Fire as a Means of Controlling Velvet Mesquite, Burroweed, and Cholla on Southern Arizona Ranges

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A THOROUGH study needs to be made of the possibility of controlling undesirable shrubs or trees by fire on southern Arizona ranges. Other control methods, even if effective, are generally so costly as to prevent their general adoption on low-value range. Yet, it is on these low-value ranges that control is frequently most urgently needed.

It has been known for many years that certain shrubs are readily killed by fire while others are very difficult to eradicate in this way (*1*, *6*). Many observers of range conditions in the Southwest and elsewhere have suggested the use of fire as a tool to control undesirable trees and shrubs (*1*, *3*, *6*, *7*).

In 1907, Thornber (*7*) noted that when an area supporting burroweed (*Aplopappus tenuisectus*) was burned, all of the plants were killed, even when only partly charred. Such shrubs as catclaw (*Acacia greggii*), creosote bush (*Larrea tridentata*), Mormon tea (*Ephedra trifurca*), velvet mesquite (*Prosopis velutina*), and graythorn (*Condalia lycioides*), were also killed.

Thornber, in 1910 (*8*), again reported on burning as a means of shrub control. He stated that burroweed, creosote bush, Mormon tea, and hackberry could be killed at very small expense by burning during the dry foresummer, i.e., May to June, inclusive. He noted further that charred stumps, occurring on certain areas, were an indication that fires had occurred commonly in the past and that velvet mesquite, formerly held in check by occasional fires, was at that time spreading.

In the same year Griffiths (*3*) noted that areas formerly grass covered on the Santa Rita Experimental Range, by 1910 supported an abundant growth of young velvet mesquite and other shrubs. During the seven years that he had observed the area he noted a very definite increase in both shrubs and mesquite. He says in this connection: "The probability is that neither protection nor heavy grazing has much to do with the increase of shrubs here, but that it is primarily the direct result of the prevention of fires.—The prediction is ventured that the time is coming when these foothill grassy areas, which now have only an occasional small shrub, will be as shrubby as the deserts and lower foothills below them, if not more so". He continues with the thought that although mesquite may have been spread to some extent on the Santa Rita Experimental Range by grazing animals, its increase was more probably due to grazing that removed the combustible ground cover, thus preventing fires.

Griffiths concluded that before the area was grazed by domestic stock it probably produced more grass than in 1910 and that it was formerly burned at rather frequent intervals. In his opinion this burning had little effect on the grasses but almost entirely prevented establishment of undesirable shrubs. Because of the slow growth rate of the shrubs he felt that they could be controlled by fires occurring only once in ten years. He believed also that were it not for recurrent fires the then grass-covered mesas would have been dominated by shrubs as were the more

sparsely vegetated drainage areas where fires rarely or never occurred.

In 1916, Wooton (*9*), working on the same area as Griffiths, observed that Griffiths' prediction concerning the increase of mesquite and shrubs was slowly coming true. Occasional fires, some of them hot enough to kill trees 10 to 12 feet high had been the only restricting influence on the spread of trees and shrubs.

In a later publication (*10*) Wooton observed that following the introduction of livestock, certain of the prairie regions formerly covered by grasses became brush-covered. Before these areas were grazed the grasses were frequently burned and all shrubs killed. Although grasses recovered quickly from such burning, shrubs were usually just reappearing by the time another fire occurred. Wooton observed that because of the destruction of grasses by livestock, fires became less frequent until they finally occurred only rarely or not at all. This allowed the shrubs to mature, and resulted in an alteration of the appearance of the range and in a modification of its grazing capacity.

In 1908 Cook (*2*) observed that opinion in South Texas was "definite and unanimous" that extensive regions once grass covered had been invaded by a dense growth of mesquite, prickly pear and other shrubs. That this invasion has continued and is still going on today is a matter of common knowledge among students of Texas ranges.

Cook accepts this "unanimous" opinion and attributes the absence of shrubs on the grassland to the occasional fires that swept the country; he assumes also that the invasion of shrubs was a direct result of the absence of fires.

Young, Anderwald and McCully (*11*), on the other hand, incline toward the view that the spread of mesquite in Texas may probably be attributed more to the breaking down of the original sod than to the absence of fires. They comment that repeated fires have failed to kill the buds in the "root node", and postulate that the dense sod formerly characteristic of much of the now mesquite-infested portion of Texas largely prevented germination and establishment of mesquite. This theory may be correct, although it would seem that breakdown of the sod during severe droughts would have permitted establishment of mesquite or other shrubs. However, regardless of the effect of fires on shrub invasion of Texas ranges, the conclusions reached there may not apply to other regions where other species or varieties occur.

The writer had the opportunity in the period between 1933 and 1935 to make studies and observations on two burned areas near Tucson, Arizona. These studies, although not very extensive, indicate that broadcast burning has a place, and possibly a very prominent place in southern Arizona shrub-control programs involving such plants as burroweed, velvet mesquite, and cholla.

Beach Ranch Study

The Beach Ranch is located about 25 miles southeast of Tucson on the northwestern bajada or outwash slope of the Santa Rita Mountains. This ranch is typical of large areas in southern Arizona that support such plants as burroweed, Rothrock grama (*Bouteloua rothrockii*), three-awn grasses (*Aristida spp.*), cholla (*Opuntia fulgida*), and velvet mesquite. The bajada slopes to the west with about a 3% gradient.

Mean annual rainfall, based on records taken on the Santa Rita Experimental Range, 3 miles south of the area studied, is about 12 inches. Summer temperatures (as based on the Santa Rita records) are high, varying from about 70° F. at night to 100° F. in the daytime. Winter tem-

peratures usually go a little below freezing at night and rise to 50° or 60° F. in the daytime. Humidity is low during most of the year.

The principal perennial plants on the area were burroweed, cholla, and bisnaga (*Echinocactus wislizeni*), Rothrock grama and three-awn (*Aristida ternipes*). Mesquite and palo verde (*Cercidium floridum*) were the principal trees but these occurred rather sparingly. The principal annual grasses were six-weeks grasses (*Bouteloua aristidoides* and *Aristida adscensionis*). The former of these was chiefly instrumental in carrying the fire.

A burroweed infested area containing between 300 and 400 acres was burned in June 1933. Although local spots were not touched by the fire, the grasses were sufficiently dense to give a rather uniform burn. Spread of the fire was aided by a strong southeast wind. The fire was set by Mr. Beach, owner of the ranch, to determine whether it was possible to kill burroweed by broadcast burning. The portion of the range on which the fire occurred was badly deteriorated as a result of overgrazing and invasion by burroweed and cholla.

On four separate occasions in 1935 (two years after the burn) counts were made of the number of perennial plants of the principal species that grew on representative portions of both the burned and unburned range. Each count was made on a different, representative portion of the area and included no less than 68 and no more than 214 meter-square quadrats. The results of these counts are shown in Table 1.

The total number of perennial grass plants was at all times considerably higher on the burned than on the unburned area.

TABLE 1

A comparison of perennial vegetation on burned and unburned range, Beach Ranch area

	AVERAGE NUMBER OF INDIVIDUALS PER SQUARE METER							
	Counts made March 7		Counts made April 4		Counts made May 31		Counts made June 4	
	Unburned	Burned	Unburned	Burned	Unburned	Burned	Unburned	Burned
Rothrock grama	16.00	27.00	5.40	22.30	6.25	14.67	6.18	13.74
Three-awn grasses	.18	.16	T	T	.32	.15	.59	.03
Total grasses	16.18	27.16	5.40	22.30	6.57	14.82	6.77	13.77
Burroweed seedlings	10.00	2.30	3.00	1.40	4.04	1.00	15.06	.51
Cholla	.15	.02	T	T	.18	.07	.21	.06
Total shrubs	10.15	2.32	3.00	1.40	4.22	1.07	15.27	.57

Study of individual species shows that three-awn grasses, although nowhere very abundant, were more plentiful on the unburned range. Rothrock grama, the principal grass in the region, was more abundant on the burned than on the unburned portion. There was a tendency for the total number of Rothrock grama plants on the burned range to decrease as the season advanced. This decrease may have been due to the fact that the cleared area received much heavier grazing by cattle and jackrabbits than the brushy, unburned area.

There were more burroweed seedlings and chollas on the unburned than on the burned range. In addition to the specific

counts, general notes on the area show that all the burroweeds and approximately 50 per cent of the chollas, mesquites and bisnagas were killed by the fire. No specific counts were made on these plants because interest at the time was centered primarily on burroweed.

When first visited in March there was a heavier stand of the 1934 crop of annual grasses on the burned than on the adjacent unburned area. Following the 1935 summer growing season annual grass growth was estimated to be approximately twice as heavy on the burned as on the unburned portion.

The small number of burroweed seedlings on the burned area two years after the fire is of particular importance since it indicates that reinvasion of burroweeds may be slow, even on small areas surrounded by a large number of mature, seed-producing plants.

Effect on Erosion

Paradoxical as it might at first seem, burning decreased erosion on the Beach Ranch area. Observations showed that although there was definite accelerated water erosion on the unburned range, it was comparatively light or lacking on the burned area.

The reduction in erosion following burning took place in the following manner: On the unburned range the soil directly beneath the crown of the plants was protected considerably from the direct beating effect of raindrops. As a result of this protection soil loss from beneath the plants was less than from the unprotected areas between. As burroweed crowns intercept little moisture, most of the precipitation falling on the plants reached the ground. Flowing from the mounds beneath the weeds, it concentrated in the lower, eroded areas. The resultant accelerated erosion was often sufficiently heavy to prevent establishment of grasses except in the immediate vicinity of the bushes.

Following burroweed removal the formerly protected mounds of soil were washed into the depressions until the entire surface became essentially plane. In addition, the better grass stand that developed after the fire aided in further reducing soil loss. At the time of this study, only two years after the fire, erosion appeared stabilized in spite of the cattle and jackrabbits that concentrated on the area. After the 1935 summer rains there was a rather uniform cover of annual and perennial vegetation over the entire burned area. Before burning, erosion apparently prevented establishment of a uniform stand.

Sierrita Mountain Study

An area of 35 to 40 acres in the Sierrita Mountains about 20 miles southwest of Tucson was burned in April or May, 1933. The burned area had a plant cover essentially the same as the Beach Ranch burn except that the number of shrubs was less per unit area. Topography and climate did not differ appreciably from the Beach Ranch.

On July 5 and 6, 1935, plant counts were made in the same manner as on the Beach Ranch area, and with rather similar results (Table 2). It will be noted from Table 2 that the total number of grasses was greater on the burned than on the unburned area. Shrubs were more abundant on the unburned portions. Although there was no black grama, bush muhly, cottongrass, or feathergrass on the burned area, there were too few of these species on the unburned area to permit drawing very definite conclusions. The somewhat more abundant Rothrock grama and three-awn grasses were more plentiful on the burned portion. Tanglehead, on the

other hand, was more abundant on the unburned area.

For every 71 burroweed plants on the unburned area there was only one on the burned. The trees and larger shrubs were too large to lend themselves well to meter-square quadrat counts and an estimate was made of the mortality of these. An estimated 75 per cent each of chollas, mesquites, and bisnagas was killed by the fire. There was also a 25 per cent mortality of yuccas (*Yucca elata*) and 90 per cent of paloverdes. Wright baccharis (*Baccharis wrightii*) was a little more abundant on burned than unburned range. The principal value of this observation lies in the fact that this small half shrub, which is highly palatable, was not killed by the fire.

TABLE 2

A comparison of perennial vegetation on burned and unburned range, Sierrita Mountain area

SPECIES	NUMBER OF INDIVIDUALS PER SQUARE METER	
	Burned	Unburned
Black grama	.00	.31
Bush muhly	.00	.09
Cottongrass	.00	.02
Feathergrass	.00	.04
Rothrock grama	.20	.02
Tanglehead	.05	.09
Three-awn grasses	1.59	.90
Total grasses	1.84	1.47
Burroweed (mature)	.01	.71
Burroweed (seedling)	.25	5.16
Cholla	.01	.02
Snakeweed	.13	.66
Wright baccharis	.05	.00
Total shrubs	.45	6.55

As on the Beach Ranch area, there was less erosion on the burned than on the unburned area.

Shrub Reinvasion 15 Years After the Burns

The writer did not have an opportunity to revisit the areas until 1948, 15 years after they burned. Small as they were, and surrounded on all sides by seed-producing shrubs, there was little expectation that they would still retain their individuality.

On the Beach Ranch the examination showed an apparently complete reinvasion by burroweed. Chollas also were about as plentiful as on the unburned range though the bulk of the plants were small. Mesquite was considerably more abundant where the fire had not occurred.

On the Sierrita Mountain area there had been little reinvasion by any shrubs. Burroweeds marked the old fire line almost as sharply as they did in 1935. They were still abundant where the fire did not run but were almost absent on the old burn. Similarly, there had been no appreciable reinvasion by mesquite, paloverde or other shrubs. The dead trees and shrubs that were present in 1935 were now gone, the victims of cattle rubbing, termites and decay. As a result the old burn was in rather marked contrast to the surrounding brushy range (Figs. 1, 2).

Why the difference in rate of reinvasion to shrubs on the two sites? A part of the answer probably lies in the size and shape of the two, a part in surrounding vegetation. The Beach Ranch burn was long and narrow, ranging from a few feet in places to a hundred or so in others. Chollas grew abundantly on all sides. Joints from these were doubtless carried in and dropped by both cattle and rodents, and it was almost inevitable that a large number should take root.

The Sierrita burn, in contrast, while oblong was much more regular in outline and considerably wider in relation to

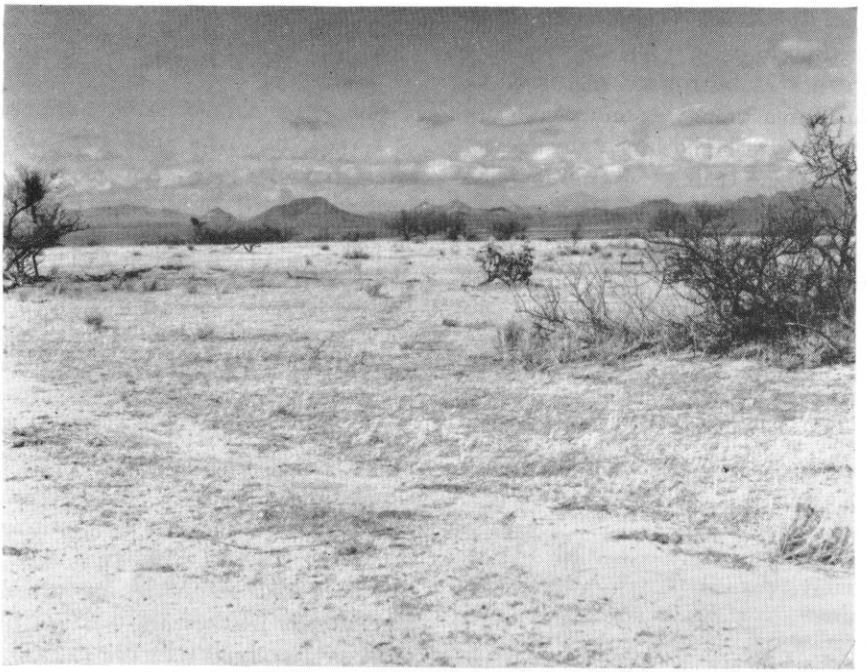

FIG. 1. Sierrita Mountain burn—15 years after burning. Note relative absence of shrubs.

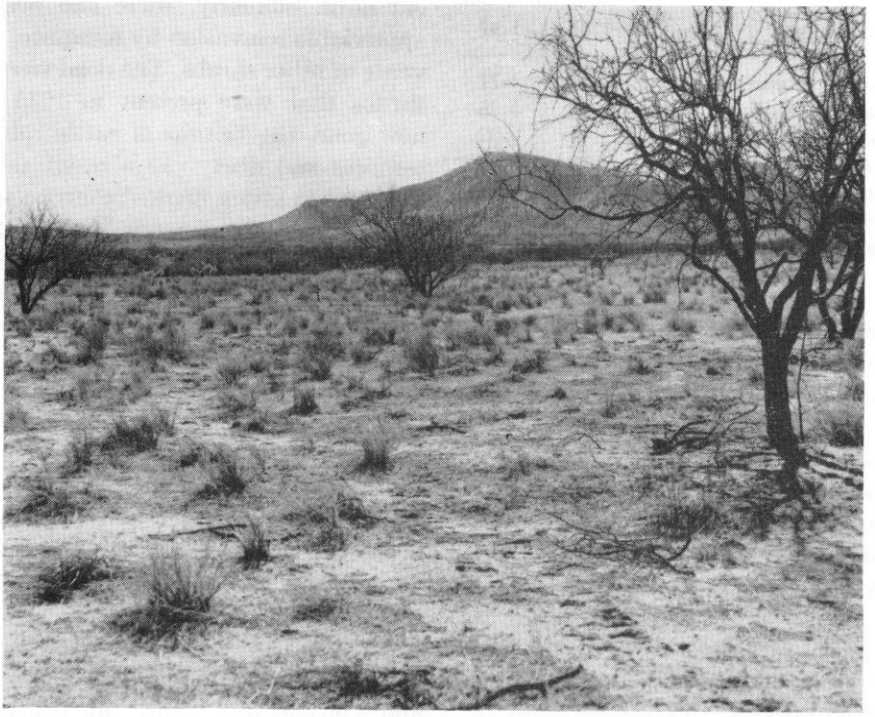

FIG. 2. Sierrita Mountain bajada adjacent to burn. Camera in same location as for Figure 1 but facing in opposite direction. Note relative abundance of shrubs.

length. It was not surrounded by a dense stand of cholla as was the Beach Ranch burn. These facts help to explain the difference in cholla reinvasion. They do not necessarily throw light on the failure of burroweed to reinvade. Regardless of the reason, however, the fact remains that this reinfestation had not occurred even after 15 years. This is the more remarkable in view of the fact that burroweed first blossoms at an age of 18 to 24 months, that the plant is a prolific seeder, and that the seeds are wind borne.

Griffiths' assumption that a fire no oftener than once in 10 years would keep burroweed and other shrubs in check seems to be borne out by the Sierrita burn. The Beach Ranch burn, in spite of its small size, also seems to bear this out with reference to the longer-lived woody species such as mesquite and paloverde.

Discussion and Conclusion

Many desert shrubs growing in southern Arizona can be rather effectively controlled by broadcast burning. Control is more nearly complete on burroweed than on the other species observed, although even on velvet mesquite trees 5 to 10 feet in height, a rather effective kill has been observed. These general conclusions were reached as early as 1910 by workers of the Bureau of Plant Industry and the University of Arizona. The conclusions reached by those early workers have been corroborated by an analysis of the effect of two burns that occurred in 1933.

In the case of burroweed, there is no doubt that burning during the dry season just preceding the summer rains may be almost 100 per cent effective. The effect of running ground fires on other common shrubby species, however, needs additional thorough study. Control of shrubs by fires is often difficult because the ground cover is too sparse to carry a fire. This difficulty can be overcome in part by excluding livestock from the area to be burned for a winter or a winter and summer season preceding burning.

When chopped or otherwise cut down at or above ground level velvet mesquite almost invariably stump sprouts and eventually develops another tree. Why many individuals of the species behave differently after burning is not known. An explanation is suggested here that may account for this seeming inconsistency.

Ground fires in velvet mesquite country are rarely hot enough to burn into the xylem of such large shrubs or trees as mesquite. They may, however, kill the cambium and all tissues outside the cambium. In effect, therefore, these trees have been girdled, thus depriving the roots of carbohydrates though not preventing translocation of minerals, carbohydrates and water from the roots into the stems. Girdling is known to be an effective method of killing many hardwood trees that normally stump sprout vigorously if cut down. The lethal effect of burning on velvet mesquite may be due to the same physiological principle.

Although the total number of grass plants, regardless of species, was greater after burning on both areas studied, the evidence as to the effect of fire on the various grasses is rather inconclusive. Both burned areas were small and as a result pressure from rabbits and domestic livestock was considerably heavier than on the adjacent range. No counts of either of these animals were made. Both were observed, however, to show a marked preference for the relatively open, burned areas. As a consequence, the burns were subjected to rather heavy overgrazing.

Although the Beach Ranch and Sierrita Mountain areas were studied primarily to obtain information on burroweed and forage species, the observations made on trees and other shrubs are also of value. While investigations to date are

indicative rather than conclusive, they do suggest a relatively cheap and effective method of keeping these plants in check where ground cover is adequate to carry a fire.

LITERATURE CITED

1. CLEMENTS, F. E. Plant Succession and Indicators. The H. H. Wilson Co., New York, 453 pp. 1928.
2. COOK, O. F. Change of Vegetation on the South Texas Prairies. Bur. Pl. Ind. Cir. 14, 7 pp. 1908.
3. GRIFFITHS, DAVID. A Protected Stock Range in Arizona. U. S. Dept. Agric. Bur. Plant Indus. Bul. No. 177, 28 pp. 1910.
4. HANSON, HERBERT C. Revegetation of Waste Range Land. Colorado Exp. Sta. Bul. 332: 1–9. 1932.
5. PICKFORD, G. D. The Influence of Continued Heavy Grazing, and of Promiscuous Burning on Fall-Spring Ranges in Utah. Ecology 13: 159–171. 1932.
6. STODDART, L. A. AND A. D. SMITH. Range Management. McGraw-Hill Book Co. Inc., New York, 547 pp. 1943.
7. THORNBER, J. J. 18th Annual Report. Ariz. Expt. Sta. 228 pp. 1907.
8. THORNBER, J. J. Grazing Ranges of Arizona. Univ. of Ariz. Agr. Expt. Sta. Bul. 65, pp. 245–360. 1910.
9. WOOTON, E. O. Carrying Capacity of Grazing Ranges in Southern Arizona. U.S.D.A. Bul. No. 367, 40 pp. 1916.
10. WOOTON, E. O. The Relation of Land Tenure to the Use of the Arid Grazing Lands of the Southwestern States. U.S.D.A. Bul. No. 1001, 72 pp. 1922.
11. YOUNG, V. A., F. R. ANDERWALD, AND W. G. MCCULLY. Brush Problems on Texas Ranges. Texas Agr. Exp. Sta. Misc. Pub. 21, 19 pp. 1948.