Shrub Control and Reseeding Effects on the Oak Chaparral of Arizona[1]

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Highlight

Burning-reseeding and burning-reseeding-herbicide treatments near Dewey, Arizona significantly reduced oak chaparral shrub cover for over 7 years and resulted in significantly greater grass production for 5 to 7 years. Grass production was up to 770 lb/acre greater on treated areas than on untreated, depending on the type of treatment, number of years following treatment, and various environmental factors.

The greater part of the six million acres of oak chaparral in Arizona lies in the foothill areas of the central part of the state (Nichol, 1952). Most of this area is used for cattle grazing in spring-fall or yearlong. However, in some areas the brush is so thick that it limits grazing by cattle. Also, the numerous evergreen shrubs that dominate the rolling to steep slopes of the chaparral compete so severely with the native and reseeded perennial grasses that 5 to 15 acres may be required to support a cow for one month (Rich and Reynolds, 1963).

A major objective of range research in the chaparral type is to study methods of converting undesirable brush to grass. An important secondary objective is to study the cost, efficiency, and longevity of these treatments since these characteristics determine the success of brush-to-grass conversion operations from a grazing management standpoint. Two methods of shrub control which appear suited to widespread use in the chaparral are burning and herbicide treatment, singly or in combination.

The primary purpose of this study was to evaluate longevity of brush control effects following burning-reseeding and burning-reseeding-herbicide treatments. This was done by comparing vegetative crown cover on the treated areas to adjacent unburned areas. Another objective was to evaluate the relationships between these treatment effects on the crown cover of the dominant shrub, turbinella or shrub liveoak *(Quercus turbinella)* and the production of perennial grass. Scientific terminology follows Kearney and Peebles (1964).

Review of Literature

The use of fire as a means of reducing shrub cover in the chaparral type and increasing understory grasses and forbs has received considerable attention in recent years. The reduction of shrub canopy in the chaparral due to burning is generally followed by rapid regrowth of the shrubby species due to sprouting and enhanced germination and growth of shrub seedlings (Sampson, 1944). Furthermore, growth and production of desirable plants is inversely related to the reduction of shrub canopy (Glendening, 1959; Schmutz and Whitham, 1962). The actual composition and recovery of the permanent cover ultimately depends on pre-fire vegetative composition, such as the proportion of major dominants which are sprouters, and site characteristics such as exposure, soils, slope, elevation, and moisture conditions (Horton and Kraebel, 1955).

Application of herbicides to fire sprouts and seedlings of chaparral brush species appears to be the best overall method of controlling unwanted shrub growth. In California, Leonard and Carlson (1957) found that 2,4-D was effective on fire sprouts of chamise *(Adenostema fasciculatum)* during the most susceptible period, but during less susceptible periods a mixture of 2,4-D and 2,4,5-T was most effective. In Arizona, Lillie (1959) found that 2,4-D and 2,4,5-T were the most effective herbicides tried on fire sprouts of turbinella oak.

Further studies on turbinella oak by Schmutz and Whitham (1962) showed that there was no consistent difference between treatments of silvex [2 (2,4,5-trichlorophenoxy) propionic acid] and 2,4,5-T and that repeated light annual applications were generally more effective than single heavy applications.

Experimental Procedure

Study Area.—The study area was northeast of Dewey, Arizona on the Henderson Ranch and Prescott National Forest. Study sites were within a 5 mile radius of each other in the lower half of T14N and the upper half of T13N R1½E and R2E Gila and Salt River B & M. Elevations ranged from 4900 to 5350 ft.

The dominant shrubby vegetation on all of the sites was turbinella oak. Other shrubby species included pointleaf manzanita *(Arctostaphylos pungens)*, wait-a-minute bush *(Mimosa biuncifera)*, skunkbush sumac *(Rhus trilobata)*, desert ceanothus *(Ceanothus greggii)*, Wright mountainmahogany *(Cercocarpus breviflorus)*, and hollyleaf buckthorn *(Rhamnus crocea)*. The most abundant halfshrub was broom snakeweed *(Gutierrezia sarothrae)*. Other halfshrubs were shrubby buckwheat *(Eriogonum* spp.) and toadflax penstemon *(Penstemon linarioides)*. Dominant grasses were the seeded lovegrasses—Lehmann lovegrass *(Eragrostis lehmanniana)* and weeping lovegrass *(E. curvula)*. Native grasses were scarce, the most abundant being sideoats grama *(Boute-*

[1]*Contribution from the Department of Watershed Management, Arizona Agricultural Experiment Station, University of Arizona, projects Hatch 285 and 292. Journal Article No. 1021. Appreciation is expressed to the U. S. Forest Service and the Henderson Ranch for their cooperation in this study.*

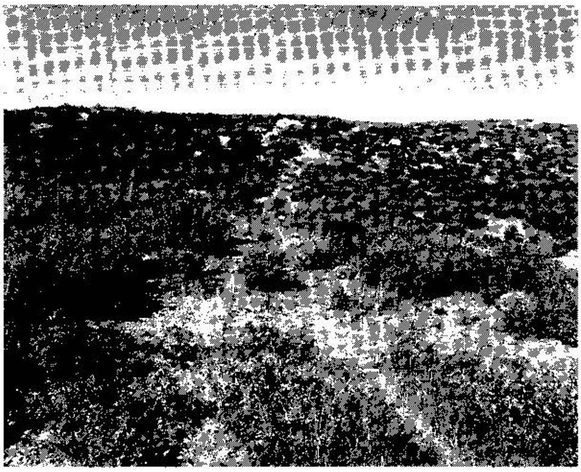

FIG. 1. Typical unburned (left) and burned-reseeded (right) areas on 1958 site. Note distinct reduction of oak and enhanced grass production on burned-reseeded area. Photograph September 1963.

FIG. 2. Burned-reseeded-herbicide-treated area on 1958 site showing production of Lehmann lovegrass. Note damaged clumps of turbinella oak in foreground and left center. Photograph September 1963.

loua curtipendula) and threeawn *(Aristida* spp.). Purslane *(Portulaca* spp.) was the dominant forb on all study sites.

A soil survey by G. E. Wendt, U.S. Soil Conservation Service, Prescott, Arizona, 1960, showed that the soils are predominantly of the Gaddes and Cordes series. The Gaddes series are residual granitic soils 4 to 18 inches in depth. The Cordes series are deep soils formed from alluvium of mixed origin—granite, basalt, schist, and limestone.

Climate of the study area was classified as semi-arid or low-altitude steppe.[2] Since no precipitation station is located on the study area, data from Poland Junction, a station 11 miles southeast with similar elevation and exposure was used.[3] Using this data and the Green (1959) altitude-precipitation curve, annual precipitation at the study sites was estimated to range from 14.5 to 15.7 inches, almost equally distributed between winter and summer months, and approximately 1 inch above normal in 1963.

Temperature data from Prescott (Sellers, 1960) indicates that diurnal temperatures range from the upper 40's or lower 50's to the mid- or upper-80's in the summer and from the mid-50's to below freezing in winter. Extremely cold temperatures for extended periods of time are rare and the average frost-free period is 140 days.

Methods.—The study was conducted on portions of 4 areas that were burned in 1955, 1956, 1958, and 1959. These areas totaled approximately 600, 14,000, 960, and 640 acres, respectively. Following burning, all areas were reseeded to Lehmann lovegrass, weeping lovegrass, or a mixture of the two.

Using the paired plot technique, comparable unburned areas were selected for study adjacent to each burned area (Fig. 1) and similar herbicide-treated areas were located within the 1956 and 1958 burned areas (Fig. 2). A burned-reseeded area with an adjacent unburned area or a burned-reseeded area with included herbicide-treated area and adjacent unburned area is referred to as a "site." Sites were designated by the year in which the area was burned.

Herbicide-treated areas selected for this study were those that received three consecutive yearly applications of the low volatile propyleneglycolbutylether (PGBE) ester of silvex following burning. The herbicide-treated area on the 1956 site was a 126x690-foot plot. It was treated in May 1957, 1958 and 1959 with 1.67 lb/acre/year acid equivalent of silvex applied by airplane. The 1958 site was a 100x436-foot plot treated in 1959, 1960, and 1961 with 3 lb/acre/year applied with a tractor-mounted spray boom.

Crown cover of plants was estimated on all areas during late August and early September, 1963. The sample on each area consisted of twenty 2x43.56-foot belt transects established by grid from a randomly located starting point. Crown cover estimates were made along each side of a 43.56-foot tape using a 1-ft^2 frame, divided into one 0.5- and five 0.1-ft^2 sections.

In addition to crown cover, perennial grass production estimates were made on all sampled areas of the 1956 and 1958 sites. Perennial grasses were clipped at the ground line on 10 of the 20 transects on each area of the 1956 site. On the 1958 site, 20 transects on the burned-reseeded, 14 on the burned-reseeded-herbicide-treated, and 10 on the unburned were clipped. Grasses were oven-dried at 95 C for 48 hours and weighed.

Vegetation was grouped into 5 classes for convenience of analysis—turbinella oak, other shrubs, half-shrubs, grasses, and forbs. Crown cover estimates were converted to percent and grass production data to pounds per acre. Significance of crown cover and grass production data was evaluated by analysis of

[2] *Personal communication from Mr. C. H. Reitan, Institute of Atmospheric Physics, University of Arizona, Tucson. 1963.*

[3] *Personal communication from Mr. Paul C. Kangieser and Mr. Gerald Barger, U. S. Weather Bureau, Phoenix, Arizona and Asheville, North Carolina, respectively, 1964.*

variance and Duncan multiple-range tests (Steel and Torrie, 1960). Analyses were run by the Numerical Analysis Laboratory at the University of Arizona, Tucson.

Results

Since pretreatment data was not available, results were based on the assumption that on each site at the time of treatment, areas to be treated were the same as the untreated areas.

Crown Cover.—In general, the average crown cover of turbinella oak, other shrubs, and halfshrubs was less on the treated areas than that on the unburned areas (Table 1). In contrast, the average crown cover of grasses and forbs was greater on the treated than on the unburned areas.

The crown cover of turbinella oak, the dominating shrub, varied from an average of 24% on the unburned to 19 and 3% on the burned-reseeded and burned-reseeded-herbicide treated areas, respectively. On the individual sites, differences in oak cover were significant between all treatments and all sites.

Crown cover of other shrubs was also generally reduced by treatment. On the average, it was 10% on the unburned, 5% on the burned-reseeded and 1% on the burned-reseeded-herbicide treated. On individual sites differences between unburned and burned-reseeded treatments were significant on the 1955 and 1958 sites, but not significant on the other two sites. Also, other shrubs were significantly fewer on the herbicide-treated areas than on either the burned-reseeded or unburned.

Halfshrub crown cover was variable. It averaged about 5% on the unburned and burned-reseeded-herbicide treated areas and 3% on the burned-reseeded. On individual sites, halfshrubs were significantly less on the burned-reseeded than on the unburned area of the 1959 site, but not significant on the other 3 sites. On the 1956 site, they were significantly greater on the burned-reseeded-herbicide treated area than on the burned-reseeded or unburned, but no differences were observed on the 1958 site.

Average crown cover of perennial grasses varied from less than 1% on the unburned to 4 and 24% on the burned-reseeded and burned-reseeded-herbicide treated areas, respectively. The difference between the burned-reseeded and unburned areas was significant on the 1958 site, but not significant on the other 3 sites. However, grass cover was significantly greater on the burned-reseeded-herbicide treated areas than on the burned-reseeded or unburned areas at both the 1956 and 1958 sites.

Although crown cover differences of forbs were not as great as for other classes of plants, average crown cover on the treated areas was nearly twice that on the unburned. They varied from 4% on the unburned to 7 and 8% on the burned-reseeded and burned-reseeded-herbicide treated areas, respectively. On individual sites forb cover was significantly greater on the burned-reseeded than on the unburned at the 1959 site, but not significant at the other 3 sites. On the 1956 site, forb cover was significantly greater on the burned-reseeded-herbicide treated area than on the burned-reseeded or unburned, but there were no significant differences between the 3 areas on the 1958 site.

As a result of these counteracting treatment effects between classes of plants, overall differences in the average total crown cover due to treatments were not large, varying from 45% on the unburned to 37 and 41% on the burned-reseeded and burned-reseeded-herbicide-treated areas, respectively. However, statistically, the difference between overall unburned and burned-reseeded treatments was significant.

Table 1. Effects of burning-reseeding and burning-reseeding-herbicide treatments on 5 classes of chaparral vegetation near Dewey, Arizona. Percent crown cover measurements were made in 1963 on sites burned in 1955, 1956, 1958 and 1959.

Classes of Vegetation	Crown cover percent by sites and treatments												
	1955 Site		1956 Site			1958 Site			1959 Site		Average—All Sites		
	N[1]	B-R[2]	N	B-R	B-R-H[3]	N	B-R	B-R-H	N	B-R	N	B-R	B-R-H
Turbinella oak	21.8	16.8	29.6	25.5	3.8	27.2	19.8	2.1	18.4	13.8	24.2	19.0	3.0
Other shrubs	14.4	6.6	7.6	4.8	0.5	9.2	3.2	1.3	9.1	5.4	10.1	5.0	0.9
Halfshrubs	4.7	3.8	6.7	4.2	9.4	2.5	0.2	0.2	8.2	2.9	5.5	2.7	4.8
Grasses	0.1	0.1	0.3	0.2	9.1	1.9	10.5	38.7	0.0	3.3	0.6	3.5	23.9
Forbs	3.8	6.2	7.6	8.2	13.6	2.8	4.4	2.6	2.6	10.2	4.2	7.2	8.1
Total	44.8	33.5	51.8	42.9	36.4	43.6	38.1	44.9	38.3	35.6	44.6	37.4	40.7

[1] N = Native unburned
[2] B-R = Burned-reseeded
[3] B-R-H = Burned-reseeded-herbicide treated

As with overall treatment effects, there were counteracting differences in the crown cover of the various classes of plants on an individual site basis. These changes resulted in no significant differences in total crown cover between treatments except on the 1956 site. On this site, the total cover on the burned - reseeded - herbicide - treated area was significantly less than that on the unburned, but the total cover on the burned-reseeded area did not differ significantly from that on the unburned or burned-reseeded-herbicide treated areas.

The difference in crown cover among classes of plants was highly significant on both an individual and all-sites basis. This verifies the obvious conclusion that some plants such as turbinella oak are able to attain a greater degree of dominance than others.

Also, the analysis of variance for the interaction of classes-of-plants by treatments was highly significant for both the individual sites and all-sites analysis. This indicates a high degree of variability between classes of plants in their response to burning and herbicide treatments. For instance, cover of turbinella oak was less on burned-reseeded and burned-reseeded-herbicide-treated areas than untreated areas, while crown cover of grasses was just the opposite.

The analysis of variance for all sites showed that both the classes-of-plants by years and the classes-of-plants by treatments by years interactions were significant. This shows that although a general trend was observed for the response of each class of plant to burning, the degree of response varied between sites. This is probably due to the fact that the sites were not all burned in the same year and that fires varied in intensity. Differences may also have resulted from distinct intersite variability of environmental conditions.

Grass Production.—Results of clipping studies on the 1956 and 1958 sites showed that on the treated areas where the cover of the dominant turbinella oak was less than on the untreated, the production of perennial grasses was generally greater (Fig. 3).

On the burned-reseeded area of the 1956 site, turbinella oak cover was 25% as compared to 30% on the unburned. There was no significant difference in grass production. However, on the burned - reseeded - herbicide treated area where turbinella oak cover was 4%, perennial grass production was significantly greater, 280 lb/acre as compared to 3 lb on the untreated.

On the 1958 site, where turbinella oak crown cover on the burned-reseeded was 20% as compared to 27% on the un-

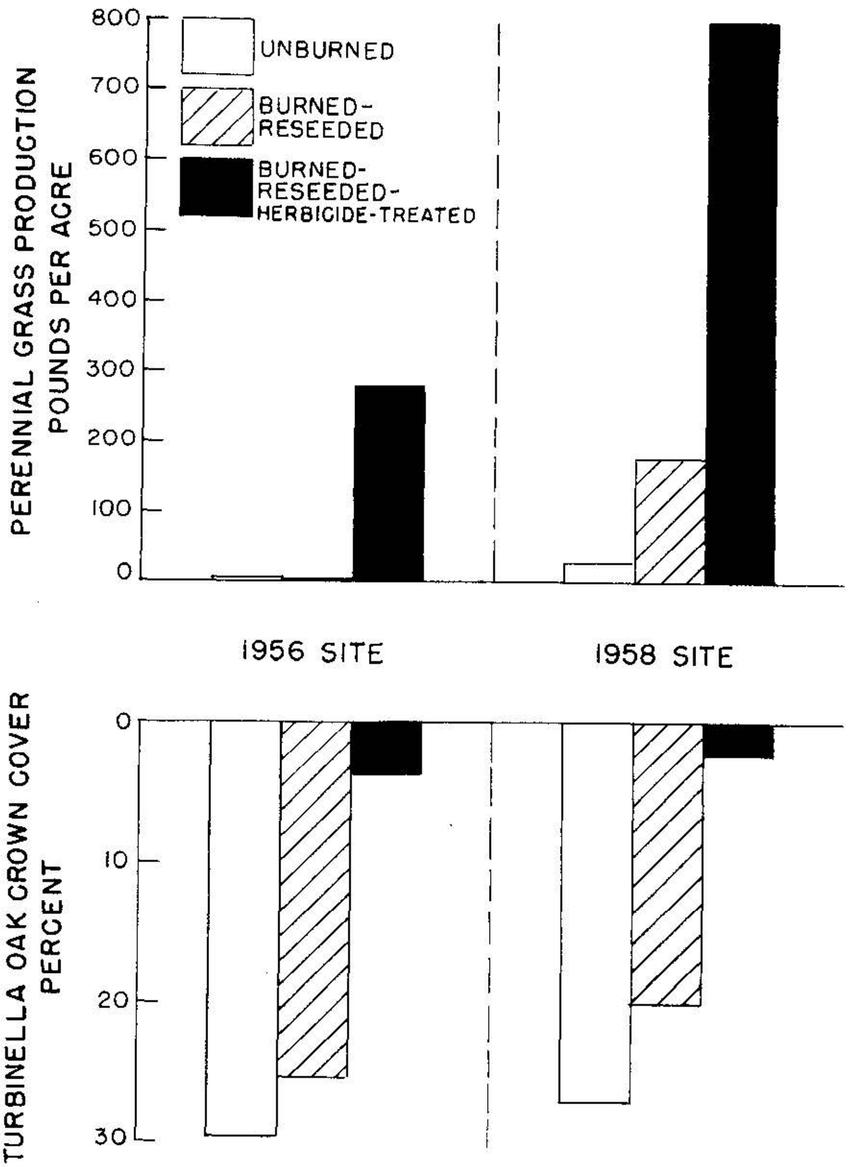

FIG. 3. The relationship between turbinella oak crown cover and perennial grass production on the burned-reseeded, burned-reseeded-herbicide-treated, and unburned areas of the 1956 and 1958 sites.

burned, perennial grass production on the burned-reseeded was 6 times greater, 179 lb/acre as compared to 31 on the unburned area. On the burned-reseeded-herbicide treated area where crown cover of turbinella oak was 2%, perennial grass production was 803 lb/acre or 26 times greater than on the unburned. Similarly, the grass production on the burned-reseeded-herbicide treated was 4 times greater than on the burned-reseeded area.

An analysis of the correlation between grass production and oak crown cover did not show a distinct linear relationship. However, the results did show that the herbicide treatments maintained significantly greater grass production for more than 5 to 7 years.

Discussion and Conclusions

Results of this study indicate that areas in the turbinella oak-dominated chaparral of Arizona treated by burning and reseeding will be revegetated by shrubs within 4 to 6 years to the point that native and reseeded perennial grasses are crowded out. The varied response of each class of vegetation between sites (or years of treatment) implies that the relative revegetation rate probably depends on some factor or combination of factors in the treatment or environment such as intensity of fire, species and stand of grass, grazing intensity, climate, soils, aspect, and elevation. For example, an area burned and reseeded 4 years previously showed approximately the same degree of turbinella oak crown cover recovery (75%) as an area burned and reseeded 8 years before (77%). Also, since the brush had not regained complete pre-fire density on any site (Table 1), this study indicates that more than 8 years is required for complete recovery of the oak.

On the 1956 and 1958 burned-reseeded-herbicide-treated areas, crown cover of turbinella oak and other shrubs was significantly less than on adjacent unburned areas, indicating that three consecutive applications of silvex may provide control of shrubs and maintain greater grass production for longer than 5 to 7 years after the treatment.

The lesser cover of halfshrubs on the burned-reseeded areas as compared to untreated on all sites can probably be explained by the detrimental effect of fire on the halfshrubs and their seed source. However, the differential effect of the herbicide on the halfshrubs is difficult to explain. Factors which may have resulted in more halfshrubs on the herbicide treated area at the 1956 site and not at the 1958 site, may include differences in competition by weeping vs. Lehmann lovegrass, respectively; differences in grass form or density, 9 vs. 39%; differential effects of herbicidal rates, 1.67 vs. 3 pounds; seasonal differences in moisture and temperature; differences in soils, elevation, or exposure; and/or differences in grazing pressure on both halfshrubs and grasses.

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