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RESPONSE OF UNDERSTORY VEGETATION TO PRESCRIBED BURNING IN YELLOW PINE FORESTS OF CUYAMACA RANCHO STATE PARK, CALIFORNIA

Earl W. Lathrop and Bradford D. Martin

Introduction

"Fire is a good servant, but a poor master."
—Finnish proverb

Today fire is increasingly recognized as a part of the world's ecology. Fire is a physical factor whose periodic occurrence has been of great importance to man and nature over the centuries (Mutch 1970). Whole biomes, such as those of the grasslands and California chaparrals, have become adapted to periodic fires producing "fire climaxes" (Hanes 1971). In the distant past, fires occurred naturally in environments without man's interference. Indians and pioneers indicated that natural fires swept over much of the grasslands, chaparrals, and forests of North America (Weaver 1951; Box et al. 1967). When a fire started, it would run its course until it went out naturally.

Indians used frequent and widespread fires knowledgeably to extend the range of those plants on which they depended. Indians set burns in order to make hunting easier, to enhance feeding grounds for game, to facilitate the gathering of seeds, bulbs and berries, and to increase the production of useful plants (Cooper 1961). Many early explorers who observed Indian burning practices noticed how usefully and discretely they used fire. With fire, the Indians kept their forests open, pure, and fruitful (Miller 1887).

Early settlers also used fire for mining, lumbering, and grazing. Miners used fires to remove slash after cutting trees for mining props and fuel, and to clear the landscape to facilitate their activities. Today some of the best pine stands in California occur in these areas where miners did heavy burning (Biswell 1974). However, most of the burning done by lumbermen was not beneficial, and many of the heavily cut and burned areas have turned to chaparral (Show and Kotok 1924).

The destructive fires of the early settlers caused much concern by some thoughtful observers. As a part of the conservation movement, legislation was passed in 1872 to prevent the setting of fires. In 1905 the U.S. Forest Service adopted a firm policy of virtual fire exclusion on its lands, with the California Division of Forestry following in 1924 with a policy which covered private lands also (Clar 1959; Kilgore and Briggs 1972). Today, modern man has been stopping fire with equipment and machinery, and has suppressed the amount of burning in the environment. But even with the most modern aerial and ground equipment and the best-trained firemen, wildfires cannot be totally eliminated. With man's earnest interference, fires do occur at less frequent intervals. However, with these longer time spans between fire, fuels build up to enormous levels and cause fires to become uncontrollable and widespread (Dodge 1972; Talley and Griffin 1980). The costs of these wildfires in terms of life, natural resources, and money are very high (Wilson and Dell 1971).

Investigators in the past few years have realized that the U.S. Forest Service policy of fire exclusion has not been favorable for our environment either. In order to reduce high fuel levels and reintroduce fire into the fire-suppressed areas, government agencies and researchers have been conducting prescribed burns (Weaver 1957; Biswell 1959, 1960). Prescription burns are for the most part light intensity fires that are initiated when fuel moistures, humidity, and wind velocity make the fire controllable. Studies have shown that burning involves a major disturbance to vegetation initially, but tends to generate new and fresh plant growth.

Various studies have revealed that shrubs have invaded some areas that they did not previously occupy as a result of fire exclusion. When periodic prescribed burns are conducted these shrubs are eliminated and checked from these areas upon which they have encroached (Grelen 1978). Vulnerability of shrubs to fire is due to the thin bark surrounding the trunk. Trees, however, are not affected by light-intensity burning because of their thicker bark. In the southeastern coastal plain, periodic prescribed burns have been found to maintain pine forests in more desirable stages of succession. Wood quality of these pine trees is also improved as a result of fire (Odum 1969).

Controlled burns may also enhance communities for wildlife by removing dense vegetation that physically impairs habitation by animals (Vogl 1973). Fire removes dead plant material, in turn stimulating fresh, palatable growth upon which animals can browse or in which they can hide (Vogl and Beck 1970; Kessler and Dodd 1978).

Although research has shown periodic prescribed burning to be beneficial in some locations, each area must be evaluated separately to understand the results of such a program (Biswell 1974).

In April 1978, Cuyamaca Rancho State Park started a prescribed burning program in order to reintroduce fire in the park communities. Burning was conducted in the yellow pine forests of this park, which is located in the Cuyamaca Mountains of eastern San Diego County, California. This location offered an excellent opportunity to study a prescribed burning program. Thus the California State Forest Service conducted light-intensity prescription burns in three jeffrey pine-black oak (*Pinus jeffreyi-Quercus kelloggii*) woodland sites in the West Mesa and East Mesa areas (Fig. 1). These were: 1) the Paso Picacho burn, initiated April 24, 1978, with an air temperature

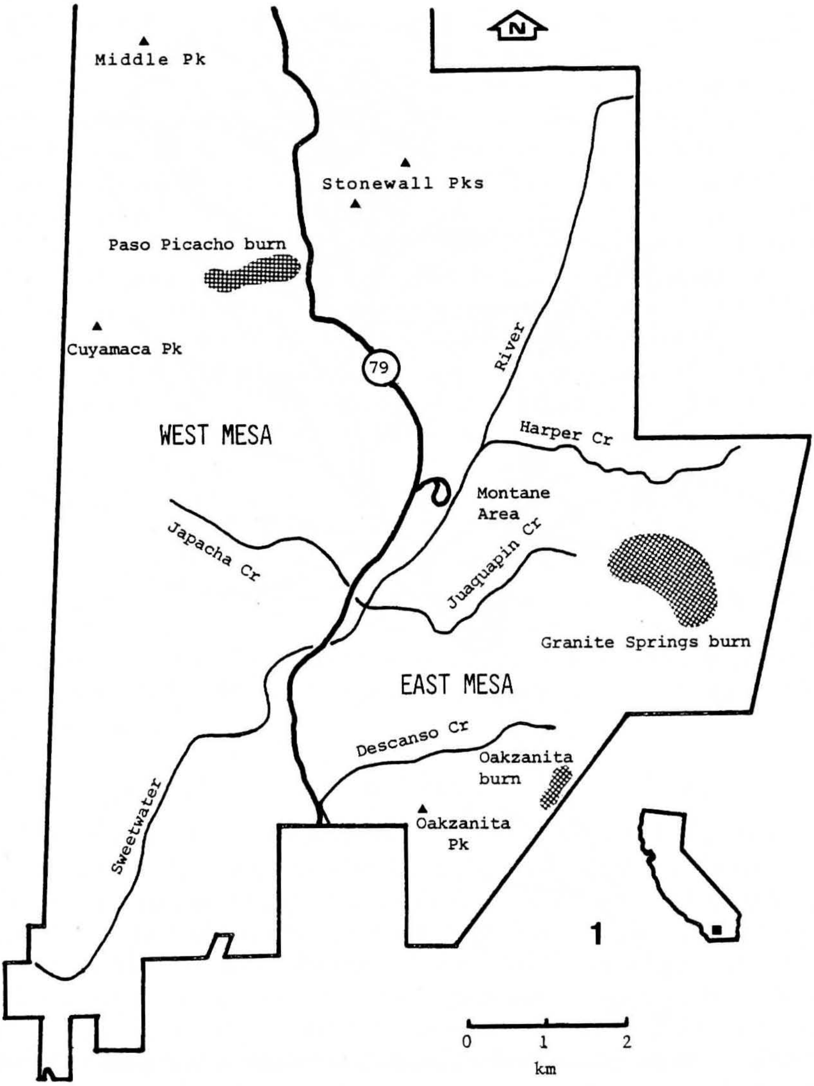

Fig. 1. Map of Cuyamaca Rancho State Park showing the location of the Paso Picacho (elev. 1493 m), Granite Springs (elev. 1515 m), and Oakzanita (elev. 1478 m) prescription burn sites. After Martin (1981).

of 18 C, a relative humidity of 30%, a fuel moisture of 9–12%, and a wind velocity of <16 km/hr. This burn covered approximately 6 hectares of a portion of the forest which had a light to dense understory of chaparral; 2) the Granite Springs burn, conducted December 11–15, 1978, covered ap-

Fig. 2. Branch of *Arctostaphylos pungens*, drawn natural size by Mark Ford.

proximately 85 hectares of forest with mostly grass understory. Prescription was an air temperature of 13 C, a relative humidity of 17–37%, a fuel moisture of 7.5%, and a wind velocity of 4–9.6 km/hr; 3) the Oakzanita burn, 1.2 hectares in size, December 3, 1979, in dense chaparral understory of the forest. Prescription was an air temperature of 18–24 C, relative humidity of 18–25%, fuel moisture of 6–8%, and a wind velocity of $<$6.4 km/hr. Postfire analyses were conducted in the field May through July, 1980, approximately 2 yr, 1½ yr, and 6 mo following the prescribed burns for the Paso Picacho, Granite Springs, and Oakzanita areas respectively.

The dominant shrub of the chaparral understory is Mexican manzanita (*Arctostaphylos pungens*). Figure 2 shows a branch of this shrub which stands 2–3 m high. Mexican manzanita is a nonsprouting shrub because it lacks a basal burl (Raven 1966; Munz 1974). There is some speculation, yet untested, that this shrub is much more widespread in the understory of the park's forest now than it was in the past. There is some thought that earlier wildfires, which have swept through parts of Cuyamaca Rancho State Park (e.g., the Conejos wildfire which swept through parts of the park in 1950), may have accentuated the spread of chaparral into what were once grass understories of these woodlands. Conceivably Mexican manzanita is checked by prescription burning, the low-intensity burn destroying the vegetative structure, but not breaking the dormancy of the seeds as would likely happen under wildfire conditions.

Since a "park-like" openness of the forest is better for both aesthetics and access by wildlife (mainly deer), this condition is preferred by park managers. The hypothesis this study is testing is that there is a significant reduction of understory shrubs in the burn sites as a result of the prescription fires. If a large percentage of the shrub density in the forest is made up of a nonsprouter (e.g., Mexican manzanita), shrub regrowth will be minimal and thus the fires might help to open up the understory of the park's forest on a long term basis.

Methods

Information regarding history, dates, and prescription of the three burns was obtained from Cuyamaca Rancho State Park, Montane Headquarters, Descanso, California. The quadrat method was used to compare understory vegetation in control (adjacent, unburned area with equivalent physiognomy, slope, and exposure as the burned area) and burned study sites. Woody species were measured within 100 m^2 quadrats (10 m × 10 m) randomly placed along transect lines in control and burn sites. The number of quadrats sampled at each site was: 1) Paso Picacho, 26 control, 30 burn; 2) Granite Springs, 29 control, 33 burn; 3) Oakzanita, 11 control, 15 burn. The number of individuals of each species of trees and shrubs were counted in each quadrat and their trunk diameters were recorded following the methods of Cox (1980) and Wilson and Vogl (1965). Mean density of trees and shrubs from the total quadrats at each site was calculated and expressed as the number of individuals per hectare (no./ha). Basal area was calculated from diameters and summed as a percentage of ground covered by each species. Total basal area is the percentage of ground surface covered by all species.

Density of woody seedlings and saplings was also determined from the 100 m^2 quadrats and expressed as number per hectare (no./ha).

Table 1. Mean density (no./ha) of trees at three sites in yellow pine forest of Cuyamaca Rancho State Park, California.

Species	Sites		
	Paso Pacacho	Granite Springs	Oakzanita
Abies concolor (Gard. & Glend.) Lindl.	4		
Calocedrus decurrens (Torr.) Florin.	803		
Pinus flexilus James	3		
Pinus jeffreyi Grev. & Balif.	156	193	158
Quercus agrifolia Neé.	43	40	205
Quercus chrysolepsis Liebm.	53		
Quercus kelloggii Newb.	41	124	27
Total all quadrats	1103	357	390
Total per control/burn quadrats	1039/1165	369/345	374/407

Similarity of vegetation between the control and burn quadrats was computed by Jaccard's coefficient of community similarity (CCj) as described by Brower and Zar (1977). The formula is: $CCj = C/(S_1 + S_2 - C)$ where S_1 and S_2 are total basal area or total species in communities 1 and 2 respectively, and C equals total basal area or total species common to both communities. Values were calculated both from basal area and species.

Comparison of herbaceous understory vegetation was done at two of the sites—Paso Picacho and Oakzanita—by counting individuals of each species in smaller, 1 m^2, quadrats which were placed randomly along the same transect lines as the larger quadrats. Density was calculated and is expressed as number per meter square (no./m^2) Analysis of the differences of woody vegetation between control and burn areas was done by *t*-testing, with level of significance, $\alpha = 0.05$.

Results

The trees in the yellow pine forest burn sites were not affected by the burning, except for those with very small trunk diameters (2–8 cm). Table 1 shows the species and density of the mature trees as calculated from the quadrat data of each of the three study sites.

The greatest change which took place because of the prescription burns was a significant reduction in density and basal area of shrubs in the forest understories at the three burn sites. Seedlings and herbaceous species were also variously affected.

Calocedrus decurrens and *Pinus jeffreyi* were the dominant trees at the Paso Picacho study area, which also contained the greatest variety of species. *Pinus jeffreyi, Quercus agrifolia,* and *Q. kelloggii* were the only trees found at all three study areas (Table 1). This provided diverse sites for testing

Table 2. Mean density (no./ha) of understory shrubs in unburned (control) and burned quadrats (100 m²) at three sites in yellow pine forest of Cuyamaca Rancho State Park, California.

	Sites					
	Paso Pacacho		Granite Springs		Oakzanita	
Species	Control	Burn	Control	Burn	Control	Burn
Arctostaphylos glandulosa Eastw.			7	0	28	0
Arctostaphylos pungens HBK	438	40	24	0	3318	233
Ceanothus leucodermis Greene					18	0
Ceanothus palmeri Trel.	38	3			18	0
Cercocarpus betuloides Nutt. ext. T. & G.			0	3	9	7
Eriogonum fasciculatum Benth.					73	0
Holodiscus discolor (Pursh) Maxim.	4	0				
Quercus dumosa Nutt.					10	0
Rhamnus californica Esch.					55	0
Total	480	43	31	3	3529	240

prescription burning in the understories, because the shrub density and species richness also varied considerably at the three study areas. *Arctostaphylos pungens* was, by far, the dominant shrub, and the only one found in all three areas. The Oakzanita area contained the greatest density and variety of shrubs, with Granite Springs having the lowest density (Table 2). Results relating to the effects of the prescribed burning on shrub densities and basal areas refer to the total shrubs of each study area. However, since *Arctostaphylos pungens* is the dominant shrub, this species, most likely, has the most influence on any changes noted in mature shrubs.

Trees, as mentioned previously, were not significantly affected by the fires, but data comparing total basal area and CCj values in control and burn sites are included for comparative reference with shrubs. Any differences in tree values between control and burn sites are due to slight differences in community structure between the burn area and the adjacent unburned

Table 3. Mean basal area (%) of shrubs and trees in control and burn sites at the yellow pine forest study areas.

	Sites					
	Paso Picacho		Granite Springs		Oakzanita	
	Control	Burn	Control	Burn	Control	Burn
Shrubs	0.12	0.02	<0.01	<0.01	0.25	0.03
Trees	0.59	0.62	0.36	0.45	0.22	0.21

Table 4. Jaccard's Coefficient of Community Similarity (CCj) for shrubs and trees of control and burn sites at the three study areas in yellow pine forest of Cuyamaca Rancho State Park. CCj values were calculated on the basis of basal area (Table 3) and on number of species. A similarity coefficient of approximately 0.7 is considered an indication that the two communities (sites) are virtually identical (Wittaker 1975).

Area	CCj (basal area)	CCj (species)
Paso Picacho		
Shrubs	.16	.66
Trees	.56	.71
Granite Springs		
Shrubs	<.01	<.01
Trees	.72	.72
Oakzanita		
Shrubs	.12	.25
Trees	.84	1.00

control. Likewise, close tree values attest to similarity between control and test sites, particularly the Oakzanita site.

Effect of Burning on Trees and Shrubs

The close similarity of the mean density, basal area (Table 1, 3), and the relatively high CCj values (Table 4) indicate that the trees are nearly equivalent in both control and burn sites, and were thus not appreciably affected by the fire. The few smaller trees which were top-killed by the fire are almost all resprouting at the base, particularly *Quercus* spp.

Shrub density was reduced by a mean of 91% in burn quadrats compared to the control quadrats. This reduction is significant ($p < 0.01$) as determined by the *t*-test. The dominant shrub, *Arctostaphylos pungens,* was reduced significantly, $p < 0.05$ and $p < 0.01$ respectively, for the Paso Picacho and Oakzanita burn sites. The relatively low density of shrubs at the

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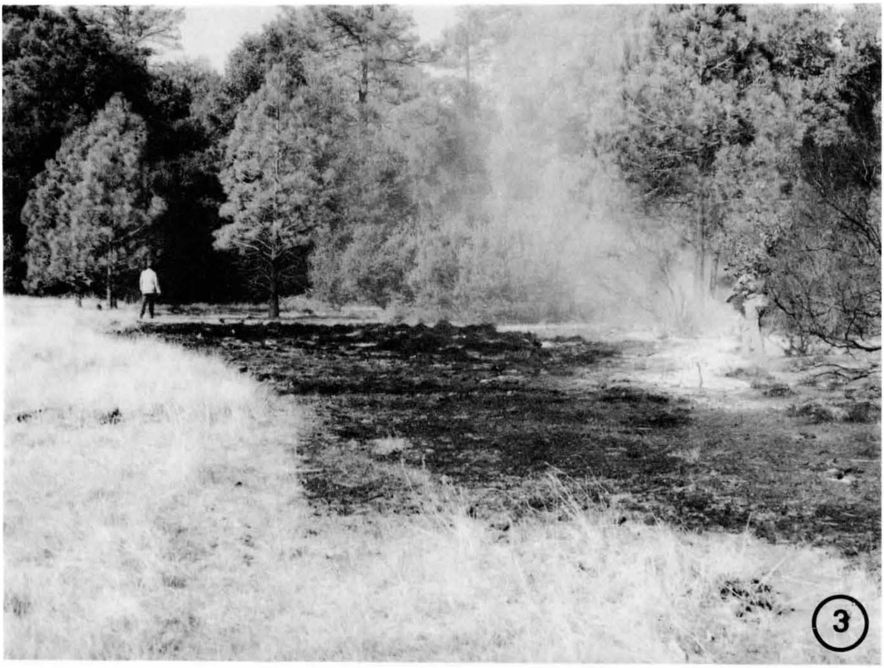
Figs. 3–4. 3. Scene in yellow pine forest of Cuyamaca Rancho State Park showing smoldering remains of a portion of the Oakzanita prescription burn of December 3, 1979. A dense understory, partially burned, consisting mainly of *Arctostaphylos pungens,* can be seen beneath the dominant canopy trees, *Pinus jeffreyi* and *Quercus kelloggii.*—4. Photograph, taken December 4, 1979, showing a few scattered, burned snags of *Arctostaphylos pungens* in the understory of yellow pine forest at the Oakzanita burn site. The large tree in the right foreground is *Quercus kelloggii.*


3


4


5


6

Granite Springs control site did not permit an adequate comparison for shrub reduction due to the fire (Table 2). The total basal area for shrubs was 85% and 88% less in burn sites at the Paso Picacho and Oakzanita sites respectively (Table 3). Likewise, CCj values, based on basal area of the shrubs, were low at the same sites (Table 4). The CCj values based on the number of species of shrubs (for the Paso Picacho and Oakzanita sites) were somewhat higher, undoubtedly reflecting the inability of the prescription burn, with its low intensity, to totally remove all species. The few shrubs that survived the burn tend to be located in unburned patches, or "islands," which were left due to insufficient ground cover to carry the fire (Fig. 3, 4).

To determine the extent of resprouting of shrubs following the burns, subsequent observations were made at the Oakzanita site, the site which contained the greatest density and variety (Table 2). In March 1981, *Arctostaphylos pungens,* a nonsprouter, was still completely top-killed (Fig. 5) 18 mo following the burn. However, *Arctostaphylos glandulosa* was resprouting from basal burls at the same location (Fig. 6). The small size of these 1½-yr-old resprouts suggests that regrowth of these shrubs has been slow after the burn. Other shrub species noted resprouting at this time included: *Ceanothus leucodermis; C. palmeri; Cercocarpus betuloides; and Rhamnus californica.*

Table 5 gives a summary of total density and number of species of shrub and tree seedlings and saplings counted in the control and burn quadrats at the three burn areas. Results, however, were inconclusive. *Arctostaphylos pungens,* which comprised only 11% of the seedling density (Table 5), showed an increase in the burn site at Paso Picacho but a decrease in the Oakzanita burn site compared to the control. *Ceanothus palmeri,* the only other shrub seedlings found, showed an increase in burn sites. *Calocedrus decurrens* comprised, by far, the greatest percentage of tree seedlings and saplings at the Paso Picacho area, with 90% and 93% decrease of seedlings and saplings respectively in the burn sites. *Quercus chrysolepis,* also found only at the Paso Picacho site, had a slight increase of seedling density in the burn site, but, although saplings of this species were present in the control site, none were found in the burned areas. This was also typical for all the other tree species shown in Table 2. At least some saplings of each species were found in control sites which contained the mature trees, but none were observed in the burn sites except for *Calocedrus decurrens, Pinus jeffreyi,* and *Quer-*

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Figs. 5–6 5. Photograph of burned and dead standing stems of *Arctostaphylos pungens,* a nonsprouter, taken March 1981, 15 mo following the Oakzanita prescription burn.—6. Scene showing *Arctostaphylos glandulosa* resprouting from basal burls 15 mo after being stem-killed in the Oakzanita prescribed burn.

Table 5. Mean density (no./ha) of seedling and saplings of shrubs and trees in control and burn quadrats (100 m^2) at study sites in yellow pine forest of Cuyamaca Rancho State Park. Number in parentheses ( ) indicates the number of species contributing to the seedling/sapling densities.

	Sites					
	Paso Picacho		Granite Springs		Oakzanita	
	Control	Burn	Control	Burn	Control	Burn
Seedlings						
Shrubs	35 (2)	280 (2)	—	6 (1)	82 (1)	100 (2)
Trees	4212 (5)	1324 (5)	1806 (3)	440 (3)	4018 (3)	8450 (2)
Saplings						
Shrubs	23 (1)	—	—	3 (1)	—	7 (1)
Trees	1720 (6)	100 (2)	85 (3)	3 (1)	54 (3)	—

cus agrifolia. Saplings of these species, however, were very sparse in the burn area compared to the control. The only significant increase of seedlings of tree species as a result of the burning appears to be with *Quercus* spp. (Table 1). However, even two of these species (*Q. agrifolia* and *Q. kelloggii*) had decreases in seedling densities in some burn sites as well as increases at others.

Effect of Burning on Herbaceous Vegetation

Table 6 summarizes the total mean density of understory grasses and forbs in control and burn sites of the Paso Picacho and Oakzanita areas as counted in 1 m^2 quadrats. The total number of species (R), including grasses and forbs, is also shown for each control and burn site. The results, like those for seedlings and saplings, are variable and show no specific pattern to reflect the response to the burn. Annual grasses increased in density at burn sites 2 and 3 of the Paso Picacho area, and forb density increased here as well, but not at the Oakzanita site. Total overall diversity, including grasses and forbs, increased somewhat in the burn sites of both study areas. Although total density was greater in the control site at Oakzanita, possibly because it was the youngest burn, 50% of this density was due to the dominant herb, *Solidago californica* Nutt., which was reduced 39% in the burn area. Other dominant forb species which were also reduced substantially in the burn site were *Galium andrewsii* Gray and *Leptodactylon pungens* (Torr.) Rydb. ssp. *halii* (Parish) Mason.

Conclusions

The results of this study are helpful to the understanding of the effects of fire on vegetation. Stone (1965) stated drastic changes in composition of

Table 6. Mean density (no./m²) of herbaceous ground cover in unburned (control) and burn quadrats (1 m²) at two sites in yellow pine forest of Cuyamaca Rancho State Park, California. K = number of 1 m² quadrats sampled, R = number of species per site.

	Sites					
	Paso Picacho				Oakzanita	
Habit	Control K = 40, R = 11	Burn 1 K = 40, R = 12	Burn 2 K = 40, R = 24	Burn 3 K = 40, R = 23	Control K = 41, R = 21	Burn K = 40, R = 30
Annual grasses	1.00	0.71	3.01	3.08	0.00	0.57
Perennial grasses	0.65	0.66	0.11	0.00	0.27	0.81
Forbs	1.41	3.17	4.23	4.13	17.03	10.82

many plant communities in national parks have occurred over the last 50 years due to fire-exclusion policies. He maintained that prescription (controlled) burning should help forests and other communities restore and maintain their natural composition. Since one of the main purposes for prescription burning in the yellow pine forests of Cuyamaca Rancho State Park was to attempt to create a more "park-like" appearance by reducing the dense understory shrubs in some areas without destroying the trees, these three burns contributed greatly toward this goal. Mature shrubs were significantly reduced and the mature trees, however, were not significantly affected. Almost all of the shrub reduction is accounted for by the dominant shrub *Arctostaphylos pungens*. Biswell and Schultz (1958) also found a high (93%) reduction of *Arctostaphylos* spp. from a prescription burn in a yellow pine forest. Vogl and Schorr (1972) assume that frequent burning in the upper elevations of the San Jacinto Mountains would favor pines over the manzanita chaparral. Periodic burning in the yellow pine forests of Cuyamaca Rancho State Park might be similarly effective.

Arctostaphylos pungens seedlings were very infrequent in all of the control and burn sites of Cuyamaca Rancho State Park. Vogl and Schorr (1972) state that, unlike other species of manzanita, *Arctostaphylos pungens* does not produce numerous seedlings as a result of the low-intensity fires of prescription burns. The reduction of less dominant shrub species (Table 2) was also apparent as a result of the burns; unlike *Arctostaphylos pungens*, however, these shrubs are sprouters and are therefore recovering slightly (Fig. 5, 6).

Although the results of the influence of the prescription burning on seedlings, saplings, and herbaceous understory vegetation were inconclusive, this study verified our hypothesis that dense understory shrubs could be significantly reduced without permanent damage to trees. What makes this shrub reduction important though, is the possibility that the bulk of the shrub cover will not likely grow back soon. The dominant shrub, *Arctostaphylos pungens*, did not produce very many seedlings after the fire, and since it is a nonsprouter, any shrub regrowth will likely depend on the subdominants, which are relatively sparse compared to *Arctostaphylos pungens*.

Literature Cited

Biswell, H. H. 1959. Reduction of wildfire hazard. Calif. Agri. 13(6):5.

———. 1960. Prescribed burning in ponderosa pine. Calif. Agri. 14(10):5–6.

———. 1974. Effect of fire on chaparral, pp. 321–364. *In* T. T. Kozlowski and C. E. Ahlgren [eds.], Fire and ecosystems. Academic Press, New York, New York.

———, and A. M. Schultz. 1958. Manzanita control in ponderosa. Calif. Agri. 12(2):12.

Box, T. W., J. Powell, and D. L. Drawe. 1967. Influence of fire on south Texas chaparral communities. Ecology 48:955–960.

Brower, J. E., and J. H. Zar. 1977. Field and laboratory methods for general ecology. Wm. C. Brown Co., Dubuque, Iowa. 194 p.

Clar, C. R. 1959. California government and forestry. Calif. Div. Forest.

Cooper, C. F. 1961. The ecology of fire. Sci. Amer. 204:150.

Cox, G. W. 1980. Laboratory manual of general ecology. Wm. C. Brown Co., Dubuque, Iowa. 237 p.

Dodge, M. 1972. Forest fuel accumulation a growing problem. Science 177:139–142.

Grelen, H. E. 1978. Winter and spring prescribed fires on Louisiana pine bluestem range, pp. 242–244. *In* D. N. Hyder [ed.], Proceedings of the First International Rangeland Congress. Society for Range Management, Denver, Colorado.

Hanes, T. L. 1971. Succession after fire in the chaparral of southern California. Ecol. Monographs 41: 27–52.

Kessler, W. B., and J. D. Dodd. 1978. Responses of coastal prairie vegetation and Attwater prairie chickens to range management practices, pp. 473–476. *In* D. N. Hyder [ed.], Proceedings of the First International Rangeland Congress. Society for Range Management, Denver, Colorado.

Kilgore, B. M., and G. S. Briggs. 1972. Restoring fire to high elevation forests in California. J. Forest. 70:266–271.

Martin, B. D. 1982. Vegetation response to prescribed burning in Cuyamaca Rancho State Park, California. Symposium Proceedings, Dynamics and Management of Mediterranean-type Ecosystems. San Diego, California. June 22–26, 1981. 1 p. (in press).

Miller, J. 1887. Paper read before American Forestry Congress. Rep. Amer. Forests Congr. 10:25–26.

Mutch, R. W. 1970. Wildland fires and ecosystems—a hypothesis. Ecology 51:1046–1051.

Munz, P. A. 1974. A flora of southern California. University of California Press, Berkeley, California. 1086 p.

Odum, E. P. 1969. The strategy of ecosystem development. Science 164:262–270.

Raven, P. H. 1966. Native shrubs of southern California. University of California Press, Berkeley, California. 132 p.

Show, S. B., and E. I. Kotok. 1924. The role of fire in the California pine forests. U.S. Dep. Agr. Bull. 1294:1–80.

Stone, E. C. 1965. Preserving vegetation in parks and wilderness. Science 150:1261–1266.

Talley, S. N., and J. R. Griffin. 1980. Fire ecology of a montane pine forest, Junipero Serra Peak, California. Madroño 27(2):49–60.

Vogl, R. J. 1973. Effects of fire on the plants and animals of a Florida wetland. Amer. Midl. Natur. 89:334–347.

———, and A. M. Beck. 1970. Response of white-tailed deer to Wisconsin wildfire. Amer. Midl. Natur. 84:270–273.

———, and P. K. Schorr. 1972. Fire and manzanita chaparral in the San Jacinto mountains, California. Ecology 53:1179–1188.

Weaver, H. 1951. Fire as an ecological factor in the southwestern ponderosa pine forests. J. Forest. 49:93–98.

———. 1957. Effects of prescribed burning in ponderosa pine. J. Forest. 55:133–137.

Wilson, C. C., and J. D. Dell. 1971. The fuels buildup in American forests: A plan of action and research. J. Forest. 69:471–475.

Wilson, R. C., and R. J. Vogl. 1965. Manzanita chaparral in the Santa Ana mountains, California. Madroño 18:47–61.

Wittaker, R. H. 1975. Communities and ecosystems. Macmillan Publishing Co., New York. 385 p.

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