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Increase in Number of Dominant Plants and Dominance-Classes on a Grassland in the Northern Chihuahuan Desert

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Abstract

Between 1915 and 1932, 104 permanent 1 × 1-m quadrats were established on grasslands of the Jornada Experimental Range in southern New Mexico. Primary- and secondary-dominant species were determined from the first quadrat records and each quadrat was reevaluated in 1981 to determine current dominants. The first records showed that 13 species of perennial grasses occupied all primary- and secondary-dominant positions on all quadrats. In 1981, there were 12 perennial grass species as primary- or secondary-dominants. Six shrub species occurred as primary- or secondary-dominants on 47% of the quadrat sites in 1981. Dominance-classes, i.e., single-species dominance or two-species dominant combinations, increased from 24 to 43. Thus, vegetation on this range has become more diverse and this diversity must be considered in grazing management.

Key Words: black grama; tobosa; burrograss; shrub invasion, *Bouteloua eriopoda, Hilaria mutica, Scleropogon brevifolius*

Vegetation in the northern portion of the Chihuahuan Desert has been classified or mapped as desert-grassland transition (Shreve 1917), desert savana (Shantz and Zon 1924), desert plains grasslands (Clements 1920), desert shrub grassland (Darrow 1944), and shrub-steppe (Kuchler 1964). Widespread encroachment of shrubs into former grasslands of this area has been well documented (Buffington and Herbel 1965, York and Dick-Peddie 1969). The spread of shrubs has been attributed to heavy livestock grazing in the late 1800s and early 1900s, seed dispersal by domestic and small herbivores, and recurrent droughts (Buffington and Herbel 1965). Honey mesquite (*Prosopis glandulosa* Torr. var. *glandulosa),* creosotebush [*Larrea tridentata* (DC). Cov.], and tarbush (*Flourensia cernua* DC.) were the principal invading shrubs and were formerly restricted to more localized sites in the area (Gardner 1951, Stein and Ludwig 1979).

Classifications of vegetation are usually based on dominant species. As Brown (1982) has noted, it may now be a moot question whether some areas are classified as a disclimax semidesert grassland or Chihuahuan desert shrub. However, a better understanding of the vegetation is possible if changes in dominant species can be determined. Specific sites for which detailed vegetation records were available for periods of up to 65 years were examined to determine changes in dominant species.

Materials and Methods

This study was conducted on the Jornada Experimental Range located 37 km north of Las Cruces, N.M. (32°37'N, 106°40'W). Most of the 78,266 ha Experimental Range lies on undulating plains of the Jornada basin near an elevation of 1,260 m. On the east, the Experimental Range extends to the crest (2,833 m) of the San Andres Mountains. Average annual precipitation on the plains is 230 mm, with 52% occurring in July, August, and September. The frost-free period averages 200 days but the effective growing season, when soil water and temperatures are favorable, is often 90 days or less. Mean monthly maximum temperatures are highest in June (36° C) and lowest in January (13° C). Many soil types occur on the Experimental Range with textures ranging from coarse to fine, but sandy soils predominate. The major soil families represented include: thermic Typic Torripsaments; thermic Typic Haplargids; thermic Typic Calciorthids; thermic Ustollic Calciorthids; and thermic Ustollic Haplargids (Bullock and Neher 1980).

The Jornada Experimental Range was established in 1912 but organized research did not begin until 1915 when it was placed under the administration of the U.S. Forest Service (Ares 1974). In 1915, 34, permanent 1 × 1-m quadrats were established and charted for the first time. Additional quadrats (only mentioning those where markers still exist) were established in 1916 (8), 1919 (14), 1921 (3), 1924 (2), 1926 (17), 1927 (21), 1929 (2), 1931 (1), and 1932 (2), for a grand total of 104. A decimeter grid was used to chart the quadrats until 1925 and a pantograph was used thereafter (Paulsen and Ares 1962). With few exceptions, all quadrats were charted each year until 1947. Only a portion of the quadrats were charted each year after 1947, resulting in discontinuous records for individual quadrats. Charting was discontinued in 1979.

Quadrats were selected to represent the major grassland types found on the Experimental Range and were usually placed at 0.8-km intervals along lines radiating from permanent watering points (Nelson 1934). The quadrats were placed on grasslands dominated by: black grama [*Bouteloua eriopoda* (Torr.) Torr.], (57 quadrats); tobosa [*Hilaria mutica* (Buckl.) Benth.], (22 quadrats); burrograss (*Scleropogon brevifolius* Phil.) (12 quadrats); poverty threeawn (*Aristida divaricata* Willd.) (6 quadrats); and blue grama [*Bouteloua gracilis* (H.B.K.) Griffiths] (6 quadrats). A single quadrat was located on a gypsiferous area dominated by gypgrass (*Sporobolus nealleyi* Vasey). The blue grama-dominated quadrats were located in the San Andres mountains, while all others were on the plains. Plant nomenclature follows Correll and Johnston (1970).

The primary- and secondary-dominants were determined from the first quadrat charts made at each site. Species with the greatest basal area were designated as dominants. Because quadrat locations were carefully chosen to represent average conditions of a vegetation type, we believe that in most cases the quadrats were representative of relatively homogeneous grassland areas from 1 to many hectares in extent. This belief is supported by estimates made at the time of establishment of the percentage composition of grasses, weeds (forbs), and browse (shrubs) for the vegetation type the quadrat represented (size of area considered in the estimates is not known). At 77 sites shrub composition was 5% or less, at 16 sites 6–20%, at 9 sites, 21–40%, and > 50% at only 2 sites.

Primary- and secondary-dominants were determined at the quadrat sites in 1981, when stature and abundance of shrubs, as well as grass basal area, were used in designating dominant species. Shrubs designated as dominants did not always occur within the quadrats, but their density and stature in the immediate vicinity of the quadrat (within 3 m) made them an obvious dominant of the site. Only where mesquite dunes had formed and the dominant mesquite plants were usually 3 to 20 m apart was an area larger than 6 m in diameter considered. We believe that if our criteria had been applied at the time of quadrat establishment, only 2 sites (those with > 50% shrub composition) would have had a chance of having shrubs named as dominants. Single dominant and two-species dominant combinations were considered dominance-classes. In some cases it was possible to designate more than 2 dominants. For clarity, however, only primary- and principal secondary-dominant is reported.

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Results

Black Grama Vegetation Type

Fifty-seven quadrats were placed in the black grama type according to the early records. The first records showed 21% of the quadrats had black grama as a sole-dominant (Fig. 1). Red threeawn (*Aristida longiseta* Steud.) was the principal secondary-dominant, occupying this position in 35% of the quadrats.

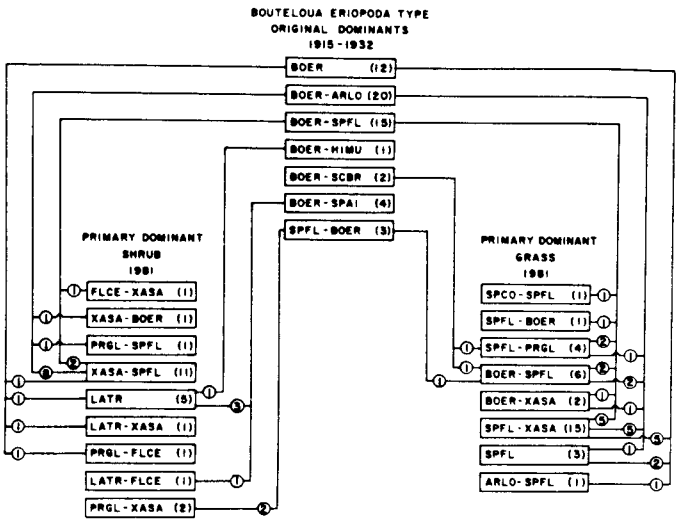

Fig. 1. *Dominance-classes and dominants on 57, 1-m² quadrats when established on black grama grasslands between 1915 and 1932, and on the same quadrats in 1981. Numbers in parentheses within dominance-class boxes denote number of quadrats. Numbers in circles show how many quadrats had a change from one dominance-class to another. Species codes are: ARLO* = Aristida longiseta, *BOER* = Bouteloua eriopoda, FLCE = Flourensia cernua, *HIMU* = Hilaria mutica, LATR = Larrea tridentata, *PRGL* = Prosopis glandulosa, *SPAI* = Sporobolus airoides, *SPCO* = S. contractus, *SPFL* = S. flexuosus, *and XASA* = Xanthocephalum sarothrae.

Mesa dropseed was a secondary-dominant in 26% of the quadrats and the primary dominant in 5% of the quadrats. Other secondary-dominants included alkali sacaton [*Sporobolus airoides* (Torr.) Torr.], burrograss and tobosa (Fig. 1).

The first records show 7 dominance-classes, with 6 primary- and secondary-dominant species. There were 17 dominance-classes with 8 dominant species in 1981. In 1981, only 33 quadrats (58%) retained grasses as the primary-dominant (Fig. 1). Black grama was not found on or in the immediate vicinity of any of the 12 quadrats where it was sole-dominant originally. In 1981, black grama was primary-dominant on 8 quadrats and secondary-dominant on 2 quadrats. In the grass-dominated quadrats, black grama had largely been supplanted by mesa dropseed, which was primary-dominant on 23 quadrats and secondary-dominant on 8 quadrats (Fig. 1). Spike dropseed (*Sporobolus contractus* Hitchc.) was primary-dominant on 1 quadrat in 1981, although it was not a dominant originally. Red threeawn was secondary-dominant on 20 quadrats originally, but in 1981 was not a secondary-dominant on any quadrat and was primary-dominant on only a single quadrat. Tobosa, burrograss, and alkali sacaton no longer occupied secondary-dominant positions on any quadrat.

Counting the suffrutescent broom snakeweed [*Xanthocephalum sarothrae* (Pursh) Shinners] as a shrub, shrubs have become primary-dominants on 24 (42%) of the 57 quadrats (Fig. 1). In 1981, broom snakeweed was primary-dominant on 12 quadrats. It was also secondary-dominant on 4 quadrats with other shrubs as primary-dominants and on 17 quadrats with grasses as primary-dominant. Shrubs were either the sole-dominant or both primary-dominant and secondary-dominant on 11 (19%) of the quadrats. Creosotebush, mesquite, and tarbush have all become primary-dominants on former black grama sites (Fig. 1).

Seven of the quadrats were originally established within small livestock exclosures (0.04 ha) that have remained intact on the black grama type. Black grama remained as primary-dominant on a quadrat within only one exclosure. Four of the quadrats protected from livestock grazing had shrub species as primary-dominant. One protected quadrat had mesa dropseed as sole-dominant and another had spike dropseed as primary-dominant.

It was impossible to determine when either mesquite, creosotebush, or tarbush became established on all sites they dominated in 1981. A mesquite plant appeared within one quadrat in 1916 and persisted to 1981. Another mesquite plant was present in a quadrat since 1924 and a tarbush plant was present within another quadrat since 1956. Broom snakeweed has been present within some quadrats since 1915 and has increased in abundance since 1926. Percentage frequency of broom snakeweed within quadrats on the black grama type averaged 9 and 25% for the 1915 to 1925 and 1926 to 1936 periods, respectively; percentage frequency in 1981 was 58%.

Tobosa Vegetation Type

There were 9 quadrats established on the tobosa type from 1915 to 1919 and another 13 established from 1926 to 1927, for a total of 22. The first quadrat charts show 5 dominance-classes with 5 species as primary- or secondary-dominants (Fig. 2). In 1981, there

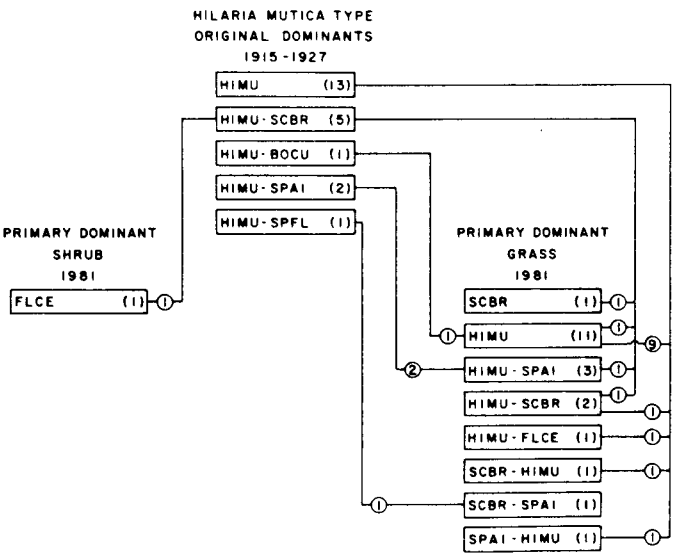

Fig. 2. *Dominance-classes and dominants on 22, 1-m² quadrats when established on tobosa grasslands between 1915 and 1927, and on the same quadrats in 1981. Numbers in parentheses within dominance-class boxes denote number of quadrats. Numbers in circles show how many quadrats had a change from one dominance-class to another. Species codes are: BOCU* = Bouteloua curtipendula, *FLCE* = Flourensia cernua, *HIMU* = Hilaria mutica, *SCBR* = Scleropogon brevifolius, *SPAI* = Sporobolus airoides, *and SPFL* = S. flexuosus.

were 9 dominance-classes and 5 species as primary- or secondary-dominants. Tobosa was originally sole-dominant on 13 quadrats and in 1981 was sole-dominant on 11 quadrats. Burrograss had displaced tobosa as primary-dominant on 3 quadrats. Sideoats grama [*Bouteloua curtipendula* (Michx.) Torr.], originally a secondary-dominant on 1 quadrat, was not present in 1981. Tarbush dominated the single quadrat within a livestock exclosure on this vegetation type in 1981.

Burrograss Vegetation Type

There were 12 quadrats established in the burrograss type, 6 from 1915 to 1916, and 6 from 1926 to 1929. The first records show 7 dominance-classes with 6 species as primary- and secondary-dominants. In 1981, there were 10 dominance-classes with 8 primary- and secondary-dominant species (Fig. 3). Burrograss,

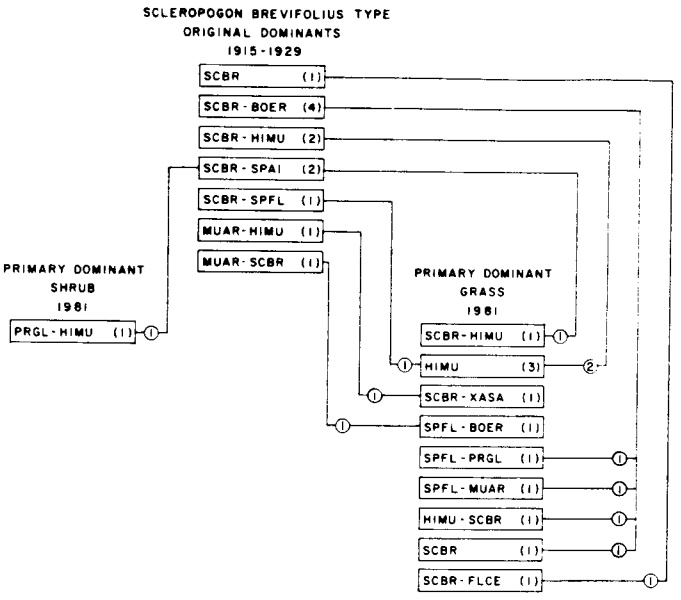

Fig. 3. *Dominants on 12, 1-m² quadrats when established on burrograss grasslands between 1915 and 1929, and on the same quadrats in 1981. Numbers in parentheses within dominance-class boxes denote number of quadrats. Numbers in circles show how many quadrats had a change from one dominance-class to another. Species codes are BOER* = Bouteloua eriopoda, *FLCE* = Flourensia cernua, *HIMU* = Hilaria mutica, *MUAR* = Muhlenbergia arenacea, *PRGL* = Prosopis glandulosa, *SCBR* = Scleropogon brevifolius, *SPFL* = Sporobolus flexuosus, and XASA = Xanthocephalum sarothrae.

originally the primary-dominant on 10 quadrats, dominated only 4 quadrats in 1981. Ear muhly (*Muhlenbergia arenacea* Buchl.) was dominant on 2 quadrats originally, but in 1981 was only secondary-dominant on 1 quadrat. Tobosa and mesa dropseed have become primary-dominants on 4 and 3 quadrats, respectively. At the time of quadrat establishment black grama was a secondary-dominant on 4 quadrats, but in 1981 it was a secondary-dominant on only 1 quadrat. Alkali sacaton, even though it was a secondary-dominant on 2 quadrats originally, was not a dominant in 1981. In 1981, the only dominant shrubs were mesquite (primary-dominant, 1 quadrat) and broom snakeweed (secondary-dominant, 1 quadrat) (Fig. 3). Burrograss maintained its dominance on the single quadrat within a livestock exclosure in this vegetation type.

Other Vegetation Types

Six quadrats were established on the poverty threeawn type in 1926. At that time there were 2 dominance-classes and 2 primary- and secondary-dominant species. Poverty threeawn was sole-dominant on 3 quadrats, primary-dominant on 3 quadrats, and black grama was secondary-dominant on 3 quadrats. In 1981, there were 2 dominance-classes and 2 dominant species. Mesquite was sole-dominant on 4 quadrats, and primary-dominant on 2 quadrats with broom snakeweed as secondary-dominant. According to notes made when the quadrats were established in 1926, mesquite was in the area. These mesquite plants have grown and trapped sand, forming large coppice dunes which now dominate the landscape. One of the quadrats was originally located within a livestock exclosure and had mesquite as sole-dominant in 1981.

Between 1921 and 1927, 6 quadrats were established on the blue grama vegetation type in the mountains. There were 3 dominance-classes with 4 primary and secondary-dominant species. Blue grama was the primary-dominant on 5 quadrats and sand muhly (*Muhlenbergia arenicola* Buck].) was the primary-dominant on 1 quadrat. Black grama was the secondary-dominant on 5 quadrats and hairy grama (*Bouteloua hirsuta* Lag.) was a secondary-dominant on 1 quadrat. In 1981 there were 5 dominance-classes with 6 dominant species. Blue grama (4 quadrats), sand muhly (1 quadrat), and black grama (1 quadrat) were primary-dominants. Secondary-dominants included winterfat [*Ceratoides lanata* (Pursh) .T. Howell] (1 quadrat), black grama (2 quadrats), blue grama (1 quadrat), hairy grama (1 quadrat), and red threeawn (1 quadrat). Two of these quadrats were established within livestock exclosures. None of these quadrats outside the exclosures have been grazed by domestic livestock since 1946.

The single quadrat established in 1931 on gypsiferous soil was dominated by gypgrass. A Torrey mormontea plant (*Ephedra torreyana* Wats.) was present within the quadrat and had reached sufficient stature by 1981 to rank as a secondary-dominant.

Discussion

Primary- and secondary-dominant species increased from 13 to 18 at the 104 quadrat sites. Principal new dominants were broom snakeweed, mesquite, tarbush, and creosotebush. A major shift among grass dominants was the replacement of black grama by mesa dropseed. In southern New Mexico, black grama depends on vegetative reproduction (Nelson 1934) and reestablishes very slowly. Because black grama was nearly eliminated on several range types during the severe drought of 1951–56 (Herbel et al. 1972), plants such as mesa dropseed, which readily reproduce from seed, were able to occupy former black grama areas when drought ended. Demographic studies based on populations of black grama and mesa dropseed within some of these quadrats suggest maximum life spans of 28 and 18 years for black grama and mesa dropseed, respectively (Wright and Van Dyne 1976). Replacement of long-lived black grama plants by relatively short-lived mesa dropseed suggests that the latter forage resource is inherently less stable. Annual plants were not abundant in 1981 because precipitation was below average (202 mm). However, in more favorable years annuals would probably assume a seasonally dominant position on many of the quadrat sites.

Tobosa and burrograss types exhibited more stability than did the black grama type. This may in part be due to the occurrence of tobosa and burrograss on finer-textured soils (Buffington and Herbel 1965) which have greater water holding capacity than the sandy soils occupied by black grama. Another contributing factor could be that black grama received more grazing pressure than the relatively less palatable tobosa and burrograss. The burrograss type has been classified as a serial stage leading to a tobosa climax (Campbell 1931). Although this may be the case on a few sites, persistence of burrograss on other sites indicates it is a very stable vegetation type and should be considered to occupy a climax position of its own.

Dominance-classes increased from 24 to 43. This means that the vegetation has become more diverse. This increase in diversity of dominants appears to have been the result of interactions of grazing pressure and climatic fluctuations. Due to the very small size of the exclosures protecting quadrats from livestock grazing little can be said other than dominance shifts from grasses to shrubs did occur on protected quadrats. Replacement of grasses by shrubs has also occurred in large exclosures (up to 259 ha) on the Experimental Range (Hennessy et al. 1983). Changes in dominance on sites protected from grazing indicate that grazing has not been the sole cause of change. The establishment of long-lived mesquite, tarbush, and creosotebush means that these dominants will persist for many years unless removed through shrub control programs. The dominance of the relatively short-lived broom snakeweed and perennial grasses is more vulnerable to climatic impacts and the data indicate that few sites retain the same dominants for extended periods. The shrub-grass complex in the northern Chihuahuan Desert may best be viewed as what Connell and Sousa (1983) have termed a "continuum of temporal variability." Managing this complex as a grazing resource requires an awareness of the successional trend toward shrub cover and the instability of grass cover. A high degree of flexibility in management options is required.

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