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EFFECTS OF WILDFIRE ON A SONORAN DESERT PLANT COMMUNITY¹

Steven P. McLaughlin and Janice E. Bowers²

Fires occur frequently in desert grassland at the eastern margin of the Sonoran Desert (Wright 1980), but fires in the desert proper are reported to be very infrequent and of low intensity (Humphrey 1974). Wildfires require both an adequate fuel load and an agent of ignition. While lightning storms are common during the summer in both desert and desert grassland, production of annual and perennial herbs in the desert is generally far too low to provide a fuel load capable of sustaining fire.

Unusually heavy precipitation during the winter of 1978–1979 did result in high production of winter annuals and several fires occurred the following spring and summer in the desert regions of Arizona. One of the largest was the Granite Burn, which was started on 29 June 1979 by a lightning strike and covered 11 500 ha south of Florence, Arizona. This paper describes the effects of the Granite Burn on the perennial vegetation.

The study area is located ≈ 20 km southeast of Florence at an elevation of 670 m. Topography is level with typical haplargid soils developed from acid igneous alluvium (Buol 1966). Vegetation is typical of the Arizona Upland subdivision of the Sonoran Desert as defined by Shreve (1964). The dominant species are bursage (*Ambrosia deltoidea*), paloverde (*Cercidium microphyllum*), and creosote bush (*Larrea tridentata*). Cacti are visually conspicuous, including saguaro (*Carnegiea gigantea*), buckhorn cholla (*Opuntia acanthocarpa*), hedgehog (*Echinocereus fasciculatus*), barrel (*Ferocactus wislizenii*), and prickly pear (*Opuntia phaeacantha*).

Methods

Field work was conducted in January 1980 and February 1981, ≈ 7 and 19 mo, respectively, after the fire. In 1980, cover and density of all living, woody plant species were recorded in 4×100 m belt transects, five transects each in burned and unburned vegetation. Locations of unburned transects were selected on the basis of proximity and apparent similarity to the burned transects. Several species in the study area were not sufficiently abundant on the transects to determine adequately that fire caused mortality. For

these species, the numbers of plants root-killed (not sprouting), shoot-killed (sprouting), and with living tops were recorded in a separate census of an adjacent tract of burned vegetation. Fifty to 200 individuals were counted for each species. In 1981, burned transects were resampled and the mortality census was repeated.

Results and Discussion

The density and cover of the common perennials on the study area are given in Table 1. The burned area represented in the transects appears to have been fairly similar to the unburned area before the fire, with the exception that creosote bush was relatively more abundant on the unburned transects.

Effects of the fire can be inferred by comparing the burned and unburned transects. Density and cover of all species on the burned area were 9% and 16%, respectively, of that on the unburned area in 1980. Density and cover in 1981 on the burned transects were only slightly higher than in 1980. These increases were the result of sprouting by bursage and creosote bush; no seedlings of woody perennials were observed on the burned transects in 1980 or 1981. The apparent decrease in density of creosote bush in 1981 is the result of sampling problems. This species vegetatively reproduces by a splitting of the root crown to form large clumps (Barbour 1969). Although we attempted to record consistently such clumps as single individuals, separate root crown sprouts within large clumps were occasionally recorded as two or more individuals in 1980.

Mortality and sprouting estimates for 10 species are given in Table 2. Only the 1981 data are presented since severity of damage among many cacti and sprouting ability of several shrub and tree species could not be determined in 1980, only 7 mo after the fire. Many plants survived by escaping the fire, i.e., small unburned patches of vegetation were found throughout the burned areas. With the exception of these patches, nearly all trees and shrubs were shoot-killed, i.e., the tops were completely burned. Sprouting of shoot-killed trees and shrubs varied from 1% for bursage to 37% for creosote bush.

Among cacti, the large-diameter species, saguaro and barrel cactus, had the lowest mortality. Many severely burned plants of both species are still standing and producing flowers and seeds. Mortality was highest among the smaller size classes of saguaros. We observed 94% mortality in saguaro plants < 1 m tall in 1980. Nearly all of these young saguaros occurred below the canopy of paloverde trees, where fuel loads and fire intensity were presumably highest. By 1981, many of the small carcasses conspicuous in 1980 could not be seen since branches and litter had accumulated

TABLE 1. Density and cover of perennial species on unburned and burned transects. Dashes indicate that no plants of that species were found with living shoots.

Species	Unburned area		Burned area			
	Density (No./ha)	Cover (%)	1980 census		1981 census	
			Density (No./ha)	Cover (%)	Density (No./ha)	Cover (%)
Trees and shrubs						
<i>Ambrosia deltoidea</i> (Torr.) Payne	6790	7.4	475*	0.4*	540*	0.7*
<i>Cercidium microphyllum</i> (Torr.) Rose & Johnst.	30	6.3	10	2.0	10	2.0
<i>Ephedra nevadensis</i> Wats.	40	0.9	—*	—*	5*	trace
<i>Hymenoclea monogyra</i> Torr. & Gray	30	0.2	15	trace	15	0.1
<i>Larrea tridentata</i> (DC.) Cov.	45	1.3	125	0.3	95	0.6
<i>Ziziphus obtusifolia</i> (Hook. ex T. & G.) Gray	5	0.1	—	—	5	trace
Cactaceae						
<i>Carnegiea gigantea</i> (Engelm.) Britt. & Rose	15	trace	5	trace	5	trace
<i>Echinocereus fasciculatus</i> (Engelm.) L. Benson	205	0.1	35*	trace	20*	trace
<i>Ferocactus wislizenii</i> (Engelm.) Britt. & Rose	20	trace	15	trace	15	trace
<i>Mammillaria</i> spp.	290	trace	5*	trace	5*	trace
<i>Opuntia acanthocarpa</i> Engelm. & Bigel.	225	0.5	5*	trace	10*	trace
<i>Opuntia fulgida</i> Engelm.	5	0.1	15	0.1	15	0.1
<i>Opuntia phaeacantha</i> Engelm.	20	trace	—	—	—	—
Other†	25	trace	—	—	10	trace
Total	7745	17.0	705*	2.8*	750*	3.5*

* Significantly different from unburned transects ($P < .05$).

† Includes *Ambrosia ambrosioides* (Cav.) Payne, *Brickellia coulteri* Gray, *Haplopappus tenuisectus* (Greene) Blake, *Lycium parishii* Gray, and *Trixis californica* Kellogg.

on the ground. A small percentage of sprouting occurred in the two caespitose cacti, hedgehog and *Mammillaria* spp.

Phillips (1962) and Humphrey (1963, 1974) postulate that fire plays an insignificant role in desert ecosystems because fuel loads are inadequate to support fire. In the Sonoran Desert, the potential fuel load consists primarily of winter annuals. Following a wet winter, production of annuals may approach $1000 \text{ kg} \cdot \text{ha}^{-1} \cdot \text{yr}^{-1}$ (Patten 1978). In comparison, maximum herbage production in desert grasslands in Arizona varies from 280 to $1350 \text{ kg} \cdot \text{ha}^{-1} \cdot \text{yr}^{-1}$ (Wright 1980).

Average winter (October through April) precipitation at Florence is 156 mm. During the 1978–1979 winter Florence received 385 mm of rain. The previous winter was also much wetter than normal, with Florence recording 300 mm of winter rainfall. These were the wettest two consecutive winters on record.

We hypothesize that two such consecutive wet winters may be required for the development of a fuel load adequate to sustain fire in the Sonoran Desert. Seed reserves in the soil probably decline following a number of dry winters. A wet winter will result in both higher production of annuals and the addition of large numbers of seeds to the soil. The combination of a second wet winter and increased seed reserves will

TABLE 2. Mortality and sprouting* of dominant species on the Granite Burn.

Species	Percent of all plants shoot-killed	Percent of shoot-killed plants sprouting	Percent mortality of all plants
Trees and shrubs			
<i>Ambrosia deltoidea</i> *	93	1	92
<i>Cercidium microphyllum</i>	83	25	63
<i>Ephedra nevadensis</i>	84	9	76
<i>Larrea tridentata</i>	97	37	61
<i>Prosopis juliflora</i>	74	32	50
Cactaceae			
<i>Carnegiea gigantea</i>			
Plants 0–40 cm tall	58	0	58
Plants 41–200 cm tall	33	0	33
Plants >200 cm tall	11	0	11
All plants	31	0	31
<i>Echinocereus fasciculatus</i>	91	3	88
<i>Ferocactus wislizenii</i>	59	0	59
<i>Mammillaria</i> spp.*	98	2	96
<i>Opuntia acanthocarpa</i> *	98	0	98

* Estimates based on transect data, as: Percent shoot-killed = $100(A-B)/A$; Percent sprouting = $100(C-B)/(A-B)$; Percent mortality = $100(A-C)/A$; where A = Number of living plants on unburned transects; B = Number of living plants on burned transects in 1980; C = Number of living plants on burned transects in 1981.

result in production of sufficient annuals to sustain fire. Unfortunately, data on production of annuals in the Sonoran Desert are inadequate to test this hypothesis.

The large reductions in cover and density and high mortality of dominant species observed on the Granite Burn are comparable to fire effects in the desert grassland. Frequent lightning storms, high air temperatures, and low relative humidity in the desert in June create favorable conditions for fire. The only remaining factor, an adequate fuel load, may be present following two consecutive unusually wet winters.

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EFFECTS OF WETTING AND DRYING CYCLES ON THE GERMINATION OF SEEDS OF *CYPERUS INFLEXUS*¹

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In the cedar glades of middle Tennessee, *Cyperus inflexus* Muhl. (Cyperaceae) is one of only three species of summer annuals which grows in the shallow soil (2–5 cm deep) zone bordering bare limestone. If soil moisture and light conditions are nonlimiting, seeds (achenes) can germinate from mid-April to mid-September; however, the peak of germination is in April. Flowering and seed-set occur in summer and early autumn. Plants from seeds that germinate in late summer have a short growing season, but they usually produce one to two spikes and several viable seeds. Seeds are dispersed from September to November and overwinter on the soil surface.

Freshly matured seeds of *C. inflexus* are innately dormant and require a moist chilling treatment (stratification) to break dormancy (Baskin and Baskin 1971a). Stratified seeds do not germinate in darkness,

and long days are required for a high percentage of germination (Baskin and Baskin 1976). The light requirement for germination is not fulfilled by exposing seeds to light during the stratification treatment (Baskin and Baskin 1971b). Seeds undergo seasonal changes in their germination responses, and they can germinate at field temperatures in spring and summer but not in autumn and winter (Baskin and Baskin 1978).

Although middle Tennessee normally receives irregular showers throughout the summer, the shallow soils in the cedar glade habitat of *C. inflexus* are subject to both short and long periods of drought (Freeman 1933). Some seeds of *C. inflexus* do not germinate until they have experienced several cycles of wetting and drying of the soil and thus they have imbibed and then been dried a number of times before soil moisture and/or other environmental factors trigger germination. Imbibition-desiccation (wetting and drying) cycles have been reported to increase germination rates in several species when seeds ultimately are placed on a continuously moist substrate (Austin et al. 1969, Hegarty 1970, Berrie and Drennan 1971, Wilson 1971, Hanson 1973, Vincent and Cavers 1978). The purpose of this investigation was to test the effect of wetting and drying cycles on the germination of *C. inflexus* seeds and to interpret the response in an ecological context.