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Chapter 6:

Historic and Current Conditions of Southwestern Grasslands

Introduction

Southwestern grasslands today share general differences from their pre-Euro-American settlement conditions. With few exceptions, grasslands—whether in the desert, prairie, or mountains—were, prior to non-Indian settlement, more diverse in plant and animal species composition, more productive, more resilient, and better able to absorb the impact of disturbances. Southwestern grasslands today are missing the elements of disturbance regimes that kept them functioning in the prelivestock period. Such interruptions include human activities leading to loss of palatable plant species and keystone grazers such as the buffalo and prairie dog. The loss of most fire events resulted in the accelerated loss of soil from wind and water erosion, including loss of the highest productivity sites from gully formation. Soil changes also include loss of soil pore space through compaction, decrease of soil organic matter, retention of surface water, and nutrient cycling processes whether permanent or temporary. The result is a loss of large-scale connectivity by isolating grasslands through urbanization and other anthropogenic influences.

The frequency, magnitude, and extent of these changes vary among major kinds of grasslands and among landscapes and plant communities occurring within them. But almost everywhere in the Southwest, the amount of change is vast. Perhaps if early alarms voiced by Wooton in 1908 in New Mexico, Griffiths in 1901, and Thornber (1910) and Jardine and Hurt (1917) a few years later had been heeded, much of the subsequent disruptive change could have been averted—at least in those places not already degraded too far to recover and resemble their former state.

For example, Humphrey (1987) and Turner and others (2003) photographed landscapes along the Southwestern United States-Mexico boundary to document changes in vegetation as seen in prior historical photos. From the severely degraded conditions in the 1890s and the limited amount of recovery since, many irreversible changes had already taken place in the unforgiving climate along the border. Farther north, Aldo Leopold wrote in 1924 (p. 8), "[In] northern Arizona there are great areas where removal of grass by grazing has caused spectacular encroachment of juniper on park areas. But here again both grass competition and fire evidently created the original park, and both were removed before reproduction came in." Many thousands of pages have been written since that time, with sound recommendations for moving Southwestern grasslands back toward ecosystem sustainability. Much progress has been made toward recovery, but still the gap widens across tens of millions of acres.

With the exception of older Euro-American occupations such as in the Rio Grande Valley, most change has taken place since the end of the Civil War and the

beginning of the cattle era. The cattle boom began in 1865, reached its height about 1885, and gradually adjusted to an environment that no longer included a frontier. Between 1875 and 1883, much of the grassland was fenced with barbed-wire (Hollon 1961). The advent of the railroads increased the extent, area, and rate of change, shrinking grasslands, as they once were, into smaller, relictual fragments, and relegating them to remote locations, or at least locations remote from water. The 1936 Department of Agriculture report to the Senate titled "The Western Range" documented the widespread degradation of the grasslands. Some 553 million acres of Western rangeland, 76 percent of the total, were continuing to degrade at the time of the report (USDA 1936). Much of the upland deterioration has been halted, with restoration of adequate vegetation cover to stem upland erosion over at least a majority of the grasslands. However, the creation of gullies had effectively and almost universally dewatered the grasslands with the exception of the flatter portions of the shortgrass prairie. The gullies reduced the effectiveness of the precipitation across the grasslands with some loss of cienega and sacaton communities. Recovery of the grassland cover in the uplands has occurred and continues, but without parallel restoration of the incised valley floors and basins.

Pre-Euro-American settlement grasslands are difficult to describe accurately. Qualitative and descriptive information must be pieced together and inferences made from inventories of isolated and protected landscape fragments, pastures managed for good and excellent rangeland health, properly functioning watersheds, historical documents, life-history studies of plants and animals, professional experiences of those working and doing research in grassland ecosystems, and documented accounts of early explorers and land survey records.

Reference conditions that describe what any sustainable historic grassland community should ecologically represent are difficult to achieve. Even the most homogeneous grassland has extremely dynamic ecological processes. Plant species readily vary with time on any given site according to rainfall patterns and the latest disturbance process. Vegetation dynamics in grasslands can be characterized by the shifting patterns of abundance and sequential species replacement over time, or succession. The complex patterning of small-scale partitioning by grassland species in less degraded conditions makes consistent classification challenging at a finer scale.

For all except the montane grasslands, increased vegetative cover and productivity of pre-Euro-American settlement grasslands are hypothesized to have increased convective warm season precipitation over today's rainfall amounts (Grissino-Mayer 1996). However, drought in earlier times was just as important a disturbance factor as it is today. Short-term deviations in rainfall amount and timing influence species frequency and occurrence, but long-term changes have an effect on grassland boundaries and extent.

The lower elevation grasslands have numerous plant species in common. Long-term climate changes enable some species to spread long distances while others retract in ebb and flow across time and space. The result leaves relictual pockets of species far from their normal associates, with big bluestem (*Andropogon gerardii*) migrating from the tallgrass prairie to the Zuni mountains of New Mexico, and black grama (*Bouteloua eriopoda*) from the desert grassland to Kansas and Oklahoma. While today's conditions favor movement of more invasive species, the more diverse and resilient systems of yesterday would have favored periodic expansion of a wider variety of species.

Because they were more diverse than the grasslands of today, all grasslands in the Southwest were historically able to withstand drought. Tilman and Downing (1994) found grassland species richness led to greater drought resistance because some grasses within the complex of species were more drought resistant than others and partially compensated for the decreased growth of the less drought resistant species. This appears to have been most prominent in the prairie grasslands, although their topographic homogeneity may have made such relationships more noticeable. The higher diversity in all grasslands would have had the similar benefits of fire, hail, insect outbreaks, and other disturbances. Even with the benefit of increased diversity, there were periodic events of sufficient magnitude to overcome the resiliency of any grassland. The common situation in grassland ecosystems, both then and now, is to be in a state of transition from some type of disturbance.

Wooton (1908) noted the New Mexico Territory included approximately 300 grasses and sedges, of which only 25 or 30 furnished the "great bulk" of livestock forage. Livestock homogenized the grasslands, masking or eliminating both local and regional differences. The ecotones of the nonmontane grasslands were naturally broad. Tolerance limits of species such as blue grama (*Bouteloua gracilis*) and sideoats grama (*Bouteloua curtipendula*) were broader than the limits of the major grasslands.

It is useful to look at the distribution of accompanying shrubs to set a practical boundary for the various grasslands. The limits of big sagebrush (*Artemisia tridentata var. tridentata*) help set a climatic and physiographic boundary for Colorado Plateau and Great Basin grasslands. Creosote bush (*Larrea tridentata*) likewise is an aid in approximating the boundary for desert grassland and shrubland. The zone of integration between *Yucca glauca* of the shortgrass prairie and

the taller *Yucca elata* of the desert grassland provides a good boundary. The ecotone between the two is the home of *Yucca intermedia*, an intermediate between the two yuccas.

Montane Grasslands

Montane grasslands ranged from the alpine and subalpine regions at high elevations through the ponderosa pine (*Pinus ponderosa*) ecosystem at lower elevations. These grasslands were the most naturally fragmented and ranged in size from thousands of acres, such as those in the White Mountains of Arizona where grasslands covered about 80,000 acres above 9,000 feet (Baker 1983), to only a few acres, limited by topography or the surrounding forest. The origin and maintenance of these grasslands, except for those few acres in the alpine, are a subject of debate, perhaps because the causative factors not only vary from place to place but also usually combine to create a variety of effects. Below the alpine zone, fire and climate appear to have been the major factors in both the creation and maintenance of these grasslands. For wet meadows, fire may have been the ultimate creator of many openings; with soil moisture levels beyond what trees could tolerate maintaining them. Wind desiccation, and snow and ice abrasion readily maintained at least the larger meadows and may have interacted with drought and/or insect and disease outbreaks in the creation of some meadows. The greater level of soil organic material and higher inherent productivity of meadow communities helped grasses and grasslike plants play a major, competitve role in maintaining these grasslands as tree free.

In pre-Euro-American settlement times, most montane grasslands would have been less fragmented with a greater degree of connectivity, and their total acreage would have been greater. Almost all of these grasslands, either large or small, have either yielded acreage to forest, or disappeared altogether. Inhibition of water movement through the soil—due to compaction by livestock and ungulate wildlife—decreased soil moisture availability because of increased tree density in surrounding forests. Water diversions and road development combined to reduce the condition and extent of wet meadows.

The alpine ecosystem in the Southwest has few gentle slopes conducive to development of grasslands. Most alpine is dominated by the forb-rich fellfield community, but where the topography permits, Kobresia (*Kobresia myosuroides*) dominated communities of sedges and grasses are considered cushion plants and develop what can be termed a grassland (Andrews 1983). Baker (1983), in his study on Wheeler Peak, identified 10 alpine communities in a complex mosaic defined mainly by slight variations in topography, exposure to wind and sun, and snow accumulation. In the harsh elements above timberline, "grassland" turf is compact and complete in cover except where broken by surface rock or pockets of gopher activity. Where the sod has been broken, as in the case of heavy sheep use, or misplaced recreation trails, wind erosion unravels the turf to the rocky substrate below. The degraded area expands until a change in aspect or a surface rock boundary is reached. The loss is permanent. Old soil level marks on rocks near Santa Fe Baldy reveal near complete loss of the Kobresia community in that area. Unlike other grassland communities, fire is not likely to have played a role in either the creation or maintenance of the alpine grasslands. Pre-Euro-American settlement alpine grasslands would have covered a few thousand acres.

As with subalpine Thurber fescue (*Festuca thuberi*) grassland communities, there is considerable intermixing with other grasses such as oatgrass (*Danthonia* spp.), which tends to favor slightly less productive sites than Thurber fescue. Thurber fescue is often well in excess of a meter tall and is much sought after by large herbivores. Thurber fescue, was more of a community dominant and was more widespread in pre-Euro-American settlement times than in today's subalpine grasslands. The result has been an expansion in dominance of sheep fescue (*Festuca ovina*) from above, and Arizona fescue (*Festuca arizonica*) from below. These high elevation (more than 8,500 feet) grasslands were, and continue to be, diverse in both grasses and forbs.

Allen (1984) documented extensive reductions of the Thurber fescue grasslands in the Jemez Mountains within the previous hundred years as both the conifer and aspen forests expanded. An interrupted fire regime and a decreased grassland competitive ability due to overutilization by large herbivores have contributed to a widespread reduction in Thurber fescue grasslands. These high elevation grasslands are well adapted to periodic fire.

The Arizona fescue (*Festuca arizonica*)/mountain muhly (*Muhlenbergia montanus*) grassland community in the mixed-conifer and ponderosa pine forests were naturally less productive and less diverse than the Thurber fescue community, but far more widespread. These grasslands and their variations, such as the screwleaf muhly (*Muhlenbergia virescens*) community, were the most extensive montane grasslands of the Southwest. A few relictual areas still have mountain muhly as a significant component in lower elevation woodland openings, but how common this once was is unknown. Because these grasses were the primary grasses in the understory of the open pine forests, even the smaller forest openings had a greater connectivity than in the understory-deficient, dense pine forests of today. In 1911, Woolsey (quoted in Fletcher 1998,

p. 86) described the typical yellow pine forest of the Southwest as a "pure park-like stand made up of scattered groups of from 2 to 20 trees, usually connected by scattering individuals. Openings are frequent, and vary greatly in size. Within the type are open parks of large extent…"

Arizona fescue and screwleaf muhly are cool season species, and mountain muhly is a warm season grass. Between the two variations is a natural ebb and flow in composition in step with periodic variations in seasonal precipitation. Arizona fescue is more tolerant of fire than mountain muhly. Large Arizona fescue grasslands in what would otherwise be the upper extent of ponderosa pine forest, such as Hart Prairie near Flagstaff, appear to have burned with a higher frequency. This favored Arizona fescue over mountain muhly and limited the density of surrounding ponderosa pine, resulting in an extremely open forest. The 1904 inventory of forest conditions on what is now the Coconino National Forest (Leiberg and others 1904, p. 35) noted "large parks occur in townships 21 and 22 north, ranges 4 and 5 east, one of them containing 16,000 acres."

The cool season growth of Arizona fescue played a large role in maintenance of the larger parks and smaller openings by directly competing with ponderosa pine seedlings. Maximum growth of ponderosa pine coincides with maximum growth of Arizona fescue. Pearson (1949) reported that numerous ponderosa pine seedlings had started in an Arizona fescue opening in the prolific seedling year of 1919, but all had died within a year. Where Arizona fescue was suppressed or reduced by cattle grazing, the survival of ponderosa pine seedlings increased, and a point was quickly reached where ponderosa pine dominated. Today, Arizona fescue still continues to decrease in the dense forest understory across much of the Southwest.

Before the replacement of most wet meadow plant diversity with Kentucky bluegrass (*Poa pratensis*), wet meadows were typical for all but the narrowest and steepest drainages in Southwestern forested communities. The expansion of Kentucky bluegrass was made possible by heavy livestock use in the wet meadows. Compaction of wet meadow soils, particularly during dry years, inhibited water movement below ground, effectively shrinking the wet meadow and resulting in the elimination of riparian vegetation and favoring expansion of Kentucky bluegrass. Kentucky bluegrass has also replaced native grasses in some of the upland meadows (Dick-Peddie 1993).

Desert Grasslands

The climatic potential for desert grasslands has been more or less similar to that of today for the past 4,000 years (Van Devender 1995). Desert grassland in the pre-Euro-American settlement era occupied extensive acreage across the Southwest between 3,000 and 5,000 feet elevation. (Martin 1975). The grasslands were largely free of "brush," and streams and rivers dissecting the grasslands were lined with galeria forests and marshes (cienegas) (Bahre 1995). Just how much some portions of the desert grassland have changed can be visualized from a description of southeastern Arizona in the mid-19th century:

> The valley bottoms were covered by a dense growth of perennial sacaton grass, oftentimes as high as the head of horseman and so thick and tall that cattle, horses, and men were easily concealed by it. The uplands were well covered with a variety of nutritious grasses, such as the perennial black grama, and the many annuals that spring into growth during the summer rainy season. The abundant vegetation, both on highlands and in valley bottoms, restrained the torrential storms of the region so that there was no erosion in valley bottoms. Instead the rainfall soaked into the soil and grew grass.
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> Sloughs and marshy places were common along the San Simon, the San Pedro, the Santa Cruz and other streams, and even beaver were abundant in places where it would now (1919) be impossible for them to live. (USDA 1937, p. 23)

Another reference from the same era noted beaver on the Rillito and on the Santa Cruz where they had "many dams that backed up water and made marshy ground" as far down as Tucson (USDA 1937, p. 11).

Conditions began to change rapidly with the buildup of the livestock industry. Harvest of native grasses as hay contributed to the decline. Bush muhly (*Muhlenbergia porteri*) was sufficiently abundant that in 1879 and 1880 hundreds of tons were delivered as hay to military posts in Arizona (USDA 1936). The summer of 1885 was unusually dry, and 1886 had half the normal rainfall (Hastings 1959). The major portion of the desert grassland received between 8 and 14 inches of precipitation annually with a small segment in southeastern Arizona and a portion of southwestern New Mexico's bootheel, receiving approximately 14 to 20 inches.

Typically, the uplands within the grassland yielded runoff in summer thunderstorms, irrigating the alkali sacaton (*Sporobolus airoides*) and tobosa (*Pleuraphis mutica*) in floodplains below. Except during major thunderstorm events, the desert grassland likely offered only a slight contribution of water to perennial streams and rivers. Vegetation along most drainages and in the floodplains would have been sufficient to reduce peak flows originating in the uplands.

Much of the historic literature addressing the desert grassland expresses some concern about the expansion of desert shrubs. Pre-Euro-American settlement desert grasslands occupied large areas today covered at least in part by creosote, burroweed (*Isocoma tenuisecta*), mesquite, and other shrubs undesired by the livestock manager.

> Many plains and uplands of the Chihuahuan Desert in southern New Mexico are in transition from a perennial desert grassland to a mesquite dominated shrubland. Shrubs encroach into grasslands by individual plants becoming established into islands of mesquite with a greater biodiversity than the surrounding grasslands. The mesquite islands eventually coalesce into mesquite "front" and biodiversity decreases. (Beck and others 1999, p. 84).

Similar increases in shrubs were seen 3,900, 2,500, and 990 years ago. Shrub increases late in the 19th century were a natural response to drought. This response differed from earlier episodes due to the additive factor of massive numbers of livestock (Van Devender 1995).

York and Dick-Peddie (1969) investigated survey records beginning in 1858 for 31 townships in southern New Mexico and found they had changed from approximately 75 percent covered with grass to less than 5 percent grass cover at the time of the study in the late 1960s. One of their findings yielded a clue on the origins of the spread for mesquite in the uplands. They found a detailed 1882 map of the vegetation west of Las Cruces. Scattered across the mesa were scattered pockets of mesquite. Each of those "small locations" was found to have a Native American campsite near its center. The Native Americans used mesquite extensively for food and later as food for their horses. Other sites such as breaks on the edges of watercourses also were found to have a mesquite component.

The drier portions of desert grassland in New Mexico were apparently less adapted to fire than desert grasslands of southeastern Arizona where the higher precipitation provided greater fuels and connectivity for fire to spread (Bahre 1985). Tobosa and the sacatons are well adapted to fire, but these grasses favor topography where moisture accumulates. The typically patchy vegetation of drier, upland black grama sites would have restricted fire spread. In periods of greater than average rainfall, the connectivity of vegetation would have expanded, increasing the likelihood of fire in black grama dominated communities. Black grama does not fare well after fire with rainfall amounts typical of most of the desert grassland. A prescribed burn in black grama was conducted on the Bernalillo Watershed (White and Loftin 2000) near the northern limits of the desert grassland in November 1995 and January 1998. In May of 2001, marked differences were still evident between burned areas previously dominated by black grama and adjacent unburned black grama stands. Neither area had been more than minimally grazed by trespass livestock in several decades. At a landscape scale, infrequent and patchy burns in drier portions of the desert grassland would have enhanced diversity. Desert grassland developed under conditions of lower fire frequencies than other Southwestern grasslands. Fire events followed by wet years would have little lasting impact on community structure, but when followed by drought, the result could be a long-term change in community structure (McPherson 1995). The greatest threats to existing Southwestern desert grasslands include uncontrolled grazing, desertification, introduction of exotic and invasive species, and urban development (Havsted 1996).

Unique and isolated sites such as Dutchwoman Butte, and Research Natural Areas such as Otero Mesa, Bernalillo Watershed on the Cibola National Forest, and Rabbit Trap on the Gila National Forest, would be useful in establishing reference conditions for some of the communities within the desert grassland. Of greater importance are larger areas such as the Appleton-Whittell Research Ranch in southeastern Arizona where fire has been maintained. The most severely degraded elements of desert grasslands, such as the giant sacaton community, are hardest to find in suitable condition for use in characterizing reference conditions. The extreme variability of desert grasslands across its range makes application of any standardized reference condition problematic at best.

Great Basin Grasslands

Brown (1982) recognized grasslands above the Mogollon Rim in Arizona as having an affinity with those in the Great Basin. However, in our (this current) assessment they are being referred to as Colorado Plateau grasslands. Therefore, in the context of this current assessment, the Great Basin grasslands ranged southeast to the Rio Grande Valley from just south of Albuquerque, north to the Colorado border. They also extended at least as far south as the San Augustin Plains in New Mexico. Brown (1994) called them Great Basin Grasslands to emphasize that influence, but believed they were transitional between his Plains grassland to the east and the true Basin and Range communities to the west and northwest.

Weddell (1996) reported that summer drought was the primary factor excluding large herds of bison from the steppe of the Intermountain West. As a result, there was a lack of significant selective pressure from large herbivores, limiting the co evolution between ungulates and Intermountain grasses. This left native grasslands vulnerable to invasion by exotic grasses (particularly cheatgrass, *Bromus tectorum*) when livestock grazing degraded these grasslands. "The Western Range" (USDA 1936) cited a Forest Service study in western Utah where during the 1931 to 1934 drought a 20 percent decrease in forage plants occurred on ungrazed plots, but the reduction was 60 percent on nearby overgrazed areas.

One situation that makes grassland particularly vulnerable to degradation is a higher complement of cool season grasses, which are more sought after by livestock and are less resistant to grazing than

warm season grasses, coupled with the soils prone to erosion across the majority of the Great Basin grassland. The complement of factors degrading other grasslands—mainly interruption of the fire regime and heavy use by livestock during dry years—may have caused greater change here than even in the desert grassland. Acre for acre, the Great Basin in pre-Euro-American settlement condition had greater hydrologic function (infiltration) and higher primary productivity than the desert grassland.

The spread and increased density of junipers by expansion onto deeper, formerly grassland soils has long been a concern (Johnsen 1962, Miller and Wigand 1994, Wright and others 1979), and the condition continues today. Even if it became politically acceptable to reintroduce fire to manage juniper (*Juniperus* spp.), sagebrush (*Artemisia* spp.), and other shrubs, the break in fire connectivity due to the myriad of incised watersheds (gullies) together with the lack of grasses productive enough to provide needed fire intensities, make restoration efforts challenging.

With the exception of some more mesic portions of the Great Basin grassland, defining reference conditions is challenging because of a reduced productivity and species diversity. The Rio Grande watershed's Rio Puerco is one of the most infamous and degraded watersheds in the Southwest (Dortignac 1960). Portions of the Rio Puerco have been grazed at least 100 years longer than most of the other Great Basin grasslands. Current trends could lead to similar conditions of other watersheds within the Great Basin grassland.

Plains Grasslands

The pre-Euro-American settlement Plains Grasslands are better understood when placed in context of the tallgrass and shortgrass components of the midcontinental expanse of grasslands. Dr. John Weaver, student of the American Prairie, shared more than 40 years of study in his 1954 book *North American Prairie*. He explained:

> When the white man came to North America magnificent grassland occupied the central part of the continent. From Texas it extended north to Manitoba, where it gave way to boreal forest. From the forest margins of Indiana and Wisconsin it extended westward far into the Dakotas and half way across Kansas. Early settlers designated this great area of waving grasses bedecked with wonderful flowers as Prairie. Beyond, even more extensive but drier and sparser grassland stretched away to the Rocky Mountains. This was early designated as the Great Plains. (Weaver 1954, p. 2).

The Prairie and Great Plains were separated according to the height of dominant grasses—in essence, their productivity.

Prairie grasses were classified into three groups according to the height they attained. Any grass that normally attained a height of 5 to 8 feet, or more, belonged to the tallgrass group. Big bluestem (*Andropogon gerardii*), switchgrass (*Panicum virgatum*), and sloughgrass (*Beckmannia syzigachne*) fell into this category. Midgrasses were 2 to 4 feet tall and included species such as little bluestem. On dry ridges and crests of hills, especially in Western prairie, were the shortgrasses, 0.5 to 1.5 feet tall. These grasses included blue grama, hairy grama, and buffalo grass. Species with "great" drought resistance, such as side-oats grama, blue grama, and buffalo grass (*Buchloe dactyloides*), or those adapted to evade drought, such as western wheatgrass (*Pascopyrum smithii*), usually occurred in most of the prairie only in small amounts because they were not normally able to compete with tallgrasses. These grasses increased rapidly and occupied large areas in intense drought (Weaver 1954).

Dr. F.W. Albertson described the typical situation in the mixed-grass prairie just before the turn of the 20th century.

> The vast majority of the land was native prairie. It was neither broken for cultivation nor overgrazed by livestock. Short grasses and low growing broadleafed herbaceous plants occupied the hilltops. Many of the hills were dotted with bunches of little bluestem and in the favored areas such as buffalo wallows, side oats grama, and big bluestem were common. The hillsides were occupied primarily by big and little bluestem, side oats grama, Indian grass (*Dichanthelium acuminatum*) and panic grass (*Sorghastrum nutans*). All but the little bluestem and side oats grama were dominant on the lowlands" (Albertson 1949, p. 10).

Dr. Albertson also noted that the dust storms of severe droughts in the 20th century, magnified by cultivating lands that could not support sustained agriculture, also occurred as natural events in severe droughts before 1900.

The higher productivity of the mixed grass prairie brought with it more frequent and higher intensity fires than fires in the shortgrass prairie. In 1924, Shantz noted tallgrass prairies were often burned in late summer or winter, and that early settlers and travelers could find safety only by starting backfires. The flames were impossible to pass through to the safety of the burned areas behind (Weaver 1954). In 1825, Joseph C. Brown was surveyor in a party marking what was to become the Santa Fe Trail. Brown noted that Cow or Cold Water Creek, near the Great Bend on the Arkansas River in Kansas, marked the beginning of the shortgrass prairie, and the shortgrass was the boundary of the annual burning of the prairie (Hollon 1961).

Risser and others (1981) included as mixed grass prairie, the strip of sandy soils with Havard shin oak (*Quercus havardii*) and midgrasses running across the Texas Panhandle into eastern New Mexico about Tucumcari. This community is also common along the southeastern border of New Mexico. In 1844, Josiah Gregg described a portion of the community as a

region covered with sandy hillocks entirely barren of vegetation in places while others were covered with shin oak and plum. In 1845, Lt. J. W. Albert found the community to be a continuous succession of sandhills with sand sagebrush and Havard shin oak. Big bluestem, sand bluestem, Indiangrass, switchgrass, giant dropseed (*Sporobolus* spp.), plains bristlegrass (*Setaria leucopila*), cane bluestem (*Bothrichloa barbinodis*), and sideoats grama are among the grasses. The range of this community has not increased since the mid-19th century (Peterson and Boyd 1988). However, the composition appears to have less of the component of taller grasses and more sand sagebrush and mesquite than before the livestock era. The oak component grows slowly and is long lived. It is estimated to have made up only 5 to 25 percent of the prelivestock era community. While in some areas the oak component has not expanded onto former grasslands (Peterson and Boyd 1988), in other areas at least the individual oak motts now occupy what was once a mixed grass prairie community. Both midgrass and tallgrass components and oak are well adapted to most fire regime variations (Peterson and Boyd 1988) while mesquite is not. Simpson (1977) contended the range of mesquite had not spread, just the densities within the range. Mesquite densities, within the strip identified by Risser and others (1981) as mixed-grass, continue to increase, but others found mesquite present in the community in 1845 (Abert and Carroll 1999).

Even though more acreage remains for the mixed grass than the tallgrass prairie, the patchiness of the grasslands means the ecosystem operates on a much smaller scale than in the prelivestock era. Fire is implemented as a management activity by individual landowners rather than occurring at landscape scales (Weaver and others 1996). Herbivory by livestock has different impacts on prairie forbs and grasses than by buffalo. Even where a high diversity of forbs remains, fragmentation favors a continued reduction in associated animal species. Homogenization of large or small pastures by livestock reduces the inherent ability of the ecosystem to withstand drought. Intense development of stock tanks across native prairie pastures interrupts the functioning of watersheds, limiting free flow of water with a coincident loss of biological diversity. Interruption of the natural fire regime likely had as much to do with expansion of oak and sand sagebrush in Oklahoma and mesquite in Texas and New Mexico as did overgrazing by livestock.

Establishing reference conditions for the mixed-grass prairie is even more difficult than for the other grasslands because of the diversity needed to provide the ecosystem's response to climatic variability. Fragmentation limits the value of potential reference sites, excluding smaller areas, even those in excellent condition. Allowances must be made for both fire, and the suite of short-, mid-, and tallgrasses necessary to withstand drought events. The buffalo, hugely reduced in number, is a missing keystone link across most of the mixed-grass prairie.

Colorado Plateau Grasslands

Castetter (1956) lumped the shortgrass prairie, or steppe, and the Great Basin grassland into a mixed prairie "association" because the grasses were also those of the true steppe and occurred as a "climax composition" in more or less equal amounts of mid- and shortgrasses. Throughout the association, blue grama was felt to be the climax dominant. Sideoats grama was an important component as was hairy grama. Mostly in lower spots topographically, western wheatgrass was "rather common" in association with blue grama. On sandy soils, little bluestem was a common associate often found with sand bluestem and Indian grass. In low saline areas, alkali sacaton stands were common. On the elevated plains, the cane cholla (*Opuntia* spp.) and soapweed (*Yucca elata*) were uncommon due to grass competition.

Blue grama is the common species among Southwestern grasslands, being even more abundant today in degraded conditions of some grasslands than in the prelivestock era. The resistance of blue grama to drought and heavy grazing played a major role in the sustainability of the shortgrass prairie. Buffalo benefit from this survival mechanism because the grazed lawn has a denser concentration of younger, higher quality forage. Having many small shoots also facilitates rapid response to ephemeral water availability limiting loss to drought and speeding recovery after defoliation (Coughenour 1985). Blue grama is one of the grasses best adapted to periodic water stress. Blue grama has a high root/shoot ratio because a high proportion of carbohydrates are translocated below ground instead of being used to grow shoots. This increases survivability and keeps carbohydrate resources higher than in less drought tolerant grasses (Detling 1979). Blue grama was the ideal grass on the flat expanses of shortgrass steppe where winds limited snow deposition and increased desiccation in the spring, and where growing season precipitation was scattered in time and space, requiring frequent dormancy and regreening in a single growing season. Blue grama was the ideal grass in higher use areas where herbivores large and small would have eaten and trampled a less-adaptive species to oblivion.

Fire in the Colorado Plateau grasslands was of low intensity but adequate to keep woody shrubs from expanding. At the edge of sandier soils, wildfire would have restricted sand sagebrush. Fires could reduce pricklypear (*Opuntia* spp.) by either killing the plant in a hotter fire or by burning the spines, making the

Arizona vistas: Contrasts of exurban development, near Flagstaff (above), with undeveloped land, farther south near Naco and the U.S./Mexican border (below). (Photos by John Yazzie)

cactus more available to a wide range of herbivores. Abert and Carroll (1999) noted the short flame lengths of the typical wildfire, saying it was not difficult to pass through the flame front unharmed.

The prickly pear was widespread and likely increased during drought periods just as it does today. Pricklypear can withstand drought better than most steppe plants, and its shallow root system utilizes moisture from even light rainfalls (Branson 1985). Pricklypear increases in overgrazed areas, and it can increase during drought even in grasslands protected from livestock.

The best sites for developing reference conditions in the Colorado Plateau grasslands are on large private ranches because they are less patchy than areas administered by the Federal government. A variety of grazing intensities would best depict the variation found in the pre-Euro-American settlement era.

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