south bank of a west-flowing tributary which joins Ranch Creek across from the Rincon Windmill. Approximately 480 meters west of the Ranch Creek channel.

Description: Erosional scallops on the gently sloping bank have revealed sparse amounts of lithic debitage.

Material Collected: None

Cultural Affiliation: Unknown

41 OL 18

Location: On a hilltop on the west side of Ranch Creek approximately 1.3 kilometers upstream from the cottonwood grove below Landergin Mesa.

Description: The hilltop is covered by a layer of eolian soil and pebbles, from which a moderate concentration of lithics is eroding. The site area is linear, measuring 30 by 7 meters.

Material Collected: A projectile point of *Young* design (Alibates); a broken extremely thin oval biface (Tecovas); a corestone (Alibates); a blade with a modified tip (end scraper) (Alibates); a median thinned biface fragment (Alibates); and a utilized flake (Alibates).

Cultural Affiliation: The *Young* projectile point paradigm is connected generally with bow-and-arrow technology, placing this site within post-Archaic times.

41 OL 20

Location: In the second terrace above the junction of Billy's Creek and Ranch Creek. The site rests between the channels of Ranch Creek and the combined drainage.

Description: The cultural materials are eroding from the large cut face that forms the second terrace. Stratigraphy exposed suggests that a soil cap has covered the original surface of the second terrace, after which the cut face was formed. Lithic, ceramic, and hearth materials are in situ approximately 30 centimeters below the present ground surface, or scattered on the first terrace surface below the cut face.

Material Collected: Three sherds of *Borger Cordmarked* pottery possessing a complex temper of angular or rounded quartz with small amounts of pyrites, feldspar, and quartzite.

Cultural Affiliation: Panhandle Aspect

41 OL 24

Location: At the east base of a large, free-standing mesa on the west side in the mid-valley of Middle Alamosa Creek, approximately 3.2 kilometers upstream from Battleship Mesa and .8 kilometer downstream of Espendiza Windmill.

Description: The site is a remnant soil platform isolated by erosive forces that have dissected the valley interior into a badlands topography. Cultural material is eroding from the edges of the soil and is concentrated in steep-sided, deep gullies leading away from the site. No materials are visible on the soil surface. Lithic materials are the most abundant items, particularly large cores, flakes, and blades of quartzite, but some ceramic remains were also present.

Material Collected: A long, thin, triangular projectile point similar in design to *Maud* (Suhm and Jelk, 1962) (Alibates); a large, crude circular biface (brown quartzite); a utilized flake (Alibates); 28 sherds of plain brown pottery with scraped exteriors and a heavy temper of quartz sand with lesser amounts of biotite and muscovite mica; one sherd of plain brown pottery with a scraped exterior and a heavy quartz sand temper with a lesser amount of iron pyrite; and a single sherd of a cream-colored, polished pottery with angular quartz and quartz sand temper and a white-slipped interior.

Cultural Affiliation: Without a large sample of the material culture in this site, it is difficult to defend with confidence the identification of this site as Late Prehistoric; there are clues, however. While the triangular projectile point is a very common feature of Plains prehistory, this particular form is less often seen. None have been illustrated from Panhandle

Aspect sites, but some have been recovered from late prehistoric Apache sites in New Mexico (Gunnerson, 1969) and on the West Central Plains (Gunnerson, 1958). The pottery from 41 OL 24 is a long-lived form that comes out of the northern Rio Grande valley where historic and earlier Indians often traded for ceramics.

Locality A

Location: In the cut banks of the Middle Alamosa Creek channel in the headwater area, approximately 2.25 kilometers north of the southernmost ranch trail crossing the Middle Alamosa.

Description: Bones of modern bison are eroding from opposing sheer walls cut by the channel. One piece is over 6 meters above the channel floor, while the others are about 1 to 2 meters above the channel floor. Burial material is red alluvial mud. Enough bone is present in some places to indicate primary burial. Areal extension is approximately 70 meters.

Material Collected: A small oval uniface of Alibates flint was collected from the slump at the base of one of the walls. It was not associated with any bone, but no other human material could be found on the ground surface above the wall.

Sites on the Canadian River Highlands

41 OL 5

Location: Atop the highlands immediately east of the Alamosa Creek-Canadian River juncture; a small pour-off has been established in the west escarpment of this highland, and the site is being exposed in the upper area of the drainage.

Description: The head of the pour-off reaches eastward towards a deflation area where some flakes of Alibates agate or Tecovas jasper are exposed along with numerous broken or battered quartzite cobbles. The covering material which is being removed slowly appears to be an uneven layer of eolian soil.

Material Collected: None

Cultural Affiliation: Unknown

41 OL 6

Location: On the west side of a prominent, wind-sculpted mass of sandstone that lies on the top of the highland east of the Alamosa Creek-Canadian River juncture. On the west side of a ranch trail that runs south from the Flowing Well at el. 3237.

Description: There is an irregular accumulation of eolian material containing sparse amounts of lithic and ceramic materials at the base of the sandstone mass. Some obsidian flakes were observed.

Material Collected: A fragmentary, asymetrical, small, thinned biface somewhat like a *Fresno* projectile point (Alibates); two flakes of obsidian; and a very large, tabular biface worked only at the edges; a sherd of a plain grey pottery that is adundantly tempered with large angular quartz fragments.

Cultural Affiliation: The triangular projectile point and the obsidian militate for the assignment of this site to the Panhandle Aspect. The sherd is similar to some *Borger Cordmarked* except that its surface is smooth.

41 OL 7

Location: On a small ridge atop a large, relatively flat highland east of the Alamosa Creek-Canadian River junction. A ranch trail from the Ranch Creek bottoms to the Alamosa Creek-Canadian River floodplain is approximately 50 meters west of site.

Description: Deflation areas in the eolian soil cover on the north and west sides of a sandstone ridge have exposed lithic flake and milling tools.

Material Observed: Sandstone slab metates and loaf-shaped one-hand manos with one or two opposing sides ground flat.

Cultural Affiliation: Archaic, Formative, or Late Prehistoric.

41 OL 42

Location: On a small promontory extending north from a large highland mass immediately west of the junction of Alamosa Creek and the Canadian River.

Description: The site is on a small platform overlooking the Canadian River channel with an unrestricted view in excess of 2 kilometers up and down the valley. The platform is accessible with ease only from the south and is slightly lower in elevation than the average highland surface. Stone, pottery, bone, and shell materials are exposed on the edges and surface of an eolian soil cap. Previously eroded materials are strewn down the three slopes adjacent to the site. Milling slabs were observed several meters down the west slope. Site has been surface collected previously. Area is approximately 100 square meters.

Material Collected: A fragmentary side-notched *Harrell* projectile point (Alibates), an Aspen leaf-shaped large biface (grey quartzite), and seven sherds of *Borger Cordmarked* pottery with coarse angular quartz temper.

Cultural Affiliation: Panhandle Aspect

41 OL 43

Location: On the top edge of a low ridge on the north side of the highlands west of the Alamosa Creek-Canadian River junction. This ridge is adjacent to 41 OL 42 to the west.

Description: A small 4-square-meter area of lithic debris eroding from a soil cap overlooking the Canadian River.

Material Collected: A single fragment of a steeply flaked uniface (Tecovas).
Cultural Affiliation: Unknown

41 OL 44
Location: On the west side, top, of a north ridge that forms the northern extremity of the highlands west of the Alamosa Creek-Canadian River junction.
Description: A small oval mano and an oblong-grooved milling slab in situ (?).
Material Collected: None
Cultural Affiliation: Unknown

41 OL 45
Location: On top of the northern end of a long north ridge at the east end of the highlands west of the Alamosa Creek-Canadian River junction.
Description: An almost inconsequential scatter of lithic materials, probably all surficial.
Material Collected: None
Cultural Affiliation: Unknown

41 OL 46
Location: On the top of the highlands west of the Alamosa Creek-Canadian River junction, at the head of a "birdfoot"-shaped canyon cut into the east side.
Description: Several hearth concentrations with associated lithic debitage covering an oblong 16 meter by 10 meter area. The ground surface is gravel, and a nearby eroding sheet of eolian soil may have once covered the site.
Material Collected: None
Cultural Affiliation: Unknown

41 OL 47
Location: Atop the junction of a south-projecting ridge and the highland proper at the east end of the highland west of the Alamosa Creek-Canadian River junction.
Description: A 20 by 20 meter square area of lithic debitage and bone debris being eroded from an eolian soil. In some places the material has been let down to an exposed underlying gravel.
Material Collected: None
Cultural Affiliation: Unknown

41 OL 48
Location: On top of this highland just west of Alamosa Creek-Canadian River junction where the highland area is narrowest with opposing erosion canyons nearly meeting.
Description: A substantial area of exposed lithic, ceramic, and bone materials is exposed by sheet erosion of a flat, eolian soil surface. Two structures are indicated by squared mounds, and some foundation outlines measuring 3 by 2 meters and 2.5 by 2 meters. The southwest corner of one has been destroyed by pothunters, otherwise the structures are nearly intact, being anchored by mesquite growth. The total site area is poorly defined since little material can be seen on the surface; it may be connected to 41 OL 47.
Material Collected: Two sherds of *Borger Cordmarked* pottery possessing a coarse, angular quartz temper.
Cultural Affiliation: Panhandle Aspect

Sites in the Canadian River Lowlands

41 OL 50
Location: In the bottom lands on the south side of the Canadian River approximately 1.9 kilometers upstream from the Fort Worth and Denver (Burlington Northern) Railroad crossing.
Description: The masonry remains of a Mexican sheep ranch "plaza" are built on the edge of a low, gently sloping river terrace in the Canadian River bottoms. The site consists of several buildings, all built of stone, laid out in a semi-contiguous L-shape. Metal objects and bone are fairly abundant on the ground around the structures. Early photographs shown the authors by the present landowners suggest that the site has deteriorated somewhat in the last forty years from natural forces.
Material Collected: None
Cultural Affiliation: Pastores, Mexican ranchers of the 19th century

Anomalous Situations

Two sites visited by the authors do not fit neatly into a zonal description. Both are substantial ruins of masonry structures set atop small, free-standing mesas. The structural density is such that the majority of the top surface was used. The environmental position of these sites, then, is actually a function of their position atop the mesa and the position of the mesa as a whole in its immediate surroundings.

41 OL 4 Landergin Mesa
Location: On the top of a large, free-standing mesa in the valley of Ranch Creek approximately .5 kilometer east of the creek channel and 2.1 kilometers upstream from the junction of Ranch Creek and Alamosa Creek.
Description: The mesa is just over 55 meters tall with steeply sloping sides and a thick sandstone cap. At the top, the sandstone cap froms a sheer wall over 6 meters high on the south side, but thinning to just 12 meters on the north side where access to the top is possible.

The top of the mesa has a substantial, rectangular structure that appears to be composed of contiguous square rooms of differing sizes. This structure is covered, for the most part, by a thick layer of eolian soil. A few possible stone wall remnants were visible. At one place, they seem to indicate edge-set slab construction, but all other instances appear to be horizontally laid. The structure seems to have covered nearly all of the usable mesa top with the exception of the west side where a long open area is littered with grinding slabs and manos.

The activities of "pot hunters" have badly destroyed much of the interior room fill, and screen-dirt piles are seen everywhere. Two of the "pot holes" appear to be no more than a few months old. In the material discarded by the "pot hunters" are contained abundant amounts of bison bone, ceramics, obsidian, and other lithics. The walls of the recent "pot holes" show series of stratified layers of bone and charcoal.

Material Observed: Landergin Mesa has been designated a National Historic Landmark, and collecting activities require permission from the Department of Interior of the federal government. Since this study is more of a reconnaissance than a detailed survey, such permission was not sought, and materials were not collected.

Observed materials include two side-notched *Harrell* projectile points (Alibates, obsidian), abundant obsidian flakes, numerous sherds of *Borger Cordmarked* pottery (tan, black, olive), a single sherd on of black-on-cream Rio Grande glazeware, two bone awls, and several fragments of mussel shell.

Radio Carbon Dates: A sample of charcoal was processed in 1966 by the University of Wisconsin Radiocarbon Laboratory. The date obtained was 620 + 70 (A.D. 1330) (Baerreis and Bryson, 1966).

Zonal Comments: Landergin Mesa is located in the broad valley floor of Ranch Creek, a lower tributary valley. Its top is level with the surrounding highlands, but cannot be considered to have immediate access to any substantial upland surface; the nearest is over 400 meters away. The physical setting of the site, then, is a function of its base location which is just slightly higher than the valley floor adjacent to the Ranch Creek channel.

41 OL 8 Mesa Alamosa
(Panhandle-Plains Historical Museum No. A627)

Location: A small mesa top on the south side of West Alamosa Creek approximately 1.7 kilometers downstream from where the creek makes a bend, changing the direction from north flowing to east flowing.

Description: The mesa rises approximately 46 meters above the valley floor and is 160 meters from the edge of the surrounding highland prairie. The mesa capstone, as at Landergin Mesa, forms a sheer wall in many places but is not so monolithic, allowing access from several directions. The top is about 40 meters by 15 meters in area. The surface configuration indicates fairly extensive ruins beneath an eolian soil cap, but actual room outlines are discernible in only a few places. The depth of the soil may be as much as 1.5 meters. Near the edges of the mesa top (on the west side) where the underlying sandstone cap is exposed, numerous mortar holes and milling places may be seen. Cultural material is quite abundant on the lower slopes and basal area of the mesa where it has been buried by colluvium washed down from the mesa flanks and then reexposed by current erosion. From the mesa, one has a good view of the valley to the east, a moderate view west, but no view to the north or south where steep valley walls rise slightly above the height of the mesa.

The site has not been as badly plundered as Landergin Mesa, but several "pot holes" are visible, along with piles of screened earth and discarded cultural material. While bone, charcoal, and obsidian flakes are abundant in these rejection heaps, there seems to be less cultural material than on Landergin Mesa.

Material Collected: Two side-notched *Harrell* (quartzite, Alibates) and two *Fresno* (Alibates) projectile points; five fragments of *Harrell* or *Fresno* projectile points (Alibates); two triangular bifaces (Tecovas, quartzite); a diamond-shaped, alternate edge beveled knife (Alibates); a blade with a finely retouched edge (black quartzite); miscellaneous flakes (obsidian, clear quartz, opaque white quartz, Tecovas, sandstone); 35 sherds of *Borger Cordmarked* pottery (two of the cordmarked sherds have mica in their aplastic ingredients and also are the only sherds showing multidirectional cordmarks; all other sherds are tempered with angular quartz); one sherd of a plain grey pottery with a sparse temper of angular quartz and a very well-smoothed exterior; a sherd of plain brown pottery with an abundant temper of angular quartz and a roughly wiped exterior; and four fragments of mussel shell.

Zonal Comments: The base of 41 OL 8 is definitely associated with the lower tributary valley, but the closeness and accessibility of the neighboring highland makes it a strong factor in assessing the biophysical position of the site.

Synthesis

The sites located in the course of this study represent the patterned behavior of their creators. This behavior is the result of autogenic cultural development, sociocultural interactivity, and the forces of the noncultural, natural environment both as a primary agent, and as a malleable resource. The location of sites and their content, their arrangement over time and space, reveals *partial* evidence of the effects of these forces.

ECONOMIC PATTERNS

Paleo-Indian Patterns

The authors failed to locate any definite sites of the Paleo-Indian stage. The bone localities may prove to be sites of human activity, but the odds are against it. Most of the known Llano, Folsom, and Plano sites are "kill sites" and are usually involved with a waterlain sediment. The interpretation, then, is that Llano and Folsom subsistence revolved around valley bottoms, or at least moist environments on the Plains. Remembering that the early Spanish explorers on the Plains reported a prominent practice of waterhole hunting amongst the Plains Indians, there is some soundness in that argument. But time and accident may have obscured our view. Real people do not usually live in marshes or stream beds. Higher, drier living sites, those places most likely to reflect a total subsistence strategy, suffer more from the vicissitudes of erosion, particularly when long time periods are involved. In contrast, those activities carried on near active water, fluvial or pluvial conditions, stand the best chance of long-term preservation.

Jack Hughes (personal communication) points out that many of the Paleo-Indian projectile points recovered from surface exposures are found along the edge of the caprock escarpment and has suggested that further investigation might show a pattern of living "high" while "killing" low. The idea has merit. At some places along the high elevations of the caprock, a panoramic view of the moist valley bottoms could be obtained. From there, game animals drawn to the moist, vegetated valleys below could be spotted, their route of travel observed, and a plan of interception worked out. The taking of the beast then occurred below.

Archaic Patterns

The Archaic Stage, represented by 41 OL 39 and the Little Sunday site (Hughes, 1955), appears as a distinct change in site location, although this may be a function of its relative youth. Both sites are "living sites," measured by the abundance of burned rock and ash in 41 OL 39 and by the variety of artifacts recovered from Little Sunday (boiling stones, milling stones, decorative shell, sixteen classes of flaked stone tools). The reasons for the placement of 41 OL 39 are not immediately apparent. The position is not a defensible one by any standard of measure, nor does it offer immediate access to water or vegetal resources, although both are available in the greater vicinity. The advantages that are offered are an excellent visibility of the valley, combined with a relatively easy access to the Plains above and the moist watercourse below. The location represents a hunting pattern of subsistence which had its roots in the previous Paleo-Indian period. Given the unpredictably of bison movements, the optimum qualities of a site would be the ability to observe large areas, even while attending to the relatively mundane aspects of living, and the easy access to the several biophysical zones that would supply the total subsistence economy.

Formative Patterns

No definite Woodland sites were discovered during the fieldwork for this report. The Lake Creek site (Hughes, 1962) in Hutchinson County is situated on a small, flat terrace of land approximately twenty feet above a boggy stream channel. The terrace is backed by the valley slopes. Jack Hughes relates (personal communication) that many of the Plains Woodland sites known in the Canadian River area are located also in valley bottoms, usually around head-springs.

The Panhandle Aspect is abundantly represented in the sample obtained for this report. A total of 15 sites was located.

On the caprock edge, there is one identifiable site of the Panhandle Aspect (41 OL 25); this site has one visible structure on it, with several surface anomalies suggesting other structures. The caprock slopes also have a Panhandle Aspect site (41 OL 26) which shows only a small mound which may prove to be a house, but shows no recognition features at the present.

Three Panhandle Aspect sites were observed in the tributary headwater valleys. None contain any structural remains. One (41 OL 27) shows a rather large, exposed charcoal concentration, while another (41 OL 33) displays a moderate amount of burned rock. Two of the 3 sites in this area are topographically high (41 OL 27, 41 OL 28) but the third (41 OL 33) is low in relation to its surroundings.

Only one of the two sites located in the intermediate area is affiliated with the Panhandle Aspect; it (41 OL 21) sits on top of a prominent hill in the cedar breaks, and has no structural remains.

There are 3 Panhandle Aspect sites on the lower tributary highlands. The depth of the eolian soil cap on 41 OL 22 may hide structural remains, but none could be observed on the surface. The same is true at 41 OL 19 although the soil cap is not as thick and the chances correspondingly less; the site does produce copious quantities of bone, some of it burned, in the back dirt of rodent holes. The third site here has little soil and few artifacts.

While there are 12 sites in the lower tributary valley, only 2 of them can be identified as Panhandle Aspect. In one (41 OL 20) there is a spacious distribution of artifacts and hearth materials low at the junction of two creek channels. The other (41 OL 16) has sparse cultural material and seems entirely surficial.

Two Panhandle Aspect sites were visited in the Canadian River highlands, one of which (41 OL 48) has 2 visible structures. The other site (41 OL 42) has an accumulation of eolian material sufficient to obscure from view structures which might be present; no indications of structures could be observed, however. In the lowlands below, no Panhandle Aspect sites were discovered.

Lastly, the 2 anomalously located sites (41 OL 4) and (41 OL 8) are of the Panhandle Aspect, both showing large, contiguous room structures and abundant cultural debris. Landergin Mesa sits in a lower tributary valley but its living surface is at a level even with the flanking highlands, perhaps confering the advantages of both areas, visibility and moisture, on its inhabitants. Similarly, Mesa Alamosa (41 OL 8) enjoyed the best of both environments with the added benefit of proximity and access to an adjacent highland surface.

Much of the literature on the Panhandle Aspect ignores the ecological aspects of individual site locations. In some of the older writings, basic data (such as the relative elevation) are woefully unclear. The Tar Box Creek ruins (Holden, 1929) are on a hilltop overlooking a creek, more than 30 meters below. The Antelope Creek ruins (Holden, 1930) are on a midslope ledge that offers an excellent view of the valley, indicating a highland (?) position, albeit one that has a valley bottom close below it. Saddleback Mesa (Holden, 1933) is similar to Landergin Mesa, although lower. From the sketch map, the position of the Coetus Creek ruins (Studer, 1934) appears to be low, on a steep slope along a spring-fed draw. The sites excavated by Duffield (1964) are somewhat better described but still difficult to place. The Conners site is located on a gentle hilltop within the river valley (highland?); Medford Ranch is on an erosional terrace midway between the valley floor and adjacent highlands; Spring Canyon is high, on the edge of "rolling breaks."

The pattern of settlement in the Panhandle Aspect is difficult to interpret. Few clues are available from previous investigations because of the paucity of locational information and the bias in favor of structural remains. No pattern of chronological variation or spacial distribution has been proven. Two arguments can be explored, one diachronic and one synchronic, as testable hypotheses to account for the observed phenomena. Admittedly, these ideas are speculative.

In the first, site location is a function of a chronology of social and economic development. The Woodland occupation, represented by the Lake Creek site, is assumed to be the progenitor of the Panhandle Aspect, either by an immigration from the eastern Plains or by the diffusion of concepts and artifice to an older, resident valley population. This incipient Formative period is characterized by the development of new economic patterns over the old Archaic base. Hunting was joined by agriculture practiced in the moist soils surrounding spring locations as the mainstays of the subsistence system. The requirements of food production, then, may have tied peoples loosely to specific areas and promoted a more limited strategem of locational shifting.

The large, nonstructural Panhandle Aspect sites are illustrative of this transitional age. Those located in lower valley bottoms could represent the agricultural activity coupled with associated seasonal exploitations of wild plants, aquatic animals, and opportunistic hunting at watering places and animal crossings. The headwater and intermediate area sites, with their excellent visibility, can then be taken as a manifestation of the Archaic portion of the economy: primary hunting of bison and deer and secondary gathering of upland plant products.

As the agricultural portion of the economy improved its technology, a strong incentive for the combination of these activities might have developed. The product was the construction of permanent, noncontiguous structures in locations that offered good visibility to accommodate hunting and proximity to agricultural areas. The harvesting in wild plant communities could be accomplished by means of short trips.

The further intensification of the food-producing system allowed or led to the establishment of the large, contiguous-roomed buildings typified by Landergin Mesa, Mesa Alamosa, Saddleback Mesa, Antelope Creek, and the others. The duality of the economy remained intact, however, and habitations were still sited in locations possessing the attributes of good visibility and adjacent agricultural potential. The causes of this continued dualism lay in the Plains climate and the relative abundance of the bison. The possibility of naturally retarded domesticate harvests forced the Panhandle Aspect peoples to retain a proficiency in wild resource capitalization, and the potential food realization from bison hunting encouraged its retention in the economic fabric.

The alternative to this scenario of development is a static picture of social or economic differentiation.

Leaving in abeyance for a moment the questions of origin and progression, the Panhandle Aspect sites may be viewed as partial expressions of a synchronic cultural whole. The large contiguous-roomed structure sites may have been the permanent settlements for the majority of the population. The smaller, noncontiguous-roomed structures could have been, then, seasonal situations for tending outlying agricultural fields or perhaps the perennial residence of less socially integrated elements of the population. Open, nonstructural sites might represent hunting and seasonal gathering encampments. The activities of the structural sites are revealed by their locations. Each is topographically high but near a valley bottom where the vegetation was most prolific, potential wild resources the greatest, and agriculture the most feasible. The height of these sites may be an indication of opportunistic bison hunting. In contrast, the major nonstructural sites, save one, seem to depict a calculated exploitive effort of primary hunting and secondary gathering, perhaps on a seasonal basis similar to the economy of eastern Plains Indians typified by the Omaha (Fletcher and La Flesche, 1911) and the Mandan (Bowers, 1955). In short, each situation represents a diad of the economy; a botanical emphasis in the structural sites, an animal-oriented effort in the nonstructural sites.

These two explanatory themes are not exclusive of each other, nor do they exhaust the total realm of possibilities. They mainly help outline the dimensions of the problems to be solved in the Panhandle Aspect. Many more factors—such as pressures between hostile social groups (both mesas in this study have as their most outstanding attribute a fortresslike inaccessibility), climatic shifts, animal population changes, cultural influences emanating from the Rio Grande pueblos or the eastern plains and woodlands, even insect problems—need be taken into account.

The point is that there are reasons, ostensibly, for the variations in site location and structure during the Panhandle Aspect that have eluded solution thus far; if we fist accept the axiom that human behavior is patterned then we must also accept that an archaeological culture is likely to have a chronological dimension as well as a functional one which in the past operated to produce the remains which we see today. It is through the kind of speculative questions which we have presented that problem-oriented research is born. Unfortunately, it is this type of effort which has seldom been seen in Texas.

Late Prehistoric/Historic Patterns

The only Late Prehistoric/Historic Indian site visited by the authors (41 OL 24) is located in a lower tributary valley. Casteñeda, in his record of the Coronado expedition, reported that the Teya Indians camped *in* deeply cut stream valleys. Studer (1931) reported, however, that Late Prehistoric/Historic Indian material is often found superimposed on Panhandle Aspect ruins.

The post-Panhandle Aspect occupation in the Canadian River valley had returned to basically a hunting and gathering economy, with some limited horticulture. Considering the Spanish observations, the site probably was located near a popular bison watering spot and close to exploitable vegetal resources. Whether the camp was occupied on a fortuitous or seasonal basis cannot be determined now, but historic observations make it clear that the site was almost certainly used on an intermittent basis.

The historic "plaza" is on the Canadian River floodplain. Whether the other Plazas in the Canadian River valley are similarly located is unknown to use. Without such comparative data, the reasons for the location are not immediately comprehensible. One explanation seems quite plausible, however. During shearing or slaughtering time, large aggregations of stock were gathered that required abundant forage. The growth of grass was best in the valley bottoms, and the authors suppose that the "best of the best" was in the Canadian River bottoms. This, coupled with the desire to supplement a meat and wild food diet with truck farm produce (which requires more moisture than the Indian domesticates), is sufficient for a provisional explanation.

SOCIO-CULTURAL DIMENSIONS

The conjectures of Jennings (1968) on the social organization of Paleo-Indian peoples has already been stated, and the authors see no reason to dispute them. The social organization of any archaeological people for which historic observations are not available will be shrouded always in mystery. The best one can hope for is a generalization based on the observations of still-existing cultures.

There is little doubt that the majority of hunting and gathering cultures are organized on the band level. The tenuousness of their existence and their generally arduous daily routine make the band the most advantageous structure. Beyond this, reasoning by analogy breaks down. Service (1962) relates a variety of band structures that owe their peculiarities to problems of social interaction or to unique factors in their economies. Since the response of any two groups to a similar element in the natural environment or sociocultural system is often different, a complete reconstruction of a band organization based on analogy is simply impossible.

There is little detectable change between the Paleo-Indian stage and the Archaic stage in the Canadian

River valley except for lithic technologies and the resources exploited. Archaic man continued to hunt the largest animals available, but the economic base was essentially the same as in historic times. The interactive effect on culture of the peculiar resource mix on the Great Plains has been discussed by Oliver (1962), who showed that the essential social organization of those cultures *not possessing Formative origins* was the band. Since the groups analyzed by Oliver had a superior technology conferred by the horse and bow, the case for Archaic bands is so much greater.

The advance of economic systems in the Formative from purely hunting and gathering to partial food production wrought many changes in the Canadian River valley. These economic developments spawned new concepts of property and religious structure which expanded the need for institutionalized roles and for established modes of conflict, exchange, and accommodation (Smith, 1972). The cultural system, then, sought greater levels of stability, expressed by the commitment to building and maintaining permanent structures. At the outset, these settlements may have been simple lineal groupings. By the construction of the large, contiguous-roomed structures, however, the culture may have developed social structures larger than simple lineages to soften and mitigate the anxieties of high-density living. Like the historic Indians of the Plains who engaged in food production, a corporate group larger than bands or simple lineages, a tribe, was the expression of this elaboration.

The recovery of Puebloan pottery, turquoise, and obsidian from Formative sites in the Canadian River valley is illustrative of the nature of relations with the peoples of the Rio Grande valley in New Mexico. In much the same fashion as the historic Plains Apache, the Canadian River valley peoples were engaged in an extensive system of trade, probably providing meat and hides in return for the artifice of the Pueblos; but unlike the historic trading, vegetal foodstuffs probably played an insignificant role. Exactly how much commerce in ideas or concepts also occurred is problematic. The stone houses of the Panhandle Aspect bear many similarities of construction with some distinctive Puebloan styles (Krieger, 1946), and it is probable that the basic mechanics of stone masonry were learned in the Pueblos to the west. But just as many features of eastern Plains earth lodge architecture can be seen in the stone houses. Moreover, the apparent nontransmission of ceramic technology is puzzling. The mere acquisition of Puebloan pottery indicates that a value was placed on southwestern plastic arts, yet no attempt at duplicating either forms or decorative features can be detected in the only indigenous ceramic product, *Borger Cordmarked.* Thus while the direct material transfers are evidence of social contact, the nature of the conceptual traffic between these cultures is indistinct.

Of less recognizable import are the relations between the Formative peoples in the Canadian River valley and other cultures on the Plains. Much of the Panhandle Aspect material culture is the same as is found elsewhere. Bison tibia digging sticks appear to have been more popular in the Panhandle Aspect than the scapular hoes that were prominent in contemporary Nebraska and Kansas, and some differences in the form and decoration of pottery exist, but the general pattern is similar. Since the economies and material cultures of other Plains groups were roughly commensurate with the Panhandle Aspect, the comparative or absolute economic advantages on which trading relations could be built were absent, and the interaction between these groups consequently is submerged for want of material representation.

In most cultures of tribal organization, a certain amount of external warfare is common. Service (1962) identifies the objectives of warfare at the tribal level as booty or territory, to which one more may certainly be added: reputation. The acquisition of wealth through warfare certainly may be a goal, but often it is merely symptomatic of the dominant mores of the tribe that prescribe this activity as a way of fulfilling the requirements of an institutionalized role. The typical nature of tribal warfare is "continual threat, sniping, and terrorization" (Service, 1962:104). To some extent, then, the location of ruins on Landergin Mesa, Mesa Alamosa, Saddleback Mesa, and others may reflect a defensive strategy. For the present, however, further archaeological proof of extensive warfare is lacking, and its existence must remain conjectural.

The end of the Panhandle Aspect marked a partial return to Archaic lifeways to the Canadian River valley, and Spanish records (Winship, 1904; Hammond and Rey, 1953; Thomas, 1935) indicate that the Plains was dominated by a plethora of fractious bands. In later historic times, this was the pattern of many equestian Indians (Bryant, 1953; McAllister, 1955; Richardson, 1940; Wallace and Hoeble, 1952).

CONCLUSIONS

Human beings do not react to the web of life solely through their genetically-derived organic equipment. Culture, rather than genetic potential for adaption, accommodation, and survival, explains the nature of human societies (Steward, 1955:32).

A culture can go no further than its ability to accommodate or its capacity to generate change in its biophysical setting. The two aspects of human ecology, man's creativity and nature's providence, stimulate each other and—paradoxically—limit each other by the stimulus. Stable adaptions are maintained both because the resource base has a particular composition and because man's capacity or inclination to take advantage of those offerings matches their relative beneficence or poverty.

In the Canadian River valley, there may be a strong strain of adaptive stability represented in the Archaic pattern, one that seems to have continued into the Formative. Habitations located on high vantage points probably attest to the value placed on the hunting of large animals and, in the Formative, bear witness to a reluctance to abandon that resource in favor of total reliance on food-producing technologies. The hestitation stemmed likely from the abundance of bison that made an abandonment of hunting simply too difficult, which in turn robbed the Formative peoples of the stimulus to develop more intensive horticultural methods. At the same time, the unpredictable climate of the valley may have continually kept the human population in a position where they had to maintain the Archaic facets of their economies.

If climatological factors terminated the Formative as Baerreis and Bryson (1965) suggest, it also reinstated a partially Archaic lifeway. The failure was cultural. Either the inhabitants were not disposed to reintroduce heavier horticultural systems, or their abilities were not sufficiently developed. The latter problem still crops up sporadically on the Plains despite our own technological achievements.

The coming of historic immigrants, Mexican and American, brought an advanced technology to the Plains, one that could use the vast tracts of grassland and plains soils as a primary resource. But until their arrival, the strategem of existence was an oscillating one of Formative florescence and Archaic persistence.

EPILOGUE

During the fieldwork for this report, the authors met many of the landowners and citizens of Oldham County. Nearly all expressed curiosity about archaeology and support for the work being done. Many saw it as an effort to conserve the heritage of man in the Canadian River valley.

Yet, in walking the countryside and visiting archaeological sites, the authors saw much destruction of that heritage. The more spectacular sites, the ones with stone masonry structures, had been badly plundered. Gaping holes scar the face of Landergin Mesa and Mesa Alamosa. An entire corner of one structure at 41 OL 48 has been obliterated.

There is a popular notion that archaeologists study pots and arrowheads. It is a simple half-truth. Flint flakes, burned bones, shattered shell, insect parts, dried human feces, and many other ordinary, often repellent, things enter the calculations. Moreover, the "things" themselves offer limited vistas. Each is the result of human manufacture, alteration, use, and ultimately, discard. The manner of their discard, represented in the ground by spatial clustering and stratigraphy tells more about a people and their way of life than the object itself in isolation.

The forces that created the archaeological sites in the Canadian River, the Indian ancestors, are gone, dead, and will never be resurrected. The remains of the lives of other peoples at other times are a precious gem that is offered to us if we are smart enough to grasp for it. And like the perfect stone, once torn from the ground and sold from simple greed, it can never be recalled, never bought back, never regained. But if it is carefully lifted, reverently cut, and thoughtfully preserved, its value is increased. This is why our society trains and supports professional archaeologists and their institutions.

The manner of a land's ownership is indifferent in perspective. Many fine examples of public ownership and preservation of antiquities exist; just as many or more can be found on private land. Conversely, there are private landowners who have permitted or participated in willful and immoral acts of destruction, and there are public lands which have suffered grievously from the callous neglect and thoughtlessness of their administrators. There is a need for an understanding among the landed, the landless, public persons, and private: the lives and lifeways of departed peoples are *our* legacy, and each of us is its steward.

A land's archaeology is part of its wealth; a peoples' respect for the heritage it forms gives a richness of spirit beyond purchase.

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FIGURE 1

Bone Locality B. Close view of Mammoth tooth.

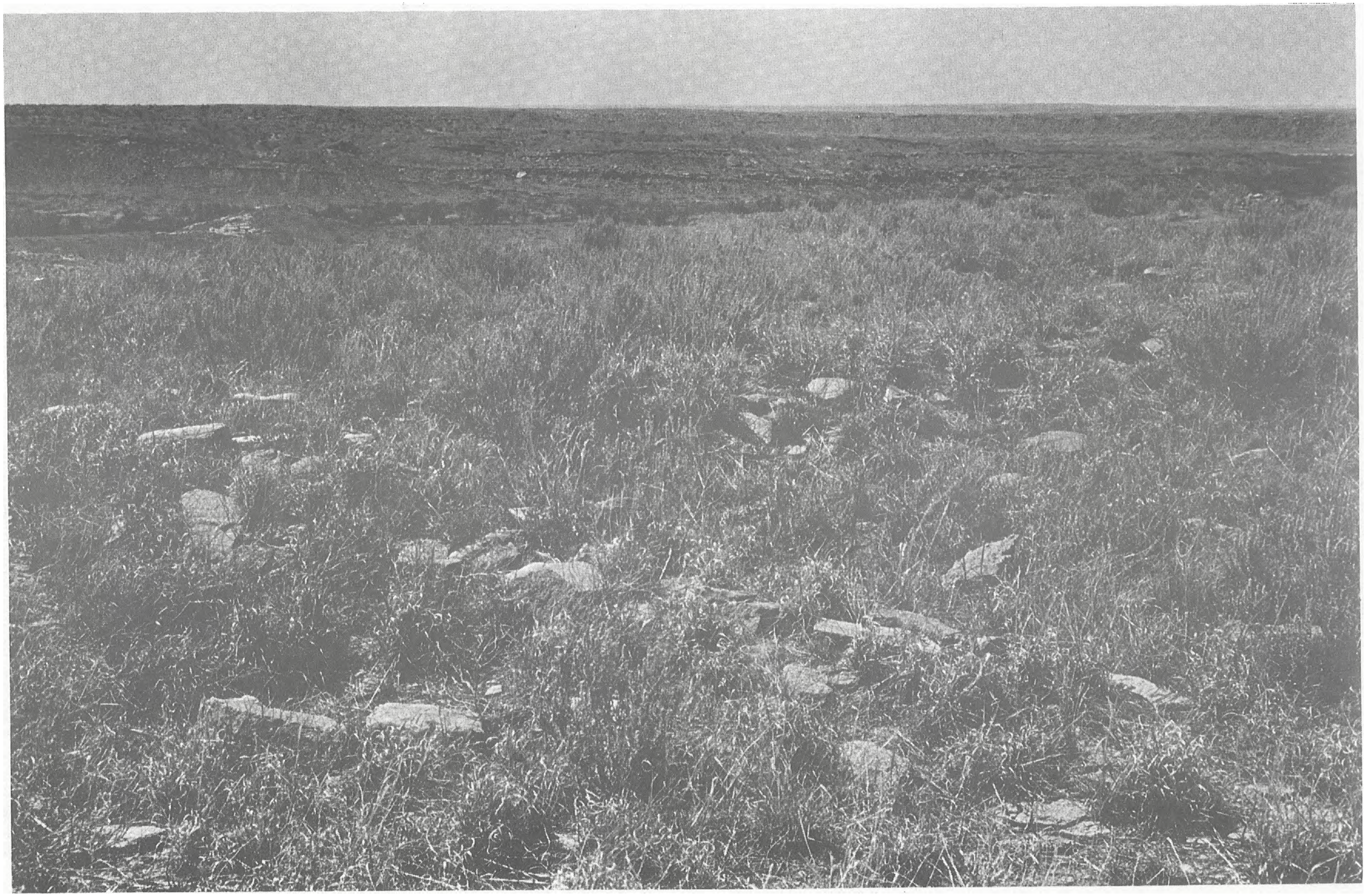


FIGURE 2

41 OL 2. Landergin Mesa – visible ruins on the top.

FIGURE 3
41 OL 8. View from the adjacent highland to the south; West Alamosa creekbed is in the background.

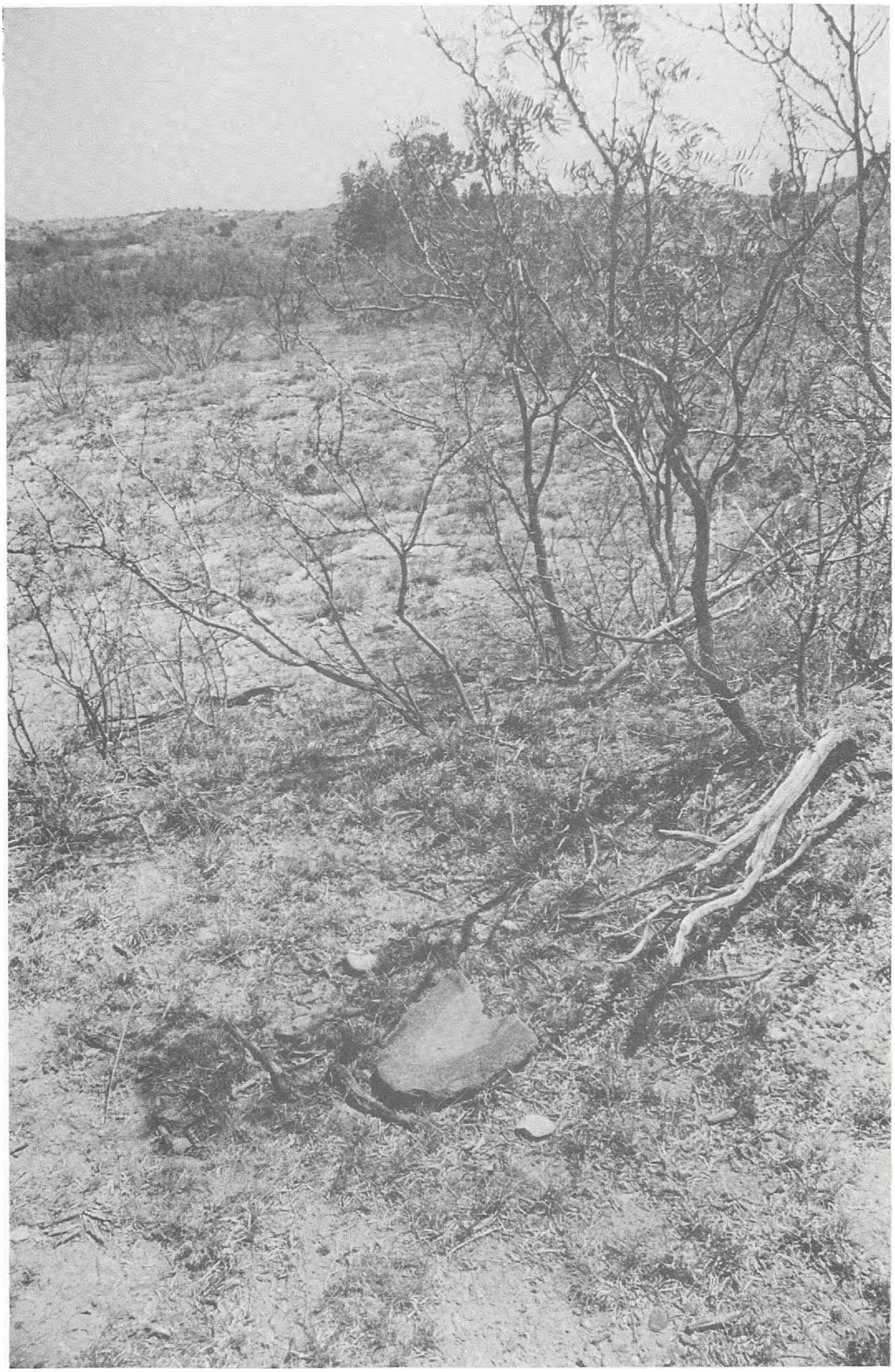


FIGURE 4
41 OL 10. View south; metate in foreground marks the site's northern extent.

FIGURE 5

41 OL 14. Cultural materials are restricted to the cut-face.

FIGURE 6
41 OL 18. Cultural material is eroding from the hillslope immediately behind figure. 41 OL 2, Landergin Mesa is in the far background.

FIGURE 7
41 OL 20. Cultural material is exposed in the upper 40 cm. of the out-face in center, kneeling figure gives scale.

FIGURE 8

41 OL 21. Darker soil is the cultural deposit.

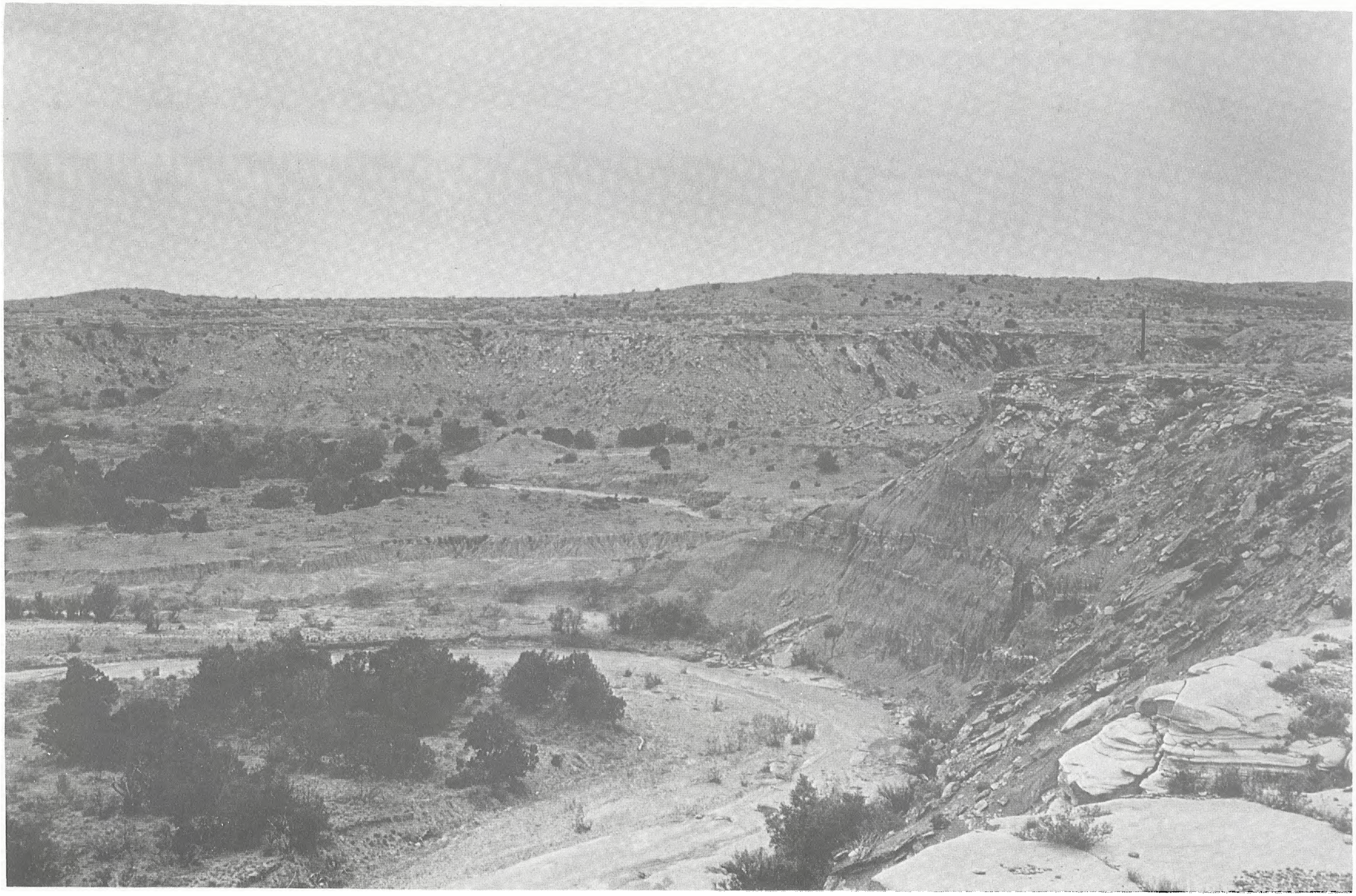


FIGURE 9

41 OL 22. Arrow shows site location.

FIGURE 10
41 OL 24. Remnant soil cap is the flat surface above the erosion in the center.

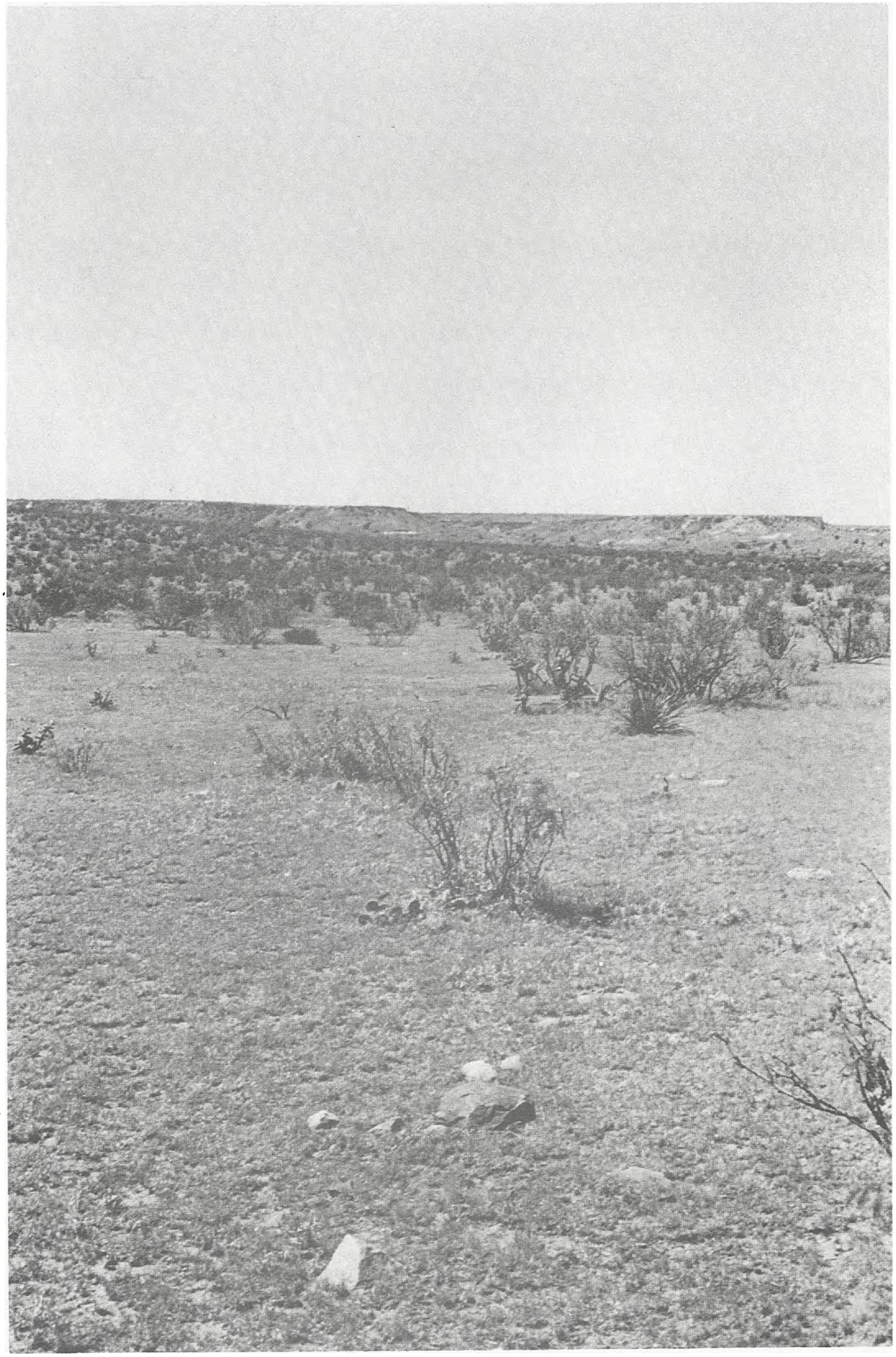


FIGURE 11
41 OL 29. Large corestone in the foreground.

FIGURE 12
41 OL 31. Exposed slab-lined pit.

FIGURE 13
41 OL 36. Hearth concentration in the foreground; 41 OL 39 in the background (arrow).

FIGURE 14

41 OL 42. Site surface with the Canadian riverbed in the background.

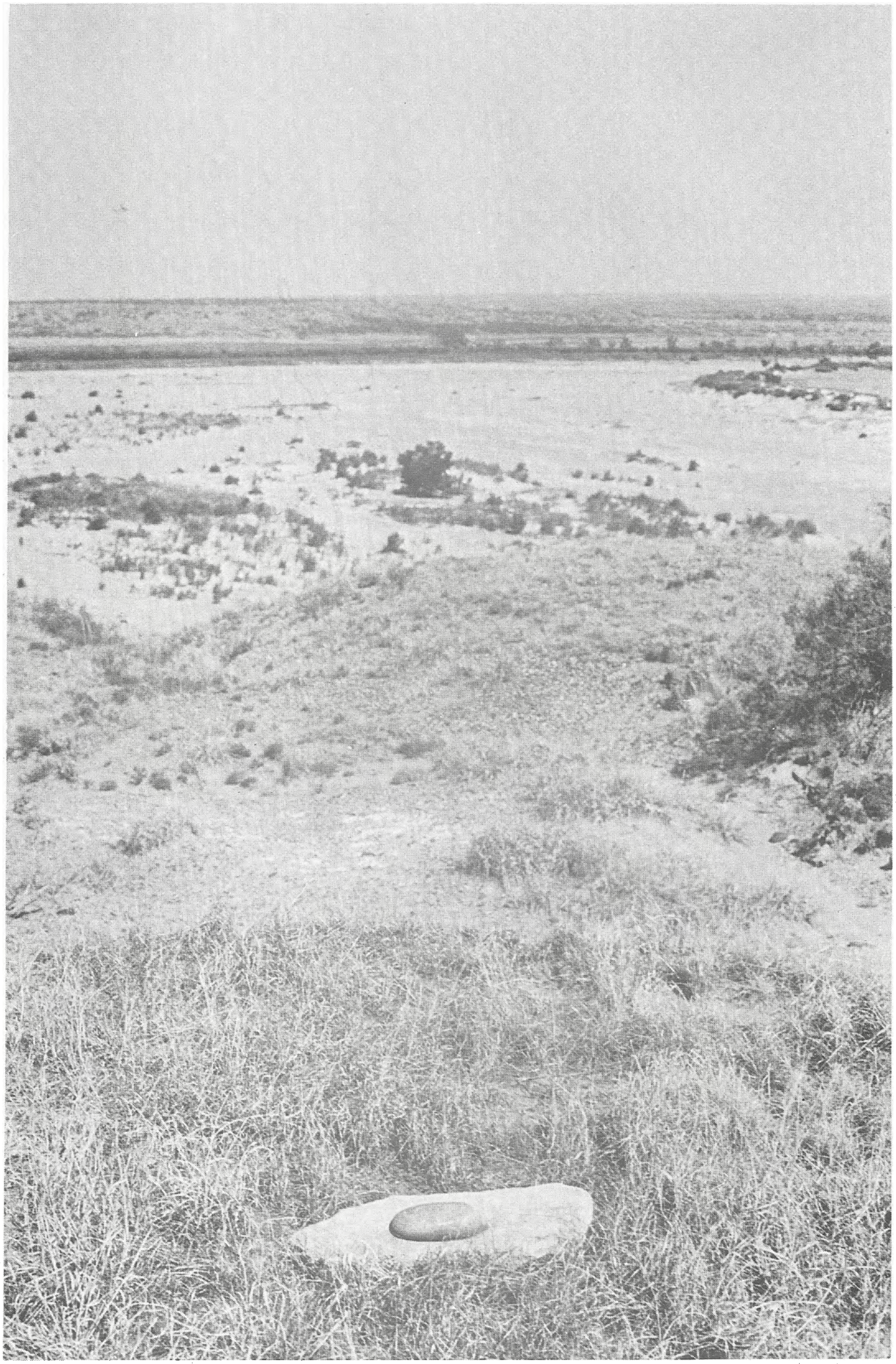


FIGURE 15
41 OL 44. Mano and metate as found by the authors; Canadian river bottoms in the background.

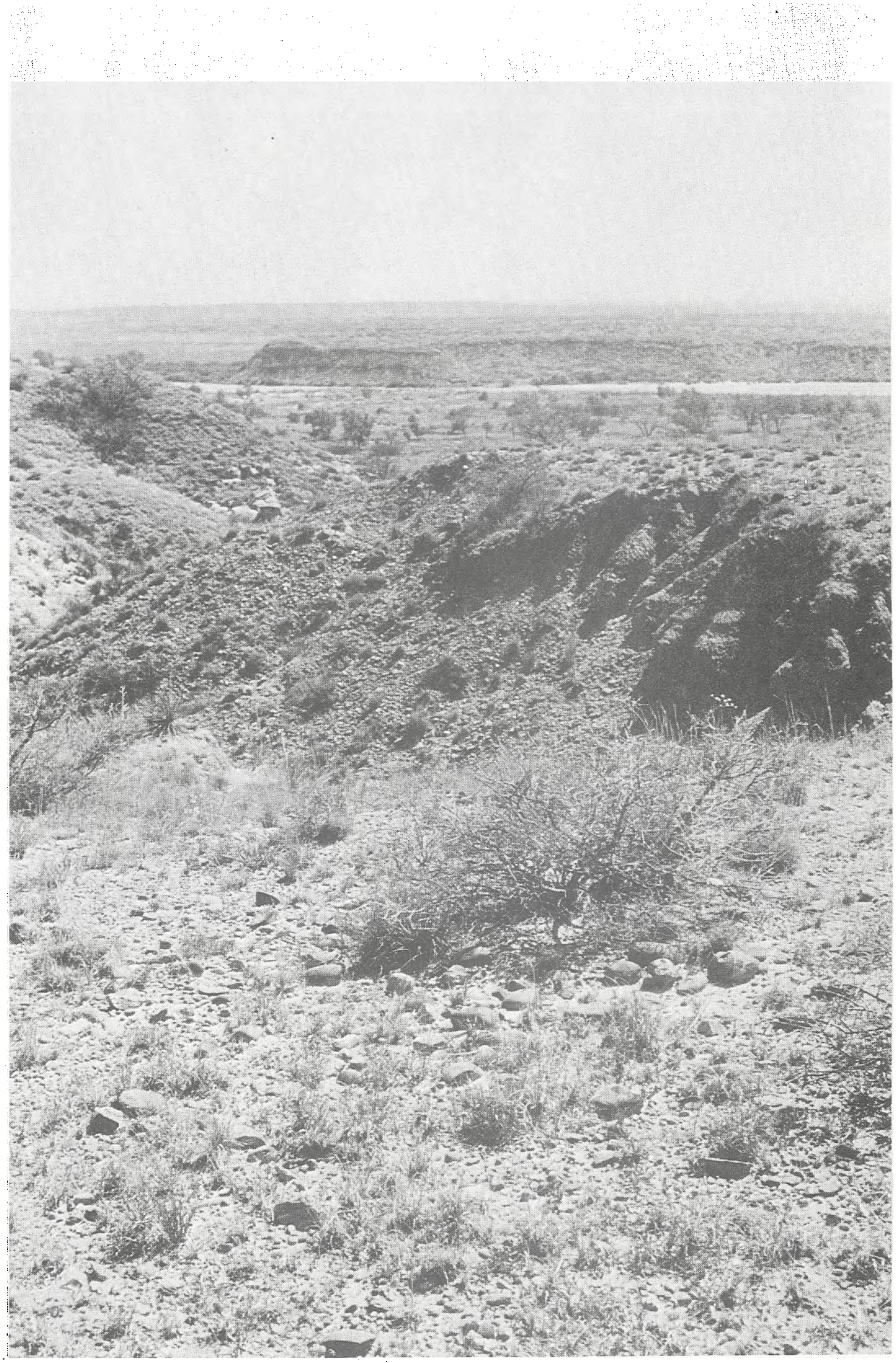


FIGURE 16
41 OL 46. Hearth concentration in foreground; Alamosa creekbed in the background.

FIGURE 17

41 OL 49. Cultural layer is barely below the ground surface to the right.

FIGURE 18

41 OL 50. 19th Century Mexican Sheepherders' Plaza

FIGURE 19

Thin bifaces

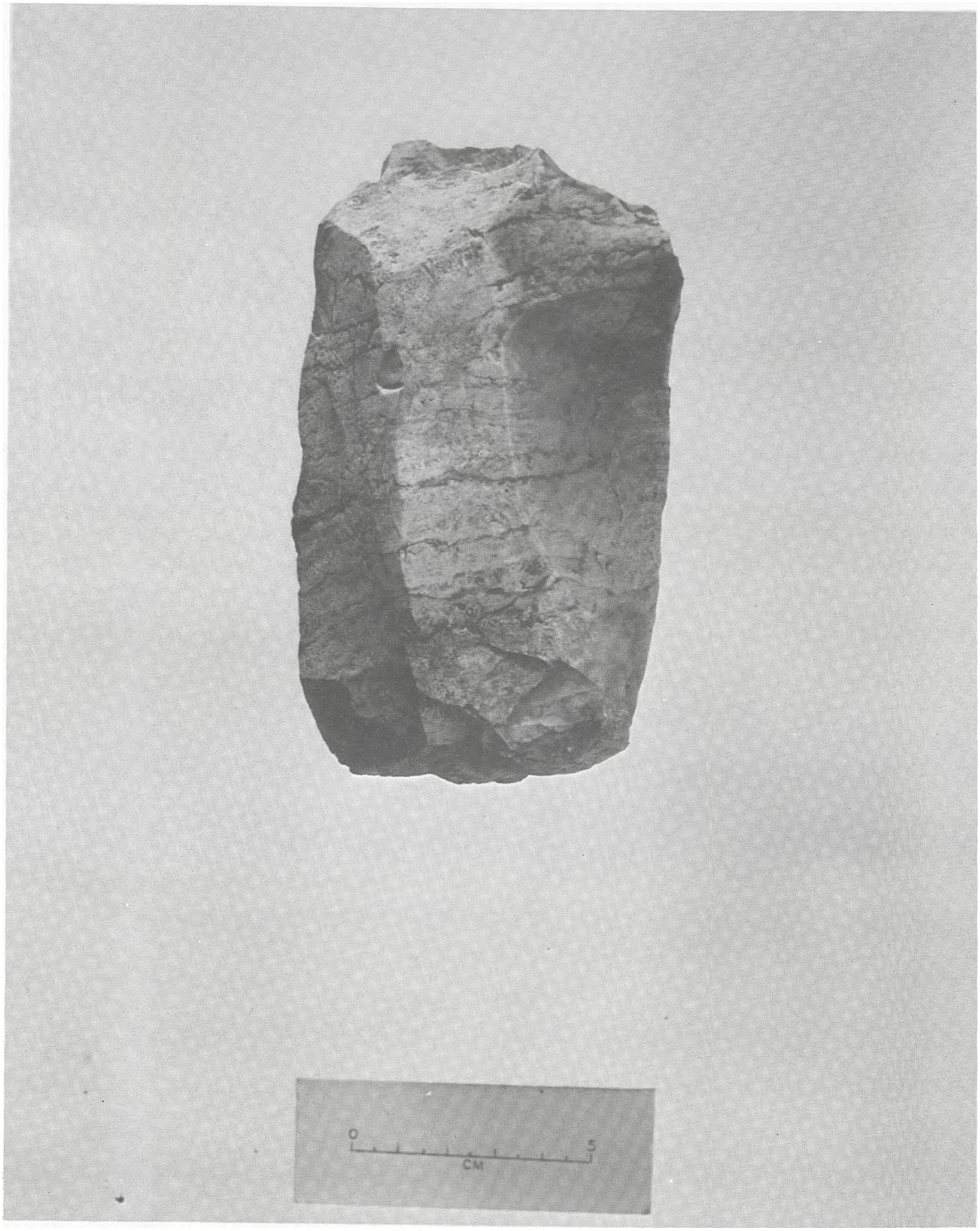


FIGURE 20

Alibates Dolomite Core

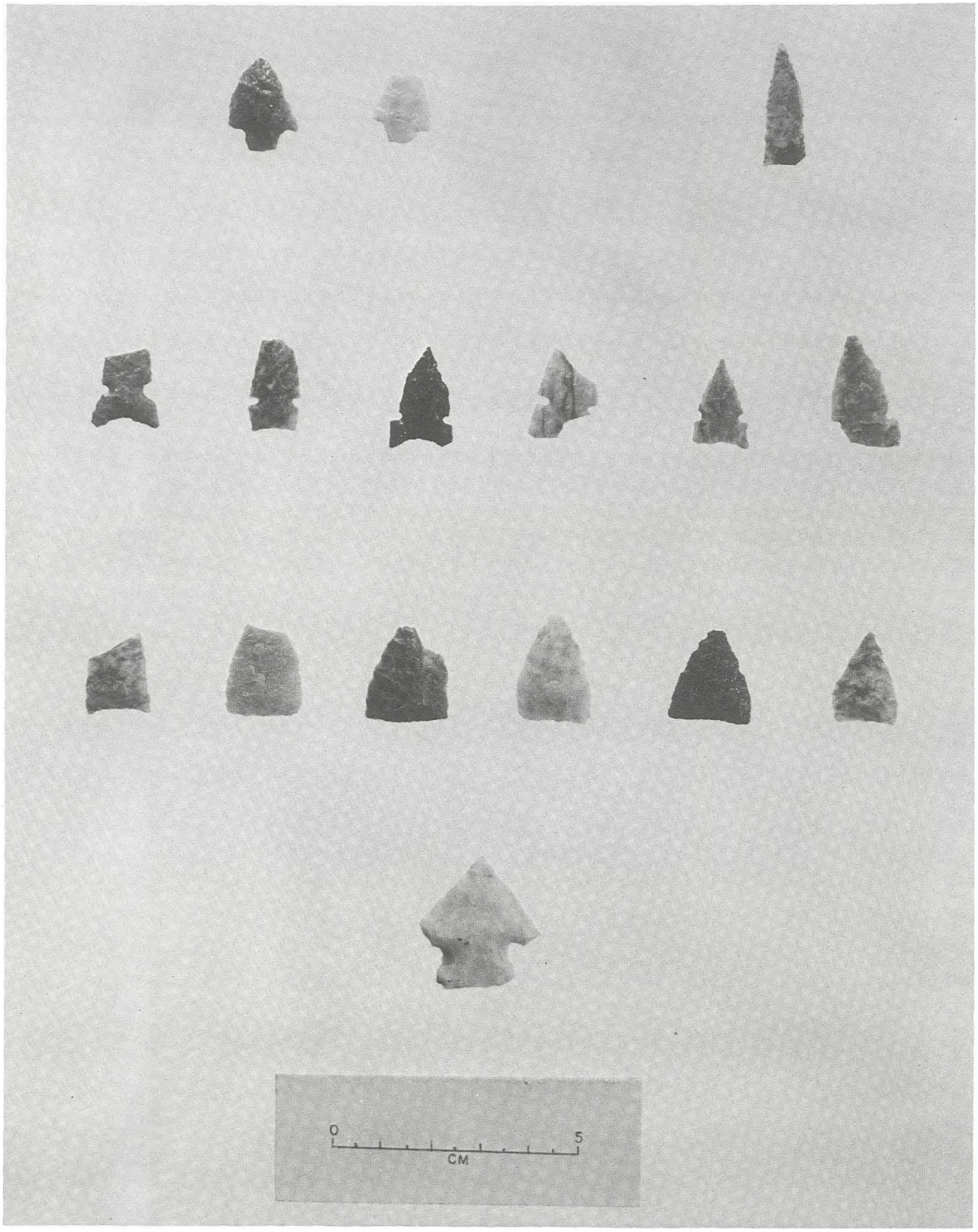


FIGURE 21
Representative Projectile Points: Bottom—Ellis; second row—Fresno; third row—Harrell; top, L to R—Alba-like (2), Maud-like.

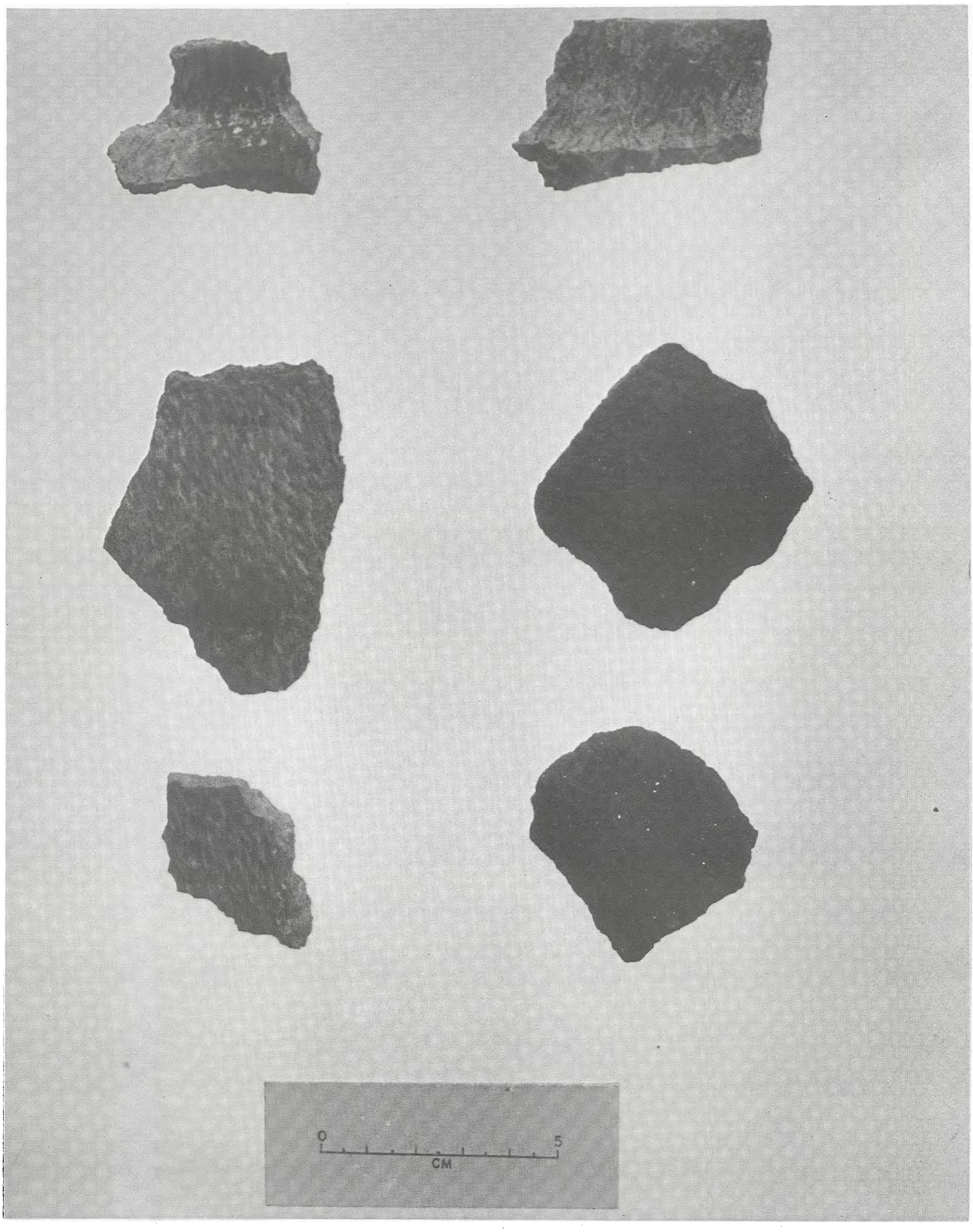


FIGURE 22

Borger Cordmark Pottery Sherds

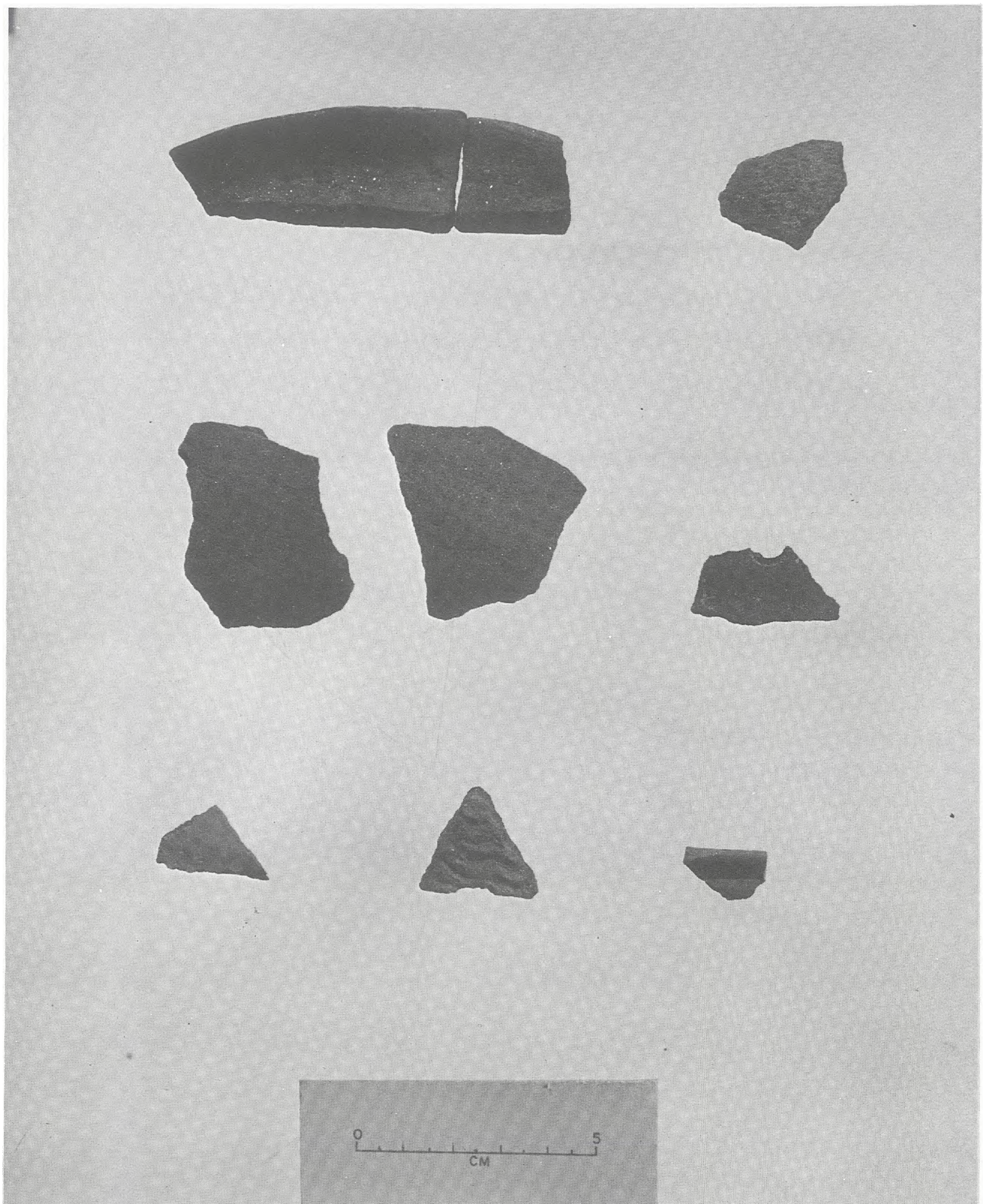


FIGURE 23
Non-Cordmarked and Trade Wares: Top row micaceous brownware; middle row, L to R–micaceous brownware (2) pyrite-tempered brownware; bottom row, L to R–micaceous brownware, wavy-line corrugated; glazeware.

N

MAPS TO ACCOMPANY

CANADIAN BREAKS

A Natural Area Survey

Part VII of VIII

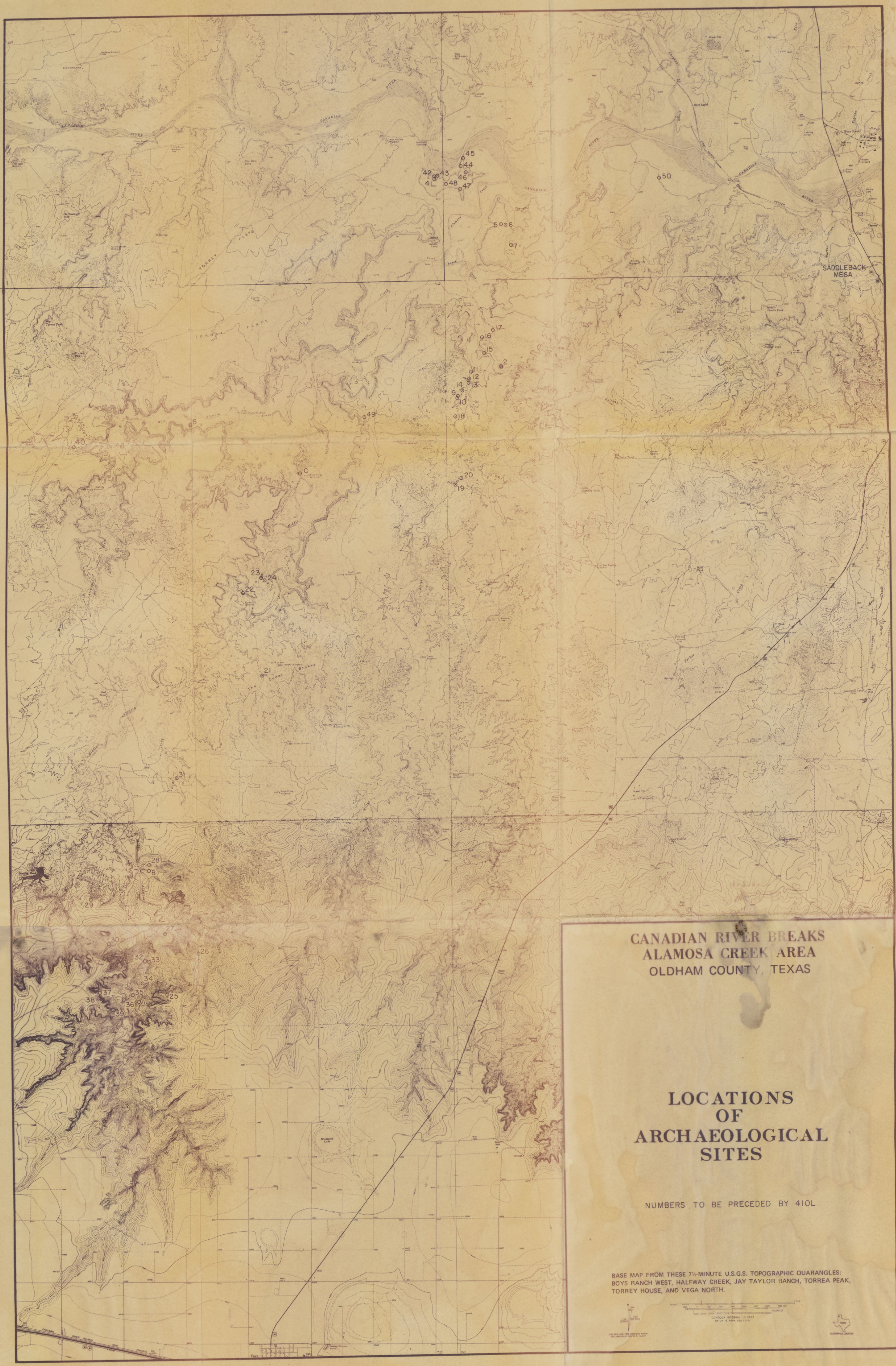
1. Locations of Archaeological Sites
2. Major Plant Associations

[redacted]

DIVISION OF NATURAL RESOURCES AND ENVIRONMENT

The University of Texas at Austin

1975



CANADIAN RIVER BREAKS
ALAMOSA CREEK AREA
OLDHAM COUNTY, TEXAS
LOCATIONS
OF
ARCHAEOLOGICAL
SITES
NUMBERS TO BE PRECEDED BY 41OL
BASE MAP FROM THESE 7½-MINUTE U.S.G.S. TOPOGRAPHIC QUARANGLES:
BOYS RANCH WEST, HALFWAY CREEK, JAY TAYLOR RANCH, TORREA PEAK,
TORREY HOUSE, AND VEGA NORTH.
CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL
SADDLEBACK MESA

CANADIAN RIVER BREAKS
ALAMOSA CREEK AREA
OLDHAM COUNTY, TEXAS
MAJOR PLANT ASSOCIATIONS
JUNIPER - GRASSLAND
SALT CEDAR
MESQUITE - GRASSLAND
BASE MAP FROM THESE 7½-MINUTE U.S.G.S. TOPOGRAPHIC QUARANGLES: BOYS RANCH WEST, HALFWAY CREEK, JAY TAYLOR RANCH, TORREA PEAK, TORREY HOUSE, AND VEGA NORTH
CONTOUR INTERVAL 10 FEET
DATUM IS MEAN SEA LEVEL
UTM GRID AND 1966 MAGNETIC NORTH DECLINATION AT CENTER OF SHEET
QUADRANGLE LOCATION
TEXAS
FIG 1
FIG 2
FIG 3
FIG 4
FIG 5
FIG 6
T1
T2
T3
T4