Some Ecological Relationships Between Creosotebush and Bush Muhly

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Highlight: *Some ecological relations between creosotebush and bush muhly were observed and measured to determine the influence of bush muhly on creosotebush environment and vigor when the bush muhly is growing within the creosotebush canopy. Bush muhly growing within the creosotebush canopy significantly reduced the light intensity reaching the lower limbs of creosotebush. Shade screens used for simulating bush muhly shading did not significatly reduce the light reaching the creosotebushes but still appeared to influence the new growth of creosotebush leaves. Evidently, surface reflection under the screens still permitted sufficient light for some plant growth. No new basal stem growth was observed in creosotebushes where bush muhly was removed after occupying more than half of the aerial space of the creosotebush. There were more dead stems (50%) in creosotebushes growing with bush muhly present than in those without (20%). The amount of moisture in leaves and stems of creosotebush was significantly less when bush muhly was present.*

Bush muhly (*Muhlenbergia porteri*) is often found growing under the canopy of creosotebush (*Larrea tridentata*) where their geographic ranges overlap. In areas where cresotebush is of small stature, 1 m or less tall, bush muhly appears to affect the creosotebush detrimentally and in some instances observers have speculated that bush muhly may actually be responsible for its death.

Creosotebush, an evergreen shrub of little forage value, covers more than 180 million hectares across southwestern United States and northern Mexico, often in nearly pure stands with little variation in size of plants (Kearney and Peebles, 1960; Vallentine, 1971). Creosotebush occupies dry plains and mesas at elevations of 1,600 m or less. Often there is little herbaceous understory with very little or almost nonexistent annual production. Creosotebushes usually have leaves growing along the entire length of the many stems arising from the crown area. Where bush muhly is found growing under and within creosotebush canopy, creosotebushes often have leaves growing only on the upper few decimeters of each stem (Fig. 1). If lower leaves are present, they appear smaller than those on the end of the stems.

Bush muhly is a many branched, perennial grass occupying dry mesas, canyons, and rocky deserts of southwestern United States and northern Mexico. It originally existed in extensive stands in parts of its present range, but is now generally found growing under the protection of shrubs and sub-shrubs (Gould, 1951). It is grazed mainly in winter when other species become scarce (Gardner, 1951). This grass is reported to have high forage value (Kearney and Peebles, 1960). However, recent observations suggest that it is of only average palatability, but has low resistance to grazing because of its branching characteristics, and is easily damaged if grazed heavily. The shrubs under which bush muhly is usually found offer it some protection from large herbivores.

The purpose of this study was to learn about the association between bush muhly and creosotebush and to study the effect of bush muhly on (1) height of lowest leaf of creosotebush, (2) number and size of leaves on creosotebush, (3) stem mortality on creosotebush, (4) moisture content of leaves and stems of creosotebush, and (5) soil pH and texture.

Study Area

This study was conducted in 1972 on New Mexico State University's Agriculture Experiment Station Ranch, 32 km north of Las Cruces. The study site was a 5.6-ha exclosure at an elevation of 1,400 m. In 1954, the area was rejected as to having any future potential for experimental management practices due to a lack of grass species and unfavorable environmental conditions (Personal communication, Kenneth A. Valentine, 1972). Bush muhly was first observed growing in the area in 1960, and the area was later protected from grazing in

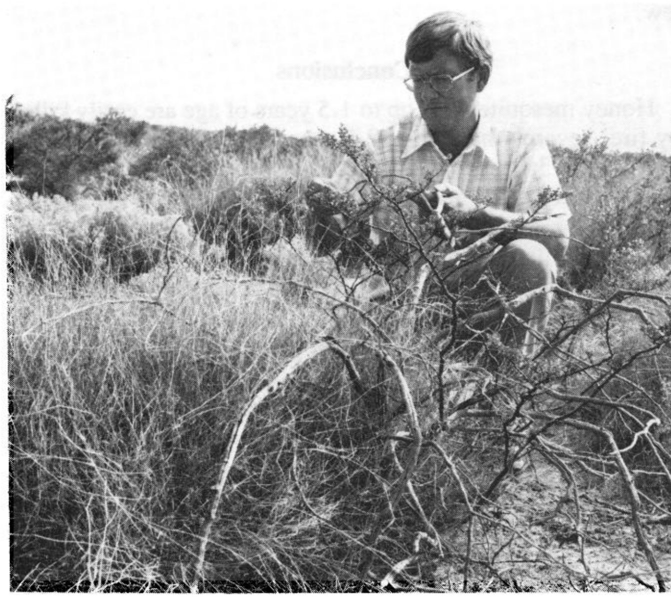

Fig. 1. *General view of study area. Note the creosotebush stems extending above the bush muhly.*

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1965. During this study creosotebush was the dominant plant, with a population of over 4,900 plants per hectare, of which 90% had bush muhly growing under their canopy. The bush muhly growing under the creosotebush varied from seedlings to mature plants over ½ m tall and with diameters of more than 1 m. In the study area about 60 bush muhlys per hectare were found growing alone, and at the base of most were the dead crown and stems of a creosotebush. These bush muhlys had an average basal area of 670 cm^2 and an average height of ½ m. Other plant species relatively common in the exclosure included six-weeks grama (*Bouteloua barbata*), burrograss (*Scleropogon brevifolius*), silver leaf nightshade (*Solanum eleagnifolium*), desert holly (*Perezia nana*), broom snakeweed (*Gutierrezia sarothrae*), and tarbush (*Flourensia cernua*).

Soils in the area are mainly sandy loams underlain by indurated calcium carbonate at depths varying from a few centimeters to 76 cm and more (Valentine and Gerard, 1968). The area is exposed to predominant westerly winds which are strongest during the spring months. Wind erosion is often quite severe, having caused complete removal of topsoil in certain areas.

The climate of the area is arid, with a 38-year average annual rainfall of 22.9 cm. An average of 12.0 cm falls during July, August, and September, the main growing season on the range (Paulsen and Ares, 1962). The warmest month of the year is June, with an average maximum temperature of 34°C; the coolest month of the year is January, with an average of 13°C.

Methods and Procedures

Twelve plots 60 m by 45 m were established in the exclosure. All sample creosotebushes used in this study either growing with bush muhly or growing alone were selected randomly along either pace or line transects in each plot. For a creosotebush to be counted as one occupied by bush muhly, the bush muhly had to have a canopy cover 50% or greater (except where determining effect of bush muhly on height of lowest leaf) than the canopy of the creosotebush. Tillering is the primary means of vegetative reproduction for bush muhly, so under most creosotebushes there was only a single bush muhly growing.

Control Plants

Five creosotebushes, growing without bush muhly, 40 cm to 100 cm tall were tagged as control plants in each plot. On three stems of each control creosotebush, the number of leaves growing on the end 15 cm were counted in March. In September the number of leaves were recounted, including those counted in March and any new ones which grew during the summer. This was done to determine the average increase in number of new leaves on each stem during the growing season. Also on these same stems the height of the lowest leaf above ground level was measured in March and September to determine if new leaves developed or old ones were shed and not replaced along the lower parts of the creosotebush stems.

Height of Lowest Leaf

On five creosotebushes growing with bush muhly in each plot, the height of the lowest leaf above ground level was measured on three stems on each creosotebush to determine if bush muhly influenced the presence of leaves growing on the lower ends of the creosotebush stems. The average height of the bush muhly growing in these creosotebushes was measured to determine any relationship between the height of bush muhly and the lowest leaf height on the creosotebush.

Fifteen creosotebushes with bush muhly occupying more than 50% of their aerial space and 15 creosotebushes with bush muhly occupying less than 50% of their aerial space had all grass clipped and removed throughout the growing season to determine if new leaves would develop and grow on the lower branches after the bush muhly was removed. These creosotebushes were randomly located over the 12 plots. The relationship between aerial space of creosotebushes and bush muhly was estimated visually.

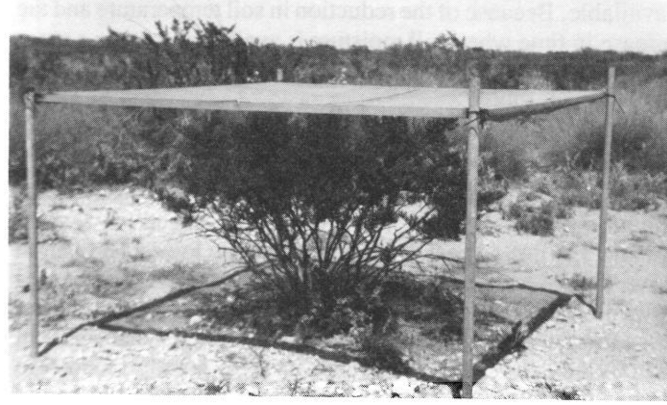

Fig. 2. *Shade screens were not as effective in stopping growth on the creosotebush as bush muhly. This may have been due to light reflection from the light-colored soil.*

Effects of Shading by Screens and Bush Muhly

At the beginning of the study eight fiber glass mesh screens (1.2 m^2) supported by steel rods were located parallel to the ground above four creosotebushes growing with bush muhly and four creosotebushes growing alone (Fig. 2). The plants were carefully selected to avoid any shading from adjacent plants. The bush muhly was kept clipped at a 2 cm stubble height under the four creosotebushes with bush muhly. On all eight shaded creosotebushes the lowest leaf height above ground level and number of leaves on the end 15 cm were measured on three stems in March. These measurements were made again in September to determine any new leaf production during the growing season.

The amount of light being received in the center of the creosotebushes under the screens was measured with a Soligor selenium cell photometer between 11 am and 3 pm on July 16 to determine reduction in light intensity. The amount of light reduction was also measured in the center of 25 creosotebushes growing with bush muhly and 25 growing alone, 15 cm to 40 cm below the top of the creosotebushes, depending on their size.

Moisture Content of Leaves and Stems and Stem Mortality

The same 50 plants measured for reduction in light intensity were used to determine a ratio of dead versus total stems. The number of live and dead stems in each creosotebush was counted to determine the ratio. Also, on each creosotebush an entire stem from each cardinal direction was clipped and stripped of leaves. The stems and leaves were weighed and oven dried at 68°C for 48 hours, then reweighed to determine moisture content.

Soil pH and Texture

Soil pH and texture were determined from samples collected under creosotebushes growing with bush muhly, from under creosotebushes growing alone, and from interspaces between creosotebushes void of herbaceous plants at soil depths of 0–5 cm, 6–13 cm, 14–20 cm, and 21–36 cm in several locations throughout the exclosure. Soil pH was determined using an indicator dye and color chart, while texture was determined by the hand-texture method.

Results and Discussion

Observations were made during this study concerning the establishment of bush muhly under shrubs. Bush muhly inflorescences break free of the parent plant and are disseminated by the wind until they are caught in a shrub. Seeds falling to the ground are provided with a suitable microenvironment for germination. Newly deposited, wind-blown soil provides a suitable covering for the seeds around the bases of creosotebushes. According to Herbel (1972), shrub cover substantially reduces soil temperature and increases the period soil moisture is available. Because of the reduction in soil temperature and the increase in time when soil moisture is available, there is a more favorable microenvironment for the germination and establishment of bush muhly.

Height of Lowest Leaf

The average lowest leaf height for creosotebush plants without bush muhly and with bush muhly, respectively was 57 mm and 335 mm (Table 1). The range of the lowest leaf height above the base of the plants was greater for creosotebushes growing with bush muhly (230–618 mm) than for the control plants (5–159 mm). Even though no actual counts were made, it was obvious that creosotebush leaves were greatly reduced in number on lower branches as bush muhly increased in height and density. The average height of bush muhly was 403 mm and therefore tall enough to shade the lower stems of creosotebush. Oosting (1956) points out that plants growing in closed stands characteristically lose lower leaves when the light penetration is insufficient to maintain necessary photosynthesis. This is in agreement with results of Donald (1961), who observed that the immediate process of competition for light in crops and pastures is neither between species nor between plants; it is competition between leaves.

Table 1. Height (mm) of lowest creosotebush leaf above soil surface on creosotebush with and without bush muhly and mean bush muhly height.

Measurements	Heights: Means	Heights: Range
Lowest leaf height on creosotebush with		
No bush muhly	57	5–159
Bush muhly	335	230–618
Bush muhly occupying more than ½ of aerial space	275	108–425
Bush muhly occupying less than ½ of aerial space	141	22–270
Creosotebush shaded, no bush muhly	92	25–130
Creosotebush shaded, bush muhly clipped	266	213–345
Bush muhly height	403	250–555

Even when bush muhly was removed, no new leaves appeared below the lowest leaf mark in the creosotebushes, whether bush muhly had occupied more than half or less than half of the creosotebush's aerial space. However, new creosotebush stems approximately 38 mm long were observed to be growing out of the bases of each shrub which had had grass occupying less than half of the aerial space, with the exception of one plant. The creosotebush that did not have any new basal stems may have been weakened by disease. The leaves on the shrub had turned brown and were rosette in shape. From observations made in this phase of the study, it appeared that once bush muhly occupied more than half of the creosotebush's aerial space, the creosotebush no longer produced new growth on the lower branches and new leaves on the ends of the branches were not as large or as vigorous appearing as in nearby creosotebushes where the bush muhly was smaller.

Effects of Shading

Bush muhly significantly ($P<.05$) reduced the amount of light penetrating creosotebush canopies, in contrast to amount of light received by creosotebushes without grass (Table 2). As the density of bush muhly increased, the amount of light coming into the center of the creosotebush decreased. The amount of light reduction under the shade screens ranged from 0% to 10%.

Table 2. Mean percent new leaf production between March and September and mean percent light reduction in unshaded and shaded creosotebush growing with bush muhly and creosotebush growing alone.

Treatment	New leaves produced (%): Means	New leaves produced (%): Rage	Light reduction (%)
Unshaded			
Creosotebush alone	38 ± 4[1]	22–47	7 ± 4
Creosotebush with grass	No data		24 ± 9
Shaded (shaded screens)			
Creosotebush alone	27 ± 3	26–27	5 ± 4
Creosotebush with grass removed	28 ± 3	25–29	4 ± 2

[1]Confidence intervals of 95% level.

The shade screens did not significantly reduce the light in comparison to that in the unshaded creosotebushes (Table 2). The less light reduction under shade screens than in the unshaded creosotebush was probably due more to a low sample size than to anything else. However, the shading by screens, though not effectively measured, was enough to cause a reduction in new leaf production. It is quite probable that if screens had been placed in vertical positions around the sides of each creosotebush in addition to the horizontal screen there would have been greater light reduction, more nearly simulating the shade created by bush muhly.

Final measurements in September of lowest leaf height under the shade screens showed no changes from measurements made in March. Lowest leaf height on creosotebush which never had bush muhly growing under it was 92 mm in contrast to 266 mm for creosotebush which once had bush muhly growing under it (Table 1). Though shading was only slight and not effectively measured in the sampling, it was enough to prohibit any new leaf or twig development along the lower branches of the creosotebushes. This indicates that creosotebush is sensitive even to slight shading. Also it should be noted that creosotebush leaves are small and may have an optimum temperature requirement. The lowered temperature resulting from shading may cause the leaves to produce little photosynthetic material. These leaves might become "sinks" instead of active "producers" and are therefore discarded by the creosotebush.

Moisture Content of Leaves and Stems

The amount of moisture in leaves and stems of creosotebushes with grass (28% and 41%, respectively) was statistically lower than in control plants (35% and 55%, respectively) (Table 3). Creosotebushes growing with grass had fewer leaves per branch with less weight, and the leaves were observed to be smaller in size than the leaves on control plants. The ratio of the average weight of photosynthetic material to the average weight of one live stem per shrub shows that the control plants had 276% more photosynthetic material (leaf weight per branch)

Table 3. Mean number of live and dead stems and mean moisture content (%) and weight (g) of leaves and stems of creosotebush with and without bush muhly present.

Creosotebush	Total	Dead	% dead	Moisture content: Leaves	Moisture content: Live stems	Weight: Live stems	Weight: Leaves	Leaves/ live stems
With bush muhly	20.8	10.6	50±9[1]	28±8	41±19	9.0	4.3	.47
Without bush muhly	19.2	5.7	30±7	35±6	55±7	8.0	10.3	1.3

[1]Confidence intervals at 95% level.

than did creosotebushes growing with bush muhly. Meyer et al. (1966) found that low light intensities favor stomatal closure, which restricts the entering of carbon dioxide and possibly inhibits photosynthesis. Meyer's findings, coupled with the fact that there is less leaf and stem moisture and less photosynthetic material on creosotebushes with bush muhly than on creosotebushes growing alone, makes one possible explanation for the demise of the creosotebush: there is not enough photosynthetic activity to support the nonproducing parts of the plant, and so eventually the creosotebush succumbs.

Stem Mortality

If bush muhly actually causes the creosotebush to become less vigorous and healthy, then it is reasonable to expect more dead stems in creosotebush growing with grass. There was a significantly greater ($P<.05$) number of dead stems on creosotebushes with grass than on creosotebushes without grass (Table 3). The mean totals of numbers of stems were nearly equal. This difference gives additional support to the observation that bush muhly interferes somehow with creosotebush. since these plants were the ones in which light penetration was measured.

Soil pH and Texture

The soil in the study area was azonal, having a sandy loam texture with caliche (calcium carbonate) outcrop scattered over the surface. With increasing depth, average pH increased at all locations (8.2 to 8.6). Soil pH measurements were higher at all depths under creosotebushes with grass than under creosotebushes without grass or in the interspaces. A possible explanation for this observation is that bush muhly intercepts much of the rain not intercepted by the creosotebush. This moisture then evaporates before having the opportunity to penetrate the soil. However, due to the small differences between pH measurements and the azonal nature of the soil, soil pH and texture were not considered important factors in the relationship between creosotebush and bush muhly.

Conclusions

1. Bush muhly influences creosotebush growth by shading the lower branches of the creosotebush, causing the leaves to fall.

2. As bush muhly gains in stature it continues to exert greater and greater influence on the creosotebush. When it occupies more than one-half of the aerial portion of the creosotebush, it appears to exert enough detrimental influence on the creosotebush to prevent the creosotebush from recovering.

3. Since there are fewer leaves on creosotebushes with bush muhly present, we theorize that there will be a depression in the photosynthetic and transpirational rate, which may lead to an overall reduction in growth. At some point it appears that shading by bush muhly causes leaf loss sufficient to reduce the photosynthates necessary to support all the stems of the creosotebush. At this point these stems succumb. Eventually, when only one or two live stems remain, they cannot support the root system and other living cells in the creosotebush and the entire plant dies.

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