Guadalupe Sanchez de Carpenter
A.C. MacWilliams

CHAPTER 2.

Borderlands Environment, Past and Present

The major mountain ranges in the study area today were produced by Middle Miocene and younger extensional faulting. Faulting continued into the late Pleistocene as evidenced by fault scarps along the margins of the Animas, Hachita, and Playas Valleys. These long-term geologic events resulted in the present basin and range physiography of the Malpai Borderlands, as summarized by Hawley (1993).

The area is classified as Mexican Highland within the Basin and Range Province. Basins below 1,525 m (4,600 ft) form the bulk of the Chihuahuan Desert region in the Mexican Highland Section (Hawley 1993: 40). Broad intermontane basins often drain internally into playas. Integrated drainages exist only in the San Bernardino Valley, which drains into the Rio Yaqui system to the south, and in nearby areas such as the Gila River drainage system north of the Borderlands. Roughly north-south trending mountain ranges separate the basins. Low gradient bajadas extend several kilometers from mountains and their pediments toward basin centers. The few sizable drainages in the area form alluvial fans that also extend outward into basins. Much of the ground surface is covered with gravels.

Post-Pleistocene Environmental Change

There are several, sometimes competing, models for post-Pleistocene environmental change in the Borderlands region. Models are derived from geomorphological reconstructions of pluvial lake history, paleofaunal studies, palynology, and analyses of packrat (*Neotoma* sp.) middens. Climatic reconstructions from tree-ring data would be especially useful for archaeological studies; important new data encompassing much of the late prehistoric archaeological record for the Malpai Borderlands will soon be made available by Thomas Swetnam and his students.

Each approach to climatic reconstruction derives from a different body of information and provides a different perspective on change. Interpretations may be contradictory because of the spotty nature of databases, differing theoretical perspectives, and the lack of an integrated effort to reconstruct past environment. Furthermore, it may not be possible to relate climatic reconstructions directly to potential behavioral responses reflected in the archaeological records. The tree-ring record is a good example. Reconstructions are based on the Palmer Drought Severity Index (PDSI) for June because tree ring width is highly correlated with the severity of local spring drought. However, as discussed in the section on contemporary climate in this chapter, spring moisture was much less critical to prehistoric farmers dependent on summer rains, which show less variability from year to year.

Geomorphological Reconstructions of Pluvial Lakes

Three post-Pleistocene pluvial lakes existed in the Borderlands study area. These are Lake Hachita to the west of the Little Hachet Mountains, Lake Playas in the middle of the Playas Valley, and Lake Cloverdale

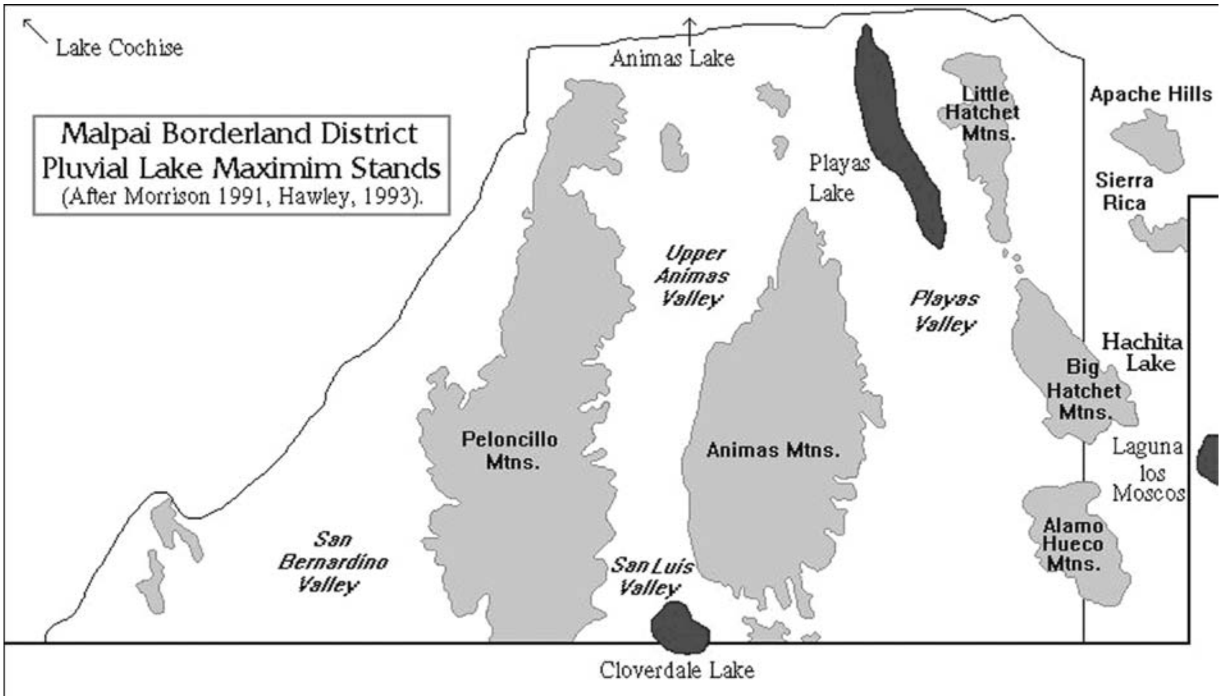

Figure 2.1. Maximal extent of post-Pleistocene pluvial lakes in the study area.

(San Luis Lake) in the San Luis Valley. Two main shore embankments have been identified around Lake Playas (Morrison 1991: 365). Fleischhauer and Stone (1982) state that this lake covered nearly 65 km^2 (25 square miles) until about 4500 B.P., reappeared briefly about 3000 B.P., and again at 1000 B.P. High pluvial lake stands in the study area are shown in figure 2.1.

Reconstructions of two lake histories north of the Borderlands deserve mention. High-stands at Lake Cochise (Wilcox Playa) have been radiocarbon dated to 13,500 and 8900 B.P., and it has been an ephemeral playa since mid-Holocene times (Waters 1986; Waters and Woosley 1990: 163). Lake Animas in the lower Animas Valley is believed by Fleischhauer and Stone (1982: 9) to have had a similar history. As with Lake Playas, shoreline age is estimated by comparison of shoreline soils with soils of known age in other basins.

Implications of Faunal Remains for Pluvial Lake History

A 12,000 year stratified sequence of vertebrate fauna from Howell's Ridge Cave in the Little Hachet Mountains in the northeastern corner of the Borderlands study area helps place the pluvial lake reconstructions in perspective (Van Devender 1995: 89–92; Van Devender and Worthington 1977). The cave is a vertical chimney in a steep limestone ridge on the dry lake bed of the Playas Valley. Thousands of bones and teeth of small vertebrates were continuously deposited in owl (Stragiformes) and hawk (Accipitridae) pellets during the entire cave sequence. Riparian fauna including Tiger salamander (*Ambystoma tigrinum*) and Colorado chum (*Gila cf. robusta*) indicate the playa contained perennial water from 12,000 to 4000 B.P., once again about 3000 B.P., and finally about 1000 B.P., supporting the geomorphological reconstruction by Fleishhauer and Stone (1982: 19).

Heavily disturbed desert grassland in portions of many Borderlands valley floors is dominated by creosote-bush (*Larrea tridentate*), salt-bush (*Atriplex* sp.), honey mesquite (*Prosopis juliflora*), yucca (*Yucca* sp.), and tar-bush (*Flourensia cernua*). These shrubs appear to have been restricted to drainages in a grassy landscape prior to 1890 (Van Devender 1995: 90). Quantitative analyses of reptile bones from Howell's Ridge Cave document similar increases in shrubs and succulents at 3900, 2500, and 990 B.P. (Van Devender and Worthington 1977).

Packrat Midden Studies

Packrat midden records from a variety of Chihuahuan Desert locations to the north and east of the study area provide evidence for the sequence of desert grassland development (Van Devender 1990; summarized in Van Devender 1995: 88–95; Van Devender and others 1987). Vegetation of the lower mountain slopes shifted from a pinyon-juniper woodland to oak-juniper woodland about

11,000 years ago and then to desert grassland about 8500 years ago. Honey mesquite dispersed into the northern Chihuahuan Desert about 9000 years ago and widespread desertscrub—notably creosote-bush and ocotillo (*Fouquieria splendens*)—appeared in these grasslands about 4500 years ago.

These data appear to contradict a mid-Holocene Altithermal drought as postulated by Antevs (1955) on the basis of geological studies in the northern Great Basin. Instead of an Altithermal drought from 8500 to 4000 B.P., Van Devender (1995: 89) suggests that the summer monsoons and desert grasslands were better developed than they are today, and in fact, attained their greatest area. This reconstruction also fits the faunal evidence from Howell's Ridge Cave.

Palynological Reconstructions

On the basis of pollen sequences from early archaeological sites at Double Adobe, Lehner, and Murray Springs just to the west of the study area, Martin (1963a,b) also argued for a wetter mid-Holocene and, in fact, for the establishment of Chihuahuan Desert grasslands in southeastern Arizona by the terminal Pleistocene. This reconstruction based on records from basin floors indicates the presence of grasslands several thousand years earlier than Van Devender's packrat midden interpretation. That middens do not directly monitor vegetation at such low elevation settings may be a factor in this discrepancy.

A study by Davis and others (2001) provides Holocene paleoecological data within the Borderlands. He reports cores from seven cienegas; six are adjacent to the study area and a seventh is from the Animas Creek Cienega on the Gray Ranch. Here, the basal ^{14}C date is about 7000 B.P. Corn (*Zea mays*) and agricultural weed pollen were recovered in a level dating approximately to 3400 B.P. (Davis and others 2001: 408).

A mid-Holocene increase in grass pollen is apparent. Davis and colleagues (2001) interpret this increase in grass frequencies, deteriorated pollen, and high fungal spore counts to indicate increased desiccation between 7000 and 5000 B.P. After 5000 B.P., there is a gradual increase in aquatic plant pollen, and the same researchers suggest standing water was present in the Animas Creek Cienega between 3700 and 1900 B.P. Based on all seven cienegas, they summarize an expansion of aquatic vegetation at 3000, 1800, and 500 to 300 B.P.

Historic increase in wetland indicators coincides with a decrease in microscopic charcoal (Davis and others 2001). Older sediments contain less organic material and fewer fungal spores, from which he concludes that annual prehistoric burning probably occurred. Before the historic period, frequent burning by indigenous peoples prevented woody plants and bulrush (*Scirpus* sp.) from reaching maturity. Pollen profiles also document prehistoric disturbance of cienega environments through the presence of corn and agricultural weeds.

Historical Changes to the Grassland

As a result of historic land use, Southwest grasslands have experienced rapid and extensive modification. The native grass growth has declined, and trees and woody shrubs, such as mesquite (*Prosopis* sp.), acacia (*Acacia* sp.), burro-weed (*Aplopappus tenuisecta*), snakeweed (*Gutierrezia* sp.), and one-seed juniper (*Juniperus monosperma*), have increased, replacing the grassland. Bahre (1991) believes that the areal extent of grasslands has not changed significantly, but that grass has been replaced by the scrubby trees and shrubs since the 1870s. The mechanisms by which this increase has taken place are not well understood, but the increase of the woody component is attributed to a combination of overgrazing and wildfire suppression. Other factors that have contributed to changes in the grassland include agricultural clearing, urban and rural development, range management policies, and the introduction of exotic plant species (Bahre 1991; Brown 1950; Brown 1994b; Cornelius 1988; Gould 1951; Hennessy and others 1983; Humphrey 1958, 1985). All of these factors affect the potential human resource distributions between historic and prehistoric times.

Precipitation and Growing Season

The Malpai Borderlands has a continental desert climate with distinct seasons. Valley locations receive about 250 mm (9.75 inches) of annual precipitation (Gabin and Lesperance n.d.; Sellers and others 1985; Tuan and others 1969). Over 60 percent of the annual rainfall occurs in the summer (fig 2.2). A marked spring drought during March, April, May, and June is characteristic. Wind intensity is also greatest during the spring months, increasing evapotranspiration. These high westerly winds spur spring dust storms, particularly in the western portion of the study area.

Precipitation totals for the 12 study area weather stations are strongly correlated with elevation (Gabin and Lesperance n.d.; Tuan and others 1969). There is also a marked reduction in precipitation from south to north as lesser mountain masses stimulate less orographic rainfall. Drawing upon higher precipitation in the mountains, drainages with upland watersheds carry the majority of water available to farmers. The spring drought is sufficiently pronounced, and snowmelt in moderate-sized

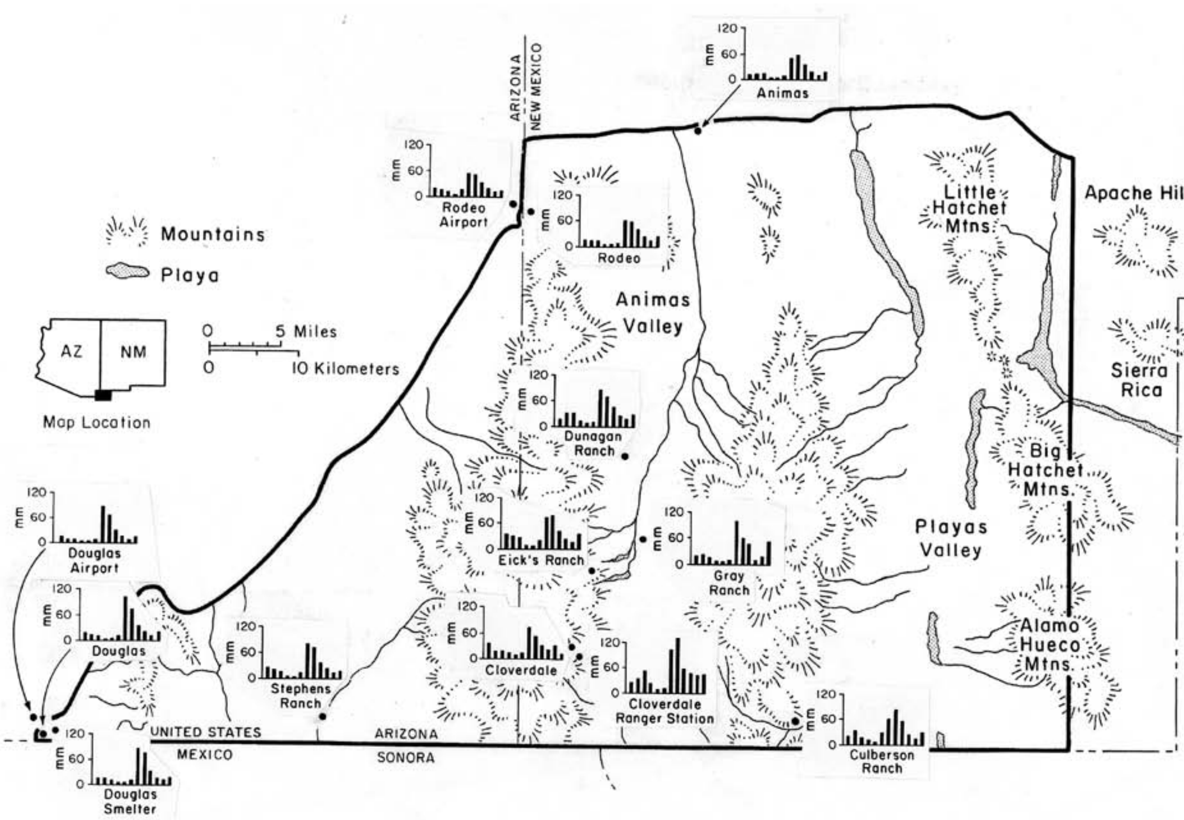

Figure 2.2. Annual distribution of rainfall for weather stations in the study area.

mountain masses is sufficiently limited that few drainages from the uplands could have supported spring crops. Although there is high year-to-year variability in annual rainfall, the amount and timing of summer storms is relatively predictable (Shaw 1993).

Summertime temperatures often exceed 40 °C (90 °F) and wintertime lows are often below zero. Although average growing season length is 215 days in some lower valley locations, temperatures as well as the seasonality of precipitation restrict the effective length for agriculture. In many parts of the study area, cold air drainage is pronounced (Mueller 1988: 28). A significant chance for killing frosts occurs relatively late in the spring and early in the fall. For instance, there is a 5 percent probability of a frost until the third week of May near Animas and a 5 percent probability again by early October. This interval leaves only 140 days where there is less than a one in 20 chance for a crop-killing freeze.

Low winter rainfall, an intense spring drought, and a frost threat as late as mid-May suggest that crops generally were not planted in the study area until after the onset of the summer monsoon season in July. Even so, planting in response to the arrival of summer rains was the previous pattern of Tohono O'odham farmers who depended on summer-dominant rainfall and hydrological sources similar to those available in the Borderlands (Bryan 1929; Castetter and Bell 1942; Nabhan 1983, 1986). Early frost or a delay in summer thunderstorms must have posed risks to successful harvests. Elevational situations above the limits of cold air inversion may have presented localized opportunities for early plantings where high water tables or springs permitted irrigation.

Borderlands Biotic Communities

Following the classification system of Brown and others (1979; Brown 1994a), several biotic communities dominate the Borderlands study area. Semidesert grassland is present in the San Bernardino Valley, in the lower Animas Valley, and throughout most of the Playas Valley. Plains grassland is concentrated in the upper Animas Valley. Chihuahuan desertscrub occurs as patches in the northeastern sector of the study area, and in the lower section of the San Bernardino Valley. Riparian vegetation is found along drainages. In some cases in closed basins, playas often display sparse, salt-tolerant species. Patches of Madrean evergreen woodland occur in the mountains above approximately 1,515 m (5,000 ft). Petran montane conifer forest occurs only at the highest elevations of Animas Peak, which rises to 2,519 m (8,519 ft) above mean sea level (figs 2.3, 2.4, and 2.5).

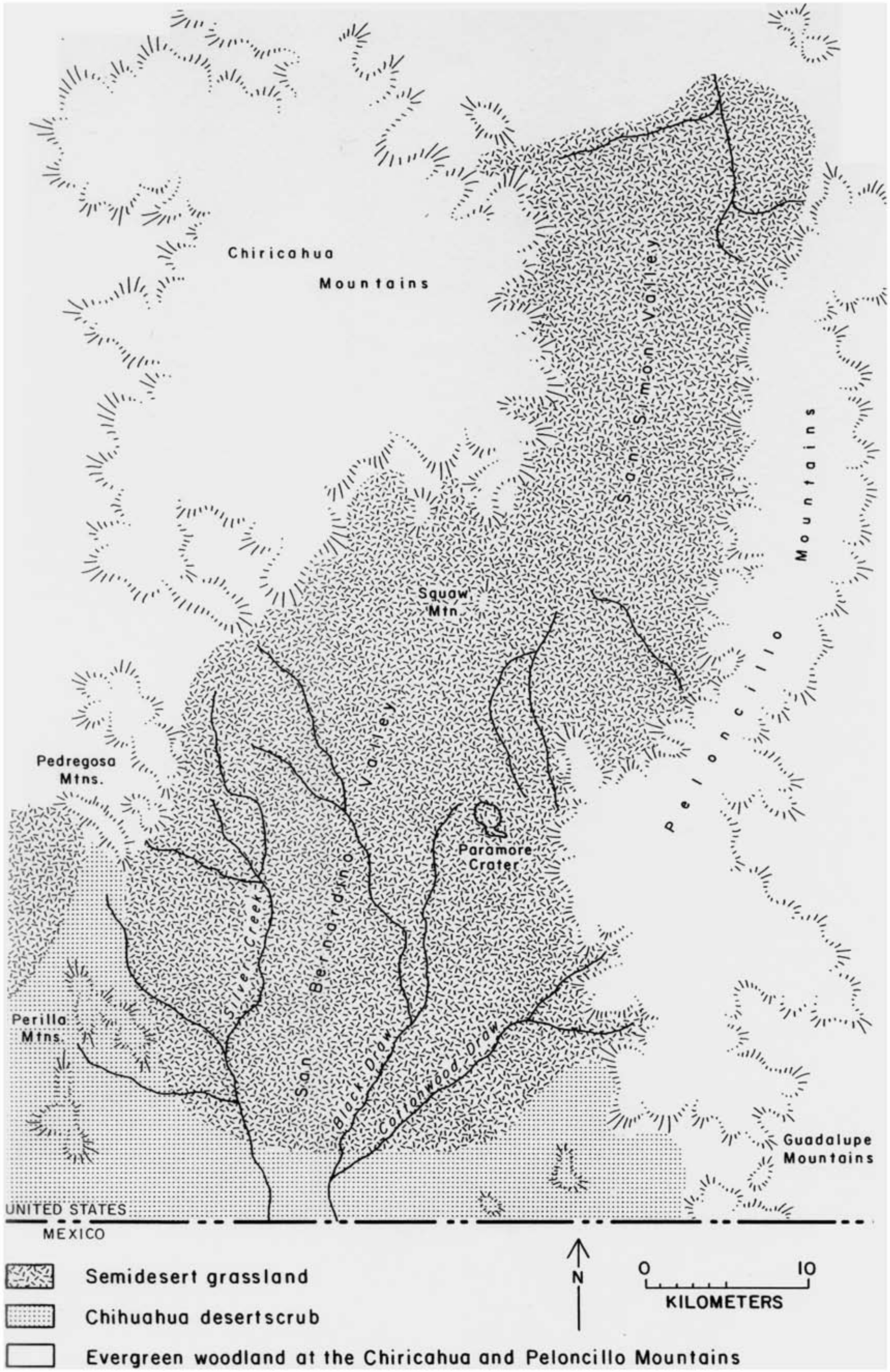

Figure 2.3. Vegetation map of the San Bernardino Valley.

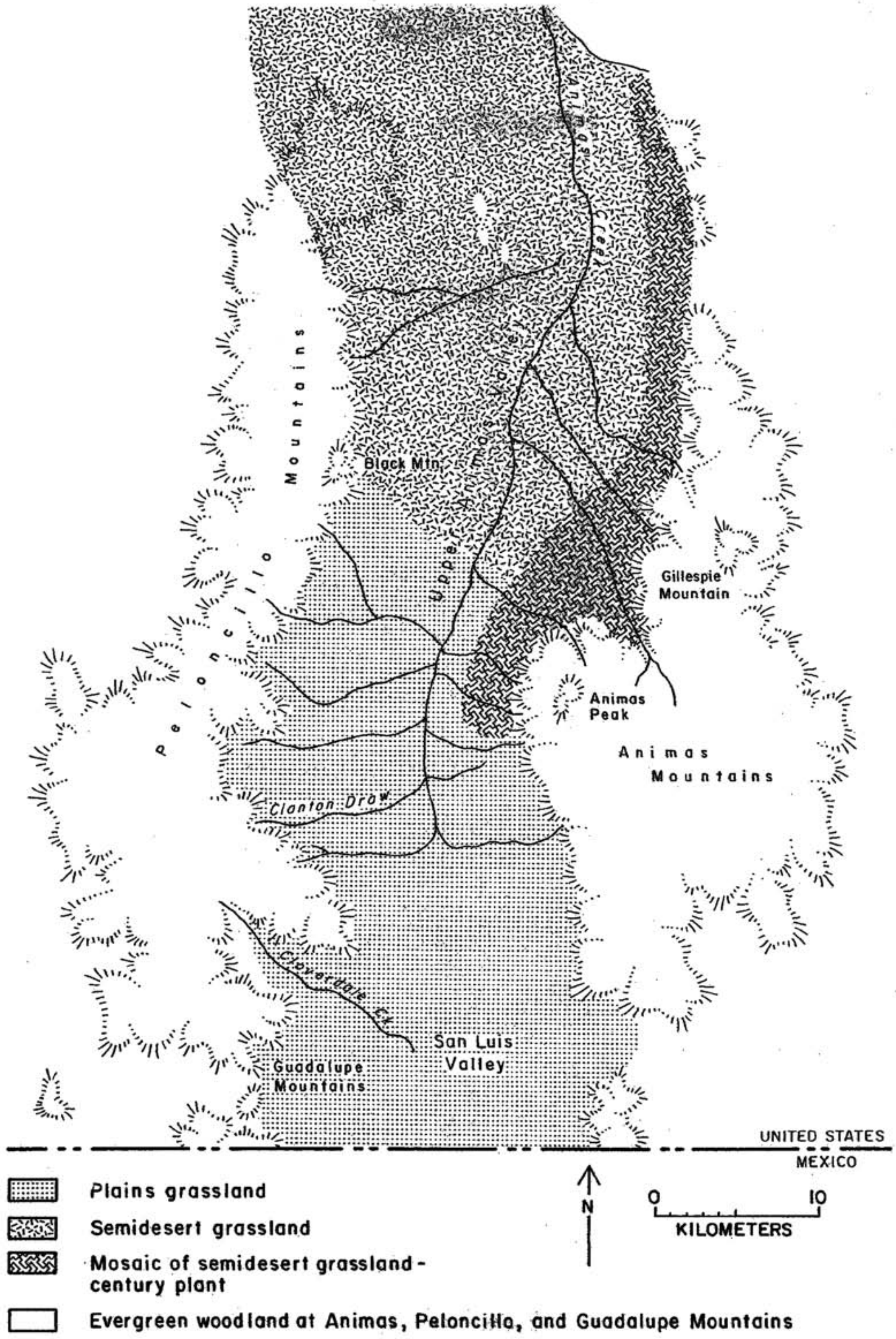

Figure 2.4. Vegetation map of the Animas and San Luis Valleys.

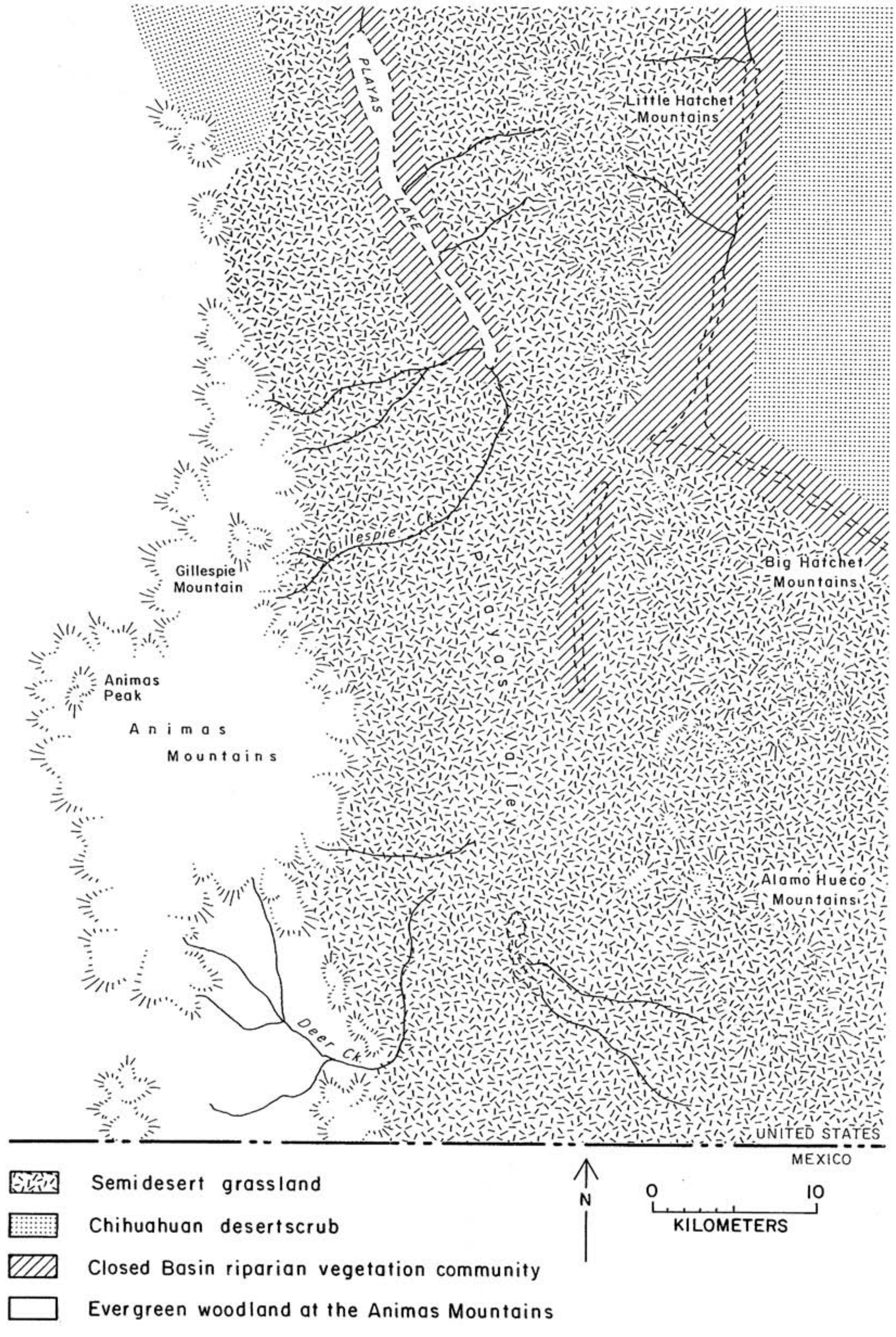

Figure 2.5. Vegetation map of the Playas Valley.

Grassland Biotic Community

Semidesert Grassland—The semidesert grassland is the most widespread Borderlands biome on the basin floors and in the lower elevations of the mountain ranges. The semidesert grassland is a transitional zone between plains grassland and Chihuahuan desertscrub and shares some of the floral and faunal constituents of both. It is nonetheless a distinctive and separate biome (Brown 1994b: 126–127). According to Dick-Peddie (1993:107), much of the desert grassland and desertscrub land in New Mexico occupy areas that were previously grassland. It is difficult to determine recent successional-disturbed desert grassland invaded by woody shrubs from original desert grassland (Brown 1994b: 127).

In general, the semidesert grassland covers gentle and moderate slopes of coarse sandy soils derived from extrusive rocks (Cornelius 1988: 1). Where it makes contact with the Chihuahuan desertscrub, it creates a complex and alternating landscape pattern over many miles. At its upper elevations, this biome usually makes contact with evergreen woodland or plains grassland. Within Chihuahuan desertscrub, semidesert grassland occurs in isolated pockets as the vegetation of enclosed-drainage playas (Bahre 1991: 23; Brown 1994b: 123).

Formerly, the grasses were perennials with reproduction principally from seed. Heavy grazing has reduced these grasses and increased low-growing sod grasses such as Mesquite grass (*Panicum obtusum*). The semidesert grassland is a perennial grass-scrub dominated landscape. Because the rainy seasons are short and somewhat uncertain, grasses and shrubs tend to grow and set seed rapidly, with most of the growth taking place during August. The vegetation ranges from pure grass landscapes to any combination of shrub, trees, and cactus. The community physiognomy of semidesert grassland is one of a landscape broken up by the uneven stature of large, diverse, and well-spaced scrub species (Bourgeron and others 1995: 20; Brown 1994b: 127; Humphrey 1958: 195). There are vast areas where climax grasses have been much reduced by competition with a wide variety of shrub, small tree, and cactus life forms.

Shrubs and small trees are locally important. In general, with the exception of mesquite and some juniper (*Juniperus* sp.) at the higher elevations, trees are restricted to riparian habitats. Stem and leaf succulents, including sotol (*Dasylirion Wheeleri*), agave (*Agave* sp.), bear-grass (*Nolina* sp.), and yucca species, are particularly well represented and characteristic of semidesert grassland in some places. Palmilla (*Yucca elata*) is often a particularly visible plant in the landscape (Brown 1994b: 127). In the mid-elevation western slope foothills of the Animas Mountains, a semidesert grassland with abundant agave forms a grass-century plant mosaic (Bourgeron and others 1995: 19).

Plains Grassland—The plains grassland biome within the study area is present in the upper Animas Valley and the San Luis Valley. These areas of plains grassland represent the southwesternmost extension of the North American Prairie. The primary upper grassland contact is with woodland; the lower elevation contact is with semidesert grassland (Brown 1994b: 115; Dick-Peddie 1993). Almost all the plains grassland is composed of short-grassland communities. These communities were significantly altered by cattle grazing and fire suppression, resulting in the current uncluttered perennial grass-dominant landscape (Brown 1994b).

The principal grass constituents are perennial sod-forming species of which blue grama (*Bouteloua gracilis*) and other gramas (*Bouteloua* sp.) are usually important. Shrubs such as salt-bush, Cholla (*Opuntia* sp.), soap-weed (*Yucca* sp.), rabbit-brush (*Chrysothammus* sp.), and snakeweed may be scattered throughout the landscape. The snakeweeds now form extensive disclimax communities over many miles of former grassland. Junipers also have invaded large acreages (Brown 1994b: 119). Cacti are locally represented in patches of plains grassland of the study area.

The San Luis Valley located south of the Animas Valley is bisected by the international border. Much of its area was encompassed by a former playa, and its unique vegetation is Great Plains grassland composed. In eastern New Mexico, dry and irrigated farming have greatly reduced the amount of plains grassland. The vegetation is widely in a state of succession shifting toward desert grassland (Dick-Peddie 1993: 104).

Chihuahuan Desertscrub Biotic Community

Areas of Chihuahuan desertscrub are covered with a low scrub vegetation. The vegetation ranges from a creosote-bush-dominated scrub on gently sloping plains to a more species-rich mixed desertscrub on upland rocky bajadas. The most common plant association of the region is creosote scrub. This association occurs on extensive areas of intermontane arid alluvial or outwash plains and bajadas that are dry most of the year. Creosote-bush is often quantitatively or at least visually dominant. These areas may have either sandy or, commonly, clayish soils that are generally of uniform texture. The diversity of plants increases in deeper soils and along minor drainage where tar-bush, acacia, mesquite, and catclaw (*Acacia Greggii)* frequently grow. The only other desertscrub communities that occur in a widespread area are salt-bush on fine-grained soils of valley bottoms and open stands of shrub mesquite on sandy, wind-eroded hummocks (Brown 1994c: 173). Outcrops, arroyos, bajadas, and foothill habitats are populated by a rich aggregate of shrubs and frequently succulents. Common plants include yuccas, sotols, agaves, and bear-grass.

In southern New Mexico and southeastern Arizona are large areas that supported grassland prior to the second half of the last century. Today these areas are occupied by Chihuahuan desertscrub vegetation. This rapid vegetation shift appears to be the result of large concentrations of domestic livestock of the late 1800s. It is difficult to tell whether present desertscrub areas are occupied by original or recently established Chihuahuan desertscrub.

Madrean Evergreen Woodland Biotic Community

This mild winter-wet summer woodland in southeastern Arizona and southwestern New Mexico is a northward extension of similar vegetation in the Sierra Madre of Mexico. The arboreal species of the evergreen woodland are locally varied combinations of oak (*Quercus* sp.), juniper, and pines (*Pinus* sp.) with lower elevation species grading upward into pine species of higher elevations. Emory oak (*Quercus Emoryi*), gray oak (*Quercus grisea*), alligator juniper (*Juniperus Deppeana*), border pinyon (*pinus discolor*), and Chihuahua pine (*Pinus chihuahuana*) are important species within the Borderlands (Brown 1994d: 59; Bourgeron and others 1995).

The mountains of the Borderlands region are so-called sky-islands of woodland vegetation surrounded by grassland and desertscrub at the lower elevations. Many of the cacti and leaf succulents of the semidesert grassland extend well up into the Madrean evergreen woodland. Interior chaparral species can also be present and are especially prevalent in thin eroded soils and on limestone (Brown 1994d: 63).

Petran Montane Conifer Forest

Montane conifer forest is confined to an isolated area of the highest Borderlands peaks in the Animas Mountains. Ponderosa pine (*Pinus ponderosa*), Douglas-fir (*Pseudotsuga taxifolia*), and aspen (*Populus* sp.) are prominent trees in these locales (Bourgeron and others 1995). Aspen tends to occur in disturbed and open habitats among other forest vegetation types.

Riparian Biotic Community

Riparian communities in southeastern Arizona and southwestern New Mexico cross-cut the entire range of vegetation zones. The communities are composed of unique riparian species as well as species that are common elsewhere. Riparian vegetation forms corridors of highly diverse habitats that are attractive to animals (Dick-Peddie 1993: 145, 147; Minckley and Brown 1994; Szaro 1989: 70); the longer the stream and the greater the elevation gradient, the more diverse the overall pattern (Szaro 1989: 87). In the Borderlands, riparian vegetation is restricted to drainage systems, most of which sustain water only occasionally, and the enclosed basins, or playas.

In the natural vegetation of the Borderlands region, cottonwood (*Pupulus* sp.) and willow (*Salix* sp.) commonly share dominance among riparian trees of low to medium elevations (Dick-Peddie 1993: 151). Other trees that are locally important in the better watered riparian communities of the Borderlands include oak, walnut (*Juglans* sp.), sycamore (*Platanus* sp.), and ash (*Fraxinus* sp.) (Szaro 1989). Floodplains have been heavily affected by historic activities over the past 150 years. One of the most obvious manifestations is the rapid and extensive invasion of alien shrub or tree species.

Internally drained depressions with watersheds of diverse size support relatively mesic habitats. The vegetation also could be included under grassland or scrub vegetation but occurs in response to the conditions of a drainage system. The typical shrubs of the closed basins are salt-bush, and occasionally wolfberry (*Lycium* sp.) occurs as a codominant; ground cover is sparse, often with clumps of grass (Dick-Peddie 1993: 153; Swanson and others 1988). Higher saline soils not subject to flooding may support an extensive grassland of specialized species. Shrubs and succulents are scattered around the edges of the playas on low Pleistocene beach ridges.

Gray Ranch Vegetation Study

An ecological inventory was performed for the Gray Ranch within the Borderlands study area (Bourgeron and others 1995). The ranch is a 130,000-ha (320,000-acre) cattle operation that includes a portion of the upper Animas Valley, the southern half of the Animas Mountains including Animas Peak, and a portion of the Playas Valley, incorporating approximately 35 percent of the study area. Vegetation patterns representative of the Borderlands region as a whole are represented. Bourgeron and others (1995) carried out the inventory using the Western Regional Vegetation Classification System (Bourgeron and Engelking n.d.). Their findings are summarized in table 2.1. This study is significant for its systematic observations of study area plant communities that refine more general descriptions of regional patterns.

Table 2.1. Vegetation classification (alliance level) at the Gray Ranch and adjacent ecoregion.[a]

Evergreen needle-leaved forest with conical crowns	
	Pseudotsuga menziesii alliance (Douglas fir)
Cold-deciduous alluvial forest	
	Platanus wrightii alliance (Arizona sycamore)
Evergreen coniferous woodlands with rounded crowns	
	Juniperus deppeana alliance (Alligator bark juniper)
	Pinus dicolor alliance
	Pinus engelmannii alliance (Apache pine)
	Pinus ponderosa alliance (ponderosa pine)
Cold-deciduous alluvial woodland	
	Populus fremontii alliance (Fremont cottonwood)
Evergreen broad-leaved shrublands	
	Arctostaphylos pungens alliance (point-leaf manzanita)
	Quercus arizonica-Quercus grisea alliance (Arizona white oak-gray oak)
	Quercus emoryi alliance (emory oak)
	Quercus toumeyi alliance (Toumey oak)
Temperate deciduous shrublands	
	Cercocarpus montanus alliance (mountain mahogany)
Deciduous subdesert scrublands without succulents	
	Rhus microphylla alliance (littleleaf sumac)
Deciduous subdesert scrublands with succulents	
	Fouquieria splendens alliance (ocotillo)
	Prosopis glandulosa alliance (honey mesquite)
Mid-grass steppe with shrubs (shrub canopy cover is 11 to 25 percent)	
	Cercocarpus Montanus alliance (mountain mahogany)
	Quercus toumeyi alliance (Toumey oak)
Mid-grass steppe without woody plants (tree or shrub canopy cover is 0 to 10 percent)	
	Bouteloua curtipendula alliance (sideoats grama grass)
	Hilaria mutica alliance (tobosa grass)
	Munhlenbergia emersleyi alliance (bush muhly grass)
	Panicum bulbosum alliance (panic grass)
	Panicum obtusum alliance (vine mesquite grass)
	Sporobolus flexuoses alliance (Sacaton grass)
	Sporobolus wrightii alliance (giant Sacaton grass)
Short-grass steppe without woody plants (tree or shrub canopy cover is 0 to 10 percent)	
	Bouteloua gracilis alliance (blue grama grass)
	Bouteloua eriopoda alliance (black grama grass)
	Bouteloua hirsuta alliance (hairy grama grass)

[a]Modified from Bourgeron and others 1995: 51–55.

Soil Types

In semiarid and arid regions, soil variation is correlated with slope and topographic position; these variables are related to topographic gradients, nutrition rating, and fertility (Bourgeron and others 1995). In southern Arizona, soils that support grasses usually contained a larger percentage of clay (25 to 50 percent), and have a higher percent available moisture (11 percent) than soils of shrub communities. Shrubs, and particularly creosotebush, are most abundant on sites where shallow, sandy soils with low available moisture, caliche hardpan, or erosion pavement result in relatively unfavorable moisture for the growth of other species (Johnson 1957: 39).

Soil Types of the San Bernardino Valley

Because soil surveys conform to state boundaries, the soil classifications and descriptions for the San Bernardino Valley are different from those for the Borderlands valleys in New Mexico. The middle section of the San Bernardino Valley is characterized by a Bonita-Graham-Rimrock Association. These are shallow-to-deep, fine-textured soils on plains and hills. This association consists of well-drained soils formed in colluvium and alluvium weathered from basalt, andesite, ash-flow tuffs, cinder, and related volcanic rocks. Riparian zones are prominent in this valley because there are three significant perennial drainages that cross the valley and contain alluvial soils conducive to farming. Silver Creek flows from the Pedregosa Mountains, Black Draw originates in the Chiricahua Mountains, and Cottonwood Draw from the Peloncillo Mountains (Hendricks 1985: 108).

The west slopes of the Peloncillo Mountains, including the piedmont, are represented by Lithic torriorthents-Lithic Haplustolls-Rock Outcrop Association. The soils are shallow, cobbly and gravelly, with generally steep slopes and rocky outcrops on hills and mountains. The soils are weathered from many different parent rocks including granite, gneiss, rhyolite, andesite, tuffs, limestone, sandstone, and basalt (Hendricks 1985: 99).

Soil Types of the Upper Animas Valley and the San Luis Valley

Figure 2.6 illustrates soil types for these valleys. The San Luis Valley, a drained lakebed on the southern edge of the Upper Animas Valley, extends to both sides of the international border and contains a unique soil type within the study area, Anamite silty clay loam. Cloverdale Loam, Cloverdale-Stellar Association and Cloverdale Stony Clay loam soils are distributed in the lower slopes and on the basin floor of the southern half of the Upper Animas Valley. The Cloverdale Series are well-drained soils on old alluvial fans in upland areas. This soil is formed from materials derived mainly from rhyolite and basalt. The Cloverdale-Stellar Association has few limitations for agricultural practices, and almost any crop can be planted (Cox 1973: 12).

In the northern section of the Upper Animas Valley on the piedmont and alluvial plain, from approximately Animas Peak to the north, the most common soil type is the Eba series. The Eba series consists of well-drained soils formed in old cobbly alluvium from mixed igneous rocks, mainly rhyolite. Eba soils are gravelly loams and are not used for agriculture at the present time (Cox 1973: 12).

Animas Creek divides the valley into eastern and western sectors. The alluvial plain of Animas Creek and its tributaries are represented by the Pima-Hawkeye complex. This soil complex is mainly in the upper Animas Valley. It occurs along Deer Creek and Whitewater Creek at the southeastern end of the Animas Mountains piedmont. These soils are used for irrigated cropland (Cox 1973: 30).

Three patches of Yturbide soils are located around the ancient San Luis Playa. The Yturbide Series consists of excessively drained soils that formed in coarse-textured alluvium on alluvial fans and slopes. A few acres have been used for irrigated cropland (Cox 1973: 42).

The terraces and lower slopes of the northern half of the Upper Animas Valley are composed of Forrest gravelly loam and the Forrest-Stellar Association. The Forrest soil is found on slightly elevated ridges, and Stellar soil is associated with the broad swales that occur between the ridges. Within the Animas Valley, these associations support short grasses and leaf succulents such as agave and yucca (Cox 1973: 15).

Soil Description of the Playas Valley

There are four soil types in the Playa Valley (fig. 2.7): the Mohave Series, the Hondale Series, the Mimbres Series, and the Yturbide Series (Cox 1973). The most widespread soil of the southern half of the Playas Valley is the Mohave Series. Mohave soils are substantial in the plain formed between the east piedmont of the Animas Mountains and the Playas Lake. These are well-drained soils formed in old alluvium from mixed igneous rocks. Mohave soils are now used for irrigated cropland.

The Mimbres Series are well-drained soils developed in old alluvium from mixed igneous and sedimentary rocks on alluvial bottoms and occur as small patches along most of the Playas Valley bottom. Mimbres soils are used for irrigated cropland. Soils of the Yturbide Series are also distributed in small intermittent patches. These are poorly suited to modern cultivated crops (Cox 1973: 42, 50).

Hondale soils are well-drained soils near playas. In the Playas Valley, saline Hondale soils surround the Playas Lake and extend to the south. Higher saline soils not subject to flooding support extensive grasslands of alkali-sacaton grass (*Sporobolus airoides*).

Study Area Lithic Resources

Resources suitable for flaked stone tools such as chert, felsite/rhyolite, and basalt are widespread in the study area. Abundant chert zones are present in southeastern Arizona; for example, the Swisshelm Formation that outcrops near Boss Ranch (Boyd 1978: 57–58) would likely have been an important source of raw materials. Usable nodular cherts also are present in the Keating Formation of the Pedregosa, Big Hachet, and Peloncillo Mountains (Armstrong and Mamet 1978: 6, 186) and in the Black Prince Formation and Horquilla Limestone of the Big Hachett Mountains (Drewes and others 1988: C12). Pleistocene terraces as well as channels of current watercourses are likely locations of secondary

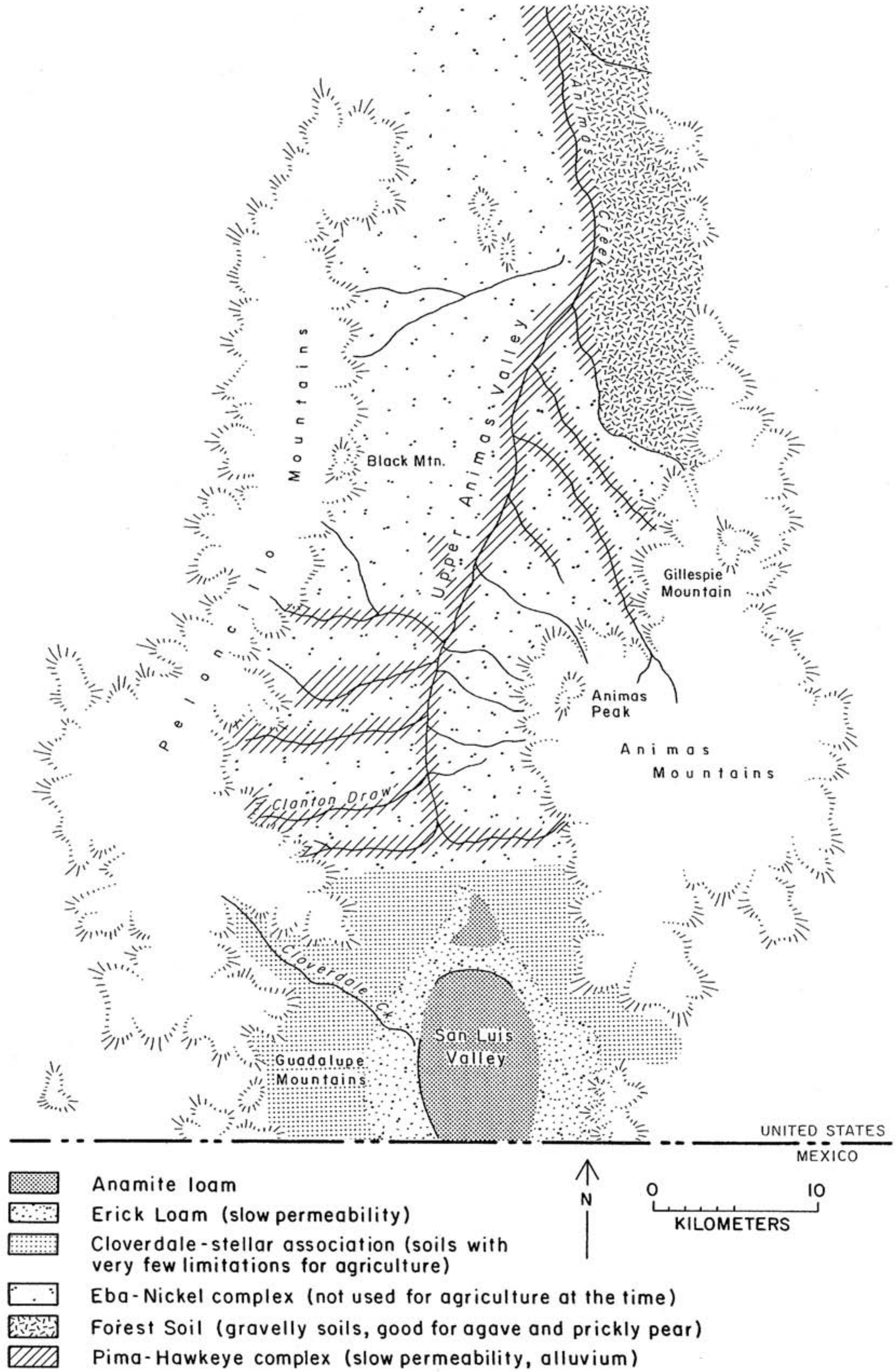

Figure 2.6. Soil types of the Upper Animas and San Luis Valleys.

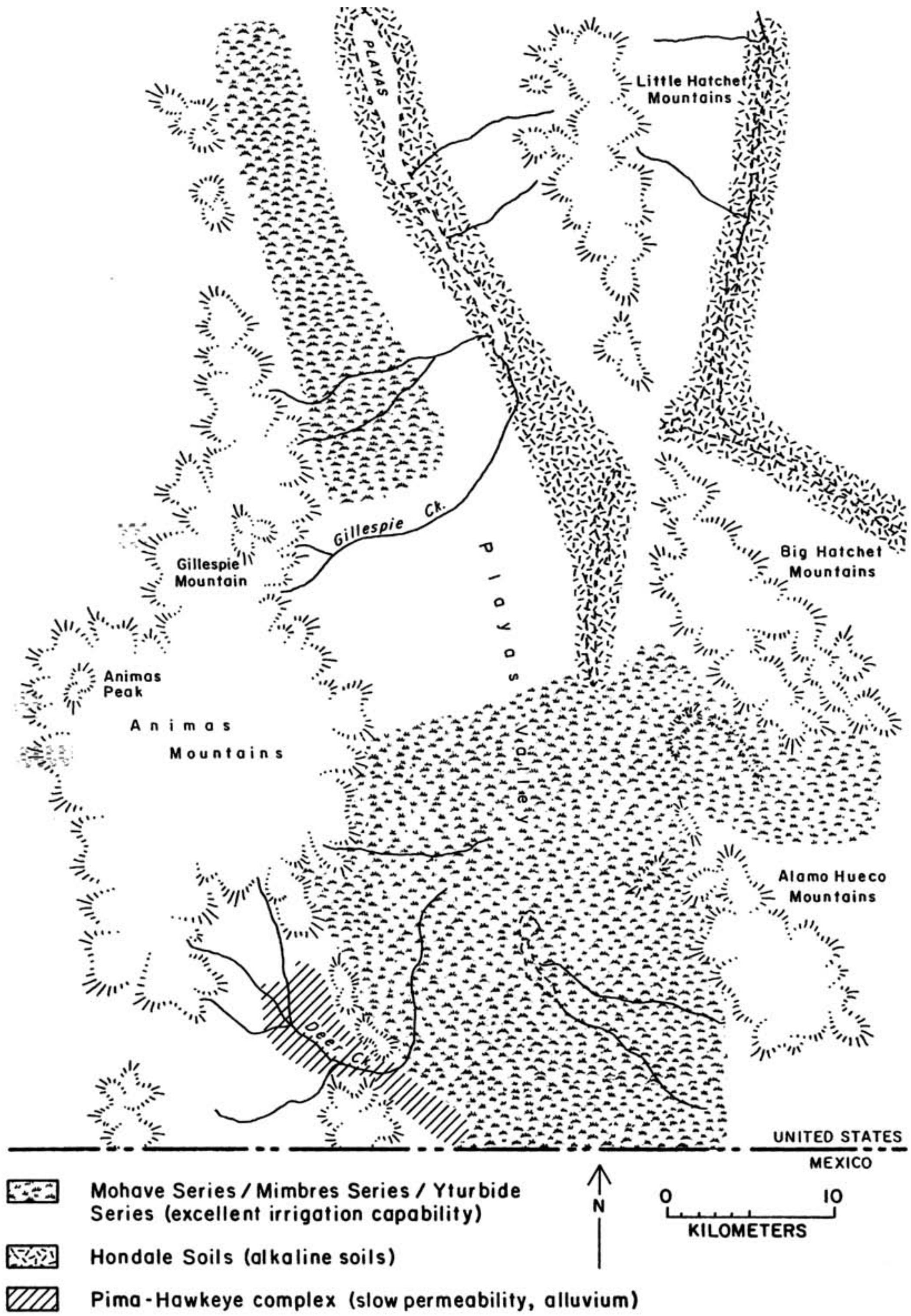

Figure 2.7. Soil types of the Playas Valley.

sources, even where the primary formations are not widely exposed.

Field reports (Fitting 1972a), file descriptions of 10 sites in the Borderlands database, and reconnaissance related to this overview suggest intensively used quarry localities for chert, felsite/rhyolite, and basalt materials throughout the study area, but no systematic study of material acquisition patterns has yet been undertaken for the Borderlands. Although no quarries for groundstone materials have been reported, basalts suitable for this purpose are widespread. Numerous basaltic flows are reported in the San Bernardino and Animas Valleys.

Antelope Wells volcanic glass is excellent for flaking and was widely sought during the late prehistoric period (Findlow and Bolognese 1980; Hughes 1988; Shackley 1988). Colors include translucent brown-green, dark gray, green-brown banded, and opaque black. The obsidian occurs as nodules (Apache tears) in the lower portions of three formations: Gillespie Tuff, Felsite formation, and Park Tuff (Findlow and Bolognese 1980: 228). Findlow and Bolognese (1980) observed obsidian nodules in Clanton Draw at the eastern edge of the Peloncillo Mountains and elsewhere in that range. Shackley (1988: 761) reports that the primary source for this material is along Deer Creek in the southeastern Animas Mountains, but that nodules also occur along Cloverdale Creek and elsewhere in the Peloncillo Mountains. Nodules also occur 15 to 20 km (9 to 13 miles) east from Deer Creek and south into Chihuahua (Shackley 1988: 761). Current distributional information indicates at least two noncontiguous sources in separate mountain ranges.

Turquoise is a lithic resource that strongly deserves further investigation. An extensive turquoise quarry is reported on the east side of the Little Hatchet Mountains at about 1,465 m (4,800 ft) above sea level (Clemons and Mack 1988: 20; Hill 1938). Known as the "Old Aztec" workings (Anonymous 1909: 762), extensive remains of prehistoric mining activity are present; Weigand and Harbottle (1993: 163) report about 200 chambered mines. The temporal span of these activities is unknown. No good description of the quality or character of this turquoise could be found in the literature.

Salt likely was available in the surroundings of playas. McCluney (1973) makes passing reference to inhabitants of the region collecting salt in such locations at the time of Coronado's expedition in the 16th century; the documentary reference or other source for this statement is unknown. Salt figured prominently in historic Southwest exchange, however, and its acquisition is even accorded a ritual context by puebloan groups such as the Hopi. Salt collecting probably was a patterned activity over long intervals and should be carefully considered in playa investigations.

Settlement Potential of Borderlands Valleys

A limited number of late ceramic habitation sites have been recorded in the Borderlands (fig 3.3), although this is by far the best known prehistoric interval. The distribution is heavily biased toward the largest sites and a few more thoroughly examined locales. The distribution of smaller settlements is so incomplete that generalizations about areas capable of supporting correspondingly small populations are difficult. Despite the lack of systematic archaeological studies, most of the largest villages probably are recognized (chapter 3).

The locations of the largest villages presumably mark relatively favored locales in which it was possible to support the most aggregated populations of the archaeological sequence. None are on perennial streams, but, with one exception, are on large ephemeral drainages near relatively wide stretches of floodplain amenable to small-scale irrigation. The exception, Pendleton Ruin, is on an alluvial fan of Cloverdale Creek in the San Luis Valley, where extensive floodwater farming would have been possible. The largest villages are all within grassland or desert scrub vegetation. This association reflects a strong need for proximity to the wild resources of low elevation zones as much as: (1) locations in a downstream position receiving combined flow from the upstream watershed, and (2) a sufficiently low gradient to successfully divert water onto fields with small canals or floodwater ditches. The following section further describes and preliminarily analyzes the potential of each study area valley for agricultural settlements, based on physical features and recorded site locations.

San Bernardino Valley

The San Bernardino Valley is bordered on the west by the massive Chiricahuas and Pedregosas (outside the study area) and the Perilla Mountains. The Peloncillo and Guadalupe Mountains are to the east. The valley continues south into Mexico. This broad Borderlands basin has no mid-valley drainage that combines runoff from the mountains to both east and west. Streams from the northern portions of the mountain ranges drain north and enter the adjacent and interconnected San Simon Valley.

In the southern part of the San Bernardino Valley within the study area, drainages flow to the south. Near the border with Mexico, streams from the mountains on both sides and streams draining a large mid-valley area begin to converge, a trend that continues south into the Mexican part of the basin. Black Draw, Silver Creek, and Cottonwood Draw are the largest drainages. Making this area even more amenable to agricultural use, the water table becomes increasingly shallow to the south (Arizona Department of Water Resources 1974), and it is shallowest of all beneath the San Bernardino Ranch. This locale was settled in the Spanish Colonial period and thereafter in historic times when springs were developed for irrigation. Sites of a variety of prehistoric periods, including the Slaughter Ranch site, cluster in the vicinity. Large sites are in the Mexican portion of the valley as well.

Sites near the middle of the San Bernardino Valley within the study area are located along southerly drainages originating in the Chiricahuas. These mountains are larger than any of the other study area ranges and create a greater orographic rainfall effect. Farther north, a site is recorded along a stream heading north from the Peloncillos. Other farming settlements are probable in similar locations along the mountain fronts and on tributaries, as drainages with upland watersheds emerge and flow onto the bajada. Possible prehistoric hot springs in the Douglas area (Swanberg 1978: 350) may have attracted special use.

The vegetation of the San Bernardino Valley is primarily semidesert grassland. Chihuahuan desertscrub occupies a southernmost sector below the mountains and near the border. The current development of desertscrub in this area may have been exacerbated by a long history of grazing. Livestock were introduced here in Colonial times (chapter 5) and ranching activities continue to be centered in the area of springs fed by the converging watercourses. Conditions in the past may have favored grassland more than conditions of today.

Animas and San Luis Valleys

The Animas Valley is bounded by the Peloncillo and Guadalupe Mountains to the west. The Animas Mountains are on the east. The Upper Animas Valley lies within the study area and is so designated by reference to its upstream position in a northward drainage pattern. The Animas Valley is conjoined without internal barriers with the San Luis Valley, which continues south into Mexico. A drainage divide separates the two valleys. The San Luis Valley receives water flowing south from the Peloncillos, a mid-basin catchment, and a narrow strip along the western edge of the Animas range.

The drainage divide between the valleys coincides with a large, transverse sandy ridge known as the Indian Dam. This natural feature marks the former maximal shoreline of a pluvial lake in the San Luis Valley. The dunes on the ridge contain numerous surface and partially buried artifact scatters, apparently representing most of the prehistoric sequence. Active springs are a few miles west of the San Luis Mountains near the Mexican border.

In the southeastern quadrant of the Peloncillo Mountains, multiple habitation sites have been recorded along Cloverdale Creek past the point where it emerges onto the valley slope. These include the large Pendleton Ruin on the fan and the Cloverdale Ruin farther upstream. The relatively broad, flat floodplain of Cloverdale Creek intrudes into and is surrounded by the mountain mass, thus receiving the benefit of higher orographic rainfall as well as the runoff from a large upland watershed. The plains grassland vegetation type of the valley floor extends upstream along an appreciable length of the floodplain, where resources of higher elevation zones also are conveniently accessible.

The San Luis Valley and adjacent segment of the Upper Animas Valley support a plains grassland vegetation, grading into a semidesert grassland farther to the north in the study area. Grassy forage is optimal among Borderlands basins. Today, antelope are most visible in this part of the study area.

Beginning near the southern end of the Animas Valley, drainages from the Animas and Peloncillo mountains join to form Animas Creek. The Animas Valley is unique among Borderlands basins in possessing such a well-integrated network with a primary drainage running almost throughout its length. Nevertheless, flow in Animas Creek is not perennial (Reeder 1957).

Habitation sites are recorded near the midsection of both mountain ranges. One settlement is situated on a tributary near the Peloncillo mountain front, and others, including Clanton Draw and Box Canyon, are located along Animas Creek. Farther to the north in the Upper Animas Valley, residential settlements again occur on tributaries from the Animas Mountains and along Animas Creek. The tributaries likely supplied short diversions of agricultural water at wider points in the floodplain and floodwater farming on alluvial fans. Optimal stretches of Animas Creek probably permitted modest irrigation. Sites in addition to those currently known seem almost a certainty along eastern and western mountain fronts and tributaries, and along the length of Animas Creek.

A shallow perched water table exists in the Upper Animas Valley, whereas ground water flow is largely unconfined in the Lower Animas Valley with the exception of an area just north of the town of Animas (Hawkins and Stephens 1983: 734). Seasonal and more extended boggy conditions occur in the areas of highest water table, including the Gray Ranch and Maddox Ranch cienegas along the margins of Animas Creek.

The only montane conifer forest in the Borderlands occurs on Animas Peak. Past this peak to the north, the low basin vegetation is semidesert grassland. Also north from the peak, agave is abundant on the low western slopes of the Animas Mountains (Bourgeron and others 1995).

Playas Valley

The Playas Valley is bordered by the Animas Mountains on the west. To the east, a series of smaller and disconnected mountains bound the basin. From north to south are the Little Hatchet Mountains, the Big Hatchet Mountains, and the Alamo Hueco Mountains. Together, these are of smaller mass than the major Borderlands ranges and produce less of an orographic effect on precipitation.

The Playas Valley is marked by internal drainage. Today there are two major concentrations of runoff in the Playas Valley proper and one outside of it, to the east of the Big and Little Hatchet Mountains. The largest playa within the basin is to the west of the Little Hatchet Mountains, receiving drainage from both sides. The other large playa is to the west of the Big Hatchet Mountains. A third small playa is the destination of streams flowing west from the Alamo Hueco Mountains.

The Animas Mountains provide the largest upland watersheds for drainages serving settlements in the Playas Valley. A large catchment in the southeastern sector of this range culminates in Deer Creek, with a relatively broad, flat floodplain along its final reaches in the mountains. Joyce Well and the Culberson Ruin are located on this segment of Deer Creek.

A cluster of habitations sites in the vicinity of the Timberlake Ruin have been recorded near the middle of the Animas range, where drainages extend onto the bajada. Although the mountains narrow and watersheds become smaller to the north, settlements are likely along the mountain front and adjacent bajadas. Sites have been discovered in similar situations along the skirts of the Alamo Hueco Mountains. To date, no habitation sites have been registered along the western edges of the Big or Little Hatchet Mountains or their tributaries but likely are present.

Basin-floor vegetation of the Playas Valley is semidesert grassland throughout. Preceramic camps or habitations might be anticipated along the shorelines of Pleistocene lakes now represented by the remnant playas. Specialized plants of saline and seasonally moist soils along playa margins also may have attracted the earliest farmers and even later inhabitants; it appears that the latest Holocene highstands of the lakes during the agricultural era may have produced persistently moist habitats and true aquatic resources.

Closing Observations

Important resources such as water, arable land, key plant and animal foods, and useful minerals have patchy distributions in the Malpai Borderlands. Alluvial valley floors are broad and have relatively homogenous vegetation cover. These valleys are bounded by high, linear, and abruptly rising mountain ranges that create spatially compressed biotic diversity because of the rapid ascent of the uplands. These diverse upland resources have restricted distributions often distant from the arable land on the valley floor. Agriculturalists wanting to procure upland resources would have traveled several days, or developed regular regional exchange. Likewise, hunting and gathering societies dependent on seasonal resources would have required large territories involving at least biseasonal residential movements from low valley floors to mountain bases.