

The Southern High Plains: A History of Vegetation, 1540 to Present

David B. Wester¹

Abstract: Considerable documentary evidence is available about the historic vegetation of the Southern High Plains (SHP). Accounts spanning about 350 years (from the earliest European explorers in the 1540s to scientists working in the later 19th and early 20th centuries), however, lead to vague and sometimes contradictory conclusions about the nature of this vegetation. The earliest documents describe the SHP as vast grassland. The fact that native soils were Paleustolls supports this description. The earliest accounts also suggest considerable vegetation diversity in certain topographic settings (for example, in sandy soils and major draws that cross the SHP). It is also certain that the SHP supported vast populations of native herbivores (which were quickly replaced by large populations of domestic livestock); were subject to climatic variability; and were frequently burned. All of these factors interact with each other at several spatial and temporal scales to affect vegetation. Based on historic documentary evidence, it is difficult to describe the precise nature of the vegetation of the SHP when it was first encountered by European explorers. Although the dominant aspect of the vegetation was that of a grassland, woody species (primarily mesquite, *Prosopis glandulosa*) were either historically present but unrecorded by early explorers in upland sites because they had limited experience in these sites and/or because recurrent fires maintained populations; or mesquite was introduced in a novel way by domestic livestock beginning in the late 1870s and 1880s. In either of these scenarios, subsequent increases in woody vegetation during the 20th century likely involved changes in fire frequency, grazing history, and climate.

“Too Grande and Too Sublime to be Imagined”

(Pike 1832, in Haley 1968:23)

“The monotonous level or billowy swells of a sea of grass unrelieved by the presence of taller plants like a shrub or tree... could fasten upon the senses a conception of the power of a victorious vegetation...” (Bray 1906:92)

“If you w’d remain in ignorance of this region of the world read descriptions of it...if you would wish to appreciate the scale of its sublimity, on which all Nature is here arranged, come and see it.” (Gilpin 1836)

Introduction

The Southern High Plains (SHP) are a 130,000-km² plateau in Texas and eastern New Mexico (Holliday 1990). Also known as the Llano Estacado, this southernmost subdivision of the High Plains section of the Great Plains Physiographic Province is “essentially an isolated remnant of the Rocky Mountain piedmont alluvial plain” (Reeves 1965:182). The SHP are bordered on the east by the Caprock Escarpment and the upper Colorado, Brazos and Red Rivers in Texas, and on the west by the Pecos River Valley. The northern border of the SHP, abruptly delimited by the Canadian River Valley, contrasts with the gradual merging of its southern boundary with the Edwards Plateau (fig. 1).

The SHP are both extensive and remarkably flat, which has led many authors to rather expressive descriptions. For

example, Carroll and others (1986:186) wrote that the SHP are “almost absolutely flat and represent one of the largest tracts of level land in the world.” Morris (1997:2) described the Llano Estacado as “perhaps the largest isolated, non-mountainous area in North America” and elsewhere (p. 20) as “one of the world’s largest and flattest plains.” Hunt (1967:225) wrote that “...the Llano Estacado [is] one of the most nearly level parts of the United States.” A USGS web site states that the “Llano Estacado [is] one the largest expanses of near-featureless terrain” (<http://tapestry.usgs.gov/features/features/html>). Whereas slopes on the SHP average only 3 m per mile (Reeves 1965), several physiographic provinces in North American (for example, the Gulf Coastal Plains and the Atlantic Coastal Plains) are also relatively flat as well as larger in areal extent than the SHP, occupying about 10 percent of the land area of the U.S. (Hunt 1967).

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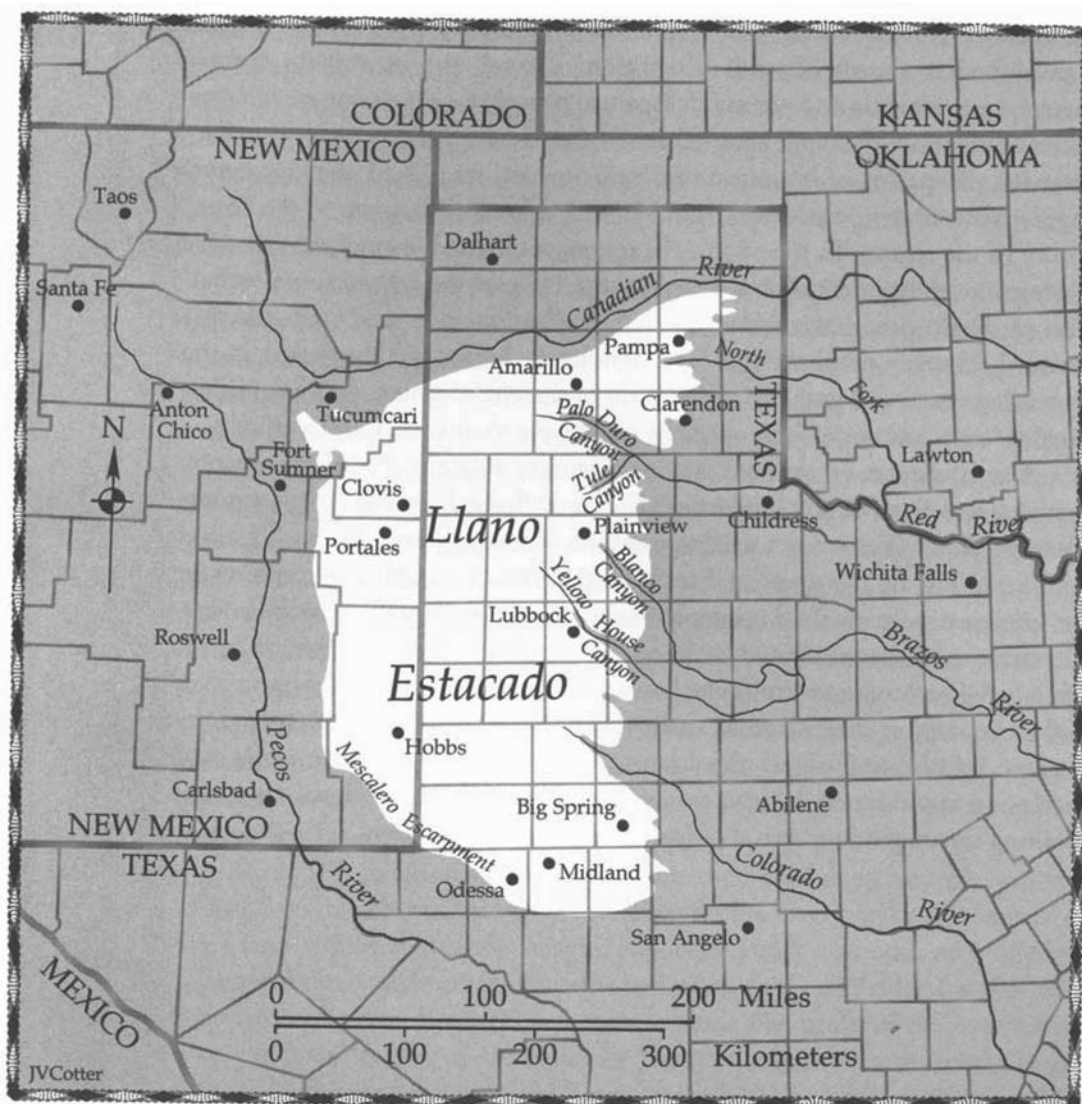


Figure 1. The Southern High Plains (from Morris 1997).

Geological History

Characterized by a semi-arid continental climate, this “virtually featureless, constructional surface” (Holliday 1989:74) is the most recent of as many as six well-developed but buried soils that comprise the Blackwater Draw Formation formed by multiple episodes of eolian sheet deposition separated by long periods of relative landscape stability over the past 1.4 million years (Holliday 1990). In fact, similarities between the Quaternary Blackwater Draw Formation and the underlying Miocene-Pliocene Ogallala Formation suggest that the SHP “has probably been a grassland or savanna grassland varying from perhaps an arid to a semi-arid or sub-humid environment for about 11 million years” (Holliday 1990:510). The topographic monotony of the SHP is relieved only by Holocene dune fields (formed during droughts of the Altithermal period) along its southwestern and western borders (Holliday 1989), thousands of playas scattered over its surface (Bolen and others 1989), over two dozen larger saline lakes, and several dry tributaries (or “draws”) of the Colorado, Brazos, and Red Rivers (Holliday 1990).

Grazing History

As part of the extensive grasslands of the North American Great Plains, the SHP have a long history of herbivory. Reviewing global patterns, Coughenour (1985:853) concluded that “extensive grasslands, grazers, and semiarid climates appeared almost simultaneously,” and suggested that many of the characteristics of grasses that are advantageous in semi-arid environments (for example, presence of basal meristems, small stature, high shoot density, deciduous shoots, below-ground storage of nutrients, and rapid growth) are also beneficial under grazing. In an influential paper, Stebbins (1981:84) concluded that “Coevolution of grasses and herbivores has progressed continuously on the North American grasslands ever since they first appeared as savannalike openings in the forest during the early part of the Tertiary period.” MacGinitie (1962:99, from Axelrod 1985:168) also suggested that “the regular association of grazing and browsing mammals on the High Plains from the Middle Miocene into the Pliocene supports the idea of a savanna-type vegetation.” Early fossil evidence in the Great Plains suggests that

cool season caespitose species (for example, *Stipa*, *Nassella*, *Piptochaetium*, and the extinct *Berrichloa*) were associated with horses and pronghorn antelope during Pliocene times. However, current dominant genera of the Great Plains (for example, *Andropogon*, *Schizachyrium*, *Bouteloua*, *Buchloe*, and *Panicum*) belong to different tribes than the Pliocene flora. Although it is uncertain when this transition occurred, Stebbins (1981) believed that the current dominant flora was absent or uncommon at the beginning of the Pleistocene glaciations. Further, he suggested that the current flora is of post-Pleistocene origin. After an extensive literature review, Axelrod (1985) agreed with MacGinitie (1962) that “most of the current formations of western North America, except possibly in the area south of Latitude 35°, are less than 10,000 years old” (MacGinitie 1962:99, from Axelrod 1985:168). The change from long-leaved caespitose species to stoloniferous shortgrasses reflects adaptations related to changes both in environment (increasing aridity) and in dominant grazers. In particular, grazers during the Pliocene were horses and pronghorn. However, *Bison latifrons*, a browser/grazer adapted to forest openings or woodlands, appeared between 500,000 and 125,000 years ago, peaked in abundance about 100,000 years ago during the Sangamon interglacial, survived until at least 30,000 to 20,000 years ago, and disappeared in late Wisconsin (10,000 years ago). *Bison antiquus*, a grazer/browser adapted to savanna or wooded steppe, probably appeared during the Sangamon interglacial and peaked during the late Wisconsin (10,000 years ago). *Bison bison*, primarily a grazer adapted to open grassland environments, appeared during the late Wisconsin and early Holocene; the southern subspecies (*B. bison bison*) reached maximum numbers about 2,500 years ago (McDonald 1981). Although about 75 percent of the megafauna of North America disappeared with the closing of the last ice age, bison numbers followed a different trend, reaching peak numbers from 9,000 to 6,000 years ago (Alford 1973).

It has been estimated that 100 million buffalo existed on the Great Plains. Buffalo hunting began in the Texas Panhandle in 1874. The southern buffalo herd was exterminated between 1874 and 1878, the northern herd was slaughtered by 1884, and by 1878, only 1,091 animals were left (McComb 1989:82-83). Almost simultaneous with the extermination of the buffalo was the removal of native Americans from the Panhandle of Texas with the battle of the Red River in 1874-1875. Carlson (1974:15) wrote that “More than most campaigns the Red River War made the immense northern border of the Llano Estacado safe for an advancing civilization.” Mexican sheep ranchers were the first graziers in the SHP (Taylor 1997). They were followed, however, and soon outnumbered by cattle ranchers. One of the first ranchers in this area, Charles Goodnight, brought 1,600 head of cattle to the Palo Duro Canyon area in 1876. By 1880, more than 100 other ranchers brought 100,000 cattle as well as 100,000 sheep into north-west Texas (Nall 1972). Thus, the native herbivores were exterminated and quickly replaced by domestic animals.

There were fewer than 500,000 cattle in Texas in 1830 (Fisher 1977:183). Cattle numbers increased thereafter

throughout the state, and by 1888 there were more than 9 million head of cattle (Brooks and Emel 2000:54). Cattle were not grazed on the SHP, however, until the 1880s (Carlson 1974). Further, the “boom” years of the SHP cattle industry did not last long. Two factors combined to lead to a collapse in the cattle industry. First, weather conditions in the years around 1870 were equable (following widespread drought conditions throughout much of the Great Plains in the early 1860s; Meko 1995:322-323; fig. 6 in Woodhouse and Overpeck 1998). Second, high livestock numbers led to overgrazing: before the worst overgrazing, 5 acres could support one steer, but by 1880, 50 acres were needed (White 1991, from Brooks and Emel 2000:55). With these two factors as background, an extremely harsh winter in 1885, and another in 1888, with “freezing temperatures and high winds...combined with loss of range due to overgrazing, [and] brought heavy losses...The cattle ranching that remained on the plains was just a remnant of the flourishing cattle trade of the late 1870s and early 1880s, never to recover the teeming numbers of that era” (Brooks and Emel 2000:55-56; also see Nall 1972; Taylor 1997). Britten (1993) indicated that millions of cattle perished following the droughts and blizzards of 1885 to 1887.

Today, the SHP are one of the most intensively-farmed areas in the United States, with 90 percent of its area in row-crop agriculture (on 11,880 farms; farm acreage is based on the following Texas counties: Deaf Smith, Randall, Parmer, Castro, Swisher, Bailey, Lamb, Hale, Floyd, Cochran, Hockley, Lubbock, Crosby, Yoakum, Terry, Lynn, Gaines, Dawson, Andrews, Martin; www.nass.usda.gov/census/census02/volume1/tx/st48_2_001.pdf, and www.census.gov/prod/2002pubs/00ccdb/dd00_tabB1.pdf). Cotton is the largest crop produced on the Llano Estacado. In fact, 15 percent of the cotton grown in the U.S. and 3.5 percent of the cotton grown world-wide is produced on the SHP (Brooks and Emel 2000:111). Texas produces more cattle (13.7 million head; Texas Farm Bureau) than any other state. The 26 counties surrounding Amarillo, Texas, have 25 to 30 percent of all cattle on feed in the U.S. (Evelt 2003).

Human History

The SHP are also remarkable for the records of human history they reveal. The earliest evidence of European people in southwestern North America (Chipman 1992:11) can be found in the descriptions of Alvar Núñez Cabeza de Vaca in the 1530s. The area is also among the earliest occupied by Native Americans – there are abundant archeological artifacts of human habitation 12,000 years ago at the Lubbock Lake Landmark site (Johnson 1987). The Paleo-Indian period on the SHP can be recognized in the following subdivisions: Clovis (11,500 to 10,000 years B.P.); Folsom (10,500 to 10,000 years B.P.); Plainview (around 10,000 years B.P.); and Firstview (from Plainview to about 8,000 years B.P.). Additional native American cultures of the Archaic Period (6,000 to 2,000 years B.P.), Woodland tradition (2,000 years B.P.), and Plains Village Culture (1,350 to 1,450 A.D.) existed on the

SHP. Early Spanish explorers encountered Apaches on the SHP. These native Americans were replaced by Comanches by 1775 (Brooks and Emel 2000:26-27, 30).

The SHP were one of the last regions settled by Texans after fighting with Native Americans ended with the Red River War in 1874-1875 (for example, Carlson 1974). Early farming settlements were simultaneous with the establishment of cattle ranches on the SHP (Nall 1972). The southern parts of the SHP were generally established earlier than the northern parts.

Several railroads (for example, the Denver & Fort Worth Railroad and the Southern Kansas Railway Company) were operating on the SHP by 1888 (Nall 1972). Big Spring began to develop around 1880 when rail service began in Howard County. Likewise, Miami began around 1887 with rail service, and Sutton and Floyd counties and the city of Lubbock were established in 1890. Although Deaf Smith County was established in 1879, it had no permanent settlers until 1887 (Burnett 1990:4). Census returns in 1880 showed a population of 5,388 residents in the 50 counties of the Llano Estacado. By 1910, the population had grown to 140,749 residents (Burnett 1990:4). In the Texas Panhandle, the population increased from 1,607 to 9,542 from 1880 to 1890 (Nall 1972). The first farm was established in 1879 in the town of Estacado (Crosby County, Texas). In 1886, Estacado became the county seat for Crosby County and Central Plains Academy, the first college on the SHP, was established in 1890 (<http://www.tsha.utexas.edu/handbook/online/articles/view/EE/hne27.html>). In 1900, 803 farms existed on the SHP. By 1910, this number swelled to 2001 farms. Continued growth was evident, with 4089 farms in 1920 and 6,161 farms in 1925 (Brooks and Emel 2000:69-70). As early as 1925, farm acreage occupied nearly 49 percent of the area of a 10-county region on the SHP (Bailey, Cochran, Crosby, Floyd, Hale, Hockley, Lamb, Lubbock, Parmer, and Potter counties; Brooks and Emel 2000:84).

In several respects, therefore, the SHP have a remarkably long history: first, with regard to relative geologic and climatic stability punctuated by periodic and sometimes devastating droughts; second, with regard to the presence of herbivores, both native and domestic; and third, with regard

to interaction with human cultures. All of these factors, whose combined influence has shaped the vegetation of the SHP, must be considered to more fully understand its dynamic history.

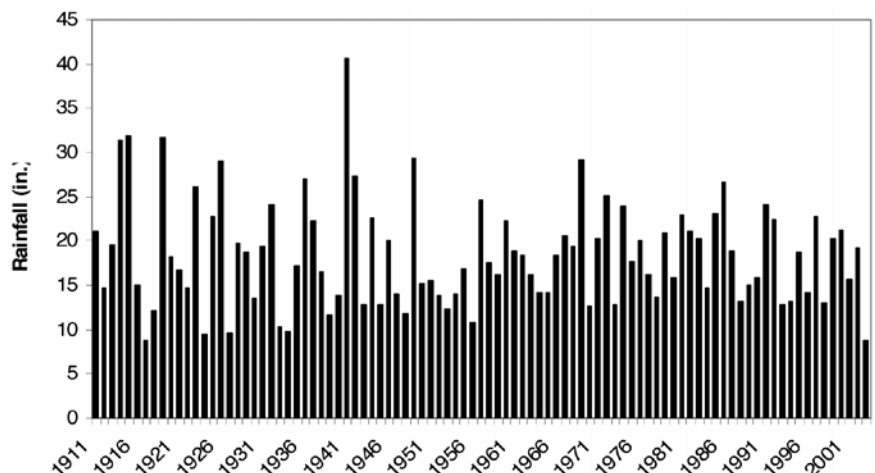
Environmental Characterization

Climate

Elevations on the SHP range from 823 m on the eastern border to 1,463 m on the west (Reeves 1965). A semi-arid or dry steppe climate with mild winters results from the combined influence of relatively high elevation, frequent intrusions of dry polar air masses, and distance from sources of moisture (NOAA 1982). Annual precipitation increases from 300 mm in the west to 500 mm in the east (Holliday 1990). The continental nature of the SHP climate, however, leads to considerable intra-annual (NOAA 1982) and inter-annual (Holliday 1990) variability in precipitation. The months of May and September typically have the highest rainfall, and the period from October to April is generally dry. In the northern SHP (Hereford, Randall County), annual rainfall averages 474 mm; May (54 mm), June (74 mm), August (82 mm) and September (57 mm) are the wettest months. In the central portion of the SHP (Lubbock, Lubbock County), annual precipitation averages 475 mm; May (59 mm), June (76 mm), August (60 mm) and September (65 mm) are the wettest months. In the southern portion of the SHP (Andrews, Andrews County), annual precipitation averages 384 mm; June (54 mm), July (57 mm), and September (56 mm) are the wettest months.

Annual precipitation also varies interannually (fig. 2). Droughts are recurring features of the climate of the SHP (for example, Woodhouse and Overpeck 1998; fig. 3). Holliday (1989) indicated that the warmer, drier conditions during the Altithermal, which initiated eolian sedimentation locally throughout the SHP between 8000 and 7000 BC, and affected all areas of the SHP between 3500 and 2500 BC, resulted in “more geomorphic change ... than any other equivalent period of time for which data are available” (Holliday

Figure 2. Annual rainfall, Lubbock, Texas (NOAA).



Palmer Drought Severity Index

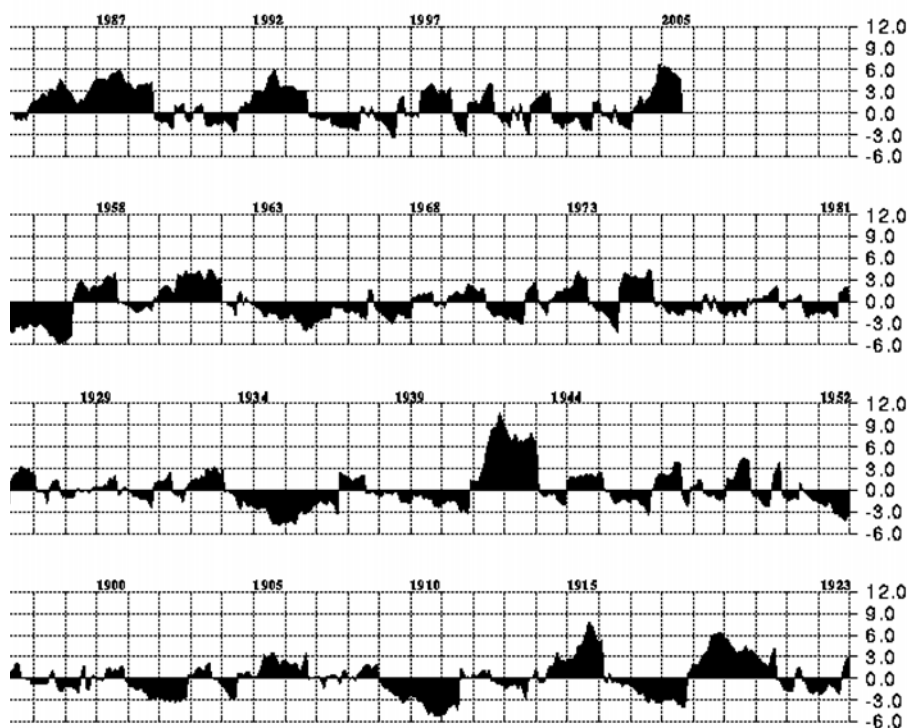


Figure 3. Palmer Drought Severity Index for the Southern High Plains, Texas (from www.ncdc.noaa.gov).

Texas - Division 01: 1895-2005 (Monthly Averages)

1889:80). In more recent times, droughts have been observed in at least some parts of the Great Plains in the last quarter of the 13th century (Woodhouse and Overpeck 1998); in the second half of the 16th century (Woodhouse and Overpeck 1998; Stahle and others 2000); and in the 1750s, early 1800s, 1820s, early 1850s to early 1860s, late 1880s to early 1900s, 1930s, and 1950s (Meko 1995; Woodhouse and Overpeck 1998) (fig. 3). It is interesting to note that (1) droughts in the 16th century evidently lasted longer than the drought of the 20th century; (2) there is little evidence of drought between the severe drought of the latter half of the 16th century and the latter half of the 18th century; and (3) despite the severity of the droughts of the 20th century, these periods were not drastic enough to cause regional mobilization of sand dunes (Woodhouse and Overpeck 2000:2696 and references therein; also see Muhs and Holliday 1995; Forman and others 2001). Periodic droughts have had significant effects of flora, fauna, and human activities.

Soils

The Blackwater Draw Formation, with a thickness that varies from a “feather-edge” in the southwest to “at least 27 m” in the northeast (Reeves 1976:217, in Holliday 1990:494) forms the surface of the SHP. This “sheet-like body of eolian sediment” (Holliday 1990:493), with the Pecos River Valley as its source, is comprised of sands to very fine sands in the southwest and finer sediments (silts and clays) toward the northeast (Holliday 1990). This pattern of textural variability

is “apparently the result of downwind sorting” (Holliday 1990:493). Additionally, the thickening of the Blackwater Draw Formation from the southwest to the northeast “is probably due to the sandy texture of the sediments in the southwest, which would be much more susceptible to wind deflation than the silty and clayey sediments in the northeast” (Holliday 1990:494). It is also likely that vegetative cover in the southwest was sparser than in the northeast because of drier conditions. This would render the southwestern portion more prone to wind deflation (Holliday 1990).

Surface soils of the SHP are very well developed. Paleustalfs are common in the central and southwestern SHP, and Paleustolls are common in the central and northeastern SHP. The Paleustolls of the central SHP are similar to the Paleustalfs of the southwestern SHP except for the presence of a mollic epipedon. The Paleustolls of the northeastern SHP additionally possess a clay to clay loam argillic horizon with prismatic structure (Holliday 1990). The complex pattern of Paleustalfs and Paleustolls in the central SHP is most likely the result of wind erosion. The “native soils were most likely Paleustolls, given the native vegetation of the region. Eolian erosion could very effectively remove much of the mollic epipedon, resulting in a soil with an ochric epipedon, but otherwise not affecting the subsurface horizons...it is possible that the soil pattern is a historic feature, resulting from many periods of dust storm activity” during recent times or the middle Holocene (Holliday 1990:498). The Paleustolls of the northeastern SHP differ from those of the central SHP because of the presence of a darker color in the upper solum and finer

textures. The finer textures are due to downwind fining. One explanation for the darker solum is that it is a “pachic epipedon, the result of slow aggradation of the surface.” As the original A horizon became buried, it was converted to a Bt horizon (Holliday 1990:501). The darker color also may have resulted in part from more vegetation biomass as a consequence of higher effective precipitation and cooler temperatures in the northeastern SHP (Holliday 1990).

Another noteworthy feature of the landscape and soils of the SHP is the relative lack of evidence of erosion compared with other parts of the High Plains. No streams have deeply incised the SHP (Loomis 1938), leaving its surface “almost untouched by erosion” (Fenneman 1931:14). Mead and Brown (1970:47) described the Llano Estacado as “the best preserved of the [Great] plains, for they have been little dissected....”

Vegetation

Early Descriptions (1540s to 1850s)

Any description of the historic southwest must begin with Álgar Núñez Cabeza de Vaca and his celebrated journey in the 1530s. Historians disagree (for example, Chipman 1987) about the exact route that de Vaca and his three companions followed. Some authors place his route as far north as Big Spring (Hallenbeck 1940, from Olson and others 1997), Midland, Texas (Terrell 1962), or Lubbock, Texas (Bryan 1956). Others suggest a more southerly route (for example, Chipman 1987, 1992; Olson and others 1997; Krieger 2002).

In Chapter 30 of his *Relación de los Naufragios* (“Account of the Disasters”), de Vaca described meeting a group of Native Americans whom he called “the cow nation:”

“...They are people with the best bodies that we saw and the greatest liveliness and ability and who understood us best and responded to what we asked them. We call them those of the cows, because most of them [the bison] die [are killed?] near here. And up that river more than 30 leagues they go killing many of them” (Krieger 2002:86, bracketed text supplied by Krieger).

Morris (1997:14-15) places this encounter on the southern margins of the SHP, perhaps near the Pecos River that flows parallel to the SHP, or alternatively near the Rio Grande River. Others, notably Davenport and Wells (1918, 1919) and Krieger (2002) located “the people of the cows” near the confluence of the Rio Concho and Rio Grande rivers near present-day Presidio, Texas and Ojinaga, Mexico. Despite these differences in location, many authors (for example, Terrell 1962; Morris 1997; Krieger 2002) have suggested that de Vaca and his companions nevertheless encountered the “Llano culture.” It was in this general area that their native guides told the travelers that:

“...there were no people that way [either] (that is, to the north), except very far away, and nothing to eat, nor water to be found... (Krieger 2002:80; text in parentheses added).

Morris (1997:14) observed that this may well have been a description of the SHP: “it is vast; it is arid; it is low in traditional foods; and it has no permanent settlements.” In the quotation above describing the “cow nation,” Hodge (1907:103, footnote 4) suggested that the phrase “near here” probably did not refer to the “immediate” vicinity of the encounter between de Vaca and the so-named native peoples, because de Vaca and his companions:

“...decided to go in search of the maize and we did not want to follow the way to the cows because this was to the North. And this was for us a great detour...” (Krieger 2002:99).

Morris (1997:15) likewise concluded that de Vaca avoided the Llano Estacado proper. Nevertheless, the encounter with the cow nation was significant. Terrell (1962:207) provided an evocative image:

“They listened to talk and tales about things of which they had never heard. To the north were endless plains, plains so unchanging, so flat and treeless, that not a mound, not a stick or bush rose to disfigure their smooth flow to the horizons. Where they ended, no one could say. They ended in the sky. On them the herds of cattle roamed in countless numbers, herds so immense that they took several suns to pass, herds that covered the earth like ragged blankets as far as a man could see and crawled like the shadows of the clouds that journeyed to nowhere.”

The description of the SHP that we can draw from de Vaca’s travels is noteworthy in two respects. First, the Llano Estacado was an extensive, featureless plain with no trees or shrubs to relieve the dreary monotony of its level landscape. Second, the SHP was the home of immense herds of native grazers. Thus, our first description of the SHP is that of a grassland, and one that was, at least at times, heavily grazed.

The impressions about the SHP that can be gathered from de Vaca’s *Relación* are important, but are unfortunately vicarious. Most historians agree that de Vaca did not observe first-hand the Llano Estacado proper. His experiences nevertheless stimulated additional interest in the southwest: Don Francisco Vasquez de Coronado’s exploration of the SHP was organized partly in response to the stories told by de Vaca and his companions about the mysteries of the New World. Prior to leading his entire expedition to the SHP, Coronado dispatched Captain Hernando de Alvarado and 20 soldiers as an advance party to explore the “buffalo plains” (Winship 1964:77). Their journey took them past present-day Pecos, New Mexico, and then east southeast to present-day Santa Rosa, New Mexico, where they crossed the Pecos River (Morris 1997:20):

“After Alvarado had sent an account of this river to Francisco Vasquez, he proceeded forward to these plains, and at the borders of these he found a little river which flows to the southwest [perhaps a tributary of the Canadian (Bolton 1964:188)], and after four day’s

march he found the cows, which are the most monstrous in the way of the animals which has ever been seen or read about...There is such a quantity of them that I do not know what to compare them with, except with the fish in the sea, because in this journey, as also on that which the whole army afterwards made when it was going to Quivira, there were so many of them that many times when we started to pass through the midst of them and wanted to go to the other side of them, we were not able to, because the country was covered with them" (Winship 1964:355-356; bracketed text added).

The description of the geography of this expedition does not explicitly indicate that this advance party actually ascended the SHP proper. It seems reasonable, however, from the abundance of bison sighted that they may well have been on the Llano Estacado. Although the accounts of this journey do not contain a description of the vegetation of the SHP, chroniclers of Coronado's main expedition to the SHP were fulsome in their descriptions.

Coronado and his vast expedition departed from near present-day Bernanillo, New Mexico, in April, 1541 for the distant "buffalo plains." Morris (1997:26-28) suggested that his party may have crossed the Pecos River somewhere between present-day Tecolotito (San Miguel County) and Colonia (Guadalupe County), New Mexico. Meyers (2003:147) suggested that they reached and crossed the Pecos River at Anton Chico (San Miguel County). The expedition then traveled east with the escarpment of the Llano Estacado to their south. Morris (1997:28) suggested that they ascended the caprock onto the Llano Estacado proper between present-day Ragland and San Jon (Quay County), New Mexico (also see Chipman 1992:38). Meyers (2003:148) suggested that the army ascended the Llano Estacado possibly at Puerto del Arroyo (in southeastern Quay County, New Mexico) or at Agua del Piedro (near Adrian, Texas).

Pedro Castañeda, "the historian of the Coronado expedition" (Winship 1964:13), provided vivid images of the SHP. He described "such great numbers of cows [that is, bison] that it already seemed something incredible" (Winship 1964:235). He recounted how a Spaniard "got lost who went off hunting so far that he was unable to return to camp, because the country is very level" (Winship 1964:235). He told how, searching for an errant advance party, "it was impossible to find tracks in this country, because the grass straightened up again as soon as it was trodden down" (Winship 1964:235). Coronado "sent some of his companions to guide the army to that place, so that they should not get lost, although he had been making piles of stones and cow dung for the army to follow. This was the way in which the army was guided by the advance guard" (Winship 1964:235). Elsewhere, Castañeda wrote:

"Who could believe that 1,000 horses and 500 of our cows and more than 5,000 rams and ewes and more than 1,500 friendly Indians and servants, in traveling over those plains, would leave no more trace where they passed than if nothing had been there—nothing—so that it was necessary to make a pile of bones and cow dung

now and then, so that the rear guard could follow the army. The grass never failed to become erect after it had been trodden down, and, although it was short, it was fresh and straight as before" (Winship 1964:302).

Coronado himself described the SHP to King Charles V of Spain:

"I traveled...until I reached some plains, with no more landmarks than as if we had been swallowed up in the sea, when they strayed about, because there was not a stone, nor a bit of rising ground, nor a tree, nor a shrub, nor anything to go by. There is much very fine pasture land, with good grass...[we went] many days without water, and cooking food with cow dung, because there is not any kind of wood in all these plains, away from the gullies and rivers, which are very few" (Winship 1964:367-368).

Even the native guides who directed the return route of Coronado's army back to New Mexico needed help navigating across this featureless landscape. Castañeda wrote:

"... these people [that is, native American guides] are always roaming over this country in pursuit of animals and so know it thoroughly. They keep their road this way: In the morning, they notice where the sun rises and observe the direction they are going to take, and then shoot an arrow in its direction. Before reaching this they shoot another over it, and in this way they go all day toward the water where they are to end the day" (Winship 1964:241).

The writings of Coronado and his chroniclers leave an unmistakable image of the Llano Estacado. It was a treeless, shrubless sea of grass, and the monotony of this featureless landscape was not relieved by any structural vegetation diversity at all.

Spanish exploration of the SHP continued after Coronado's first historic journey, and later descriptions corroborated the images that Castañeda painted. In 1599, Vincente del Zaldívar, sent out by Don Juan Pérez Oñate, an early colonizer of New Mexico, explored the northern portion of the SHP in the vicinity of the Canadian River. Along the margins of the northern SHP timber was found in abundance. Describing the Llano Estacado, however, Zaldívar wrote, "These cattle have their haunts on some very level mesas which extend over many leagues...The mesas have neither mountain, nor tree, nor shrub, and when on them they were guided solely by the sun" (Bolton 1946:230). The last major expedition in the 1600s (Morris 1997:147) was made by Juan Dominguez de Mendoza who, in the company of two Franciscan priests, found the southern part of the SHP between the Pecos River and the Middle Concho River, "all...a plain" (Bolton 1946:330). In some locations, the country was so destitute of "suitable timber" that a cross could not be erected, although there was nevertheless an abundance of mesquite (for example, Bolton 1946:328-329, 333). In the 1780s, José Mares entered

the Llano Estacado on its northwestern borders. He wrote, “I traveled very rapidly this day across a very wide plain which contains no landmarks other than an arroyo which runs to the east and which has two clumps of chinaberry trees” (Loomis and Nasatir 1967:291). Loomis and Nasatir (1967:291) and Morris (1997:173) suggested that Mares and his companions were following Tierra Blanca Creek, and eventually encountered Tule Creek, near present-day Tulia, where permanent water allowed cottonwoods and reeds to grow.

The Llano Estacado was explored by Spanish, French, and American adventurers from the mid 1500s well into the 1800s. In fact, by 1800, “generations of New Mexican buffalo hunters...had traversed [the Llano Estacado] thoroughly” (Morris 1997:153-154). Chipman (1992) and Morris (1997) provided a thorough and insightful summary of accounts of the SHP written throughout this period. It is remarkable that the basic description of the landscape and the vegetation of the Llano Estacado, as seen through the eyes of explorers from 1541 well into the 1800s, remains essentially the same. Quotations presented earlier from the writings of Castañeda, for example, can be compared to what Albert Pike, a lawyer and author, wrote in 1832:

“Imagine yourself, kind reader, standing in a plain to which your eye can see no bounds. Not a tree, not a bush, not a shrub, not a tall weed lifts its head above the barren grandeur of the desert; not a stone is to be seen on its hard beaten surface; no undulation, no abruptness, no break to relieve the monotony...Imagine then countless herds of buffalo” (Haley 1968:21-22).

Similarly, George Kendall, a newspaperman who accompanied the “Texas-Santa Fe Expedition” of 1841 (Morris 1997:229-230), wrote in 1856:

“Here we were again gratified by finding spread out before us a perfectly level prairie, extending as far as the eye could reach, and without a tree to break its monotony” (p. 216)...We were going forward at a rapid pace, the prairies before us presenting no other appearance than a slightly undulating but smooth appearance (p. 221)...Not a tree or bush, and hardly a weed could be seen in any direction. A green carpet of short grass, which even at this season was studded with innumerable strange flowers, was spread over the vast expanse, with naught else to relieve the eye” (Kendall 1856:225).

Thomas Falconer, who accompanied the expedition, wrote:

“We commenced the ascent to the grand prairie—the Llano Estacado of New Mexico. This was the great plain spoken of at San Antonio as too extensive to travel over; where we should be without timber, without water, and where many of our horses would perish...we found before us an extensive flat table-land stretching as far

as the eye could reach...Proceeding over this great prairie...[we] were out of sight of every tree and shrub. The grass was fresh and green...Though we had no wood, there was an abundance of dried buffalo chips (p. 443)...[as they approached the boundary of the Llano Estacado] below us we saw a wooded country” (Kendall 1856:445; bracketed text added).

A diary by Gallagher and Hoyle, also written in 1841, describes the Llano Estacado as “a vast level prairie as far as the eye could reach without a tree or a shrub” (Morris 1997:238). In 1844 Josiah Gregg wrote, “The high plains seem too dry and lifeless to produce timber” (Moorhead 1954:362). In one of the most famous descriptions of the SHP (near Adrain, Texas), Captain R.B. Marcy, a military explorer, wrote on June 14, 1849:

“When we were upon the high table land, a view presented itself as boundless as the ocean. Not a tree, shrub, or any other object, either animate or inanimate, relieved the dreary monotony of the prospect; it is a vast illimitable expanse of desert prairie—the dreaded ‘Llano Estacado’ of New Mexico; or in other words, the great Zahara of North America. It is a region almost as vast and trackless as the ocean...it spreads forth into a treeless, desolate waste of uninhabitable solitude” (Marcy 1850:42).

Many of the descriptions of the SHP emphasize its vastness, its absence of woody vegetation, and its dominance by short grasses. These descriptions led to an image of the SHP as the “Great Zahara of North America” (Marcy 1850:42), a perception that has been thoughtfully analyzed by a number of authors (for example, Lewis 1966; Fenton 1990; Morris 1997). The concept of the “Great American Desert” was introduced to the American public by Z. Pike in 1810: “Beyond the meridian 96° 30’ west Pike distinguished between the valley floors, which would prove to be cultivable, and the extensive upland plains, poor in soil, treeless, and desiccated for eight months of the year, which he predicted might in time become ‘as celebrated as the sandy deserts of Africa’” (Lewis 1966:35). Major S.H. Long, however, is often credited with introducing this idea after his 1820 exploration to the Rocky Mountains. The official map produced from this expedition, published in 1823, labeled the region that included the Texas Panhandle as well as Oklahoma and parts of Colorado as “Great American Desert” (Lewis 1966:35). Many historians and geographers have since suggested that Long’s assessment of the central and southern Great Plains (from the South Platte to the Canadian River) was culturally biased, or even a product of a vivid imagination (for example, Blackmar 1906, from Lawson and Stockton 1981). However, Lawson and Stockton (1981), on the basis of reconstructed climatic data, concluded that: “These years of abnormally low moisture culminated in extreme drought throughout the lower portion of the western interior. Long’s route passed through the core of this moisture deficiency. In relative terms, the region identified by Long as

the Great American Desert was experiencing drought stress exceeding that of the 1930s. Only one other period, that of the late 1720s, surpassed the intensity or extent of the drought witnessed by Major Stephen H. Long. When one considers the magnitude of this moisture anomaly, augmented by the pressures of overgrazing by buffalo, perhaps it is less reasonable to refer to the desert as an illusion. For Long and his scientific cadre, the ‘impress of geographic conditions’ represented a reality never since experienced by this cis-Rocky Mountain west” (Lawson and Stockton 1981:535).

It is also true, however, that early explorers described woody vegetation in draws, riverbeds, and ravines, most obvious around the periphery of the SHP (on all sides), but also evident in some of the more conspicuous canyons that penetrated the SHP from the eastern escarpment of the Llano Estacado. For example, Coronado’s army constructed a bridge to cross the Pecos River on the way to the SHP, clearly indicating that woody vegetation was abundant along waterways peripheral to the SHP along its northwest margin. After they had crossed the SHP, Coronado encountered the eastern escarpment of the Llano Estacado, perhaps in Tule Canyon (Chipman 1992:38; Morris 1997:56), where “colorful canyons...descended hundreds of feet to rough, scrubby flats and timbered headwater creeks far below...Where these streams poured into larger drainages...the combination of wood, water, and food were particularly pleasant. These fringing woods were cool and shady...” (Morris 1997:55-56). Morris (1997, Chapter 6) also suggested that Coronado’s army stopped at Blanco Canyon in Crosby County, where timber, water, and food were abundant, including plums, wild grapes, mulberries, and possibly hickories.

In addition, the country that lay “below” the SHP (on all sides) supported abundant woody vegetation including mesquite. In fact, it was in Union County, New Mexico, along a stream usually identified as “Major Long’s Creek” (which flows into the Canadian River near the Texas state line; McKelvey 1955:229; Thwaites 1966, Vol. XVI:85) that Edwin James, a botanist traveling with Major S. Long in his exploration of the headwaters of the Red River in 1820, provided an early written record of mesquite in the area of the SHP:

“...we found ourselves once more entering a vast unvaried plain of sand...Among the few scattered and shrubby trees met with in this district, are oaks, willows, and the cottonwood; also a most interesting shrub or small tree, rising sometimes to a height of twelve or fourteen feet. It has dioecious flowers, and produces a leguminous fruit, making in several particulars a near approach to gladetschia...The leaves are pinnated, and the trunk beset with spines, somewhat like a honey locust, but the spines are single” (Thwaites 1966, Vol. XVI:91-93).

Several military explorers provided valuable descriptions of vegetation on the periphery of the SHP. Lt. James Abert traveled eastward along the Canadian River in 1846. Throughout his report, he remarked on the abundance of mesquite as he

traveled across the Texas Panhandle. For example, in the general vicinity of Logan, New Mexico, Abert (1846) wrote:

“[The Canadian River]...has increased to 70 or 80 feet in width, with a deep and very rapid current, so that we could scarcely keep our feet whilst bathing...the [river] bottom in which we encamped is everywhere covered with various species of cactus, the sharp spines of which penetrated our moccasins, making it painful to walk about. There is a plant still more annoying, commonly called “Sand-bur.” This is a diminutive plant, lying close to the sandy surface, loaded with a profusion of little burs, which attach themselves to our clothes and blankets by their sharp prickles, and adhere with great tenacity. Amongst the sylvia, the hackberry, “Celtis crassifolia,” is quite common, and we observed, for the first time, an extensive grove of the pride of India, “Melia azederach”—a tree gifted with a beautiful form and dense foliage...The trees were every where loaded with heavy masses of grape vines, “Nitis aestivalis”...It was now the fruit season of the broad-leaved cactus, “C. opuntia,” and they were every where in great abundance...We saw to-day great quantities of the “musquit,” or muskeet, covered with its long-sabre-formed legumes. The creek is well-timbered...” (Abert 1846:29-30).

In 1849, Marcy traveled from Fort Smith, Arkansas, to Santa Fe, New Mexico, along the Canadian River, and then returned along the southern boundary of the SHP. Marcy generally corroborated Abert’s general vegetation description of the Canadian River (also see Marcy 1853, for example, Chapter 5). For example, he remarked on June 10 that: “We have passed over a high rolling prairie for the last three days, destitute of wood, except a narrow fringe of trees upon the borders of the ravines” (Marcy 1850:40). However, the following day, Marcy wrote: “We started this morning, our road continuing over the elevated plateau, destitute of water, until we reached here, where there is a fine spring creek, with a great abundance of wood and grass” (Marcy 1850:40). On June 13, he wrote: “We passed a great deal of small mesquite and numberless plants of the jointed cactus today” (Marcy 1850:41). It should be noted that despite using terms such as “high rolling prairie” and “elevated plateau,” Marcy was in fact traveling below the SHP. He did not ascend to the Llano Estacado proper until June 14 (quoted above).

Marcy (1850) returned to Fort Smith via a route across the southern boundary of the SHP. From Santa Fe, he traveled south along the Pecos River, and then turned east, crossed through the Monahans area (Ward and Winkler Counties, Texas), and reached the eastern escarpment of the Llano Estacado at Big Spring, Texas (Howard County, Texas). Along the Pecos River, Marcy wrote:

“After marching six miles further, we encamped again on the west bank of the river. Here we found the finest and most luxuriant grama grass we had seen, with

mezquite wood. Keeping down the right bank of the river, we found the valley covered in many places with a growth of small mezquite trees..." (Marcy 1850:60).

After crossing the Pecos River, Marcy wrote:

"There has been a chain of sand hills in sight to-day, running from north to south across our course, about twenty miles to the east of us, (upon the Llano Estacado,) in which our guide informs us that there is water, but that we are obliged to pass over the sandy road from some fifteen miles to get through them" (Marcy 1850:61).

Marcy crossed through the sandy country, now known as the Monahans Sand Dunes, and was surprised to find water, which his guide informed him was permanent. Having passed through the sand dunes, Marcy again encountered "hard prairie...There is good grass near the hills, and sufficient wood for fuel" (Marcy 1850:62). Although the species is not identified, it is likely that Marcy encountered mesquite to the northeast of the Monahans sand dunes. Marcy then "pushed out upon the high plain of the Llano Estacado" (Marcy 1850:62-63). He encountered Mustang Pond and then Laguna, or Salt Lake. Marcy wrote: "We marched twenty-three miles today...which brought us to the Laguna, or Salt Lake. The country has been similar to that of yesterday, over the high rolling table lands of the Mesa, with no wood except the small mezquite brush" (Marcy 1850:64). In another eight miles bearing northeast, Marcy encountered the eastern escarpment of the Llano Estacado near Big Spring. He wrote: "The mezquite trees are becoming larger as we descend from the high plain" (Marcy 1850:64). As Marcy moved east off the Llano Estacado and started towards Fort Smith, Arkansas, he described "...a perfectly level grassy glade, and covered with a growth of large mesquite trees at uniform distances, standing with great regularity, and presenting more the appearance of an immense peach orchard than a wilderness" (Marcy 1850:68).

Lt. A. Whipple explored the possibility of a railroad route along the northern SHP in 1853. He wrote:

"Ascending about two hundred and fifty feet, in about a mile from camp we reached the top of the Llano. Here, for the first time, we saw what one might call a prairie ocean; so smooth, level and boundless does it appear. It is covered with a carpet of closely cropped buffalo-grass, and no other green thing is to be seen (p. 87)... to the top of the Llano...towards the south, appears smooth, level, and of unlimited extent. It is covered with short buffalo-grass, but contains neither shrub nor tree to vary the landscape" (Whipple 1853:119-120).

Marcy explored the sources of the Big Wichita and Brazos Rivers in 1854, accompanied by W.B. Parker. Both men left descriptions of their travels. Parker (1854:160-161) described the vegetation of a spur of the Llano Estacado along the Brazos River as follows: "...and finally ascending over a steep and

dangerous road, came to a broad level plain, a spur of the Llano Estacado, covered with buffalo grass and mesquite, and extending as far as the eye could reach in a perfect level towards the dim, cloud-like mountains at the head of the Brazos." This description clearly mentions mesquite on the east-central Llano Estacado. Two additional observations, however, are pertinent: Marcy's description of this area (Marcy 1854:14) fails to mention mesquite on the Llano Estacado and Parker's description is accompanied by a footnote which states, in part, that the Llano Estacado "is...without a tree...throughout its entire surface" (Parker 1854:161). Thus, the conclusion that mesquite was dominant in this area remains ambiguous.

J. R. Bartlett traveled westward from Fredericksburg, Texas, to El Paso in October, 1850. He frequently described woody vegetation including live oak and mesquite along his route through the northern Edwards Plateau. In October, he described the vegetation near Antelope Creek, which he identified as on the tributaries of the Concho River. At this time, Bartlett was still on the Edwards Plateau:

"Our route today had been over a level prairie country, deficient of wood, save a few scattering mezquit trees of diminutive size, and light grass, indicating a poorer soil. We have noticed as we advanced westward, and ascended the high tableland of Texas [he was not on the Llano Estacado at this time], an inferior soil, and, as a necessary consequence, a more scanty herbage. The beautiful live-oak, which abounds in eastern Texas, and which grows luxuriantly in the valleys as far as the north fork of Brady's Creek, has not disappeared, save on the immediate banks of water courses. The mezquit, too, which grew large and thrifty on good soil, had not either disappeared or dwindles into a diminutive tree or mere shrub" (Bartlett 1854:74; bracketed text added).

As he approached the southern margins of the SHP near Mustang Pond, he wrote:

"The desert was not, as I supposed, a level surface, but a succession of slight elevations. Everything bore the appearance of extreme barrenness; not a tree could be seen. Mezquit chapporal, or bushes from three to five feet in height, were thinly scattered over the plain. The wild sage and Larrea Mexicana, the prickly pear and other kinds of cactus, constituted the vegetation of this desert region. Grama grass (Chondrosium) [Chondrosium?] grew in some spots, and, though completely dried up, was eaten with avidity by our animals" (Bartlett 1854:87; bracketed text added).

And at Mustang Pond, he wrote: "Finding a spot where there was plenty of dry grass, the train was stopped and the animals turned out to graze...they ate the withered grass and browsed on the twigs of mezquit bushes with eagerness" (Bartlett 1854:88).

There are, therefore, many descriptions of woody vegetation in the lower country surrounding the SHP. And despite

the poignancy of many of the early descriptions of the SHP proper as vast and featureless, it is important to appreciate that there was *some* relief to the dreariness of the Llano Estacado even between its western and eastern escarpments. Morris (1997:52ff; also see Bryan 1956:87) provided convincing evidence that before reaching the eastern escarpment, Coronado's expedition encountered Running Water Draw, which crosses the SHP in a southeasterly direction. While on the SHP probably in lower Hale County, Texas (Morris 1997:51), Coronado sent Captain Diego López on a reconnaissance trip along a bearing toward the sunrise, and along this path, Morris suggests that they encountered Running Water Draw, which provided fresh, running water. When the reconnaissance party reunited with the main army, López reported that "they had seen nothing but cows and the sky" (Winship 1964:235), clearly indicating they were on the SHP. Significantly, though, in the same area where López saw only "cows and sky," Castañeda writes that the two native Indians who had found López's party and led them back to the main army were in fact looking for fruit when they encountered López. Clearly, this part of the Llano Estacado was crossed by a draw that supported woody vegetation with fruits (Morris 1997:54). Coronado himself provided an interesting and important corroborating clue to vegetation patterns on the Llano Estacado when he wrote to King Charles V: "... [we were] going many days without water, and cooking the food with cow dung, because there is not any kind of wood in all these plains, away from the gullies and rivers, which are few" (Winship 1964:368). Similarly, José Mares, dispatched by Governor Cabello to reconnoiter a route across the Llano Estacado in the 1780s, encountered chinaberry trees along an arroyo that Loomis and Nashatir (1967:291) and Morris (1997:173) identify as upper Tierra Blanca Creek, which soon joined with running water near present-day Friona and Hereford, Texas; Mares also encountered Tule Creek, near present-day Tulia, which he described as "...permanent [with] cottonwood trees and many reeds [*tules*]" (Morris 1997:173). Additionally, mesquite occurred in certain edaphic settings. For example, Havard (1884:455) remarked that: "The most desolate parts of the Staked plains are the Sand hills—barren heaps of shifting sand. Between these are sometimes found large, vigorous mezquit shrubs." In 1901, Oberholser (Smithsonian Institution Archives, Record Unit 7176, Box 95, Folder 14) described *Rhus aromatica* and *Celtis occidentalis* on the sand dunes 45 miles south of Hereford. Finally, as indicated above, Marcy (1850) and Bartlett (1854) reported mesquite in the southern part of the Llano Estacado, north-east of the Monahans Sand Hills and near Big Spring.

Summary of Early Descriptions

For a period of about 300 years, a description of the vegetation of the SHP can be drawn, from many sources, that shares the same essential features. First, the escarpment itself, as well as the country "below" the Llano Estacado, supported abundant woody vegetation. The fact that Coronado could build a bridge across the Pecos River suggests perhaps

abundant cottonwood. In addition, Castañeda described a number of woody species (for example, *Prunus*, *Morus*, and probable *Carya illinoensis*; Morris 1997:80-81) in what Morris suggested was Blanco Canyon, which penetrates the SHP from the eastern escarpment in Crosby County. Finally, both the first record of mesquite (by James), as well as abundant references to the plant (by, for example, Abert and Marcy), provide ample evidence that this country supported abundant woody vegetation.

Second, the SHP proper was characterized by grassland vegetation over most of its vast, changeless expanse. Further, this grassland *evidently* supported no woody vegetation (but see below). Numerous quotations have been cited describing a landscape devoid of shrubs and trees, a topographic vacuum that demanded travelers to mark their routes with piles of buffalo dung to avoid disorientation and swallowed up those who strayed beyond the boundaries of the known. Third, despite the apparent monotony of the Llano Estacado, it is noteworthy that it was interrupted by vegetation diversity including woody species in and along major draws that crossed the SHP as well as in sandy soils. Coronado's telling phrase that there is not any kind of wood in all these plains, away from the gullies and rivers, which are few (Winship, 1964, p. 368), implies that the "gullies and rivers" in fact had woody species. Further, Coronado's Indian guides who found Captain Lopez were actually looking for fruit at the time, suggesting woody species in Running Water Draw in the northcentral part of the Llano Estacado. Finally, José Mares noted chinaberry trees along upper Tierra Blanca Creek (see earlier text).

Later 1800s to Early 1900s

Beginning in the late 1880s, with the "settling" of Texas, scientific interest in its natural resources spurred the commission of a biological survey of the state, including the SHP. The general descriptions of the vegetation of the SHP that have been gathered from the literature between 1541 and the 1850s are largely corroborated by Bailey's (1905) biological survey of Texas. Bailey's map of the distribution of mesquite in Texas and New Mexico (Bailey 1905, Plate III; see fig. 4) clearly showed that mesquite was absent from most of the SHP. In fact, Bailey defined the "plains" portion of the "Upper Austral Zone, Upper Sonoran Division" (Bailey 1905:33) (which included the SHP, see figure 3a in Schmidly 2002:43) by the "absence of mesquite and other shrubs of the surrounding Lower Sonoran Zone" (Bailey 1905:33; the "other shrubs" included species of *Acacia*, *Mimosa*, *Ziziphus*, *Condalia*, and *Lycium*; see Schmidly 2002:79). It is also significant that Bailey's map shows that mesquite was present along the southeastern portion of the Llano Estacado in the general area of Big Spring, which supports Marcy's (1850) and Bartlett's (1854) observations.

Bailey and his team of scientists left a wealth of valuable descriptions of the SHP and its surroundings. For example, Merritt Cary provided the following description of the Monahans area (Ward and Winkler Counties, Texas) in 1902:



Figure 4. Distribution of mesquite in Texas in 1905 (from Bailey 1905).

"Monahans is situated in a mesquite basin which is rimmed in on the southeast, south, southwest, and west sides by hard, limy ridges and on the northwest, north, northeast, and east by a range of high sandhills. A large portion of the basin is sandy, and supports a heavy growth of Ziziphus obtusifolia in addition to the mesquite. These are the only two shrubs occurring in the basin. Among smaller plants growing in the sandy soil are Mentzelia sp., Baccharis sp., and Artemisia sp. as well as Yucca stricta. The hard ridges support a heavy growth of range grasses, in addition to Larrea, Lycium berlandiera, Ziziphus, and a few mesquites... These sand hills are quite steep in some places, and are clothed with a more or less dense growth of "shin oak," except where the wind has formed "blow outs" (Smithsonian Institution Archives, Record Unit 7176, Box 93, Folder 13).

In 1892 B.H. Dutcher described the area around Stanton (southeast Martin County, Texas) as follows:

"Stanton is situated on the edge of the plateau top of the Llano Estacado or Staked Plains. Only a few miles east of the town the plain "breaks" down to the shelf that extends to the Colorado River. The surface of the country is gently undulating, is well-covered with grass and weeds, and supports a scattering growth of

mesquite trees, catclaws, etc. The trees and bushes seem to grow in groves, which are interspersed with excluded barren reaches...I was informed that the country lying to the north over the plains does not differ essentially in character from the country at Stanton" (Smithsonian Institution Archives, Record Unit 7176, Box 93, Folder 18).

Dutcher also reported:

"Mesquite. Common though not entirely covering the plains. Does not attain a height of over six or eight feet in the open. Juniperus virginiana. Common in groves along the edges of the plain overlooking the shelf below, on the red-soil mesquite plain" (Smithsonian Institution Archives, Record Unit 7176, Box 93, Folder 19).

Clay indicated that in the area of Stanton:

"Odessa, Warfield, and Stanton are situated alike on a high, grassy mesquite plain...In the vicinity of Stanton, however, there are very few mesquites, and large areas of open, grassy plain are frequent...The botany of the three localities is very similar. The principal shrubby plants noted were as follows: Ziziphus obtusifolia, Prosopis juliflora, Acacia sp., Opuntia arborescens (not noted east of Stanton), Cereus sp., Yucca stricta,

Ephedra nevadensis, *Baccharis* sp., *Grindelia*. *A rank growth of range grasses obtains throughout the region*" (Smithsonian Institution Archives, Record Unit 7176, Box 93, Folder 13).

In the northern half of the SHP, Bailey described the landscape surrounding Washburn, Texas (northeast corner of Armstrong County), in 1892 as:

"Washburn is on the Staked Plains...There is nothing to break the smooth, even monotony of almost level prairie, meeting the horizon on all sides...A low, thick growth of grass covers the country, giving an almost velvety smoothness of surface. Here and there a thistle, an Aesclepias, or Euphorbia rises a foot or so, but so scarce as to be hardly noticed. An occasional house, with windmill and fences, or cattle and horses grazing are all that break the monotony" (Smithsonian Institution Archives, Record Unit 7176, Box 92, Folder 13).

And describing a portion of Palo Duro Canyon (Armstrong County, Texas), Bailey wrote:

"Thirteen miles south of Washburn the Prairie Dog Fork of the Red River flows through an abrupt cañon of about 1,000 in depth...The top of the canyon is about a mile wide...The bottom is sandy and smooth. The river bed is small and now almost dry. The whole canon is lined with trees, brush and plants not found outside in the surrounding country, and furnishes the only timber for a long distance. Junipers are the most abundant and useful tree, being used for fence posts and fuel, and are very common along the sides of the cañon. A few cottonwoods grow along the bottom, also Celtis and chinaberry. Prosopis fills the canon and runs over the edge of prairie as also a little oak. Lyssium [Lycium?] is common, several species of Rhus, Ptelia, Cercocarpos [Cercocarpos?], Atriplex canescens, five species of cactus, Yucca angustifolia, Artemisia and others entirely new to me" (Smithsonian Institution Archives, Record Unit 7176, Box 92, Folder 13; bracketed text added).

Bailey added the following important note in a plant list of the area:

"Prosopis glandulosa, abundant in cañon, extending out along the top and a few small plants (rarely over two feet high) here and there over the prairie (Smithsonian Institution Archives, Record Unit 7176, Box 92, Folder 14).

Henry Oberholser described the landscape around Hereford in 1901 as follows:

"Hereford is located on the Staked Plains at an altitude of about 3,800 feet...For long distances in any direction from the town the country is a level or slightly rolling

grassy plain, at intervals interrupted by wide, scarcely abrupt and usually not very deep grassy valleys, or 'draws' as they are known in local parlance, which lead to the headwaters of the Red River, but contain water only after heavy rains. Close to the south side of Hereford there is, however, a spring-fed creek, the Tierra Blanca, which for some fifteen miles is a running though sluggish stream. Along the miles of its grassy valley there are frequent outcrops of friable white limestone appearing in low isolated cliffs usually close to the present stream bed. The margins of this creek are overgrown with a dense mass of cattails and rushes, while on the cliffs occurs the nearest approach to a natural growth tree [sic] anywhere to be found—a few scrubby bushes of Celtis occidentalis...Some 45 miles to the south of Hereford the general evenness of the country is broken by an extensive area of low sand hills. Here the soil changes from the dark colored loam of the environs of Hereford to the fine sand which supports a much less dense growth of grass. The highest of these hills probably is not much over 30 feet above the plain; and all are usually covered with a growth of rank weeds and bushes of Rhus aromatica, with sometimes a few low trees of Celtis occidentalis...after crossing them to the southeast the country more resembles that immediately about Hereford...The portion about Hereford is characterized by the absence of shrubby vegetation which begins to appear about 40 miles to the southward in the shape of scattered bushes of Mimosa biuncifera, this increasing in amount to the southwest until it forms in many places a low chaparral. About 50 miles south of Hereford scattered shrubby bushes of Prosopis juliflora begin to be observable, and continue to occur along the road leading southwest..." (Smithsonian Institution Archives, Record Unit 7176, Box 95, Folder 14).

Both Bailey and William Bray traveled from Gail, Texas, north to Amarillo in 1899. Bailey wrote:

"From Colorado [River] to 15 miles north of Gail the country is Colorado River valley and is characterized by an uneven, eroded surface of red beds and sand cover by a scattered growth of cactus, mesquite, etc. The escarpment of the real[?] Llano Estacado begins just west of Gail but our road does not rise onto it for about 15 miles farther north. The escarpment here is about 400 feet. To the north the country rises slowly but steadily to Lubbock, Hail [sic] Center, Canyon and Amarillo but appears as a flat plain, covered with short grass, free of bushes or trees...Most of the mesquites, thorn bushes, and cactus are left below the escarpment and soon disappear from the higher levels. Short grasses and low prairie, or plains, plants cover the top of the plains and give the characteristic smooth carpet appearance of the region. A few northern plants are met with that may be typical Upper Sonoran species

but the Upper Sonoran Zone of the top of the plains is marked rather by the absence of surrounding Lower Sonoran species than by a change from one set of plants to another...The country is mostly fenced up in pastures of enormous extent, often containing several hundred square miles, and cattle are scattered over the whole region. Except on areas where there has been no rain for a long time the range is not overstocked and the grass is abundant" (Smithsonian Institution Archives, Record Unit 7176, Box 92, Folder 16; bracketed text added).

Describing the area from the Colorado River to Gail, Bray wrote:

*"...the characteristic "red beds" formation continues. This is a country left rolling by erosion where stream ways occupy broad flat valleys which rise to picturesquely carved bluffs no where precipitous but for some areas of exposed rock. The gentler swells are covered with sandy loam and the valleys with more compact silt. On these flats the excellent range grass *Hilaria jamesii* was so abundant as to suggest a field of timothy hay. *Prosopis juliflora* is abundant over the flatland often covering the ground continuously with a large growth...On the flat stretch of some ten miles north of Gail before reaching the escarpment of the plains *Prosopis* is very abundant and still of large size. [About] ten miles north of Gail the road passes upon the Plains...Almost at once the biological character of the mesa indicates its individuality...The predominant botanical characteristic of the Staked Plains is this: A vast stretch of solid grass floor in which is an admixture of herbaceous vegetation from the south and another equally marked from the north"* (Smithsonian Institution Archives, Record Unit 7176, Box 93, Folder 8).

Bray continued in description of the "timber or shrubby vegetation of the Staked Plains:"

"Prosopis juliflora. This is a small tree of approximately normal size on the flat north of Gail. Never after ascending the escarpment $\pm$ 12 miles north of Gail does it exceed five feet in height, and is always a cluster of sprouts or very small trunks. In many places it is wholly absent for miles. At Lubbock there is still considerable mesquite one to two feet tall and the merest switches of stems. At Hale Center there is an occasional sprout of mesquite, but beyond this it disappears entirely. Going southeastward from Amarillo on the Denver City and Fort Worth line, short mesquite first appears at Goodnight station [between present-day Claude and Clarendon, Texas], sprouts two to three feet tall. Below the eastern escarpment a fairly large tree growth sets in. In general to the south and east mesquite stops at 3,500 ft... ." (Smithsonian Institution Archives, Record Unit 7176, Box 93, Folder 9; bracketed text added).

It is interesting to compare these comments (written in 1899) with Bray's description of mesquite in a 1904 publication:

"[Mesquite's] spread northward and eastward from the Rio Grande country during the past 50 years has been a marked phenomenon. By its invasion mile after mile of treeless plain and prairie have been won and reduced to the characteristic orchard-like landscape...It has pushed northward over the Staked Plains, covering half their area" (Bray 1904:34).

And in 1906, Bray provided the following poetical description of the vegetation of the Staked Plains:

"It is on these high grass plains that the complete masterfulness of the grass-land type of vegetation impresses one. The monotonous level or billowy swells of a sea of grass unrelieved by the presence of taller plants like a shrub or tree, such as the ungrazed plains presented, could fasten upon the senses a conception of the power of a victorious vegetation such as one might get in the depths of a virgin pine forest, or in the sun-beat chaparral jungle which are also the expression of dominant vegetation types" (Bray 1906:92).

It seems that Bray's descriptions of the woody vegetation of the SHP, gathered from his notes written in 1899 in conjunction with his work on the biological survey and his publications of 1904 and 1906, lack some consistency. Also, Bray's map (fig. 5), in contrast with Bailey's (fig. 4), shows that mesquite was present (although not abundant) in several counties along the southeastern border of the SHP (for example, Gaines, Dawson, Borden, Andrews, Martin, and portions of Lynn Counties).

Several vegetation descriptions in the early 20th century indicate that mesquite was present on the SHP. For example, in Clements' (1920:139-144) description of the Short-Grass Plains that extended into the Texas Panhandle, characterized by the *Buchl e-Bouteloua* association (which he later "down-graded" to the *Buchl e-Bouteloua* associates, a short-grass disclimax that resulted from overgrazing; Weaver and Clements 1936:524), Clements made no mention of mesquite. In his description of the Desert Plains in the grasslands of the southwest including New Mexico, Arizona, and Texas, characterized by the *Aristida-Bouteloua* association, Clements (1920:145) remarked that "Indeed, *Larrea* or *Prosopis* is scattered over so much [of this association] that it has often been regarded as mesquite rather than grassland." Clements explained that: "The desert plains are in close contact with but one other association of the grassland formation, namely, the short grass plains...The contact...is from Synder and Big Spring in the Staked Plains of Texas to Roswell and Socorro in New Mexico..." (Clements 1920:144-145). It is with this background that the following comment by Clements should be appreciated. He remarked: "Mesquite savannah lies typically in the desert plains, though the mesquite itself extends

northward into the short-grass association of the Stakes Plains” (Clements 1920:278).

In a description of vegetation types in the semiarid portion of the U.S., Aldous and Shantz (1924:103) included:

“Grama-Buffer, and Mesquite.—This is a very common type in the southern Great Plains of western Texas and eastern New Mexico, growing on hard lands. It is composed of an open sod of grama grass and buffalo grass, over which are scattered bunches of mesquite.”

However, Shantz and Zon (1924) mapped the Llano Estacado as short grass plains (“Grama-Buffer grass”), with tall grass prairie characterizing the sandy soils in the western portion of the SHP. “Mesquite and the desert grass savanna” was mapped in the Rolling Plains and Edwards Plateau regions to the east and south of the SHP. This latter description was also followed by Shantz (1938), where “Mesquite-Desert Grass Savanna (Desert Savanna)” was distinguished from the “Short Grass (Plains grassland)” “in that trees are scattered over a short-grass cover” (Shantz 1938:848).

Not all authors, however, recorded mesquite on the SHP. For example, in 1917 the Texas state forester, J.H. Foster wrote: “[Mesquite] is found in the Breaks of the Plains, but has gained no foothold on the high, level plains themselves, apparently being killed back by frosts” (Foster 1917:445). This is one of the few descriptions of the SHP that specifically mentions an absence of mesquite, and it stands in contrast to other quotations in this regard.

Interpretation

From the foregoing survey of the literature, an initial conclusion can be reached: although the landscape immediately surrounding the SHP was characterized by a mixture of grassland and woody species, the Llano Estacado proper supported a vast shortgrass plains grassland interrupted by woody species only in certain topographic settings (for example, in draws or on very sandy soils). This conclusion is based on the writings of Spanish explorers as well as later military explorers and naturalists, covers a period of approximately 300 years (1540s to 1850s), and is corroborated by vegetation maps of Bray (1896) and Bailey (1905).

It is also true, however, that this conclusion is contradicted by other evidence also recorded in the mid to latter 19th century. Marcy’s summary statement about mesquite, written in 1854, is important:

“...In the journeys I have made before upon the plains I had observed the mesquite tree extending over vast tracts of country...What the exact geographical range of the tree is we are as yet (with a great portion of our territory unexplored) unable to define; my own observations, however, warrant me in asserting confidently that it is only indigenous to the great plains of the west and south...Between the twenty-sixth and thirty-six parallels

of north latitude, with the ninety-seventh and one hundred and third meridian of longitude, it is found abundantly, often constituting vast tracts of wood land, and is, indeed, almost the only siloa [sic; silva?] of the section...In going north from the parallel of thirty-three degrees, (in the direction I have traveled,) the trees gradually become smaller and smaller; until at least they are mere bushes; and, finally, on arriving near the latitude of thirty-six degrees, they disappear entirely...It is a tree of short, shrubby growth, with stock averaging from four to fifteen inches in diameter, and seldom attaining a height, including its top, of more than twenty feet...[it] is often found upon the most elevated and arid prairies, far from water courses...” (Marcy 1854:25-26; bracketed text added).

When evaluating this important statement by one of the most successful military explorers of the SHP, it must be remembered that despite his lengthy expeditions, Marcy actually spent very little time on the SHP proper (which he alluded to in the above quotation when he wrote “with a great portion of our territory unexplored”). His travels from Fort Smith to Santa Fe in 1849 followed the Canadian River valley and ascended the Llano Estacado proper for only one day (June 14, 1849; Marcy 1850:12, 42). His return along the southern borders of the SHP likewise involved little time on the Llano Estacado proper (from September 28 to October 3, 1849, with one day of rest; Marcy 1850). In 1854, Marcy stated that “even the Indians do not venture to cross [the Llano Estacado] except at two or three points...” (p. 92). Thus, it might be suggested that although Marcy’s determination of the limits of the latitudinal range of mesquite was both accurate and based on extensive experience, it is not clear from his writings that he observed mesquite throughout the extent of the SHP.

Settlers in the Lubbock area described mesquite in the late 1800s. For example, Lou Stubbs arrived in Lubbock in the early 1890s and, after a wet June, noted a diverse flora of grasses and forbs as well as “green mesquite” (Burnett 1990:12). Bray’s notes recorded in 1899 described mesquite on the SHP at least as far north as Hale Center (Hale County). Slightly later, Clements (1920) remarked that mesquite extended into the shortgrass plains of the Llano Estacado, and Aldous and Shantz (1924) described a “grama-buffalo and mesquite” vegetation type as “very common” in the southern Great Plains (that is, “eastern New Mexico and western Texas”).

An inspection of a chronological sequence of maps of the distribution of mesquite, together with the written descriptions quoted above, suggests that whereas mesquite was evidently entirely absent from the SHP (figs. 4, 5, 6) or restricted to draws in the SHP in the mid and late 19th century (fig. 7), it had expanded its range into “upland” sites by the middle of the 20th century (figs. 7, 8), and virtually covered the SHP by the latter years of the 20th century (figs. 9, 10). (The distribution map in fig. 7 is from *Life Magazine* and obviously lacks the “credibility” of a refereed scientific publication, and it certainly fails to document the sources consulted for the construction of the map. Notwithstanding, it is curious that

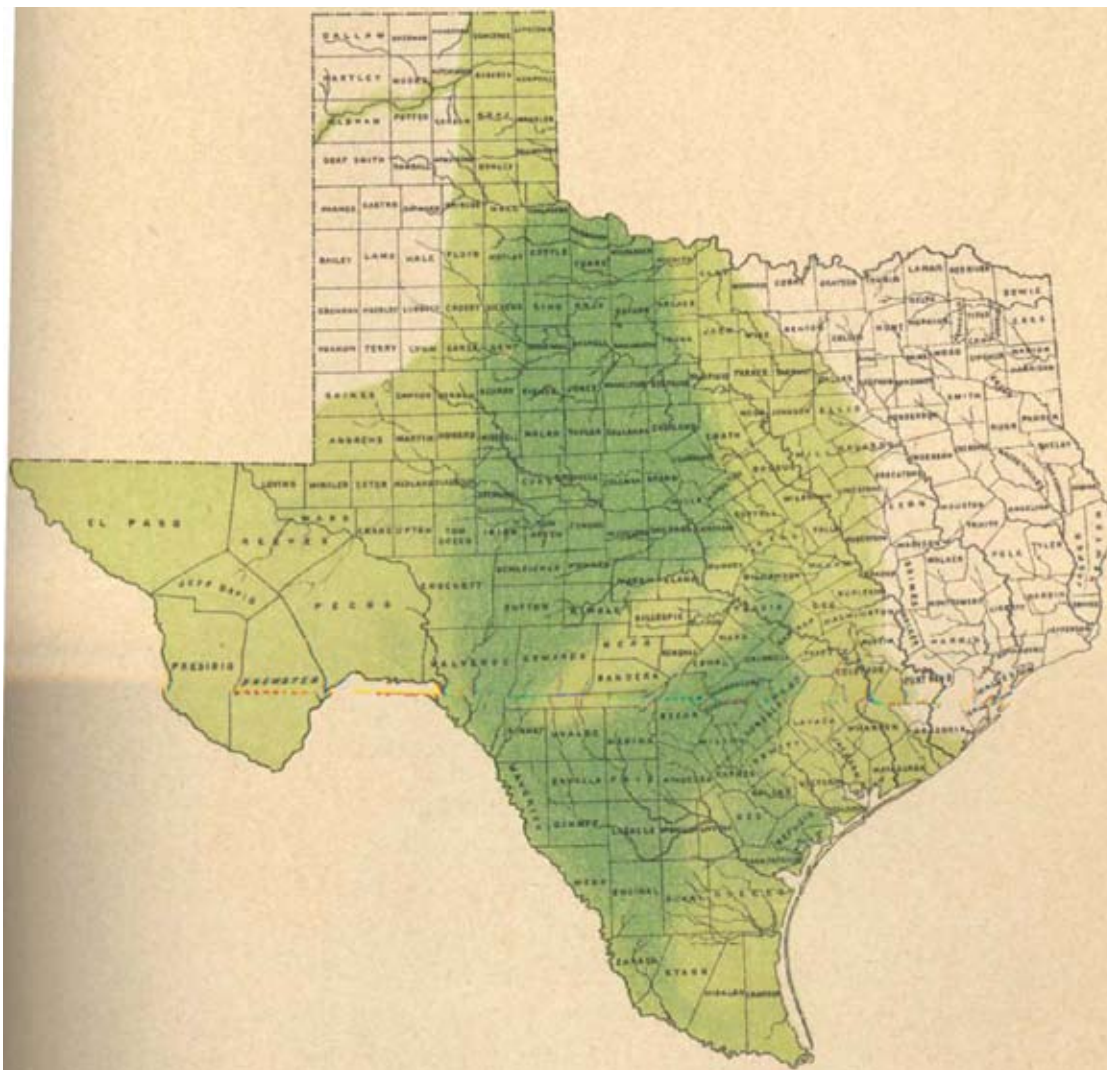


Figure 5. Distribution of mesquite in Texas in 1896 (from Bray 1896).

the distribution it shows for 1850 seems to be more consistent with the descriptions provided by the early explorers than the 1896 or 1905 distributions shown by Bray and Bailey, respectively. See Malin (1953:213) for a comment on the “authority” underlying this map.)

An Explanation

Some authors have suggested that mesquite has not expanded its range since the early 19th century, but rather it has increased in density so that plant populations are greater. Burkhart (1976:225) described *Prosopis* as a “primitive” genus that possibly originated in north Africa, and wrote: “Present distribution patterns of species of *Prosopis* do not exclude the possibility of an ancient desert flora common to both Americas which later divided and became widely separated into two centers, the Mexican-Texan center and the Argentine-Paraguayan-Chilean one...the fact that in both centers endemic species exist indicates their antiquity...”

Axelrod (1937) reported *P. pliocenica* in the Pliocene flora of southern California and observed that “Since the fossil species closely resemble their modern representatives, it is believed that the habitat implications of the fossil and living species are similar” (p. 138). He further described *P. pliocenica* as part of a “desert border element” whose modern equivalent is *P. juliflora* var. *glandulosa*. Malin (1953) advanced this interpretation with respect to the “floristic range” of mesquite generally. Johnston (1963) provided considerable supporting evidence, but limited his discussion to mesquite’s distribution in south Texas and northeastern Mexico (that is, areas “below 2,000 ft in elevation and south of the 29th parallel”; Johnston 1963:456). This explanation has been repeated by numerous authors (for example, Fisher 1977; Dahl 1982; Brown and Archer 1989, 1999; Jacoby and Ansley 1991), who, for the most part, discuss it in a general context. For example, “grassland and savanna systems” (for example, Brown and Archer 1999) or “the semiarid southwestern U.S.” (for example, Dahl 1982) are usually described without the distributional

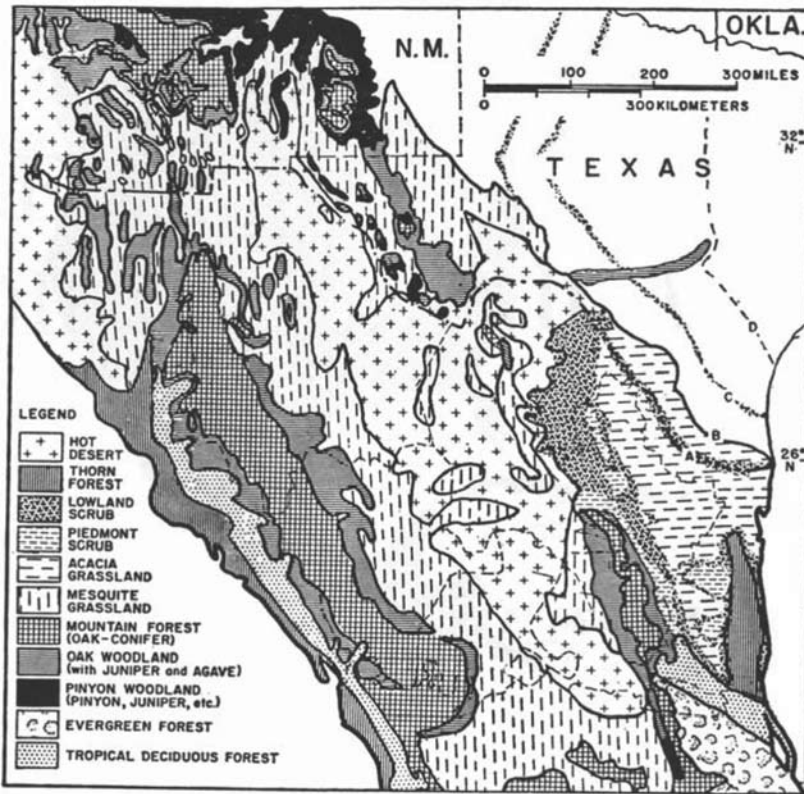


Figure 6. Probable distribution of mesquite grassland, *Acacia* grassland, and associated communities about A.D. 1600. *Acacia* grassland was believed to be present in the Rio Grande floodplain and adjacent areas (A) whereas mesquite extended to the line B. By 1923, the thorn shrubs had reached line C, and mesquite had reached line D (from Shelford 1964).

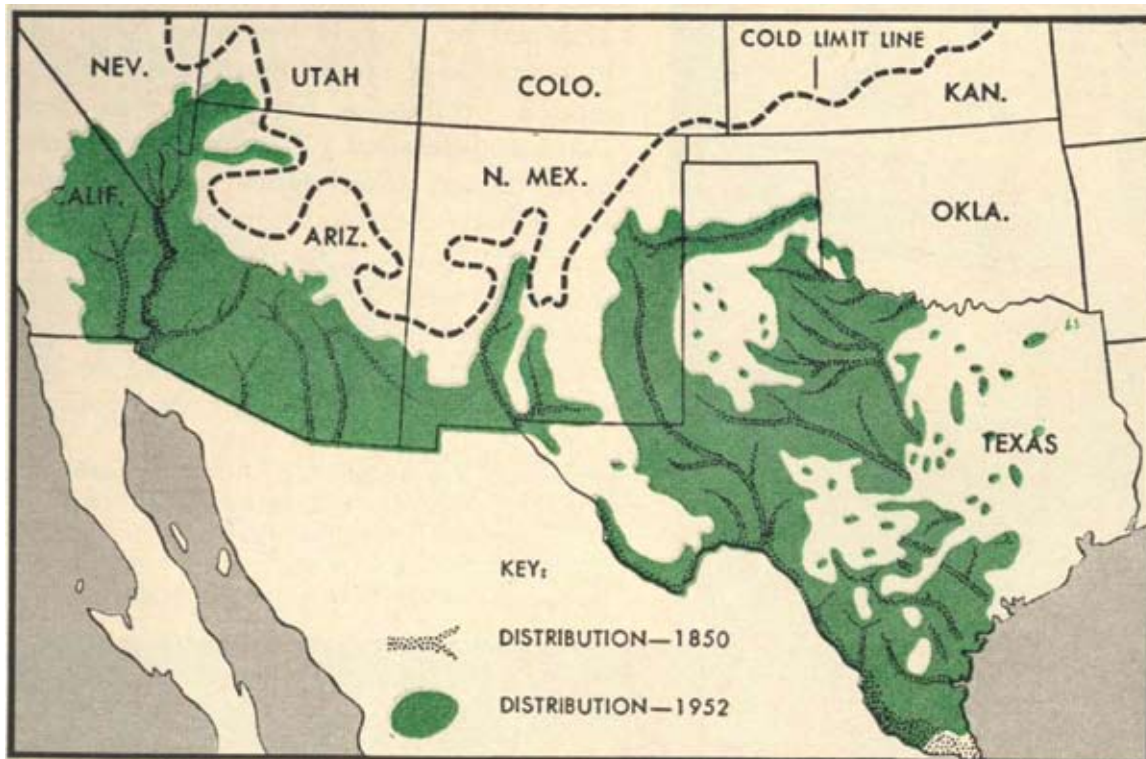


Figure 7. Distribution of mesquite (from Life Magazine 1952).



Figure 8. Distribution of mesquite in 1943 (from Allred 1949).



Figure 9. Distribution of mesquite in 1977 (from Fisher 1977).

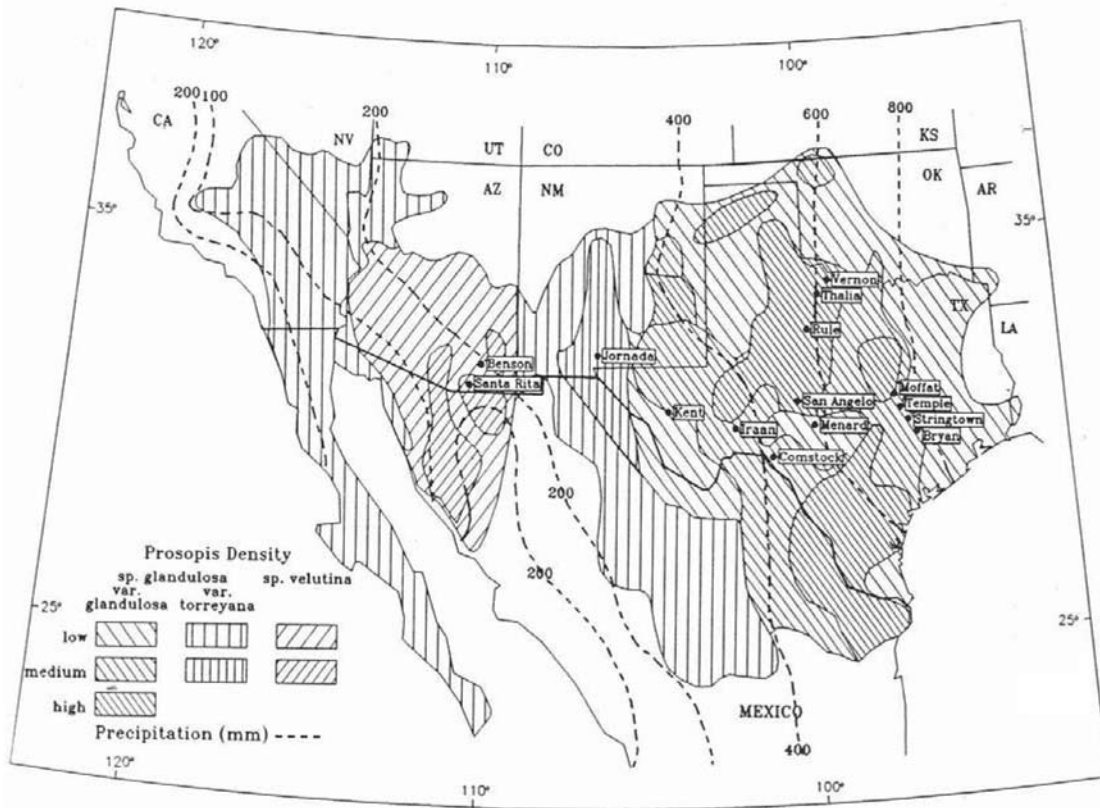


Figure 10. Distribution of mesquite in 1990 (from Johnson and Mayeux 1990).

limitations explicit in Johnston's (1963) paper (even though Johnson's paper is usually cited).

Many factors are probably involved in the population increase of mesquite, including changes in fire frequency, herbivory by both large mammals and rodents, and climate change. One of the most commonly-implicated factors is fire. In particular, many authors have suggested that periodic fires maintained relatively low mesquite population densities, and the reduction of fires allowed for increases in population densities. This explanation has a long history. For example, Cook (1908) wrote that:

"It is a matter of popular knowledge in south Texas that extensive regions which were formerly grassy, open prairies are not covered with a dense growth of mesquite...It differs locally only in the number of years since the bushes began to grow—thirty years, or twenty, or ten—subsequent to the establishment of the grazing industry on a large scale, the annual burning of the grass by cattlemen, and finally the fencing of the land for still more intensive grazing...Very often the old mesquite pioneers, the scattered trees which made the 'open mesquite country' of other decades, are still conspicuous among their much smaller progeny and the crowds of other camp-following species which now occupy the land to the almost complete exclusion of the grasses upon which the herds of former days were pastured. The change has come so gradually that even those who have the most intimate acquaintance with the

facts have not appreciated their significance...Before the prairies were grazed by cattle the luxuriant growths of grass could accumulate for several years until conditions were favorable for accidental fires to spread. With these large supplies of fuel the fires which swept over these prairies were very besoms of destruction not only for man and animals but for all shrubs and trees which might have ventured out among the grass...That such fires were evidently the cause of the former treeless condition of the southwestern prairies is also shown by the fact that trees are found in all situations which afford protection against fires [pp. 1-2]...Settlers in south Texas early adopted the practice of burning over the prairies every year; partly to protect their homes against the fires, partly to give their cattle readier access to the fresh growth of grass...While the grass was still abundant these annual burnings were able to keep the woody vegetation well in check, though no longer able to drive back the forest or even to prevent its slow advance. In spots where the grass is thin, seedling mesquites and oaks escape the flames and in a year or two begin to shade the ground and gain more protection against the dangerous proximity of the combustible grass; and even though the tops are killed by later fires the roots may send up sprouts again and again to improve the chances of becoming established [p. 3]..."

Johnston (1963:465) stated that: "It is emphasized that many 'grasslands' were infested with the ubiquitous mesquite...and

that the rapid takeover of the mesquite brush involved an increase in stature of the aerial parts of the plant and in density of stand, rather than invasion of previously brush-less areas. Most authors feel the control of fires explains the shrinkage of the grasslands. Nothing in this study contradicts such an explanation.” More recently, Dahl (1982:A-1) wrote: “Had fires not periodically swept southwestern grasslands, probably the entire area would have supported a woody overstory long before the first white men arrived in North America.” Brown and Archer (1989:25) wrote that one possible explanation for mesquite in southwestern grasslands is that: “*Prosopis* may have always been present in grassland, but recurring fires kept plants from developing in stature and producing seed.”

It may be difficult, however, to reconcile this explanation with the apparent *absence* of mesquite over most the SHP as depicted by the much of the literature reviewed here. If this explanation were true, it seems that *some* evidence of mesquite, perhaps present as small, stunted plants, would have been recorded by early explorers in upland sites, particularly in light of the fact that fire generally kills only very small mesquite plants (Havard 1884; Wright and Bailey 1982:149 and references therein). Additionally, it is noteworthy that mesquite seedlings are remarkably hardy, being tolerant of repeated top removal during the first growing season (Weltzin and others 1998) and capable of vegetative reproduction within 2 weeks of germination (Scifres and Hahn 1971). Although there are numerous statements in the literature about fires in the SHP (for example, Bolton 1946:330, 333; Hall 1947; Morris 1991:147), the only observation linking fire and the stature of mesquite discovered in the literature reviewed here was made by Bartlett (1854:75), who wrote about mesquite as he approached the southern margins of the SHP: “Where the prairies are frequently burned over, the tree is reduced to a shrubby state, a great number of small branches proceeding from one root, which goes on developing and attains a great size, though the portion above ground may not be more than four or five feet high.” In describing the grasslands of Arizona, Griffiths (1904:29) wrote: “A close examination of the broad, gentle, grassy slopes between the arroyos in this vicinity reveals a very scattering growth of mesquite...which is in the form of twigs 2 to 3 feet high with an occasional larger shrub in some of the more favorable localities...One cannot tell whether this growth indicates that this shrub is spreading or not. The present condition rather suggests this possibility” (from Turner and others 2003:xiii). The possibility exists that the small shrubs noted by Griffiths possibly had been held in check by repeated fires. In this connection, an anecdote reported by Kelton (1993:79-83) is noteworthy. Kelton recounted that O. Schwartz, who began farming in 1923 east of San Angelo, Texas (to the southeast of the SHP, which was “mostly open rangeland”, p. 79), would occasionally plow up an unseen mesquite stump that invariably had fire scars. Areas not broken out into farms later developed into dense stands of mesquite. Although this anecdote specifically relates to an area southeast of the SHP, it raises the possibility of like situations on the SHP, although no such remarks have been noted in the literature reviewed here.

A Second Explanation

A second explanation for the difference between the current and historical distributions of mesquite involves a combination of livestock grazing and fire considerations. In particular, it has been suggested that domestic livestock, which had consumed mesquite beans from trees growing along water courses, distributed these seeds through feces (see Fisher 1977 and references therein). [It should be appreciated, however, that mesquite seeds are an important food component for numerous small mammals, including kangaroo rat (*Dipodomys merriami* and *D. spectabilis*), *Perognathus hispidus*, hares (*Lepus*), and packrats (Mares and others 1977 and references therein). Additionally, Burkhardt (1976) and Mooney and others (1977) suggested that mesquite fruits evolved “to very effective endozoic diffusion through mammals and larger birds (owing to the succulent, edible legumes with hard seeds that escape digestion)” (Burkhardt, 1976, p. 225).] This mechanism of range expansion can then be combined with a reduction in intensity and frequency of fire, allowing for mesquite to establish populations in sites previously unoccupied by the species.

There are, therefore, two approaches to follow in explaining the differences between current and historical mesquite distributions over the SHP. The first approach suggests that woody vegetation (probably including mesquite) has been present on the SHP (at least since Europeans first explored the area, when written records begin), but plants went (largely?) unnoticed because recurrent fires maintained populations in a suppressed state. Further, mesquite’s current dominance, dramatic as it is, has not involved a range expansion, but rather a population explosion. The second explanation involves, first, a range expansion of woody species into a grassland (via introduction of domestic livestock), and second, a woody species population explosion.

It is likely that the factors involved in the population explosion are similar in both these scenarios and include changes in fire frequency, grazing history, and extreme climate events. Most range scientists have maintained that increases in woody plant populations require (1) a vector for seed dispersal (for example, herbivores spreading seed via defecation) and (2) a reduction in competition from herbaceous species (caused, for example, by heavy grazing or drought conditions) that provides gaps in an herbaceous stand for woody plant establishment as well as reduced competitive influence that allows for woody seedling growth. Additionally, these factors may be coupled with climatic events that favor the woody species, for example, episodically high rainfall promotes seed production and seed germination (for example, Turner and others 2003) (but see below).

It seems that an understanding of shrub dynamics on the SHP requires that a choice must be made between (i) an increase in the density of existing woody populations or (ii) an invasion of woody species into previously unoccupied areas, followed by an increase in population density. In an effort to evaluate these two scenarios, the following observations are offered.

1. Woody vegetation (which presumably included mesquite) was recorded by the earliest explorers in the draws and the sandy soils of the SHP as well as in the landscape bordering the SHP. Johnson (this proceedings) reported that mesquite, sumac (*Rhus* sp.), and hackberry (*Celtis* sp.) were present and associated with the "valley system" of the SHP as early as 4,500 B.P., with additional records of these species together with Texas walnut (*Juglans microcarpa*) in the valley system as well as an upland salina dating from 2,000 to 200 B.P. Relative to vegetation dynamics throughout the Holocene, and with specific regard to native trees, Johnson (this proceedings) stated "Occurring primarily in the valley system, an occasional hackberry and mesquite were on the uplands around lake basins depending on the period."

2. Early explorers probably traveled across the SHP along paths of the existing drainages and not in haphazard directions that would have brought them across "upland" sites (see, for example, Morris 1997:47, 97; Meyers 2003). Thus, the absence of descriptions of woody vegetation on upland sites may be a result of lack of experience with upland sites by early explorers, rather than the absence of woody plants in these sites.

3. Early explorers remarked that there were trails from the (apparently shrub-less) "high plains" of the Llano Estacado down into the wooded canyons along the margins of the SHP that buffalo used to move from the Rolling Plains to the SHP (for example, Kendall 1856:228; Morris 1997:56).

If domestic grazing animals are to be invoked as being responsible for moving seeds from woody plants (including mesquite) naturally growing in draws and canyons to upland sites through defecation (as in the second explanation, above), then it seems reasonable that buffalo, as well as numerous other large mammals and rodents, may have also fulfilled this role, leading to the possibility that native herbivores, prior to domestic livestock, may have distributed, to some extent, seeds of woody species from draws and canyons onto the SHP proper. However, Brown and Archer (1987) found no mesquite seedlings and fewer seeds in an ungrazed area compared to a grazed area in south Texas and concluded that domestic livestock were more effective agents of mesquite seed dispersal than native fauna in south Texas. These authors suggested that effective seed dispersers would be agents that "transplant large numbers of germinable seeds away from parent plants harboring host-specific seed predators and deposit them in grazed habitats where emergence and survival could be high" (Brown and Archer 1989:25). They concluded that "the apparently low densities of mesquite in grasslands prior to settlement may have been a consequence of limited dispersal or germination rather than biotic or abiotic constraints on establishment" (Brown and Archer 1987:79). Brown and Archer's characterization of an effective seed disperser is reasonable, and it is true that cattle fit this description. However,

an effective seed dispersal agent is one that would deposit a germinable seed "in areas where grasses ha[ve] been defoliated" (Brown and Archer 1989:19), and native fauna that do this also would be effective dispersal agents. With effective seed dispersal by native fauna, the absence of descriptions of woody vegetation in the literature reviewed here might then be explained by a lack of experience with these sites by early explorers, supplemented with the possibility that population densities were low and frequently-burned plants existed in a state of suppression and were thus not conspicuous to early travelers. If this reasoning is sound, then the conclusion is that woody vegetation was a natural component of the SHP, but its "dominance" as a community component was most apparent only in particular landscape settings (for example, the draws or valley systems). Further, on uplands where it may have been only occasionally present, woody vegetation was "held in check" by recurrent fires. Thus, its apparent neglect by early explorers may be explained in part by lack of experience and low populations in particular landscape settings.

In this regard, the results of Brown and Archer (1989, 1999) are pertinent. These authors showed in the Post Oak savanna of central Texas that, relative to non-defoliated plots, moderate grass defoliation increased mesquite seedling emergence by eight-fold. Further, there was no difference in seedling emergence between moderately and heavily-defoliated plots (Brown and Archer 1989). To the extent that mesquite emergence was enhanced by moderate defoliation, and because there was no difference between moderately and heavily-defoliated plots, these authors concluded that the competitive suppression that grasses may have on mesquite establishment was easily overcome; that is, "long-term and/or heavy grazing is [not] requisite for *Prosopis* encroachment into grasslands" (Brown and Archer 1989:19). In contrast, in south Texas, these authors showed that herbaceous biomass or density had no effect on mesquite seedling establishment. Instead, they documented relatively continuous mesquite seedling emergence that was also largely unaffected by moisture conditions (Brown and Archer 1999). Thus, whereas non-defoliated herbaceous vegetation was effective in reducing mesquite seedling emergence in central Texas, they concluded that "Historic grazing at [the south Texas] site appears to have altered herbaceous composition and reduced above- and belowground biomass production below the threshold level required for competitive exclusion of woody vegetation...[their] data suggest that rates and patterns of seed dispersal may be the primary determinants of *P. glandulosa* encroachment on present-day landscapes in semiarid regions" (Brown and Archer 1999:2385). These results suggest that (1) depending on past history, native vegetation unaltered by grazing may or may not be capable of excluding woody vegetation, and (2) seed dispersal is a prerequisite for woody plant invasion into grasslands.

The existence of well-developed ecotypes of mesquite extending from south Texas to central Oklahoma (Peacock and McMillan 1965; however, these authors did not study populations from the SHP proper) is also important in understanding the dynamics of this species. Although rates of evolutionary changes involved in the differentiation of ecotypes undoubtedly depend on the species and adaptive gradients in question,

Peacock and McMillan (1965:35) concluded that “Ecotypic differentiation over the northern part of its range adds weight to the historical evidence that mesquite has occupied its current distribution for a considerable period of time.”

An appreciation of the effects of (1) landscape setting (for example, draws and valley systems, or upland sites) on vegetation composition and structure, (2) both past and current grazing history on woody plant establishment, as well woody plant demographic phenomena involving both proximity of seed source and effectiveness of seed dispersal, and (3) fire, lie at the heart of understanding shrub dynamics in the SHP.

Summary

Despite considerable documentary evidence and the efforts of many ecologists, it is difficult to determine the precise nature of the vegetation of the SHP from the time of the first European explorers to the late 1800s. Based on accounts written during this time period, conclusions that can be drawn about this vegetation are vague and sometimes contradictory. For example, Coronado described a landscape with no trees or shrubs, and then added *except* away from the gullies and rivers. Marcy similarly described a landscape without trees or shrubs and then provided a delineation of the range of mesquite that included all of the SHP. Bray, in turn, wrote about the Llano Estacado as being unrelieved by the shrubs and trees, but also described mesquite as far north as Hale Center (Hale County).

There is little question that the earliest descriptions of the SHP indicate that it was a grassland interrupted by woody species only in certain topographic settings (for example, draws and canyons). The fact that “native soils [of the SHP] were most likely Paleustolls, given the native vegetation of the region” (Holliday 1990:498) suggests long-term landscape stability. It is equally clear that woody vegetation (including mesquite) was reported throughout most of the SHP by the 1890s. Finally, woody vegetation, including mesquite, has been recorded in the landscapes surrounding the SHP since 1820, and the presence of ecotypic differentiation suggests that mesquite populations surrounding the SHP have been in existence for a considerable time period. With specific regard to shrubs on upland sites of the SHP, and using mesquite as a case species, either mesquite has historically been present but went unrecorded prior to the 1890s because upland sites had low population densities, were not frequented, and/or because recurrent fires maintained populations inconspicuous, or mesquite was introduced in a novel way by domestic livestock that had been introduced in the late 1870s and 1880s. In either of these scenarios, subsequent increases in woody plant densities likely involved changes in fire frequency, grazing history, and climate.

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The Author

¹Department of Range, Wildlife, and Fisheries Mgt., Texas Tech University, Lubbock, TX. david.wester@ttu.edu