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# DROUGHT-ASSOCIATED MORTALITY OF RANGE GRASSES IN SOUTH TEXAS[1]

ALBERT D. CHAMRAD AND THADIS W. BOX

*Welder Wildlife Foundation, Sinton, Texas, and Texas Technological College, Lubbock, Texas*

*Abstract.* The effects of a 2-year drought on native grasses in South Texas were investigated on the Welder Wildlife Foundation Research Area during the summer of 1963. The percentage mortality on Victoria clay, Nueces fine sand, and Miguel fine sandy loam was determined for seacoast bluestem (*Andropogon scoparius* Michx. var. *littoralis* (Nash) Hitch.), silver bluestem (*Andropogon saccharoides* Swartz var. *longipaniculata* Gould), filly panicum (*Panicum filipes,* Scribn.), buffalograss (*Buchloe dactyloides* (Nutt.) Engelm.), Pan American balsamscale (*Elyonurus tripsacoides* Humb. and Bonpl.), and brownseed paspalum (*Paspalum plicatulum* Michx.). Mortality ranged from an average low of 34.7% for silver bluestem on Victoria clay to an average high of 76.8% for seacoast bluestem on Miguel fine sandy loam. Differences in percentage mortality between soils and between species on given soil types were highly significant. Mortality among individual clones ranged from 0% to 100%. In some instances a significant positive correlation existed between size of grass clones and percentage mortality. As diameter of clones increased, percentage mortality increased.

## INTRODUCTION

Periodic droughts, both temporary and prolonged, are characteristic of the climatic regime over much of the western and southwestern United States. Apparently, however, no significant weather cycles or patterns can be predicted (Hildreth and Thomas 1956, Waldrip 1957). During the past 3 decades, two severe, prolonged droughts have occurred over vast areas of the western and southwestern rangelands. The great drought of the thirties was recorded in the true prairies by Weaver, Stoddart, and Noll (1935), Robertson (1939), and Weaver and Albertson (1940); in the western range States by Ellison and Woolfolk (1937), and Pechanec, Pickford, and Stewart (1937); in the Northern Great Plains by Sarvis (1941); and in the Central and Southern Great Plains by Savage (1937). The drought of the fifties was less thoroughly recorded. Merrill (1953) and Young (1956) reported on the effects of that drought on Texas rangelands.

During the extended drought of the fifties many ranges in South Texas were severely damaged by a combination of drought and grazing. However, ranges which were well managed before and during this critical period responded rapidly as the drought broke in the spring of 1957. About 5 years later, South Texas experienced another severe drought which began in the fall of 1961 and lasted through the spring of 1963 (Fig. 1). The effects of this drought on important native grasses were evaluated during the summer of 1963, on the Rob and Bessie Welder Wildlife Foundation Research Area, near Sinton, in southern Texas. The specific objective of the study was to compare and evaluate mortality in relation to soils, species, and size of grass clones.

Several studies have noted relationships between soil types and plant survival during drought. In the Edwards Plateau of Texas, Merrill (1953)

[1] Contribution No. 96, Rob and Bessie Welder Wildlife Foundation, Sinton, Texas.

TABLE I. Percentage composition (basal area) of vegetation in four plant communities on the Welder Wildlife Refuge during summer of 1963

| Species* | Mesquite-buffalograss | Chaparral-bristlegrass | Bunchgrass-annual forb | Liveoak savannah |
|---|---|---|---|---|
| *Andropogon saccharoides* | 5.5 | 1.6 | — | 0.4 |
| *Andropogon scoparius* | — | 20.6 | 10.3 | 18.0 |
| *Aristida roemeriana* | 1.7 | 0.1 | 0.7 | 0.1 |
| *Bouteloua curtipendula* | 0.3 | 0.8 | — | 2.4 |
| *Brachiaria ciliatissima* | — | — | 1.4 | — |
| *Buchloe dactyloides* | 14.3 | 8.3 | — | — |
| *Elyonurus tripascoides* | — | — | 5.9 | T |
| *Heteropogon contortus* | — | — | 0.1 | 2.1 |
| *Leptoloma cognatum* | — | — | 1.1 | 1.6 |
| *Panicum filipes* | 2.3 | 0.4 | — | — |
| *Panicum obtusum* | 2.5 | 0.3 | — | — |
| *Paspalum plicatulum* | — | — | — | 5.9 |
| *Setaria firmula* | — | — | 4.3 | — |
| *Setaria leucopila* | 1.0 | 4.4 | — | — |
| *Sporobolus asper* | 9.8 | 0.4 | — | — |
| *Stipa leucotricha* | 2.3 | 1.1 | 0.1 | — |
| Bare ground and nonbasal foliage | 64.2 | 59.2 | 73.6 | 66.2 |

*Grass names are from Gould and Box (1965). Only species comprising 1% or more of the total composition are reported. An additional 52 species occurred in trace amounts.

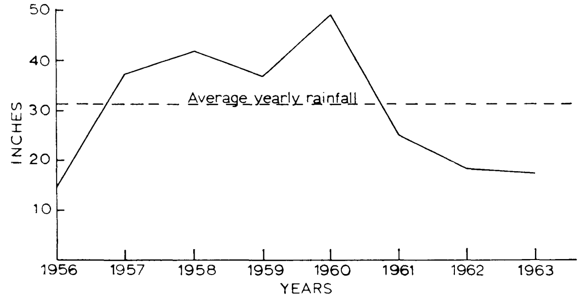


FIG. 1. Mean annual rainfall in inches on Welder Wildlife Refuge, 1956-63. (Average yearly rainfall based on long range U. S. Weather Bureau records for Sinton and Woodsboro, Texas. Refuge rainfall from unpublished records of W. C. Glazener, Welder Wildlife Foundation, Sinton, Texas.)

reported survival rates for curlymesquite (*Hilaria belangeri* (Steud.) Nash), ranging from only 5% on loose shallow soils, to 13% on tight gravelly soils, to 17% on relatively loose deep soils. Weaver and Albertson (1936) found that drought effects varied from almost no harm to plants on deep loess and glacial soils, up to 80-90% mortality on thinner soils of exposed ridges. Osborn (1950) reported that most noticeable changes in species composition during drought occurred on extremely shallow soils.

Past studies on the effects of drought indicate that for a given area certain species of range grasses are adversely affected, while others are more tolerant and drought resistant. Weaver and Albertson (1936) reported that death losses were greatest among the relatively short-rooted species of native grasses on the true prairie. Sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.) exhibited high drought resistance as did the deep-rooted big bluestem (*Andropogon gerardi* Vitman). Studies in the Texas Edwards Plateau (Merrill 1953) indicated that sideoats grama and silver bluestem (*Andropogon saccharoides* Swartz var. *torreyanus* (Steud.) Hack.) appeared to be more drought resistant than several of the more abundant short grasses, such as curlymesquite and Wright's threeawn (*Aristida wrightii* Nash).

Pechanec et al. (1937) reported that decrease in basal area and severity of disintegration of grass clones was directly proportional to the original basal area. Decrease in basal area is first evidenced in individual grass clones and later by high mortality of smaller individuals and clone remnants. Cole and Wilkins (1958) proposed the use of form classes of disintegrating grass clones as an expression of range-condition trends.

## METHODS AND PROCEDURES

Field investigations were made during 1963 on three major soil types: (1) Victoria clay, (2) Nueces fine sand, and (3) Miguel fine sandy loam. Four distinct plant communities occurred on these soil types (Table I). On the Victoria clay, vegetation was characteristic of the mesquite-buffalograss and chaparral-bristlegrass communities (Box 1961). The bunchgrass-annual forb community, also described by Box, was represented on the Nueces fine sand. A liveoak savannah community occurred on the Miguel fine sandy loam.

All plant communities were grazed at a constant moderate stocking rate of 13 acres per animal unit of cattle and deer. Grazing pressure appeared uniform on plants of the same species and on the different locations where samples were taken. Differences in utilization of plants were not measured.

The species sampled on the Victoria clay were seacoast bluestem (*Andropogon scoparius* var. *littoralis* (Nash) Hitchc.), silver bluestem (*Andropogon saccharoides* Swartz var. *longipaniculata* Gould), filly panicum (*Panicum fillipes* Scribn.), and buffalograss (*Buchloe dactyloides* (Nutt.) Engelm.). On the Nueces fine sand the species sampled were seacoast bluestem and Pan American balsamscale (*Elyonurus tripsacoides* Humb. & Bonp.). Seacoast bluestem and brownseed paspalum (*Paspalum plicatulum* Michx.) were sampled on the Miguel fine sandy loam. Seacoast bluestem, an important range species common to all soils studied, was used as the key species for evaluating the effects of soil on drought mortality.

Four sampling locations were selected on each soil type. A 500-ft pace transect was established, and at each 50-ft interval along the transect the three nearest plants of each designated species were sampled. Individual grass clones were inspected in situ, then dead materials were raked away for closer observation. The clones were then dug from the soil and broken apart to determine condition of roots, rhizomes, tillers, basal nodes, and the percentage of living and dead materials in each clone. These inspections were used to estimate percentage of basal area killed. Mean diameter and pattern of disintegration of each clone were also recorded. The transects were also sampled every 25 ft with a point frame. Basal hits were recorded to reflect species composition and density at each location.

Analysis of variance was used to test significance of differences in mortality between soils and between species. Correlations were used to determine relationships between size of grass clones and percentage mortality (Snedecor 1956).

## Results and Discussion

### *Influence of soils*

Differences in mortality of seacoast bluestem between soils were highly significant ($P < .01$). The lowest mortality, 48.7%, occurred on Victoria clay; the highest, 76.8%, on Miguel fine sandy loam (Fig. 2). The mortality on Nueces fine sand was intermediate with 66.6%. Mortality in individual clones of seacoast bluestem ranged from 0% to 100%. Grass plants died indiscriminately at all locations on any given soil type.

Numerous soil factors contribute to differences in drought-associated mortality. Soil texture, structure, and porosity all influence moisture characteristics, including infiltration, percolation, water-holding capacity, and rate and height of capillary rise.

Box (1961) reported that non-capillary pore space was not different between Victoria clay and Nueces fine sand, but the difference in capillary pore space was highly significant. The amount of available moisture in the two soils, expressed as a percentage of the dry weight of the soil, was 28.8% for the clay soils and 10.2% for the sandy soils. Box (1959) demonstrated significant differences in infiltration rates between clay soils, sands, and clay loams. Two to three times more water entered sandy soils in a 2-hr period than infiltrated clay soils.

Vegetative characteristics of the plant communities occurring on the different soils also contribute to differences in mortality. Species composition and density, extent of root systems, and litter accumulations are determined in part by soils. These vegetative attributes in turn influence rate and amount of water loss through evaporation, transpiration, and runoff, as well as infiltration and percolation of water.

### *Response of species*

Highly significant differences ($P < .01$) existed in mortality between species on any given soil (Fig. 2). Variable rates of kill occurred between plots within locations, but they were not statistically significant. Percentage kill in individual clones of all species ranged from 0 to 100.

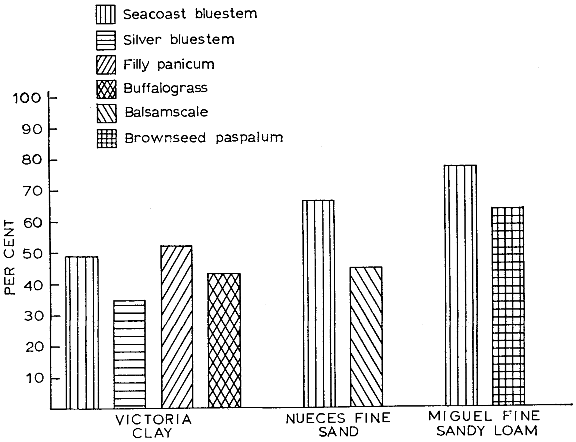


Fig. 2. Percentage mortality in range grasses on three soil types on Welder Wildlife Refuge, 1962-63.

On Victoria clay, the highest mortality was found in filly panicum, 51.9%, the lowest in silver bluestem, 34.7%. Seacoast bluestem and buffalograss were intermediate with 48.7% kill and 43.4% kill, respectively. Losses were 66.6% for seacoast bluestem and 44.9% for balsamscale on Nueces fine sand, a range of 21.7%. The highest overall mortality, but the smallest range between species, occurred on the Miguel fine sandy loam, 76.8% for seacoast bluestem and 63.8% for brownseed paspalum.

Silver bluestem, with a relatively deep root system, appears to be considerably more drought tolerant than the other species sampled on Victoria clay. On the heavy clay soils it could obtain moisture from greater depths than shorter rooted species such as filly panicum or buffalograss. Weaver and Albertson (1936) found a close relationship between root depth of most prairie grasses and resistance to drying. Filly panicum, a relatively shallow-rooted species, had the highest percentage mortality on the clay soil. Seacoast bluestem has a deep and extensive root system; however, the high density of this species (Table I) may have offset this advantage somewhat, due to greater intraspecific competition. Buffalograss, although a rather shallow-rooted species, had less mortality than either filly panicum or seacoast bluestem, due in part to its stoloniferous characteristic. Buffalograss spreads rapidly under favorable conditions (Savage 1937). When light rainfall occurred during the growing season, buffalograss was able to take advantage of shallow moisture and in some instances increase vegetatively by stolons. Such a response was reported by Weaver and Albertson (1936) during the drought of the thirties. Young (1936) reported that buffalograss had rather deeply set root crowns, was resistant to livestock trampling, and thus made fair to good recovery after rains during prolonged drought.

Seacoast bluestem had a greater percentage of mortality than balsamscale on the Nueces fine sand. Studies by Bowns (1962) in this same area indicated that the roots of seacoast bluestem and balsamscale penetrated to comparable depths, but that the roots of balsamscale had a greater lateral distribution, with fewer roots growing straight down. Most roots of both species were in the upper soil profile (Bowns 1962, Bowns and Box 1964). Since the Nueces fine sand is very freely permeable, both species responded to light precipitation. Under drought conditions balsamscale has a competitive advantage over seacoast bluestem due to (1) the high relative palatability of seacoast bluestem by livestock and (2) the greater horizontal distribution of balsamscale roots in the surface 3-4 ft of soil. Numerous other more shallowly rooted species of grasses and forbs common to the bunchgrass-annual forb community may have competed strongly with both seacoast bluestem and balsamscale for shallow, infrequent surface moisture during the drought.

Although the highest overall drought kill occurred on the Miguel fine standy loam, the difference in mortality between the two species sampled was small. Both seacoast bluestem and brownseed paspalum are relatively deep, strong-rooted species (Ruby and Young 1953, Bowns and Box 1964). Seacoast bluestem occurred in much greater density in the plant community, and intraspecific competition presumably contributed to its higher mortality.

Some factors contributing to differences in drought kill between species on the same soil and under similar management are (1) inherent physiological resistance to drought; (2) physiological resistance to the combined effects of drought and grazing; (3) morphological characteristics, especially extent and efficiency of root systems; and (4) competitive advantage or disadvantage of a species in the plant community.

In addition to climatic factors, grazing and insects have also been reported to cause an added toll of damage during drought (Savage and Jacobson 1935, Sarvis 1941, Merrill 1953, and Young 1956). The combined effects of drought and grazing reduce photosynthetic materials beyond that which would ordinarily occur under either of these stresses alone. The additional reduction of top growth causes a corresponding reduction in the amount of roots available for obtaining soil moisture (Nedrow 1937, Bowns and Box 1964, Schuster 1964). As a drought progresses the amount of growth produced continues to decrease.

### *Mortality in relation to clone size*

In some instances increased mortality was associated with size of grass clones (Table II). Only species having a wide range of clone sizes were sampled to determine effect of clone size: seacoast bluestem on each soil type, silver bluestem on clay, balsamscale on fine sand, and brownseed paspalum on fine sandy loam.

TABLE II. Relationship of clone size to percentage mortality of seacoast bluestem on Victoria clay

| Diameter class* (inches) | Number of plants | Mean percentage kill | Percentage of total kill |
|---|---|---|---|
| 1-4 | 4 | 27.5 | 1.9 |
| 5-8 | 22 | 35.6 | 13.4 |
| 9-12 | 23 | 47.8 | 18.8 |
| 13-16 | 21 | 52.6 | 18.9 |
| 17-20 | 22 | 52.7 | 19.9 |
| 21-24 | 13 | 58.5 | 13.1 |
| 25-28 | 5 | 53.0 | 4.5 |
| 29-32 | 4 | 68.8 | 4.7 |
| 33-36 | 3 | 28.3 | 1.5 |
| 37-40 | 3 | 65.0 | 3.3 |
| Total | 120 | | 100.00 |

*Based on mean diameter (inches) of clones sampled.

Significant positive correlations ($P < .05$) existed between mortality and clone size of seacoast

TABLE III. Distribution of drought-kill patterns in seacoast bluestem clones

| | Victoria clay | | Nueces fine sand | | Miguel fine sandy loam | |
|---|---|---|---|---|---|---|
| Clone description[1] | Number of plants | Percentage of total plants | Number of plants | Percentage of total plants | Number of plants | Percentage of total plants |
| Normal[2] | 7 | 5.8 | 13 | 10.8 | 2 | 1.7 |
| Hollow | 77 | 64.2 | 51 | 42.5 | 70 | 58.3 |
| Clump edge | 34 | 28.3 | 54 | 45 | 45 | 37.5 |
| Dead | 2 | 1.7 | 2 | 1.7 | 3 | 2.5 |

[1]Form class designations follow Cole and Wilkins (1958).
[2]Clones which were completely intact, or interspersed with only a few dead culms were termed "normal."

bluestem on Victoria clay and on Nueces fine sand. As clone diameter increased, percentage mortality increased. A regression coefficient of percentage kill on diameter of grass clones indicated that an increase in diameter of 1 inch increased percentage mortality by 0.73% on clay and 0.82% on sand. The relationship was not significant on Miguel fine sandy loam.

The relationship between size of clones and percentage mortality was highly significant ($P < .01$) for balsamscale on the Nueces fine sand. Mortality increased 4.79% with each 1-inch increase in clone diameter.

There was no real relationship between drought kill and clone diameter for silver bluestem on the Victoria clay or for brownseed paspalum on the Miguel fine sandy loam. The two latter species were represented by considerably more clones in the smaller size classes and a smaller range in clone sizes. Pechanec et al. (1937) reported that decrease in basal area in response to drought seems to be less in the smaller size classes.

Increase in mortality with increase in clone diameter may be attributed to intraspecific competition. Recent work with radiophosphorus (Mathis, Jaynes, and Thomas 1965) indicated that a grass clone functions as an aggregation of many independent segments or plants. These "plants" are competing with one another for available soil moisture, as well as other essential environmental constituents. As the diameter of a grass clone increases, the individual "plants" within the interior become less favorably located and are more likely to perish under drought stress. This situation contributes to the characteristic hollow center patterns exhibited by many bunchgrasses in the process of dying from old age, overgrazing, or drought (Pechanec et al. 1937, Cole and Wilkins 1958).

The pattern of drought kill within the individual grass clones was reflected most vividly in seacoast bluestem. The majority of seacoast bluestem clones showed some dead material, especially in the center (Table III). Fifty-five per cent of all seacoast bluestem clones examined were dying from the center (hollow); 36.9% were dying from the center and outer edges (clump edge). Only slightly less than 2.0% of all seacoast bluestem plants were completely dead. Seacoast bluestem is a rhizomatous variety of little bluestem (*Andropogon scoparius* Michx.). Under grazing, rhizome production tends to increase in relation to root production (Bowns and Box 1964), resulting in large, spreading clones.

Reduction in forage production due to drought can lower the range condition class and consequently the safe carrying capacity. Based on the position of seacoast bluestem in the local climax and its importance for forage production, it is suitable as an indicator or key species in evaluating range condition and range trend in the Coastal Bend Area (Gould and Box 1965, U.S. Dept. of Agriculture 1962). Following the form class designations suggested by Cole and Wilkins (1958), the distribution of drought-kill patterns in seacoast bluestem (Table III) indicated a downward trend in range condition on the study area.

Mortality of range plants was high following the recent drought in South Texas. Since losses occurred indiscriminately between plots within locations, surviving plants are distributed uniformly enough to make satisfactory recovery under normal conditions, provided that the ranges are protected from prolonged heavy grazing. The population is still intact, but forage production has been decreased.

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