Effect of Fire on Vegetation of the Chihuahuan Desert Region

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With recent increased attention to allowing full interplay of natural processes, the National Park Service has a real need for an understanding of the role of wildfire in natural areas. Carlsbad Caverns National Park, New Mexico, which is in the Chihuahuan Desert region, has sufficient vegetation on the upland areas to produce fuel for fires started by the frequent lightning strikes. Lightning- and occasional man-caused fires in and near the park provided an opportunity to observe the effect of fire upon a variety of vegetation, which is reported here. Incidental observations of the secondary effect on foraging habits of mule deer (*Odocoileus hemionus*) were also made.

Applicable knowledge regarding response of several plants following fire has been developed in Arizona, and that will be treated later in this paper. Suffice it to mention, also, that for the Southwest a variety of opinions have been expressed regarding the role of fire in grassland vs shrubland under conditions similar to those in our area. In fact, that question about the effectiveness of fire in maintaining grassland is considered in this study.

STUDY AREA AND METHODS

The 10 burn areas studied are briefly described in Table 1. They were selected to represent those mountainous portions of the park where natural fires have been most common—approximately 34 sections between 4600 and 6500 foot elevation excluding deep canyons and the escarpment face. The three burns outside the park are on land similar in topography and vegetation to those in the park.

All the area is part of the limestone reef which forms the Guadalupe Mountains and stands out above the surrounding plains. It slopes gradually upward to the southwest but is cut by several deep canyons. Soil of the ridges is a fine loam, seldom more than 6 inches deep, interspersed by gravel and boulders. Limestone bedrock is often exposed, especially on steep, south-facing slopes. Occasional ridge tops have sandstone outcrop; sandy loam soil there may be a foot deep.

Climate is semi-arid continental with summer rainfall maxima. The Carlsbad Caverns weather station, which is at 4400 foot elevation and within 18 miles of all the burns studied, has an average annual rainfall of 14 inches with 78 percent falling in the 6 months from May to October. Much of it comes during brief, intense thundershowers. Droughts are common. Annual precipitation extremes during the past 40 years have been 4.47 inches in 1951 and 43.23 inches in 1941. The variable amount of annual precipitation, irregular distribution, and rapid rate of fall on extremely thin soils make more hazardous growing conditions than the 14-inch annual average rainfall would suggest. Recorded temperature extremes at Carlsbad Caverns have been —10° and 108°F; annual average daily maximum temperature is 75°F and minimum is 51°F. Wind is common, being greatest in March. Lightning, often "dry," is common during the May-October period. At the upper elevations of the study area, temperatures are generally lower, annual precipitation perhaps 2 inches more, and winds are somewhat higher than at the Caverns station.

Vegetation in the area is predominantly evergreen shrub type. At the lower levels, shrubs are the succulents: lechuguilla (*Agave lecheguilla*), smooth sotol (*Dasylirion leiophyllum*) and the lesser oc-

curring prickly pears (*Opuntia* spp.); and the woody-stemmed forms: redberry juniper (*Juniperus pinchotii*), wavyleaf oak (*Quercus undulata*)*, skeleton goldeneye (*Viguiera stenoloba*), catclaw mimosa (*Mimosa biuncifera*) and daleas (*Dalea* spp.). Grasses: primarily curlyleaf muhly (*Muhlenbergia setifolia*), several gramas (*Bouteloua* spp.), three-awn (*Aristida* sp.) and slim tridens (*Tridens muticus*), make up from 10 to 40 percent of the plant cover. This vegetation extends to the upper limits of the area on south-facing slopes. At the upper limit, vegetation is more commonly of the woodland type, having scattered alligator juniper trees (*Juniperus deppeana*) with low Mohr's oak (*Quercus mohriana*)*, sacahuista (*Nolina texana*), hairy mountain-mahogany (*Cercocarpus breviflorus*), catclaw mimosa, and lesser amounts of lechuguilla, redberry juniper and smooth sotol. Grasses, mainly muhlys, lovegrass (*Eragrostis* sp.) and sideoats grama (*B. curtipendula*)—may comprise as much as 60 percent of the cover here.

Grazing of the park range by livestock, mainly goats, extended from the early 1900s until 1940 when it was gradually phased out. Recent use of the park and adjacent National Forest range (Burns nos. 1 and 6) has been entirely by wildlife, mainly mule deer. Cattle and horses graze the private and state lands containing Burn no. 8. Fires have been suppressed throughout the general study area for at least 3 decades; however, many of the lightning fires have been so small as to escape detection, or they burned out before suppression crews reached them.

Observations, noted in Table 1, were entirely post-burn except in one case when we incidentally arrived at a fire shortly after lightning struck. Most intensive study was at Burns nos. 1, 2 and 7, but even that was often incidental to other work. Sampling was by selection to obtain the most possible data on the direct effect of fire and on the later response of the variety of shrubs representative of the park uplands. An additional reason for selecting sites was that fire often burned in an irregular pattern, leaving unburned patches. Photo records (Figs. 1 and 2) of selected subjects were made from marked points so that they could be repeated. Unburned areas within

*Identification of oaks is tentative.

TABLE 1. BURNS STUDIED

Fire date, cause, size, location	Elevation	Slope Exposure Gradient	Vegetation type and composition	Study Visits & Photos (P)
1. 1–21–67 M* 9 acres Outside Park	6600′	Multiple	Woodland: H. m-mahogany, grasses, ceanothus, s. goldeneye	7–12–67 P 8–13–70 P
2. 6–6–67 L* 3 acres Inside Park	4900′	N Shallow	Shrub: Lechuguilla, grasses, r. juniper, sotol, oak	7–10–67 P 8–18–70 P
3. 5–18–69 M 1 acre Inside Park	5500′	SW Moderate	Shrub: Grasses, lechuguilla, sotol, r. juniper, oak	8–12–70 5–31–72
4. 7–25–69 L —0.1 acre Inside Park	5500′	Flat Ridge Top	Shrub: Lechuguilla, grasses, sotol, oak	7–25–69 8–12–70
5. 6–19–70 L 0.3 acre Inside Park	5400′	Flat Ridge Top	Shrub: Grasses, lechuguilla, r. juniper, sacahuista, s. dalea	8–17–70
6. 6–19–70 L 23 acres Outside Park	6200′	SW Shallow	Woodland: Oak, grasses, a. juniper, sacahuista	8–13–70 P
7. 6–20–70 L 31 acres Inside Park	6000′	NE Moderate	Woodland: Grasses, oak, h. m-mahogany, sacahuista, a. juniper	8–12–70 P 12–10–70 4– 5–71 4–18–72
8. 6–11–71 L 95 acres Outside Park	5000′	Multiple	Shrub: Lechuguilla, grasses, sotol, r. juniper, sacahuista	5– 2–72 5–25–72
9. 6–14–71 L —0.1 acre Inside Park	5400′	W Steep	Shrub: Lechuguilla, r. juniper, sotol	6–22–71 P
10. 6–14–71 L 2 acres Inside Park	5700′	SE Moderate	Shrub: Grasses, sacahuista, oak, r. juniper	6–22–71 10–11–71 5–31–72

M* — Man caused
L* — Lightning caused

the general fire zones or adjacent to them were used for comparison of composition and density of vegetation and condition of individual species.

RESULTS AND DISCUSSION

AGAVES

Lechuguilla, a small agave, is of particular interest because it covers much of the park (Gehlbach 1967) and severely restricts

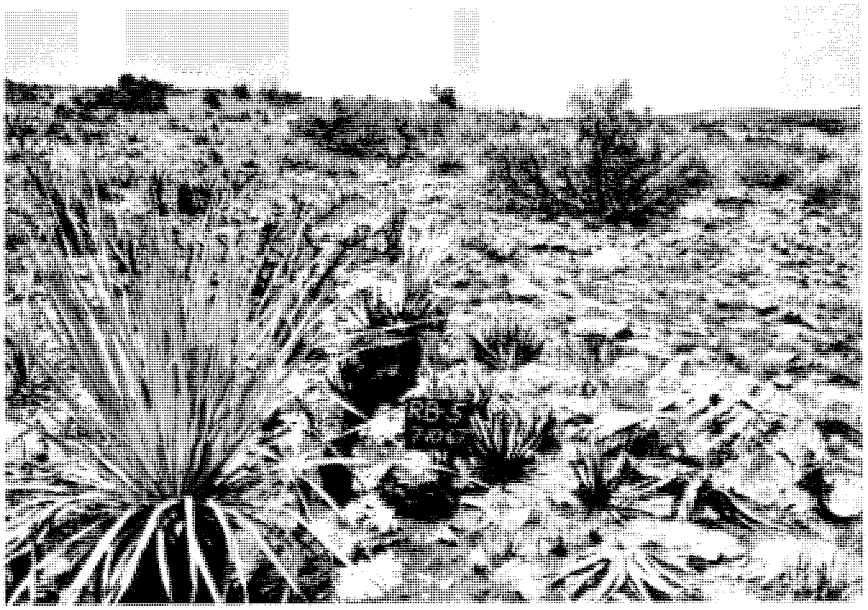
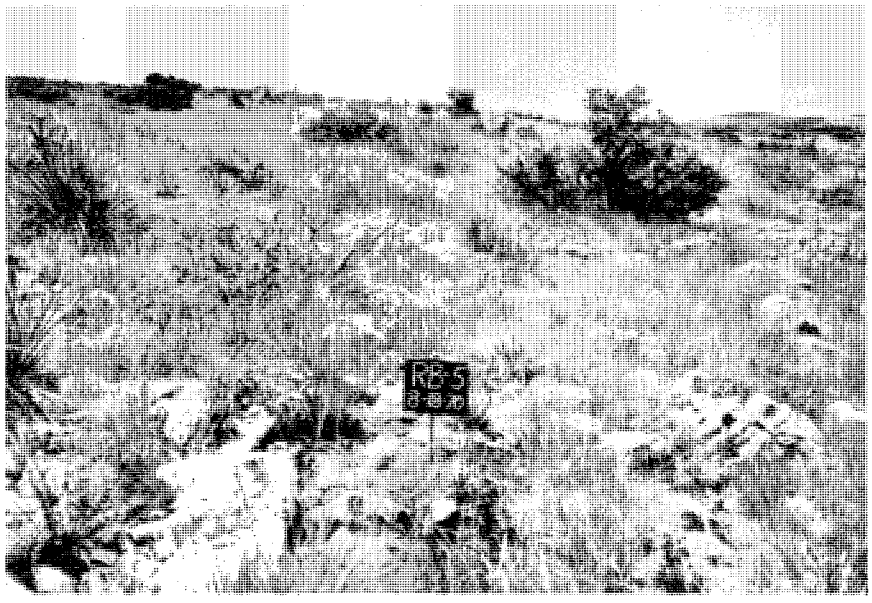


FIG. 1 and 2. Center of Burn no. 2. In the 1967 picture made a month after fire, remains of two sotols in lower left, lechuguilla in center and upper left, and of redberry juniper in left center show effect of fire. In 1970, 3 years later, sotol and lechuguilla remains were scattered, juniper crown sprouts were about 2 feet tall, and grass dominated the site. Juniper bushes in center and right background were only scorched; new twigs on the old branches rapidly restored the canopies.



foot and horseback travel. It grows in dense clones and the pointed leaves are extremely dangerous. Some range managers are of the opinion that over-grazing by livestock has been responsible for an increase of lechuguilla in the Chihuahuan Desert. Deer avidly seek the young flower stalks (each agave plant blossoms only once, then dies), and especially in winter eat young plants which are 2 to 5 inches tall. Although the heavy utilization of flower stalks limits seed production, lechuguilla is very successful because it develops offsets from rhizomes. Density of the species over the park is limited primarily by pocket gophers (*Thomomys umbrinus*) which eat the core of the plant and may kill all lechuguilla in areas as large as 10 ft^2. Most of the leaves are left to die, however, and they may carry fire.

Abundant observations confirm that lechuguilla often burns hot, and it alone can be dense enough to carry fire. Frequently grass combines with lechuguilla to carry fire. The fibrous remains of leaves on the ground serve as tinder and burn hot enough to ignite the intact dead leaves which burn even hotter and scorch the green leaves. If more than half of the green leaves are scorched the plant usually dies. Occasionally single plants within clones survived fire around them, but in no case was vegetative reproduction from doomed plants evident. Apparently the root sprouts, even though as deep as 2 inches under the soil surface, are left without food reserves to produce new offsets. We inferred that elimination of lechuguilla released grass plants, and allowed development of new grass plants within 3 years. The effectiveness of fire in eliminating lechuguilla suggests that fire might be useful in clearing trails, especially on rocky sites.

The larger Parry agave (*Agave parryi*) grows only above elevations of about 5500 feet. This species is usually of low density; and the plants are usually solitary, indicating that reproduction is mostly by seed. The flower stalks are often eaten by deer. Those stalks which survive add brilliance to the mountain landscape in late spring when they have red buds and ascending yellow flowers. By summer the fruit stalks turn dry, but they may stand as sentinels through the rest of the year. The individual plants burn much the same as

lechuguilla but they are so scattered as to be of little consequence in carrying fire.

Smooth Sotol

This sotol is a dominant plant on a variety of sites (Gehlbach 1967). It, more than any other species on the shrubland, "catches" the lightning strike. Those plants which have developed a base of dense, overlapped dead leaves burn hot. In fact, they are probably the plants that are tall enough and with tinder and sufficient fuel to start fires from lightning strikes. These large plants contribute to fire travel, but their spacing is such that other fuel is often required to carry fire from plant to plant. The plant may burn for hours and if the stem burns through, the fallen top may spread the fire by rolling downhill. Therefore, suppression crews frequently lop off the big sotols and split them open to check fire spread. Small, presumably young, plants have green leaves extending to the ground and usually are only slightly scorched.

Our findings on smooth sotol survival agree with White's (1969) on Wheeler sotol: that only severely damaged plants succumbed and "Sprouting did not occur except as refoliation from the terminal bud."

Junipers

Redberry juniper, always a shrub form on the slopes and ridges, has an 8- to 10-foot canopy of thick foliage which often extends near the ground. Dwyer and Pieper (1967) noted the susceptibility of low shrub juniper to fire in New Mexico. We noted several instances in which juniper foliage was within easy reach of low ground fire and the juniper foliage was only scorched. Apparently considerable heat is required to ignite the foliage. Lack of heat for ignition must have caused fire to stop on burn edges where juniper foliage was only scorched. Once ignited, however, it burns so vigorously that its heat and flame intensify the fire. Usually all branches are killed and the plant makes slow regrowth from the crown. The void left by the juniper canopy is often occupied by grass.

Deer prefer the crown sprouts, which may grow 12 inches the

first year and to a 2-foot length in 3 years, to foliage on old branches. Our studies of deer foods indicate a high frequency of redberry juniper in the deer diet and this confirms findings of Anderson, Snyder, and Brown (1965) on other portions of the Guadalupe Mountains. Therefore, this response of shrub juniper is of real importance for deer management.

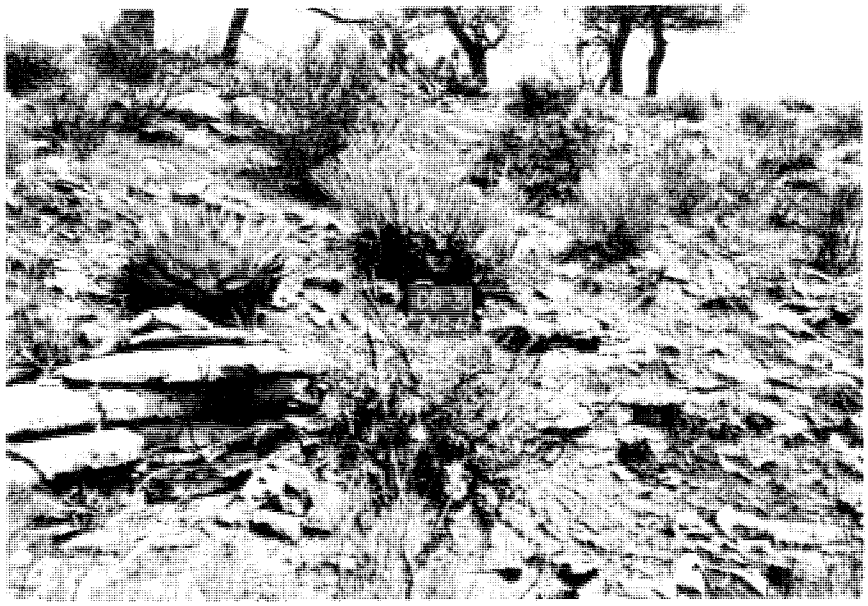
Alligator junipers usually assume tree form with the canopies high enough so they frequently only scorch, and often the tops are spared that damage. Bark is seldom burned. Sprouts form on the stem, especially around the base, and probably are even more desired by deer than the older foliage, which is of higher preference than redberry juniper.

Skunkbush

Rhus trilobata, which Gehlbach (1967) rated ". . . the leading broadleaf deciduous shrub . . ." under certain conditions, is of overall wide distribution but low density on cool sites within the study area. This 3-foot shrub is a preferred food for deer in the park. Vigorous sprouting of skunkbush after fire (Figs. 3 and 4) was noted by Pond and Cable (1960), Pase (1971), and Pond and Bohning (1971). Our observations confirm this habit with crown sprouts of 3 to 4 inches in 2 months, up to 2 feet in a year, and to 3 feet (full size) in 3 years if not held back by deer browsing. Shoots were thicker and more fully leafed than the foliage on old canopy. Browsing of shoots was usually rated as moderate. Since skunkbush in the park is often decadent, fire may well rejuvenate it and benefit deer too.

Oaks

Identification of oak species on the Guadalupes is so difficult that names have been arbitrarily used. The one called wavyleaf oak grows in dense clumps, 5 to 10 feet tall, on warmer sites than the one termed Mohr's oak which reaches a height of only 2 to 3 feet and grows in rather open patches interspersed with grass. When oak stems are close together, fire does not carry through the patch. Cases were observed where a fire in lechuguilla carried to the edge of oak



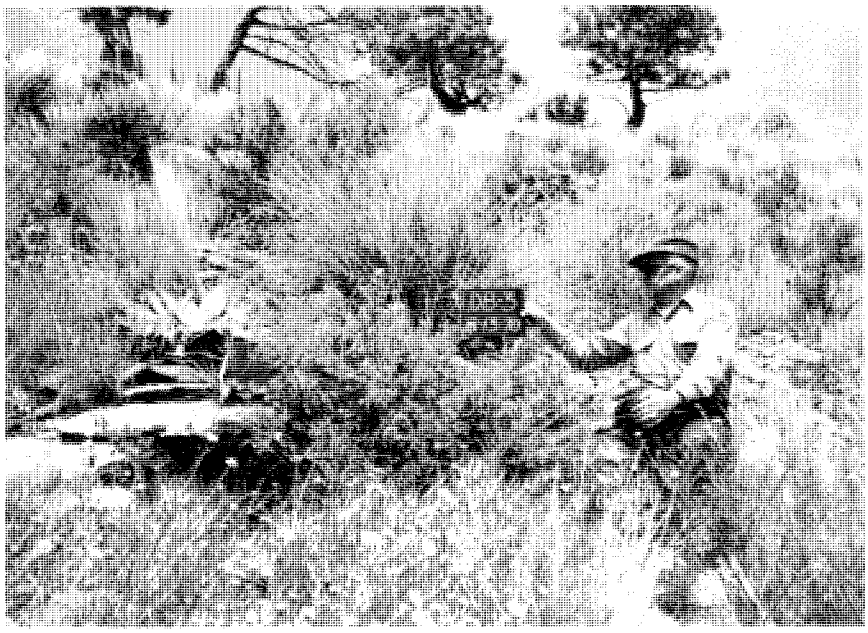


FIG. 3 and 4. Center of Burn no. 1, 6 months after January fire, and 3 years later. Skunkbush in center foreground made rapid recovery with crown sprouts. Sacahuista (behind marker board) had burned to base level and several of the leaf fascicles had been killed; but singed leaves from live fascicles grow rapidly, and addition of new leaves gave normal-appearing canopy in 1970. Skeleton goldeneye (behind man's head and in close foreground) was only scorched; it recovered rapidly from low stem sprouts. Needlegrass is abundant on the skyline in 1970.

patches and scorched the bushes sufficiently to topkill them. Apparently the dry leaves alone on the ground do not burn well enough to carry fire.

Soon after oak stems are killed by fire, crown and root sprouts develop rapidly, reaching a 3- to 4-inch height within 2 months. Several records for Mohr's oak show growth to a height of 10 to 15 inches in 3 years. This response is similar to that of shrub live oak (*Q. turbinella*) in Arizona, reported by Pond and Cable (1960) and Pond and Bohning (1971).

Oak foliage is probably a staple food for deer in the park, as indicated by our studies and those by Anderson et al. (1965). Leaves are taken while green between April and November. The vigorous sprouts following fire are frequently nipped by deer indicating preference to foliage on old stems, especially on Mohr's oak. Another factor is that leaves remain green longer on sprouts. It appears that burning improves oak as deer forage, a considerable factor at the higher elevations where oak is one of the major components of the vegetation.

Hairy Mountain-Mahogany

This evergreen is often the most common shrub on rocky sites above 5500 foot elevation. The 2- to 3-foot bushes are usually mature and sometimes decadent, which may explain their commonly charred condition after fire. Crown sprouting of this species after fire and the value of sprouts to deer in Arizona was reported by Pond and Bohning (1971).

Bushes which we presumed were topkilled (Figs. 5 and 6) by scorching or light burning seemed to produce more and longer crown sprouts than those which had burned to char. Crown sprout growth of 2 inches in 2 months, to 8 inches in 6 months (January fire) and 15 inches in 3½ years was noted. A real factor in bush rejuvenation is the degree of mechanical protection from deer browsing effected by dead branches. Since mature and decadent plants are commonly hedged and produce little available forage, fire may stimulate increased forage production of hairy mountain-mahogany, which Anderson et al. (1965) found to be a top ranking deer food in the Guadalupes.

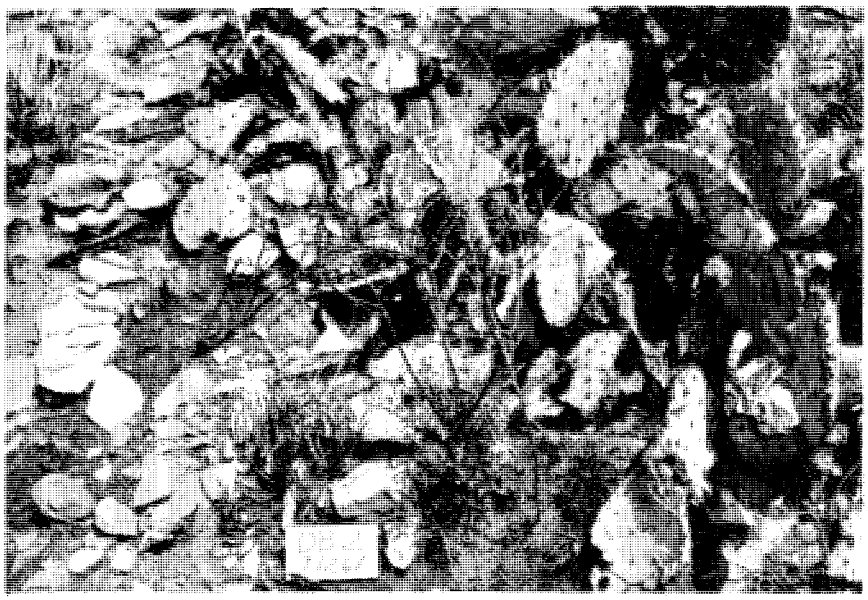
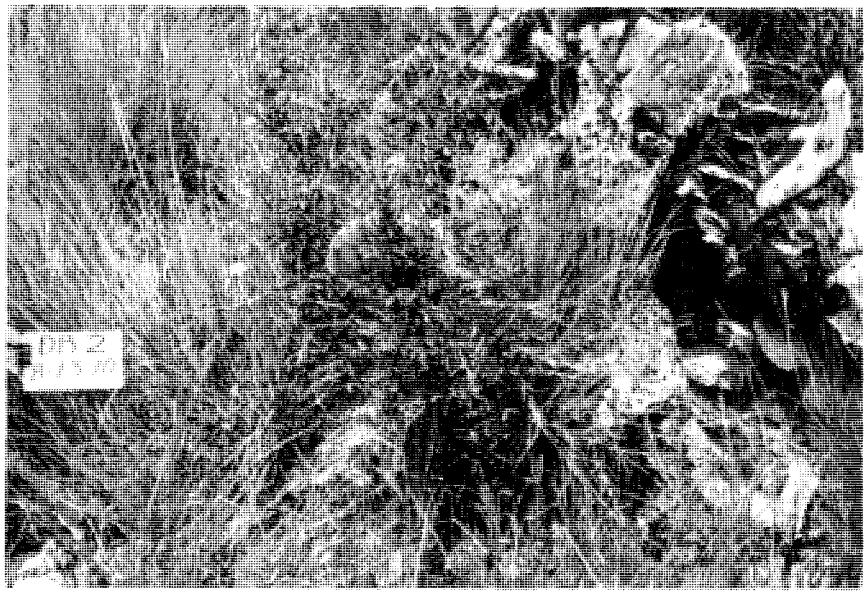


FIG. 5 and 6. Hairy mountain-mahogany, in center, was topkilled by January fire on Burn no. 1. Crown and basal-stem sprouts were 2 to 8 inches tall 6 months later, and in the following 3 years the bush had regained its pre-burn height of 2½ feet. Soil and rocks exposed by fire were covered with grass by the fourth growing season. Many of the prickly pear pads died from scorching.



Desert Ceanothus

Ceanothus greggii, a low evergreen shrub, occurs on the higher rocky sites with, but less abundantly than, hairy mountain-mahogany. Bushes are usually of 2- to 3-foot size, tightly hedged by deer, and often decadent. Remains of dead bushes indicate the species was more common several years ago. Decadence of this species in Arizona was found by Pase and Lindenmuth (1971) and Pond and Bohning (1971), and the latter authors indicated that this ceanothus is short lived and ". . . fire is necessary for the propagation of significant amounts. . . ." The above authors, as well as Pond and Cable (1960) and Pase (1971), reported the species almost never sprouted after fire. Our observations of several bushes topkilled by fire revealed only two with crown sprouts. Those on one bush had died after reaching a height of 8 inches 3 years after the January fire. Perhaps the stems and roots of this shrub burn well for we noticed that fire had followed underground on rocky slopes. Seedlings were not noted on Burns nos. 1 and 7 where the species had been present, though we did not make a detailed search for them. The abundance of seedlings found after fire by Pase and Lindenmuth (1971) indicates fire may restore this choice deer food to the park uplands.

Catclaw Mimosa

This thorny, 3- to 5-foot shrub is scattered over the park uplands, reaching sufficient density on upper sandstone sites to hamper foot and horseback travel. It underwent severe reduction of live stems with the 1970–71 drought, and appears to be losing additional foliage due to a succeeding drought. It furnishes little fuel for fire since it has an open growth form and the small leaves contribute little material when they drop in the fall. With surrounding fuel from other plants to build heat, catclaw stems do burn off. We found vigorous sprouting from the crown as did Pond and Bohning (1971). The sprouts grew to 8- to 10-inch length in one season and appear to be taken more by deer than old foliage from which they eat the leaves but seldom the twig tips. We can expect fire to reduce ground cover of this catclaw, but it will likely regain between fires.

Sacahuista

This fibrous-leafed member of the lily family has leaves over 3 feet long and may spread to a 7-foot diameter and reach sufficient density to dominate those sites with the deeper soils. Mature plants (clumps) have dead leaves in an outer fringe as well as interspersed through the green foliage. The foliage burns with such heat that even the green leaves burn to the plant base. The leaf fascicles and underlying woody caudex may burn, or be partially killed by heat penetrating beneath the surface. Loss of sacahuista, as indicated by death of fascicles, was measured to be an average of 48 percent on 100 plants on Burn no. 10, and it was estimated to be 50 percent on a north-facing slope within Burn no. 8. On both sites sacahuista had been a dominant. Probably loss is greatest among large plants with considerable dead material, on slopes. Plants recover rapidly if most fascicles survive, for the burned-tip leaves may extend up 12 inches in 2 months, and the plants may regain normal appearance in 3 years. Deer often eat the new leaves as they appear, in contrast to no apparent feeding on foliage of fully developed plants.

Other Shrubs

Skeleton goldeneye is a deciduous half-shrub prominent on the warm sites. It varies in size but seldom exceeds a 3-foot canopy and usually has an open form. Our few observations indicate a light burn will topkill it. Regeneration after fire is by root and sometimes crown sprouts. Deer occasionally feed on the leaves and tender stems of skeleton goldeneye and it appears probable that the new foliage following fire would be more desired by deer.

Silver dalea, a sprawling near-evergreen half-shrub, is an important food for deer on the lower portion of the study area. Fire kills the tops, but dense crown and root sprouts (Figs. 7 and 8) were found which reached a height of 3 inches in 2 months, and some were 12 inches (probably full height) in a year. The average height of dense foliage after a year was 6 inches, which indicates a rapid production of succulent forage for deer.

Datil yucca is a low form which usually grows in clones, thinly scattered over cool sites. In Arizona, Pase and Lindenmuth (1971)

FIG. 7 and 8. Comparable sites in and adjacent to Burn no. 5. Two months after fire, basal sprouts of silver dalea bushes in center of Fig. 7 (NB-3) had reached a height of 3 inches, a good start toward regaining the original height of 8 to 10 inches, as indicated in Fig. 8(NB-M3). Scorched lechuguilla plants in Fig. 7, in contrast to normal ones in Fig. 8, will undoubtedly die. An increase of grass will probably follow disappearance of lechuguilla.

found this species ". . . was heavily damaged . . . but few plants were killed," by burning combined with chemical treatment. We deduced from remaining ash and plant material that shredded leaves and intact dead ones burn hot, scorching and sometimes burning the live leaves. Occasionally new centers developed from plant bases, but more often, offsets (new plants) came from fleshy roots 1 to 4 inches deep. On Burns nos. 7 and 10, deer browsed most new leaves which were from 2 to 8 inches long. The proportion of such new leaves browsed was considerably greater than that noted on mature plants.

Grasses

The study area is of higher elevation and probably rougher topography and shallower soils than that considered by Humphrey (1953) when he concluded ". . . the desert grassland of southwestern United States and northern Mexico is not a true climax. Rather, it is a subclimax maintained by fire."

Standing and fallen grass material was invariably burned on the study sites. Evidence of pre-burn grass composition and density could only be deduced from adjacent unburned areas and from those grasses which survived fire. Within the burn areas dead grass crowns left questions as to what species and whether previously alive but killed by fire. Thus we were limited in reconstructing the pre-burn grass component.

Three years after fire on Burn no. 2, at the lower extreme, on a gently sloping site with relatively good soil depth, grasses were sideoats grama, slim tridens, green sprangletop (*Leptochloa dubia*), curlyleaf muhly, and lovegrass. They were in sufficient density to indicate good survival and probably an increase of quality bunchgrasses. In contrast, at highest elevation on a steep, south-facing rocky slope, on Burn no. 1, quality bunchgrasses were apparently thinned by fire, and finestem needlegrass (*Stipa tenuissima*) and a forb, (*Parthenium confertum*), were most abundant 3 years after fire. On Burn no. 7, a site of intermediate quality, littleawn needlegrass (*Stipa lobata*) was a high ranking plant the second summer after fire. This indicated a slightly lower successional level caused by fire.

Generally on the areas burned, grasses seemed to survive and probably increased where only grass material and other light fuel had burned. But at sites of hot burns from sacahuista, shaggy sotols and dense lechuguilla and datil yucca clones, the thin grasses suffered some loss. Grass material is essential to carry the fire between hot-burning plants, and it probably serves as tinder to heat foliage, such as live juniper branches, so it will burn.

Although deer in the park eat but little grass normally, they probably eat more of the succulent, readily available growth which comes shortly after wildfire.

Overall Effect of Fire

On a relatively good site, Burn no. 2, a grassland aspect prevailed 3 years after fire. This was due mainly to the topkilling of redberry juniper and low oak, to elimination of lechuguilla and large sotol plants and to increase of grass cover. Since low oak re-growth is relatively rapid, it will probably regain pre-fire status within 5 years after fire. The shrub juniper, however, may require 25 to 50 years to regain its spread from crowns. Sotols which survive will regain their cover within 3 years, but a considerably longer period, maybe 15 to 20 years, would be required for development of any appreciable proportion of plants with shaggy bases. In fact, this may be the factor which marks susceptibility to a succeeding fire, since lightning fires usually start on shaggy sotols. Catclaw mimosa, which sometimes dominates good sites, would likely regain status in 5 years. Sacahuista, on the other hand, may require considerably longer, if it ever fully regains.

On sites at higher elevation and more severe in character—with some combination of thin soil, steep slope, and southerly exposure—we can expect a temporary expression of grasses, such as needlegrass, with opportunist shrubs such as skeleton goldeneye in 2 to 3 years; and a gradual regaining of hairy mountain-mahogany cover, with quality bunchgrasses and perhaps significant establishment of desert ceanothus from seedlings in the range of 10 years.

SUMMARY

Effect of fire on the several plant categories considered is evaluated

TABLE 2. EFFECT OF FIRE ON VEGETATION, CARLSBAD CAVERNS NATIONAL PARK

Plant	Burns hot	Usually killed by fire	Type of sprouts after fire	Speed of recovery after fire	Improved as deer forage by fire	Remarks
Lechuguilla	Yes	Yes	None	Nil	No	Often main carrier of fire
Smooth sotol—						
Old Plants	Yes	Yes	None	Nil	No	Often "catches" lightning strikes
Young Plants	No	No	None	Rapid	No	
Redberry juniper	Yes	No	Crown Stem Seldom	Slow	Yes	
Alligator juniper	No	No	Stem	Slow	Yes	Foliage often too high to burn
Oaks	No	No	Root	Moderate	Yes	Oak clumps do not carry fire
Hairy mountain-mahogany	—	No	Crown	Moderate	Yes	Often rejuvenated by fire
Desert ceanothus	Yes?	No	Crown seldom	Nil	No	Roots burn out
Catclaw mimosa	No?	No	Crown	Rapid	Yes	
Sacahuista	Yes	No	Crown	Variable	Yes	Sometimes killed
Skeleton goldeneye	—	No	Crown, Root, Stem	Rapid	Yes	
Silver dalea	—	No	Root & Crown	Rapid	Yes	
Skunkbush	Yes?	No	Crown	Rapid	Yes	
Datil yucca	Yes	Yes	Root	Moderate	Yes	Deer seek new leaves
Grasses	Seldom	No	Crown	Rapid	Yes	Often main carrier of fire

in Table 2. Results are generalizations with judgment. For some categories, observations were inconclusive or lacking. Additional investigation involving measure of pre-burn condition of plants and quantification of plant responses is the next step to provide reference data needed for management of natural vegetation in the park.

This study indicates a reversion to previous cover may be expected for most categories if fire does not interfere. There may be two notable exceptions: re-establishment of lechuguilla by rhizomes and of sacahuista by seeding may be very slow processes, if they can

occur at all, in good grass cover. Fires recurring as often as every 10 years would probably maintain the grassland aspect on those sites which are relatively favorable for grass. There is the distinct possibility that quality deer forage would be increased long-term by rejuvenation of hairy mountain-mahogany and oak, and natural re-seeding of ceanothus.

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LITERATURE CITED

Anderson, A. E., W. A. Snyder, and G. W. Brown. 1965. Stomach content analyses related to condition in mule deer, Guadalupe Mountains, New Mexico. J. Wildl. Manag. 29:352-366.

Dwyer, D. D. and R. D. Pieper. 1967. Fire effects on blue grama-pinyon-juniper rangeland in New Mexico. J. Range Manag. 20:359-362.

Gehlbach, F. R. 1967. Vegetation of the Guadalupe Escarpment, New Mexico-Texas. Ecology. 48:404-419.

Humphrey, R. R. 1953. The desert grassland, past and present. J. Range Manag. 6:159-164.

Pase, C. P. 1971. Effect of a February burn on Lehmann lovegrass. J. Range Manag. 24:454-456.

——— and A. W. Lindenmuth, Jr. 1971. Effects of prescribed fire on vegetation and sediment in oak-mountain mahogany chaparral. J. Forestry. 69:800-805.

Pond, F. W. and D. R. Cable. 1960. Effect of heat treatment on sprout production of some shrubs of the chaparral in central Arizona. J. Range Manag. 13:313-317.

——— and J. W. Bohning. 1971. The Arizona Chaparral. Arizona Cattlelog. 27:16, 18, 20, 22-28; 27:13-16, 18-24.

Reynolds, H. G. and A. W. Sampson. 1943. Chaparral crown sprouts as browse for deer. J. Wildl. Manag. 7:119-122.

——— and J. W. Bohning. 1956. Effects of burning on a desert grass-shrub range in sourthern Arizona. Ecology. 37:769-777.

White, L. D. 1969. Effects of a wildfire on several desert grassland shrub species. J. Range Manag. 22:284-285.