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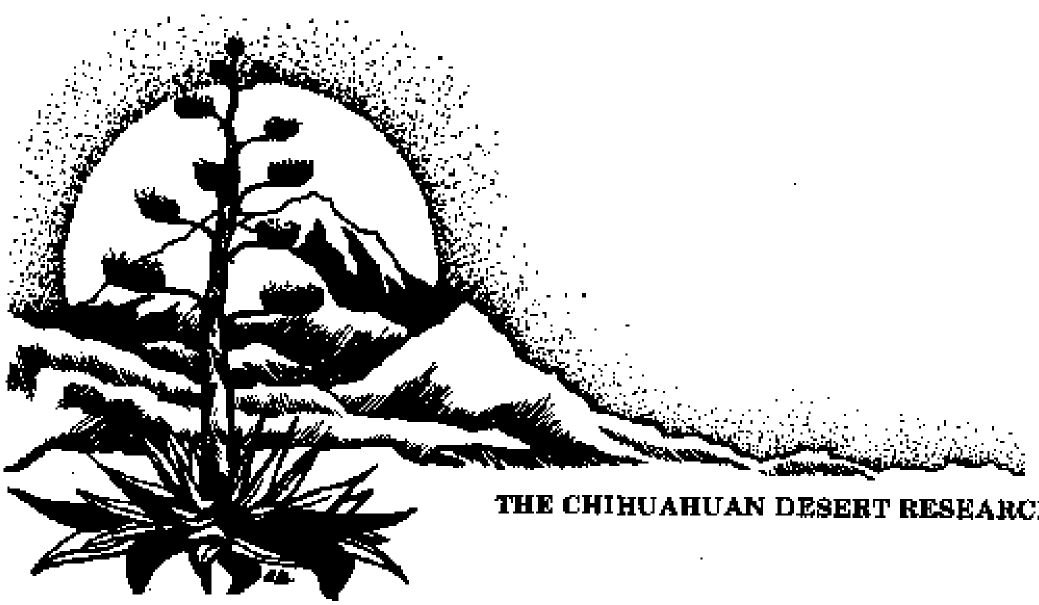

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SOME EFFECTS OF FIRE ON SHRUBS AND SUCCULENTS IN A CHIHUAHUAN DESERT COMMUNITY IN THE FRANKLIN MOUNTAINS, EL PASO COUNTY, TEXAS

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ABSTRACT.--On 15 July 1981, a fire burned about 30 ha of Chihuahuan desertscrub community in the Franklin Mountains, El Paso County, Texas. Effects of the fire on shrubs and succulents were investigated by means of transects and study plots in November 1982, 16 months after the fire. A majority of the plant species were found to have recovered almost completely primarily from underground parts, but species such as Snakeweed (Gutierrezia microcephalum and G. sarothrae), Sotol (Dasylirion wheeleri), and Ocotillo (Foquieria splendens) were eliminated to a large extent from the burned areas. Effects of the fire on cacti were quite variable with mortalities ranging from 8.3–70.0%.

The role of fire in ecosystems has been intensely investigated in recent years. Effects of fire on desert ecosystems, however, are poorly understood owing to the infrequency of such events due to the slower and often inadequate accumulation of fuel (Humphrey, 1974). Except for a few limited studies (Kittams, 1972; Humphrey, 1974; Ahlstrand, 1982), the effects of fire on Chihuahuan Desert plants is almost completely unknown.

On 15 July 1981, a fire burned about 30 ha of Chihuahuan Desert shrub (desertscrub) community in the Franklin Mountains, El Paso County, Texas. The locality is approximately 2 km WNW of the junction of Trans–Mountain Road with Gateway North–South. The fire burned up arroyos and up predominately north slopes at elevations of 1330–1650 m. The area is one of granite soil and rock outcrops dominated by Cat's–Claw Mimosa (Mimosa biuncifera), Datil (Yucca baccata), Sotol (Dasylirion wheeleri), Apache Plume (Fallugia paradoxa), Snakeweed (Gutierrezia microcephalum, G. sarothrae), Golden–Eye (Viguiera stenoloba), and other shrubs. A rich assemblage of cacti is also present. The area normally receives about 215.6 mm of precipitation a year with 80 mm falling during the winter months (October–April; NOAA, 1981). Above average rainfall of 102 mm during the preceeding winter apparently permitted the growth of enough winter annuals to increase the fuel load sufficiently to carry a fire. The fire was judged to be "cool" throughout most of the area burned with occasional unburned patches in evidence; however, some brush–choked arroyos apparently burned "hot."

METHODS

To investigate the effects of fire on woody perennial vegetation and succulents, five 50 m transects were positioned within the burned areas and a parallel transect to each was established in similar unburned habitat. Coverage was determined by the line intercept technique and density was determined by counting all the plants 2 m to the downhill side in each of the 10 transects. The quantitative studies were conducted in November 1982, 16 months after the fire. During September 1982, approximately 65 mm of rainfall fell in the area fostering luxurious growth on the mountain well into the fall. Observations on rare species were made by walking through the area and recording the fate of the plants as they were encountered. A walk–through survey was repeated 15 August 1983, 25 months after the fire to make additional observations.

Many of the cactus species were too infrequent to show up in the transect studies. To investigate the fate of burned cacti we meticulously combed 10, 100 m^2 plots for all cactus and cactus remains. Observations on rare species were made by walking through the area and recording the fate of each plant encountered.

RESULTS

The fire in July 1981, evidently reduced plant coverage to near zero. The plant coverage (shrubs and succulents) in burned areas in November 1982, 16 months after the fire, was still only 7.52% compared to 33.68% for the adjacent unburned areas (Table 1). Comparing the densities of the common plant species in the burned and unburned transects, only the densities of the two Snakeweed species (*Gutierrezia microcephalum*, *G. sarothrae*) were significantly different; indeed, they were virtually eliminated by fire (Table 1). The majority of the species listed in Table 1 were not abundant enough in the samples to detect the effects of fire on population size necessitating the use of other methods.

The walkthrough surveys provided data on the fates of some of the rarer species in the area (Table 2). A small group of species was found to be largely eliminated when topkilled. These “non–sprouters” include the two species of Snakeweed (*Gutierrezia* spp.; nearly 100% mortality of burned plants), Sotol (*Dasylirion wheeleri* 88% mortality), and Ocotillo (*Fouquieria splendens* 93% mortality). The mortality of Torry Yucca (*Yucca torreyi*) was determined to be 35% (13 of 37 killed) almost placing it in the non–sprouter category. A good case could be made for considering the response of this species to be intermediate.

A majority of the shrub species show low mortality rates (most less than 10%) recoverying when topkilled by fire (Table 2). Our observations are limited in some cases and may not be adequate for precise assignment to the “sprouter” category.

The fates of the different cactus species are quite variable. Three species were abundant enough in the 10, 100 m^2 plots to assess mortality (Table 3). Mortality of *Neolloydia intertexta* was found to be 24.5%, that of *Opuntia phaeacantha* 53.3%, and 50% in *Echinocereus*

Table 1. Results of transect sampling in burned and unburned areas.

SPECIES	UNBURNED AREA no. /ha	UNBURNED AREA % coverage	BURNED AREA no. /ha	BURNED AREA % coverage
Gutierrezia spp.*	4280	4.16	60	0.12
Viguiera stenoloba Blake	1960	4.40	1660	0.48
Mimosa biuncifera Benth.	1600	15.80	1360	4.20
Dasylirion wheeleri Wats.	260	6.40	180	0.84
Echinocereus viridiflorus Engelm.	280	0.00	160	0.00
Opuntia phaeacantha Engelm.	240	0.08	140	0.04
Dalea formosa Torr.	200	0.36	180	0.00
Yucca baccata Torr.	140	0.92	100	0.96
Fallugia paradoxa (D. Don) Endl.	100	0.92	60	0.04
Yucca torreyi Shafer	100	0.32	0	0.00
Eriogonum wrightii Torr.	60	0.00	260	0.48
Agave lechuguilla Torr.	60	0.00	0	0.00
Senecio douglasii DC.	20	0.00	0	0.00
Porophyllum scoparium Gray	20	0.00	0	0.00
Ziziphus obtusifolia (T.&G.) Gray	0	0.32	80	0.00
Parthenium incanum H.B.K.	0	0.00	100	0.04
Acacia angustissima (Mill.) Kuntze	0	0.00	40	0.24
Aloysia wrightii (Gray) Heller	0	0.00	20	0.08
Brickellia californica (T.&G.) Gray	0	0.00	20	0.00
Garrya wrightii Torr.	0	0.00	20	0.00
TOTALS	9320	33.8%	4440	7.52%

*P<.01

Table 2. "Sprouters." Species when topkilled usually recover from the root system or crown.

SPECIES	N and % MORTALITY	SUBSTANTIATING REFERENCES
Atriplex canescens (Pursh) Nutt.	(10) 0%	
Baccharis brachyphylla Gray	(15) 0%	
Chilopsis linearis (Cay.) Sweet	(12) 0%	
Ephedra aspera Engelm.	(11) 0%	
Fallugia paradoxa (D. Don) Endl.	(10)10%	
Garrya wrightii Torr.	(12) 0%	Pond & Cable, 1960.
Mimosa biuncifera Benth.	(71) 4%	Kittams, 1972; Pond & Bohning, 1971; Carmichael, et al., 1978.
Parthenium incanum H.B.K.	(12)17%	
Prosopis glandulosa Torr.	(3) 0%	White, 1969; Reynolds & Bohning, 1956; Cable & Martin, 1973.
Rhus trilobata Nutt.	(9) 0%	Pond & Cable, 1960; Pase, 1971; Pond & Bohning, 1971; Kittams, 1972.
Rhus virens Gray	(9)11%	
Sapindus saponaria L.	(15) 0%	
Viguiera stenoloba Blake	(43) 0%	Kittams, 1972.
Yucca baccata (Engelm.) Trel.	(30) 0%	Pase & Lindenmuth, 1971; Kittams, 1972.
Yucca torreyi Shafer	(37)35%	
Ziziphus obtusifolia (T.&G.)Gray	(5) 0%	

viridiflorus. The walkthrough survey added Ferocactus wislizenii with 8.3% mortality, 20% for Mammillaria grahamii and 70% for Opuntia imbricata. Additional estimates were obtained for Echinocereus viridiflorus at 50% mortality and Opuntia phaeacantha at 27.5% (Table 3).

DISCUSSION

In reviewing much of the literature on fire ecology in the southwest, it became evident that numerous factors preclude the making of meaningful comparisons to findings in studies conducted elsewhere. The most relevant studies are those of Kittams (1972) and Ahlstrand (1982) on the effects of fire in Chihuahuan Desert communities in the Guadalupe Mountains. Their fire study sites, however, receive twice the rainfall of the site in the Franklin Mountains and the communities contain a number of different species and support more trees. Some additional problems that cannot adequately controlled (at least in opportunitistic studies such as this one) are: equality of fuel loads; the differential mortality of plants in different size classes; the differential mortality of plants of equal size as a function of degree of water stress at the time of the fire; determining if a plant is actually dead, especially species that can take years to die and can become dormant; sorting out the effects of disease, browsing, grazing, etc. on subsequent mortality; comparing mortalities in cases where soaking rains follow shortly after a fire as opposed to a continued lengthy dry period; genetic differences in widely separated populations of the same species; differences in substrates as they pertain to available soil water; etc. A case in point is the findings by Rogers and Steele (1980) of such limited sprouting among burned shrubs in a Sonoran Desert plant community as compared to the findings herein and those reported by Kittams (1972) and Ahlstrand (1982) of such a high degree of sprouting among burned shrubs in Chihuahuan Desert communities. In spite of the numerous potential pitfalls, some of the findings of others in studies conducted elsewhere are worthy of comments.

White (1969) reported that a high percentage of Ocotillo survived being burned by producing basal sprouts. We estimated 93% mortality among the plants burned in the Franklin Mountains fire and observed no sprouting 25 months after the fire. We have no explanation for the discrepancy in these findings. Ocotillo is not normally vulnerable to a fire as plants are most often found growing on barren outcrops and rocky slopes or scattered through the Creosotebush community, areas that seldom acquire enough fuel to support a fire.

McLaughlin and Bowers (1982) reported 59% mortality in Ferocactus wislizenii at a study site south of Florence, Arizona, and Reynolds and Bohning (1956) reported 67% mortality, a value that included those being eaten by cattle after the spines had been burned off. We report only 8.3% mortality. Some mature plants with all but the top 10% of their spines burned off and almost all of the rib tissue killed were in flower 25 months after the fire. Humphrey (1974) reported that plants one foot or more tall were rarely killed, but the plants were then susceptible to being eaten by cattle, horses, and rabbits. Plants less than one foot tall were reported to suffer 75% mortality either from the fire or subsequent grazing damage. Most of the plants we counted were larger individuals which probably

Table 3. Mortality of cacti.

SPECIES		LIVING	DEAD	% MORTALITY
I.	Counts of living and dead cacti on 10, 100 m^2 plots.			
	Echinocereus viridiflorus Englem.	7	7	50.0
	Neolloydia intertexta (Engelm.) L. Benson	37	12	24.5
	Opuntia phaeacantha Engelm.	7	8	53.3
II.	Walkthrough survey.			
	Echinocereus viridiflorus Engelm.	6	6	50.0
	Ferocactus wislizenii (Engelm.) Britt. & Rose	11	1	8.3
	Mammillaria grahamii Engelm.	4	1	20.0
	Opuntia imbricata (Haw.) DC.	3	7	70.0
	Opuntia phaeacantha Engelm.	26	9	25.7

accounts for the lower mortality rate, and the area has no grazing from livestock.

Our estimates of mortality in Opuntia phaeacantha (mostly var. major) were 53.3% on the study plots and 25.7% on the walkthrough survey. Estimates of fire–caused mortality in related species of Opuntia in the subgenus Opuntia elsewhere are 28% (Reynolds and Bohning, 1956) and 32% (Cable, 1967). Heirman and Wright (1973) reported a mortality of 68% in 0. phaeacantha after a prescribed burn on the Texas High Plains. Wright (1974) reported that fire did not kill the prickly pear and cholla directly, but rendered them vulnerable to insect attack which caused second year mortalities as high as 85%.

Our estimate of mortality in Opuntia imbricata was 70%. Mortalities among other cholla type Opuntia elsewhere are 45% and 63% (Cable, 1972), 42% and 44% Reynolds and Bohning, 1956), and 98% (McLaughlin and Bowers, 1982). Heirman and Wright (1973) reported a mortality of 45% for Opuntia imbricata after a prescribed burn on the Texas High Plains. The plants that were burned in the Franklin Mountains were all small (about 1 m tall) which may account for the high mortality rate. Some evidence indicates that burning may increase the numbers of chollas in some areas as unburned stems held above the fire can root when they eventually fall to the ground (Cable, 1967, 1972).

Kittams (1972) and Ahlstrand (1982) have reported the effects of fire on Agave lechuguilla in the Guadalupe Mountains. Kittams (1972) reported that the dead leaves cause the plant to burn hot and he states that root sprouts as deep as two inches beneath the soil are left without food reserves to produce new offsets. Both authors considered fire effective in eliminating or controlling Lechuguilla in that area. We made limited observations on several clones that burned in the Franklin Mountains and can report that widely scattered rosettes in each of the clones survived suggesting that they would not be eliminated. We believe that further observations should be made to clarify the effects of fire on this species.

Species that took a long time to show a response were Yucca torreyi (35% were found to be recovering by sprouting from below ground 25 months after the fire), Dasylirion wheeleri (the death of plants with the trunk completely burned through takes almost two years), and Ferocactus wislizenii (some badly scourched plants flowered two years after the fire; their fate was uncertain prior to those observations). Some species showing rapid response after the fire include Mimosa biuncifera, Viguiera stenoloba, Fallugia paradoxa, and most of the other shrubs listed in Table 2 plus the small cacti such as Echinocereus viridiflorus and Neolloydia intertexta, many of which had 5 cm of new growth on the top of the stems 16 months after the fire. The observation periods of 16 and 25 months after the fire may not have been adequate to resolve the true fate of Fouquieria splendens which appeared to show 93% mortality 25 months after the fire.

The study was not conducted to investigate seedling establishment, the responses of annual or herbaceous perennial vegetation to fire, or the rate of community recovery. Nevertheless, after following the responses of plants over a two year period, our impressions are in general agreement with those of Kittams (1972) and Ahlstrand (1982). Aside from the thinning of a number of slow–growing and vulnerable species such as cacti, yuccas and sotol, and the near elimination of Snakeweed, most of the shrubs will regain prefire proportions within approximately five years after the burn.

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