Response of Chihuahuan Desert Mountain Shrub Vegetation to Burning

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Abstract

The effects of fire on vegetation in the desert mountain shrub community were studied on 3 to 7-year-old burned sites near the northern limits of the Chihuahuan Desert. Coverage and frequency of redberry juniper *(Juniperus pinchotii)* and frequency of whiteball acacia *(Acacia texensis)* were lower, while frequencies of catclaw mimosa *(Mimosa biuncifera)* and skeleton goldeneye *(Viguiera stenoloba)* were higher on burned sites when compared with unburned paired plants. Lechuguilla *(Agave lecheguilla)*, sotol *(Dasylirion leiophyllum)*, and sacahuista (*Nolina* spp.) suffered losses in excess of 50% on burned sites. With the exceptions of sideoats grama *(Bouteloua curtipendula)* and bull muhly *(Muhlenbergia emersleyi)*, all grasses had recovered or showed increases by the end of three growing seasons. All grasses had recovered or increased on 6 to 7-year-old burns. Recovery of burned plants was predominately by vegetative means, suggesting that periodic fires can be used to maintain or even increase grass coverage at the expense of shrubs in this community.

The response of native vegetation to burning has been the subject of numerous papers, especially over the last 25 years. Little, however, has been reported concerning the effects of fire on vegetation of the Chihuahuan Desert. Kittams (1973) observed the recovery of vegetation 1 to 3 years after burning in desert mountain shrub communities located near the northern limits of the Chihuahuan Desert. Bunting and Wright (1977) reported the effects of fire on desert mountain shrub vegetation 2 years after burning in the Texas Big Bend country.

Kittams (1973) noted that in burned desert mountain shrub communities, catclaw mimosa *(Mimosa biuncifera)*, skunkbush *(Rhus aromatica)*, silver dalea *(Dalea argyraea)*, skeleton goldeneye *(Viguiera stenoloba)*, mountain mahogany *(Cercocarpus montanus)*, scrub oaks (*Quercus* spp.), redberry juniper *(Juniperus pinchotii)* and alligator juniper *(J. deppeana)* usually recovered through some form of vegetative sprouting. He observed that lechuguilla *(Agave lecheguilla)*, datil *(Yucca baccata)*, and mature soto *(Dasylirion leiophyllum)* were usually killed by fire. Bunting and Wright (1977) found that fire reduced shrub cover and total grass cover 43% and 72% respectively in a desert mountain shrub community 2 years after burning. Coverage of forbs and half shrubs increased 650%. The fire significantly reduced the density or cover of sideoats grama *(Bouteloua curtipendula)*, blue three-awn *(Aristida glauca)*, sotol, and lechuguilla, whereas coverage contributed by skeleton goldeneye tripled through vigorous sprouting and seedling establishment on the burned area (Bunting and Wright 1977).

Information pertaining to other species common to the Chihuahuan Desert is available from studies conducted elsewhere. Mortality rates for cholla *(Opuntia imbricata)* and pricklypear *(O. phaeacantha)* two growing seasons after a prescribed burn on the Texas High Plains averaged 45% and 68%, respectively (Heirman and Wright 1973). Pricklypear mortality was 32% the first year following a prescribed burn (Cable 1967) and 28% the second growing season after an experimental fire (Reynolds and Bohning 1956), in two separate studies conducted in the Arizona Sonoran Desert. Survival of ocotillo *(Fouquieria splendens)* following a

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wildfire in the Sonoran Desert was 33% for heavily damaged plants and 50% for plants only scorched (White 1969). Regeneration occurred primarily through basal sprouting. Algerita *(Berberis trifoliolata)* sprouted vigorously following a wildfire in south central New Mexico (Dwyer and Pieper 1967).

The objective of this study was to document longer term effects of fire on vegetation in the mountain shrub community of the Chihuahuan Desert by examining 3 to 7-year-old burned areas.

Study Area

The study sites are in the Guadalupe Mountains of Eddy County, New Mexico, and Culberson County, Texas. The mountains, primarily limestone, are part of a Permian reef complex termed the Capitan Barrier Reef. The area's semiarid, continental climate is characterized by mild winters, warm summers, and summer showers. The mean annual temperature is 19° C (63° F) at 1,352 m (4,435 ft) in this community at Carlsbad Caverns National Park, and annual frost-free days average 226 (U.S. Department of Commerce 1967). Mean annual precipitation is 36.6 cm (14.4. in), but has ranged from less than 12 cm (4.6 in) to 110 cm (43.2 in) per year. Nearly 90% of the annual precipitation occurs between May and October.

Characteristic desert mountain shrub vegetation in the Guadalupe Mountains includes lechuguilla, sotol, and redberry juniper. Prickly pear and sacahuista (*Nolina* spp.) are generally abundant, and grama and three-awn grasses are common in the community. Vegetation of the area has been described by Gehlbach (1967), Bunting (1978), and Northington and Burgess (1979).

Methods

Seven sites that burned between 1967 and 1971 in the desert mountain shrub community of the Guadalupe Mountains were sampled during the summer of 1974. A similar unburned site was located near each burned site for comparison. Shrub intercepts were measured by species along ten 25-m (82 ft) lines placed at 5-m (16.4 ft) intervals in each pair of sites. Fifty 20 × 50-cm (7.9 × 19.7 in) plots were sampled at 5-m (16.4 ft) intervals along each intercept line using a frame. Species included within or overlapping the plot frame were recorded according to one of six cover classes with midpoint cover percentages of 2.5, 15.0, 37.5, 62.5, 85.0, and 97.5 (Daubenmire 1968). Coverage was calculated for individual species from intercept and plot data, and frequency was determined for species sampled with the plot frame. Sampling adequacy was determined by a species area curve and by plotting cumulative mean coverage (Mueller-Dombois and Ellenberg 1974).

Burned sites were located using fire narrative records for Carlsbad Caverns and Guadalupe Mountains National Parks. No information concerning fire intensity, defined as the product of fuel energy consumed and rate of fire spread (van Wagtendonk 1974), was available, but fuels were estimated not to exceed 1.1×10^3 kg/ha (0.5 ton/acre) for litter and cured grasses and 1.6×10^4 kg/ha (7 tons/acre) for living vegetation. Annual precipitation was near normal for the period since the fires, except for the year preceding the sampling period, when drought conditions prevailed.

Except for two paired sites, all sampling was conducted within the boundaries of either Carlsbad Caverns or Guadalupe Mountains National Parks on sites that had been protected from livestock grazing. The seven paired sites ranged in elevation from 1,490 m (4,900 ft) to 1,770 m (5,800 ft) on 5 to 55% slopes with mixed aspects. Four of the fires were lightning-caused and occurred during June; one each in 1967 and 1968, and two in 1971. Fires in April 1968, March 1971, and August 1971 were human caused. The burned areas ranged from 1 to 50 ha (2.5 to 125 acres).

Site elevations were read from U.S. Geological Survey 7.5 min topographic series quadrangles; slopes were determined with an Abney level; and exposures were measured with a hand compass.

Coverage and frequency of major species on the paired sites were compared between burned and unburned sites using analysis of variance and Chi-square analyses, respectively. Student's *t*-test was used to determine differences in coverage by growth forms on burned and unburned sites. Differences were judged to be significant at the 0.05 level.

Taxonomic nomenclature follows Correll and Johnston (1970).

Results and Discussion

Of the 95 species sampled in the 7 paired sites, 47 were common to 2 or more of the paired sites. Because drought conditions prevailed throughout the sampling period, few annuals were present and perennial forbs were not abundant. Most grasses were identified using vegetative characteristics.

Coverage and frequency of redberry juniper were less on burned than on unburned sites. Kittams (1973) observed that a considerable amount of heat is required to ignite this species, but once ignited it burns so vigorously that usually all the branches are killed. Regeneration occurs slowly through crown sprouts. Burned junipers in the present study regained up to 50% of their mature height during the 3- to 7-year recovery period, and the 25 to 50 years predicted by Kittams (1973) for top-killed plants to reestablish their preburn stature is a reasonable estimate.

The frequency of whiteball acacia *(Acacia texensis)* was greater on unburned than on burned sites. Although this dwarf acacia is set back by fire, this effect may be only temporary until new colonies can form from rhizomes.

Burning induces vigorous crown sprouting in catclaw mimosa (Cable 1975, Carmichael et al. 1978). It may recover from burning in as little time as 5 years (Kittams 1973). Although catclaw mimosa was not abundant on any of the sites in this study, its frequency was greater on burned than on unburned sites.

Skeleton goldeneye was more frequent on burned than on unburned sites. Kittams (1973) predicted this species would increase through root and crown sprouts 2 to 3 years after burning. An increase was evident on 3-year-old burns and it persisted through to 7-year-old burned sites.

Coverage and frequency of sotol were 75% less on burned than on unburned sites. The sheath of dead leaves surrounding the trunk makes this species especially susceptible to fire, and plants with fire-girdled trunks usually die. Sprouting occurs only from the terminal bud in lightly to moderately burned plants (White 1969, Kittams 1973). The present study as well as that of Kittams (1973) found that surviving sotol regain most of their cover within 3 years, but many more years will be required for plants to accumulate shaggy bases of dead leaves.

Sacahuista was less frequent on burned sites than on unburned. Sprouting occurred from the outer portion of the caudex in most plants that survived burning. Kittams (1973) measured a 48% loss of sacahuista on a 1971 burn. This burn was studied 3 years later, as a part of the present study. Frequency and coverage for sacahuista on the burned site were 53% and 47%, respectively, of those present on the unburned partner site.

The frequency of lechuguilla was reduced on burned sites, and its average coverage on burned sites was 19% of that on unburned sites. The plant usually dies if more than half of its green leaves are scorched (Kittams 1973). Surviving plants recover slowly from burning. A few rhizomatous offshoots were observed in the area of top-killed lechuguilla on a site burned 3 years previously. Fires of the intensity usually experienced in this area are effective in reducing lechuguilla.

Although prickly pear was not abundant on any of the sites, this species was susceptible to fire on most of the study sites. Usually only the lower pads were damaged by fire, and upper surviving pads often formed roots when in contact with soil. Mortality rates ranging from 28% to 68% have been reported for this species in other fire studies (Reynolds and Bohning 1956, Humphrey and Everson 1951, Cable 1967, Heirman and Wright 1973).

Wavy cloakfern *(Notholaena sinuata)* was present on four unburned sites and only one burned site. Coverage was greater on

Table 1. Mean coverage by growth forms on burned and unburned sites 3 and 6 to 7 years after the occurrence of fire. Data are percentages.

Growth form	Three-year sites n=4			Six to seven-year sites n = 3		
	Burned	Unburned	Difference	Burned	Unburned	Difference
Graminoids	55.3	54.0	+2	53.3	35.3	+51[1]
Forbs and ferns	5.0	6.3	-21	3.0	2.0	+50
Woody shrubs	6.5	10.3	-37	6.7	8.7	-23
Rosette shrubs and stem succulents	5.5	17.5	-69[1]	6.7	20.3	-67
Total ground cover	72.3	88.1	-18	69.7	66.3	+5

[1]Significantly different at the 0.05 level of probability.

unburned sites, suggesting a susceptibility to fire by this species. A single plant was observed growing through the remains of a lechuguilla killed 3 years before in a fire, thus indicating establishment of wavy cloakfern after the fire.

Black grama *(B. eriopoda)* was twice as frequent on burned as on unburned sites. Humphrey (1949) and Reynolds and Bohning (1956) reported that black grama density decreased on burned sites in southern Arizona. Jameson (1962) presented data that showed productivity and cover by this species were decreased on burned sites in northern Arizona, but the effects were largely overcome within 2 years after burning. Although black grama is initially set back by fire, the long-term effect found in the present study was to stimulate vegetative growth through stolon production.

The frequency of hairy tridens *(Erioneuron pilosum)* and slim tridens *(Tridens muticus)* increased on burned sites. Both species are indicators of overgrazed conditions (Pohl 1978), so the increase following fire may be the response of seral species to reduced competition from other plants.

Plains lovegrass *(Eragrostis lugens)* and three-awn grasses (*Aristida* spp.) were other species encountered more frequently on burned than on unburned sites. The mean coverage by these species on burned sites was at least 50% greater than on unburned sites.

Other grasses appeared to recover more slowly from burning. When compared with unburned sites, there were no significant differences for wolftail *(Lycurus pheloides)* or blue grama *(B. gracilis)* on 3-year-old burned sites, but the frequency of both species was greater on 6 to 7-year-old burned sites. Dix (1960) noted essentially no change in the frequency of blue grama on burned and unburned sites 1 to 4 growing seasons after burning. The frequency of sideoats grama was less on 3-year-old burned sites than on unburned sites. Bull muhly *(Muhlenbergia emersleyi)* was reduced on 3-year-old burns and showed no significant differences on 6 to 7-year-old burns when compared with unburned partners. No significant differences were found for hairy grama *(B. hirsuta)* or curly leaf muhly *(M. setifolia)* on the paired sites.

Although not included in the statistical treatment because they did not appear in a majority of the sites sampled, mountain mahogany, skunkbush, scrub oaks, silver dalea, mescal bean *(Sophora secundiflora)*, algerita, and ocotillo reproduced and grew from vegetative sprouts after burning. Neither sprouts nor seedlings of desert ceanothus *(Ceanothus greggii)* were often seen on any of the sites.

Coverage data from 3 and 6 to 7-year-old paired sites are summarized by growth form classes in Table 1. Fire-induced mortality in sotol, lechuguilla, and sacahuista was responsible for a significant decrease in rosette shrubs on burned sites. Woody shrubs exhibited a trend of decreased coverage on burned sites. No differences were significant for coverage by forbs and ferns between burned and unburned sites or between grasses on 3-year-old burned and unburned sites. Coverage of grasses on 6 to 7-year-old burns had increased significantly over that on unburned sites.

Conclusions

Woody shrub mortality was low and most of the woody species responded to burning by sprouting vegetatively. However, since annual growth increments in woody species add relatively little to the total above ground biomass, years will be required for many of these species to reestablish their preburn stature.

Losses of 50% or more for lechuguilla, sotol and sacahuista were apparent on burned sites. Surviving top-killed plants of the latter two species regained much of their preburn coverage in three growing seasons. Burned lechuguilla showed little evidence of recovery.

Hairy grama, black grama, plains lovegrass, blue grama, wolftail, slim tridens, curly muhly and hairy tridens had all increased or at least recovered on burned sites three growing seasons after burning. Only sideoats grama and bull muhly were reduced on these sites in comparison with unburned sites. All grasses had recovered and some showed increases on 6 to 7-year-old burned sites. Wright (1974) and Neuenschwander et al. (1978) reported that recovery of perennial and annual grasses in western Texas was complete one to three growing seasons after burning. A significant increase was seen in overall grass coverage on 6 to 7-year-old burns in the present study. Total grass coverage on burned sites was equal to that on unburned sites after three growing seasons.

Although the majority of species encountered in this study have developed fire-surviving adaptations, extensive fires have not been frequent in this vegetation type, at least in recent times. Grass cover was weakened by livestock grazing, which began during the late 1800's and persisted at least through the first half of this century. The reduction in grass cover prevented accumulation of fine fuels necessary for carrying fire through the vegetation and shifted the competitive balance in favor of shrubs. National Park Service fire records show that lightning-caused ignitions are fairly common in this vegetation type, but they have usually been suppressed before much area burned. Fire scarred stems, charred branches, charcoal, and other evidences of fire are seldom encountered in this habitat. Primary stem diameters of redberry juniper and scrub oaks, and densities of lechuguilla, sotol and sacahuista also suggest that fire has been absent from most of this area for many years.

The practices of suppressing fire and excluding livestock grazing, both in effect for more than 30 years on much of the study area, have permitted grasses, as well as woody and rosette shrubs, to accumulate in quantities sufficient to support fires over extensive areas. With periodic burning of perhaps every 10 to 15 years in this community, grasses can be expected to increase as shrub cover is reduced. In the absence of additional fires, coverage by shrubs can be expected to slowly increase again at the expense of grasses.

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