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**MANIPULATION OF CHAMISE BRUSH FOR  
DEER RANGE IMPROVEMENT<sup>1</sup>**

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Chamise brushlands in California occupy about 7,300,000 acres (Sampson, 1944). They are highly variable in plant species, soil fertility, degree of slope, availability of drinking water, and general suitability for deer. These brushlands are valuable mainly for watershed and game; however, some are grazed by livestock and others are being cleared for farming. Wildfires are frequent and widespread. These are typical items that must be considered wherever brushland management is undertaken for game. It is also wise to keep in mind that each brushland is different, and requires a plan all its own.

Studies, over a period of several years, have been made on the possibilities of managing chamise brushlands for deer. The investigations were centered in Lake County, but with certain portions widely scattered throughout the coastal ranges. Two objectives were foremost: (1) to determine the extent to which deer populations increase with brush cover manipulation; and (2) to study and test various methods of manipulating chamise brush for maximum deer use and sustained yield of forage.

The California Department of Fish and Game, aware of this need, contracted with the University of California for the research, with funds provided by Federal Aid in Wildlife Restoration Act, Project California 31-R. Details have been published by Biswell *et al.* (1952) and by Taber and Dasmann (1958).

**CONDITIONS OF CHAMISE BRUSHLANDS IN LAKE COUNTY**

In general the chamise brushlands in Lake County comprise two cover types, one in which chamise (*Adenostoma fasciculatum*) predominates, and one containing a mixture of broadleaf shrubs and trees, known as mixed chaparral (Figure 1). The chamise occurs mainly on south-facing slopes and drier sites while the mixed chaparral is found on the more mesic, north-facing exposures and in ravines. This intermixture of types and species is particularly favorable for deer since it provides a wide variety of forage as well as greater seasonal choice. The intermixture of browse plants in Lake County is probably as favorable for deer as most chamise brushlands in other parts of the state. Some brushlands are so nearly pure chamise that they furnish relatively poor browse.

The dominant shrubs and trees over the study areas in Lake County were chamise, interior liveoak (*Quercus wislizenii*), Eastwood manzanita (*Arctostaphylos glandulosa*), scrub oak (*Q. dumosa*), California

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FIGURE 1. Typical chamise brushland in Lake County. Chamise predominates on the south-facing exposures and many shrubs and small trees grow on the north-facing exposures.

laurel (*Umbellularia californica*), toyon (*Photinia arbutifolia*), wedgeleaf ceanothus (*Ceanothus cuneatus*), wavyleaf ceanothus (*C. foliosus*), deerbrush (*C. integerrimus*), Stanford manzanita (*A. stanfordiana*), yerba santa (*Eriodictyon californicum*), poison oak (*Rhus diversiloba*), western mountain mahogany (*Cercocarpus betuloides*), and chaparral pea (*Pickeringia montana*), approximately in that order of abundance. Some of these, of course, are more palatable and nutritious than others, and some can well be considered "weeds." The more palatable species are chamise, wedgeleaf ceanothus, wavyleaf ceanothus, deerbrush, and western mountain mahogany. The least desirable are the manzanitas and yerba santa. The others might be considered intermediate in palatability. Grasses and forbs, both annual and perennial species, are many. In dense, mature brush these are sparse, but in openings they provide abundant nutritious forage in the winter and spring months.

It is generally known that a majority of chamise brushland soils are low in fertility; also, many brushlands are extremely rough in topography. In the study areas, soils on the south exposures are mainly less than 12 inches deep, while those on the north exposures are generally 12 to 24 inches deep. The slopes average 20 to 25 degrees, with perhaps 50 percent of them too steep for land tilling equipment or bulldozers (Figure 2). Ravines are numerous, many with seeps that furnish year-long drinking water for deer. Precipitation averages 28 inches, practically all as rain between September and April, inclusive. The



FIGURE 2. Some chamise brushlands are rugged and are too steep for landtilling equipment or bulldozers.

summer months are extremely dry. The mean annual temperature is about 57° F., the extremes varying generally from about 20° to 110°. The same general pattern of rainfall and temperatures characterizes all chamise brushlands in California. The brushlands usually occur where the precipitation is between 14 and 40 inches. In areas of annual rainfall up to 14 inches, the chamise becomes open and desert-like in appearance; with rainfall over 40 inches, it generally gives way to forest growth. In areas receiving between 14 and 40 inches of rainfall, the soil is apparently more important than climate in delimiting chamise brushlands.

The Columbian black-tailed deer (*Odocoileus hemionus columbianus*) is found in abundance in Lake County chamise brushlands. This game animal is found all through the Coast Range brushlands from about Santa Barbara County north to the Oregon line (Taber and Dasmann, 1958). Over this entire area, deer are usually resident, and occupy essentially the same grounds all year. However, they may shift around somewhat, depending on food supply and weather. For example, the deer may appear under oaks on nearby ranges when acorns are dropping in the fall, or on grasslands in winter when the herbs are coming up, or in nearby fields and orchards during the hot, dry summer months, but usually such movements are for short distances and are not measured in miles.

#### BRUSH COVER MANIPULATION AND GAME POPULATION

Deer have certain environmental requirements for optimum production. Among these are: year-long forage that is palatable and nutritious; cover for escape and perhaps for resting; and drinking water. An absence of any one of these factors may make an area largely, or

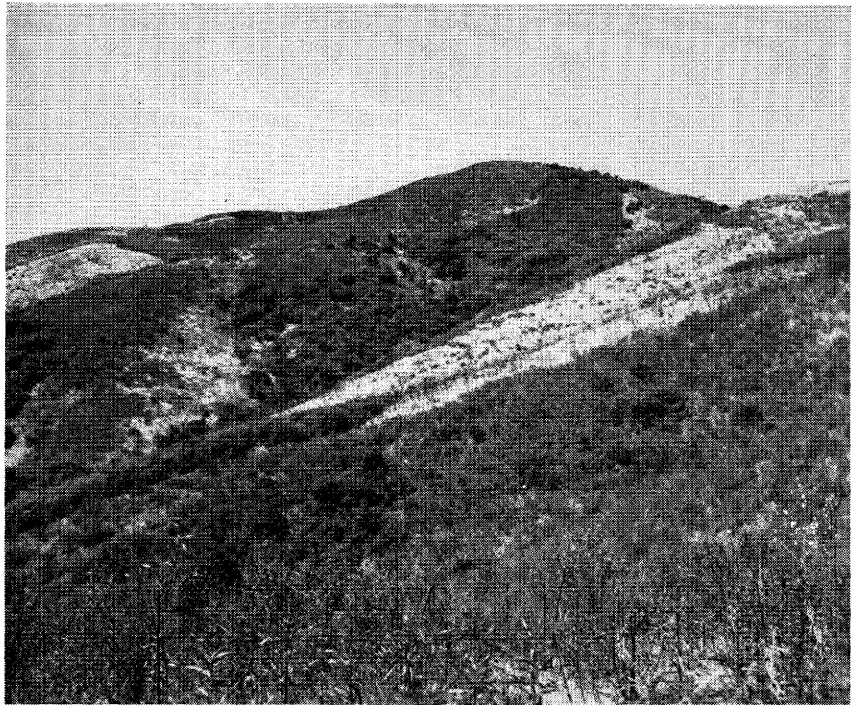


FIGURE 3. Chamise brushland on Glenn Keithly ranch in Lake County opened by control burning. The combination of openings with herbaceous forage and patches of unburned dense brush provides ideal deer range conditions.



FIGURE 4. Ideal deer range in Scotts Valley, Lake County. The pattern of openings was largely created by control burning. Most ravines have seeps that furnish year-long drinking water for deer.

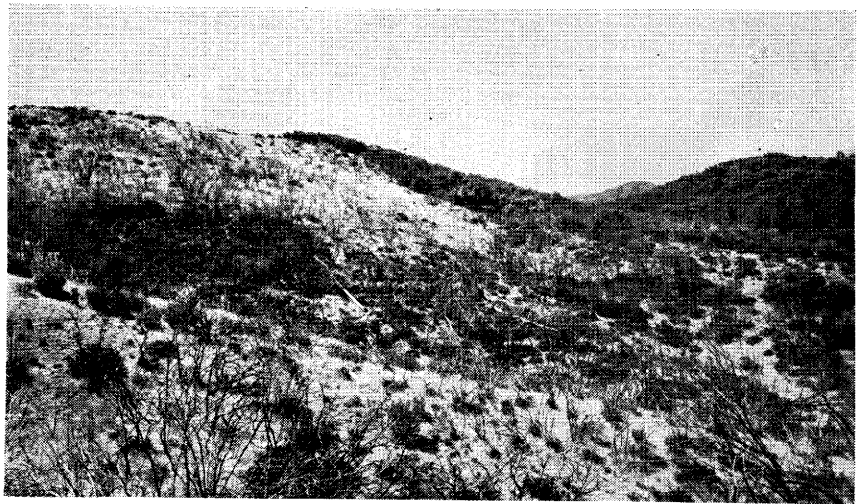


FIGURE 5. Opened brushland on Ora Ranch. Many of the sprouts that came after control burning are browsed down so that sprout regrowth is easily available to the deer.

even entirely, unsuitable for deer. With these requirements in mind, studies were designed to compare three cover areas: (1) opened brush (Figures 3 and 4), consisting of small, burned patches here and there, seeded to suitable herbaceous species; (2) heavy brush protected from fire (which served as a control); and (3) an area burned by wildfire. The size of each area was about 1,000 acres. These cover conditions are referred to in the following as opened brush, heavy untreated brush, and wildfire burn.

#### Forage Availability

Forage available to the deer was quite different under each of the three conditions of brushland. In the opened brush many herbaceous plants were present, both grasses and forbs. In addition, many of the shrubs were browsed down so that sprout regrowth was easily available to the deer (Figure 5). Edges of remaining patches of heavy brush provided an extensive strip along which the deer could browse.

In the area of heavy untreated brush there was little in the way of herbaceous plants, and on the north-facing exposures many of the shrubs and trees were tall and out of reach of the deer. Certain shrubs that normally appear after fire and persist for several years were very scarce, including wavyleaf ceanothus and yerba santa. More acorns were generally available to the deer in the heavy brush area than in either the opened brush or wildfire burn.

In the area of wildfire burn, an abundance of sprouts was available within a few weeks after the fire. This usually happens unless the fire occurs after about the middle of September, in which case sprouting may not be profuse until the next spring. A small quantity of grasses and forbs grew naturally in the wildfire burn, which was not seeded after the fire. For the most part, browse was plentiful and nutritious the first year but gradually declined in quality thereafter as the plants grew back toward maturity. Maturity is reached within 12 to 15 years where browsing is light.

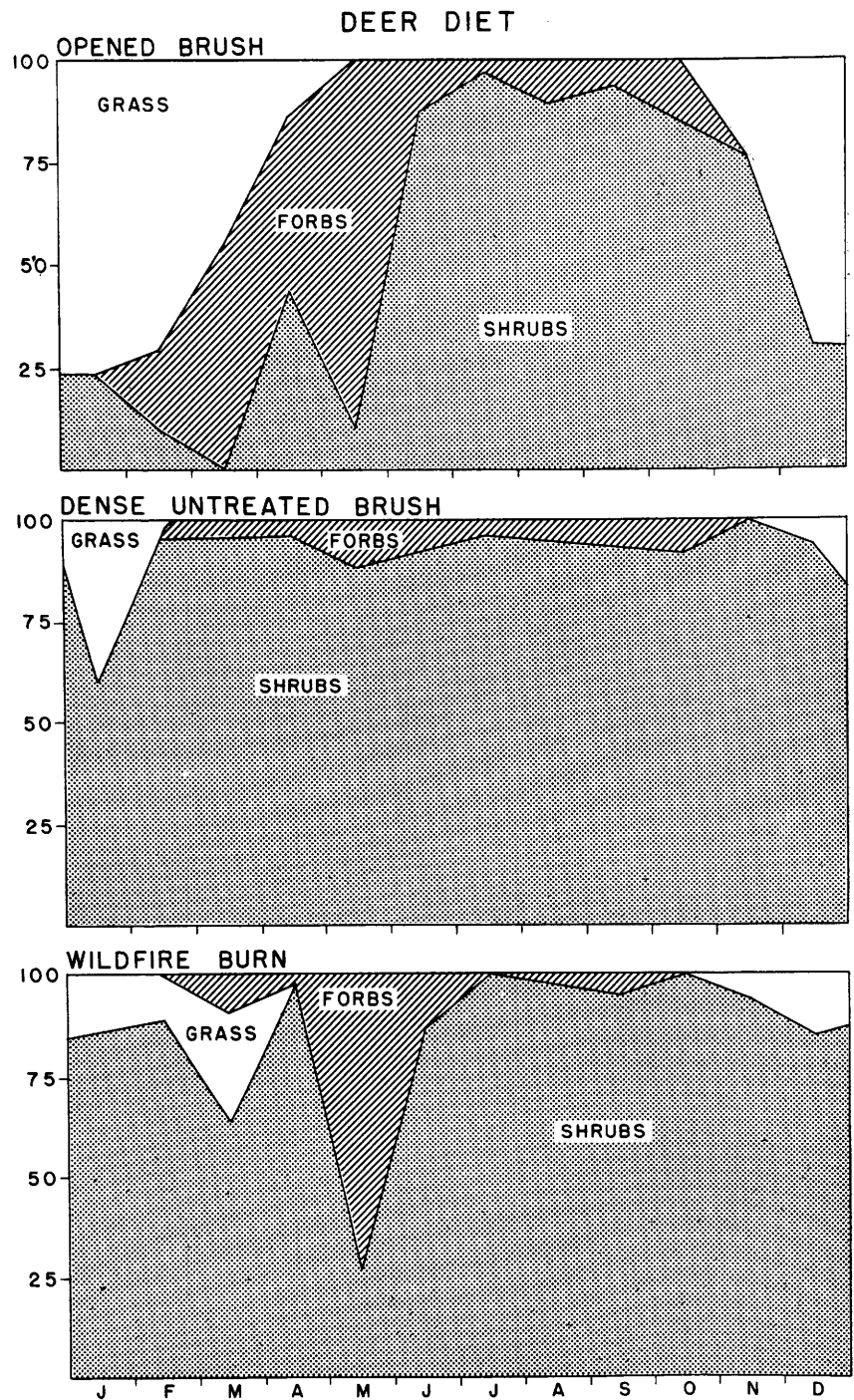


FIGURE 6. Comparative diets of deer on opened brushland, on dense untreated brush, and on wildfire burn. Grasses and forbs constitute a favorite winter and spring food item where available, but shrubs are the primary source of food in summer. (Adapted from Taber and Dasmann, 1958.)

### Food Habits of Deer

Information on the food habits of deer on the three areas was gained largely by analysis of stomach samples. Results are shown in Figure 6. For the whole year, grasses and forbs comprised more than 40 percent of the diet in the opened brush. These plants constitute a favorite winter and spring food item. In dense, heavy brush the grasses and forbs were much scarcer on the ground, and made up only about 5 percent of the diet. Here the deer were more or less forced to feed on dormant brush which was very low in nutritive value. On the new wildfire burn the grasses and forbs were more plentiful than in the heavy brush, and accounted for about 14 percent of the deer diet. In all areas the grasses and forbs were preferred in January, February, and March, and until the shrubs began to put out new growth in April.

Chamise was the most important plant on all ranges from the standpoint of volume taken. Other forage shrubs of much importance were interior liveoak, scrub oak, poison oak, deerbrush, toyon, California laurel, and western mountain mahogany—largely dry-season foods—and yerba santa, eaten in late winter and early spring before new browse appears. Many other plants were selected, sometimes in quantity, but on the average they were less important than those listed above.

The deer have rather definite feeding areas at different seasons of the year, and their selection of foods at any season is limited somewhat by the plants growing in a given area. In the heat of summer, the deer feed mostly on north-facing slopes and in stream beds. At that time, of course, the diet is high in north-slope and stream bed vegetation. In winter the deer feed on the warmer, south-facing slopes. There they take grasses and forbs, chamise, and perhaps yerba santa.

### Quality of Deer Forage

As mentioned above, deer are selective in their feeding habits. Usually they take young growth which is high in protein, moisture, and sugars, and they like acorns in the fall, if available.

Samples representing deer diet were taken from each of the three range conditions and were analyzed for protein. For a full year the averages for protein content were as follows: opened brush, 14.4 percent; heavy untreated brush, 9.2 percent; wildfire burn 16.7 percent (Taber and Dasmann, 1958). All three range conditions showed similar seasonal patterns, with the diet highest in protein in spring and lowest in the fall after the shrubs had ceased growing and the grasses and forbs were mainly dry. For the heavy untreated brush, the protein content was 7.0 percent or less from September to December, inclusive, and reached a low of 5.1 percent in November. The lowest for the opened brush was 9.2 percent in August. In general the condition of the deer followed the protein level of the forage, being high in spring and summer, declining through late summer and fall, and reaching a low point in late winter. Deer condition became lowest of all in the area of dense heavy brush. Taber (1956) suggested three reasons for the higher protein content of deer diet in the opened brush as compared with that of the heavy untreated brush: (1) the higher proportion of high protein, herbaceous forage in winter and early spring in the opened brush diet; (2) the shrubs on the opened area kept within reach of deer through

browsing pressure so that the leaves, which are higher in protein than the stems, can be selected; (3) browsing of hedged shrubs over a long period of time, stimulating regrowth which is high in protein.

#### Plant Successions

Plant populations in brushlands are in a constant state of continual change. Some of the changes may be favorable to deer but others are not. Furthermore, some of the variations are natural; others may be induced. In habitat management work it is important to be able to predict the course of changes and know how to induce those desired. It is also important to know the effect that certain successions have on range grazing capacity. But first of all, one should know the ecology and importance of each species on the range.

Among other things, successions take place because (1) some species grow taller than others and are better able to compete; (2) some are preferred food items of deer and are suppressed by heavy browsing; (3) others are scarcely eaten and are even favored by the browsing and suppression of neighboring plants; (4) some species reproduce from both sprouting and seed after fire while others reproduce only from seed.

Fire is one of the more important factors governing plant populations in brush fields. The time and frequency of burning play important roles in plant successions. Fire stimulates seed germination of most brushland shrubs and prepares a seedbed favorable for new seedlings. Fire also initiates crown sprouting of most shrubs; exceptions in the study areas were wedgeleaf and wavyleaf ceanothus, and Stanford manzanita, all of which reproduce only from seed.

After fire in dense brush, seedlings appear by the thousands in springtime. Germination seems to be greatest from fall burns and least from fires that occur about March 15 to April 1. After about April 1 the seedlings do not appear until the following spring. By that time the seedbed has become more compacted and herbaceous species have increased enough to offer competition to new brush seedlings. Furthermore, sprouts from stumps have grown enough to compete also with the new brush seedlings.

Seedlings of some shrubs, such as chamise and yerba santa, seldom become established without fire. Most of the shrubs are vigorous sprouters, except deerbrush which is a weak sprouter. Wedgeleaf and wavyleaf ceanothus and Stanford manzanita are non-sprouters. Yerba santa reproduces from seed after fire and also by sprouting if old plants are present. Later, this species reproduces and spreads by shoots from horizontal, underground stems. Because the plant reproduces in this way and is not a preferred species, it increases where other shrubs are reduced by heavy browsing. This shrub is not browsed except in winter when other, more preferred species are scarce. Some shrubs, such as western mountain mahogany and wedgeleaf ceanothus, produce seeds that germinate readily without fire.

Frequent fires can reduce the abundance of certain valuable non-sprouting species, such as wedgeleaf ceanothus. When a second fire occurs before a new crop of seeds is produced, this plant can be nearly wiped out. Thus, frequent fires favor sprouting species.



Some species appear after fire and later give way to taller and longer lived species. For example, seeds of wavyleaf ceanothus germinate with fire, but the shrub grows to a height of only 18 to 24 inches. Soon it is overtopped by taller species, and disappears from the stand until the next fire, after which dormant seeds germinate. In opened or heavily browsed brush, where other shrubs are suppressed, this species may remain in the stand for many years. Yerba santa is another species that disappears when the brush becomes heavy and dense. In dense brush this species disappears almost completely within about 20 years. With longer protection other species begin to disappear. For example, in a one-hundred-year-old brush stand in San Benito County much of the wedgeleaf ceanothus in the stand had died leaving mainly chamise.

Heavy browsing of sprouts of preferred species after fire can kill individual shrubs. Species heavily browsed, and frequently killed, on the experimental area were western mountain mahogany, deerbrush, and California laurel. Seedlings are not so easily killed as are plants that have stump sprouted.

#### Deer Populations

A census of deer on the different areas was usually taken at least twice each year, first by the pellet-group count method and later by the sample-area count method. Counts in opened brush gave a summer population density of about 98 deer per square mile after the initial brush manipulation treatment. This rose to 131 the second year, and then dropped to about 84 the fifth and sixth years, at which point the population presumably stabilized. Measurements in the heavy untreated brush gave a summer density of only 30 deer per square mile. The wildfire burn, which was dense brush before it burned, showed 120 deer per square mile the summer following burning. Some of this increase was due to influx from the areas immediately surrounding the burn. As the wildfire burn area grew older, the population fell to 106 the second year, 52 the third, and 44 the fourth. Eventually it reaches the same status as the heavy untreated brush, probably in 12 to 15 years. Usually wildfire burns recover rapidly because deer numbers are not sufficient to suppress the sprouts.

#### Fawn Production

Studies on collected does indicate that fawn production is governed largely by ovulation rate. However, ovulation rate does not tell everything because successful births and nursing are also important. Ovulation rates in adult does were approximately as follows: on opened brush range, 175 percent; on heavy untreated brush, 82 percent; on wildfire burn, 140 percent. Figures of fawn production correspond closely to those of ovulation rate but were lower, of course. The following average values for fawn production seem representative: in opened brush 145 fawns to 100 does; in heavy brush, 71 fawns to 100 does; in wildfire burn, 115 fawns to 100 does.

#### Deer Weight Differences

It was noted that opened brush and wildfire burns offered summer diets of higher quality than that offered by the heavy untreated brush. The deer weights showed essentially this same relationship, those of

the deer in the wildfire burn being highest and those of the deer in the dense brush, lowest. The difference between the extremes was about 13 pounds.

The peak weights for bucks in the opened brush and wildfire burn were reached in July. From this point they declined. Bucks in dense brush retained their fall condition better than did bucks on other ranges, probably because their acorn supply was greater. The advantage conferred by the acorn crop is short-lived, however. From an October high of nine pounds above average, the buck weights fell rapidly to a February low of 39 pounds below average. Their weight when on the wildfire burn dropped low in February too, probably because of a shortage of grasses and forbs. The bucks from opened brush with nutritious grasses and forbs maintained their condition well through the winter.

Does followed much the same condition cycle as bucks with the exception that peak condition for does was reached earlier in the summer, and in winter the drop in condition in heavy brush was not so pronounced as in the bucks. The exact reason for this is not known.

#### Resident Small Game

Although the studies were concerned chiefly with deer, observations were made of the small game populations as related to brush manipulation. The density estimates given below are based on strip-counts and observations for quail (*Lophortyx californica*), pellet counts for the California jackrabbits (*Lepus californicus*), and general observations for brush rabbits (*Sylvilagus bachmani*) and mourning doves (*Zenaidura macroura*). Valley quail are definitely encouraged by opening dense brush. In the openings, the quail find abundant herbaceous forage and seeds with cover nearby. Late summer populations of 250 per square mile were found in the opened brush. However, in the heavy brush and wildfire burn the number was only about 100 per square mile.

California jackrabbits also reach their greatest densities in opened brush, where their number fluctuated between 10 and 45 per square mile. The highest counts were made in late summer. In heavy untreated brush the number was low, only about one per square mile. In the wildfire burn the number varied from five to ten per square mile.

Brush rabbits were numerous in the heavy untreated brush, and in and around islands of heavy brush in both the opened areas and in the wildfire burn.

Mourning dove populations were highest in the opened brush, second in the wildfire burn, and very low in the heavy untreated brush.

It seems evident that in the opened brush the generous amounts of herbaceous vegetation, along with the edge effect supplied by the scattered clumps of brush, encourage the build-up of most resident small game species (Burcham, 1950). In the opened brush one finds not only the dense populations of most small game, but also cover which is most suitable for upland hunting. Even species such as the brush rabbit, which seem to be more numerous in the heavy brush than in the opened brush, may be hunted more successfully in the latter areas.

## METHODS OF MANIPULATING CHAMISE BRUSH

In the light of the foregoing results, it would seem that the general objective in management of chamise brushlands for game should be to reduce the brush cover in spots and introduce palatable herbaceous species for use in winter and early spring.

Manipulation can completely convert brush to grasses in spots, or thin the shrubs in spots to enable grasses to grow also. In the first case, browse is provided along the edges of openings, and grasses and forbs are abundant for winter and spring use. In the second case, browse comes from the scattered shrubs in the openings as well as from the edges. The latter should provide a greater total quantity of browse than the first method. The principal advantage of the first method is that the grasses in the open spots grow denser and therefore more completely cover and protect the soil.

Opening dense chamise brushland provides a desirable interspersion of food and cover. Once chamise brushlands are properly opened and the growth of herbaceous species is encouraged, good management should keep them productive over a long period of time with a minimum of further disturbance.

Methods studied in opening chamise brushlands were burning and livestock grazing, mechanical means, and chemical treatment. Seeding

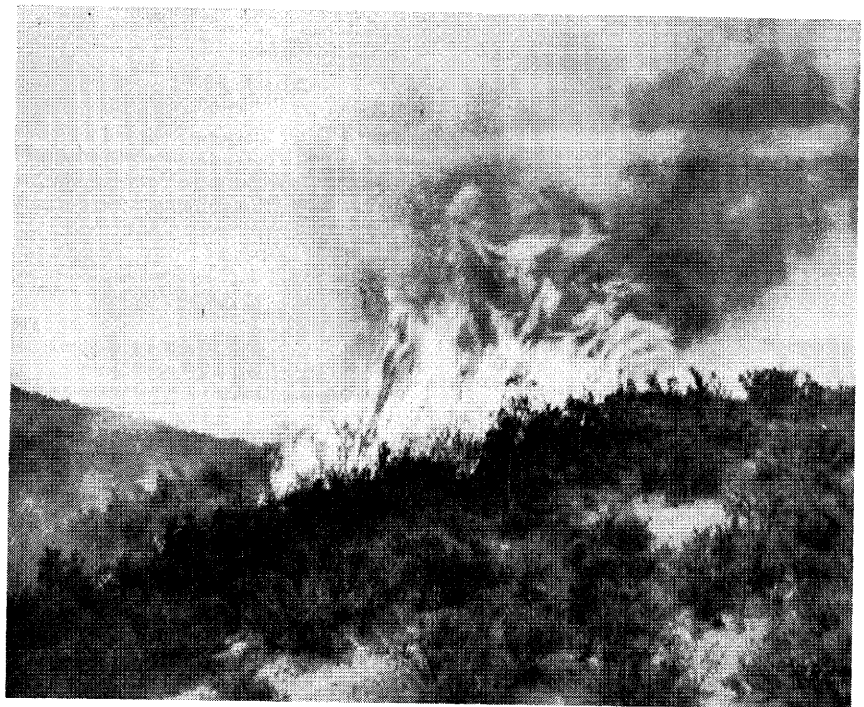


FIGURE 7. Control strip burning in May in chamise. The fire was lit at the base of the slope so that it burned uphill. It did not spread to the sides, and went out at the top. The burning was done on a clear day when the humidity was 27 percent. Grasses outside of the brush area were green.

of desirable forage plants should generally be combined with any of these methods to better establish a suitable cover of herbaceous species soon after the brush is removed. Most of the chamise brushlands opened thus far have been by a combination of methods. Although livestock grazing is of little importance by itself, it can be a powerful tool for controlling chamise brush when used in combination with burning or mechanical means.

#### Burning and Grazing

From the standpoint of game management, either spring or late fall burning has proved satisfactory in opening chamise. Spring burning, before the grasses outside of the brush areas become dry, is relatively easy, with good fire control. Any time that the humidity is around 25 to 30 percent and the wind is calm it is usually possible to light a fire at the bottom of a slope and have it burn uphill (Figure 7). Usually the fire does not spread to the sides and will go out at the top of the slope (Figure 8). Areas of decadent brush, containing considerable dead material, will burn easiest. In such areas, firing should be started when the humidity is relatively high. Late fall burning is slightly more hazardous than spring burning, and usually requires more elaborate preparations. Information on techniques in burning may be found in Arnold, *et al* (1951). Flame throwers are effective in setting fire in spring and late fall burning. The best way to learn about the use of fire is through experience in the field under the instruction of someone competent. It requires considerable planning, care, effort, and patience.

Summer burning in chamise brushlands for game is not recommended because of the difficulty and expense involved in fire control.

Studies have not gone far enough to determine precisely whether most of the burning for game in chamise brush should be in the spring or late fall, or whether a combination of the two seasons should be used. After spring burning, sprouts will appear within 3 or 4 weeks and supply a highly nutritious forage for deer during the dry summer

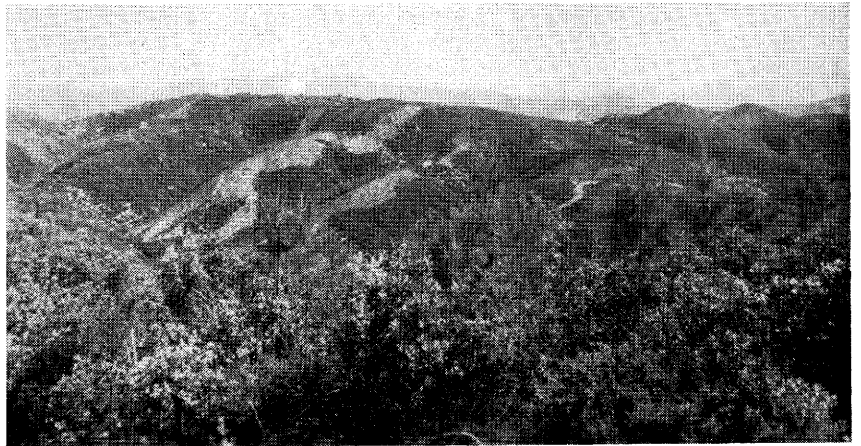


FIGURE 8. Portion of Cow Mountain recreation area in Lake County where strip burning is being done in the spring months to improve browse and cover conditions for deer.

months. However, studies thus far indicate that few brush seedlings appear on spring burns, especially where burning is done after the first of April. This would mean that sprouting species, such as chamise and manzanita, are favored over nonsprouters, such as wedgeleaf ceanothus. If this is borne out by further studies on burns made before seed maturity, it may be found that the composition of the brush cover for deer may be adversely affected by spring burning. Some fall burning may then be necessary to provide young plants of wedgeleaf ceanothus, wavyleaf ceanothus, and other valuable nonsprouting browse plants.

Control of sprouts after burning is an essential step in the opening of dense chamise brushlands. Both measurements and observations indicate that deer will probably be effective in suppressing sprouts through browsing. Sheep can also be used in some places to good advantage, especially in large burns where the deer population is inadequate to suppress the browse plants. Without utilization, chamise sprouts will attain an average height of nearly 20 inches the first summer after fall burning, and interior live oak will reach 30 to 40 inches. Thus, unless the sprouts are browsed they soon become useless as food for game. Deer and sheep are effective in controlling sprouts by killing some of the plants the first season following burning.

The extent to which deer and sheep may suppress sprout growth is indicated by measurements of chamise sprouts under various conditions of grazing use and in protected areas on two-year-old burns. Even light browsing by deer considerably suppressed the growth of sprouts. A majority of the sprouts browsed lightly by deer averaged about 18 inches in height while those protected by fenced exclosures averaged between 22 and 32 inches.

Close utilization by deer may kill many of the sprouts the first year following fire. This results in opening the brush. Some sprouts may be killed the second year, but few, if any, are killed after the sprouts are five years or more old. After the chamise plants are 6 to 8 inches tall, the stiff stems keep the deer from grazing so closely as to kill the plants.

Burned spots should usually be small—5 to 10 acres—in order to form as much edge as possible. The acreage to be burned should be decided upon before burning is started. If the deer population is dense or if a band of sheep is available to control sprout growth the first year, the acreage burned may be fairly large. In general, however, deer populations in heavy brush areas are fairly low, and the burns should be kept small. Spot burns of about 5 acres scattered here and there are probably sufficient for initiating a program of managing chamise brushlands. The spots should be scattered evenly over the whole area, rather than clumped. It is wise to proceed in stages, so that the deer can keep up with the brush sprouting. In the second or third year it might be desirable to make new burns in the region where deer use has been heavy. If the deer are effectively opening the brush, it might be well to go rather fast; but if not, proceed slowly. This procedure should continue until the desired amount of opening has been accomplished. In the end perhaps as much as 75 percent of an area can be converted to small open spots.



FIGURE 9. Mechanical manipulation of brush to improve conditions for deer. The brush was pushed over in February, with the bulldozer blade about six inches above the soil. The chamise is sprouting vigorously. Several seedlings of wedgeleaf ceanothus were found. Photograph taken on July 14, 1952.

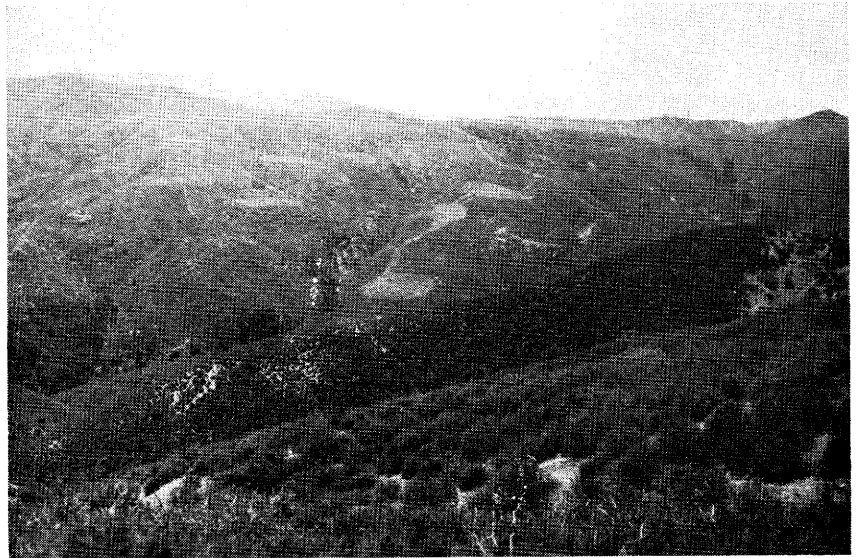


FIGURE 10. Taken on Cow Mountain recreation area in Lake County looking across Buck Canyon where open spots and trails were created by use of bulldozer and heavy disk cutter.

### Mechanical Manipulation of Brush

In suitable areas chamise brushlands may be opened mechanically by heavy disking or by pushing the brush over with a bulldozer blade six inches above the soil (Figures 9 and 10). Pushed-over brush need not be burned. There are several advantages to opening chamise brushlands mechanically. In the first place, a residue is left on the soil, which is helpful in erosion control. The residue protects reseeded grasses against frost heaving and intense heat and drying by the sun. If pushing over brush along ridge tops enables one to start herbaceous vegetation more easily, the practice may provide an added seed source for revegetation when slopes below are burned. This is an important point, for seeding failures are common in burned chamise brushlands, and any assurance of a continuing seed supply is invaluable. Mechanical means can be used in areas where it is too dangerous to attempt burning. Another advantage in mechanical control is that patterns of interspersed brush and grass can be obtained without difficulty.

The chief disadvantages of mechanical removal are that the cost may be greater than strip burning in the spring, and that many areas are relatively inaccessible to mechanical equipment. Pushed-over brush creates quite a fire hazard because much of the brush is killed. On the other hand, heavy disking tends to incorporate the residue into the soil, and the fire hazard is reduced.

### Chemical Treatment

Where the objective is complete conversion to grasses in spots, chemicals are very useful (Leonard and Carlson, 1957). After an area has undergone controlled burning, sprays should be applied to the sprouts and seedlings the following spring after the seedlings have emerged and before the soil is completely dry. Ground applications are more effective than those by airplane. However, ground applications may be very difficult or even impossible in some places because of rough topography. Some species such as interior liveoak and coffee berry (*Rhamnus californica*) may require two or three applications for complete kill.

Tests were made to learn whether chemical sprays could be applied in strips on large wildfire burns to retard development and maintain the brush cover in varying stages of development. This proved possible, but at the same time many of the preferred shrubs were killed. Therefore, the method seems impractical at present. As new knowledge is gained, it may become possible to develop and select sprays to kill certain undesirable species and not appreciably harm the better ones.

Almost any brushland range has certain species that are highly preferred and others that are scarcely touched. If the range is let alone, the better species are gradually weakened and killed, and the poorer ones are free to thrive. One way to break this trend is for the manager to discourage the undesirables deliberately with chemicals. As mentioned above, some species will require two or three treatments for complete kills. This method is expensive.



FIGURE 11. Taken on Perrini Ranch in Lake County where an excellent stand of soft chess was obtained from reseeding after fire. This species is well adapted to poor sites. On the better sites, and particularly above 2,000 feet elevation, perennial grasses did well.

#### RESEEDING CHAMISE BRUSHLANDS

When chamise brush has been removed by burning or disking, reseeding to desirable forage species is advised (Figure 11). The new grasses furnish forage for the deer in winter and spring; help protect the soil against erosion; and provide competition to the many brush seedlings that come after fire (Schultz and Biswell, 1952; Schultz *et al.*, 1955). In other words, the grasses aid in opening dense brushlands. The grasses also may be useful for a reburn if necessary. The County Farm Advisor should be consulted for advice on which species to reseed on each site.

Several annual and perennial species were used in Lake County with good results. On the poorest sites, soft chess (*Bromus mollis*) proved particularly useful and on the better sites, and above 2,000 feet, Hardinggrass (*Pharlaris tuberosa*), perennial ryegrass (*Lolium perenne*), and tall fescue (*Festuca arundinacea*) did well. In some areas legumes may prove useful (Love and Jones, 1952).

In general, seedings made about the middle or latter part of September, shortly before the start of fall rains, were the most successful. Seedings made in the spring or summer after spring burns were not as successful as those made in late summer or early fall. Seedings made in February were complete failures.



## DISCUSSION

Deer management is concerned with two main interrelated objectives: the development and improvement of the habitat, and the control of hunting. This particular study was concerned with the first of these objectives.

It is clear that food quality is an important factor limiting deer populations in chamise brushlands. The animals seem to do best when grasses and forbs grow intermixed with palatable shrubs, and when oaks are available to produce acorns for fall use. If a deer lives in an area where all of these are available, it will eat grasses and forbs in the winter and early spring, brush sprouts in the late spring, succulent herbs and brush sprouts in the summer, and acorns with some browse in the fall. The main group of these elements lacking in most chamise brushlands is herbaceous plants.

Many brushlands grow so densely that grasses and forbs are shaded out or have no growing space. In heavy untreated brush, the new green herbaceous growth which is eaten so avidly in January, February, and March, is nearly absent. Consequently, this forage comprises very little of the food of the deer which live in such an area. If deer are forced to eat dormant brush during the winter months they do not thrive so well as those which also eat herbaceous plants.

In late March or early April the shrubs begin to grow and the deer turn to the new, tender, nutritious shoots of those plants. At that time the deer make their most rapid gains in weight. However, not all shrubs are palatable to the deer—some species are much preferred to others. For example, chamise and western mountain mahogany are taken in large quantity in the early summer, while Eastwood manzanita is scarcely touched. Management, therefore, should strive to cultivate or favor the preferred species. In addition some shrubs are tall and the new growth is not available—deer seldom reach up more than four feet for food. Therefore, deer receive little benefit from such browse no matter how abundant or palatable it might be.

Another sort of availability should be considered. Deer like to feed in the partial open, and will spend more time feeding when the shrubs are separate, or at the edge of a patch, than when the plants are growing densely. So forage produced within dense thickets is not as available. Often people do not understand why there isn't enough deer forage when hills are covered with brush. However, many times the shrubs are not the right kind or they are too dense and tall for the deer to use.

Before any brush manipulation is undertaken the game manager must have a clear picture of what he is trying to attain. Knowledge of both the game population and the plant population in the brush area to be manipulated and managed is essential. On the basis of present information, several steps in the manipulation of chamise brushlands are fairly well understood.

1. The success of opening chamise brushlands is dependent upon the presence of at least a few deer in the general locality. A total absence of deer may indicate a lack of water or some other limiting factor.

2. Some brushlands are better adapted to growing grasses than are others. The more productive areas should be selected first—those where there is reasonable assurance that grasses will grow abundantly.



FIGURE 12. Chamise brushland in Lake County, with fire lanes established in preparation for control burning.

3. Whether fire or mechanical means are used in opening dense brush depends largely on the risk of using fire, brush cover conditions, terrain, etc. Where the vegetation is predominantly chamise on south exposures and mixed chaparral on north exposures, spring burning may be done without very high risk. The south-facing chamise slopes can be burned on days of relatively low humidity and with proper wind velocity and direction, from February through May, for then the north-facing slopes of mixed chaparral are not very likely to burn. On quiet days, fires lit at the bottom of the chamise slopes usually go out at the ridge tops (Figure 12). One or two men equipped with flame throwers can usually do the burning. Throughout the period from February through May, there will be many days when it is too moist to burn and others when it is too dry to use fire safely. Where fire is used, permission must be obtained from the District Ranger of the State Division of Forestry.

4. Where chamise brush occupies all exposures, and is of uniform density, the risk of using fire is greater than it is where the type of brush varies with exposure. Where grass borders the brush, burning when the grass is green adds an element of control. However, it may be dangerous to burn at any time when the wind is high and the humidity below 25 percent.

5. Where conditions for burning are hazardous and the terrain is not too steep, mechanical means may be used to open the brush. Usually this method is more costly than controlled burning. Chemicals are necessary where the objective is complete conversion to grasses in the open spots.

6. The extent to which a brush area should be opened depends almost entirely on the deer population present. Where a square mile has less than 10 deer, a half dozen scattered, opened areas, each of about five acres, may be sufficient. Where the deer population is greater than ten

per square mile, a correspondingly larger number of areas should be opened. If the new sprouts are browsed so heavily that a majority of them is killed the first season, then a larger number of spots should be opened the next year. On the other hand, if browsing is light, it is desirable to wait two or three years before additional spots are opened. Approximately 25 percent of the area should be left in well distributed, dense brush as cover for game.

7. All areas cleared of brush should be reseeded to adapted forage plants before the first fall rains. If the reseeding is not done by that time, however, it is still not too late to seed soon after the first rains, but with less satisfactory results. Insofar as possible, species valuable for forage and watershed cover should be used. It is wise to contact the local County Farm Advisor for advice on species to reseed. Where too much area is covered in the initial burn for deer to suppress sprout growth, it may be necessary to reburn in spots to retard sprouts. This should be done two to four years after the first burn, where reseeded grasses still carry the fire. In general, however, as little reburning as possible should be done for this tends to eliminate certain of the valuable non-sprouting species, and may also result in opening the brush too much. Insofar as possible, sprout growth should be retarded by deer browsing, and areas should be maintained in open condition in this way. When areas are properly opened, every care should be taken to avoid wildfires for these are likely to upset the proper interspersed of brush and herbaceous plants, and may not leave enough dense brush cover for deer.

8. In the end, attention should be given to grazing management, especially where animals other than deer use the range. The general objective should be to leave enough grass residue on the ground for an effective watershed cover, and to maintain a high level of fawn production without depletion of range carrying capacity. Where the browse species are properly utilized the grasses are likely to be properly grazed, too. Areas fully stocked with deer will scarcely support any cattle or horses because the additional animals would result in too close grazing. Utilization by sheep is similar to that by deer; where both kinds of animals use the range, proper allowance must be made for each.

9. When the range has been fully developed or improved and the deer population has increased to full range carrying capacity, the second phase of deer management should come into play—that of harvesting the excess deer through control of hunting. It would seem wise that the annual increment be harvested each year in order to keep the herd healthy and to reap the benefits of investments in habitat improvement.

#### SUMMARY

Studies were made of the extent to which deer populations increase with brush cover manipulation, and of methods of developing and improving brushlands for deer. An opened area of brushland was compared with one of heavy untreated brush as a control, and with another burned by wildfire.

Deliberate opening of chamise brushlands in spots made for a favorable interspersed of grasses and forbs, browse, and cover. Deer populations in summer, in opened brush, were about three times greater than those in heavy untreated brush. Populations in a wildfire burn were about equal to those in opened brush for a few years after the fire but then gradually declined as the brush grew back toward its former mature condition.

The general objective in the manipulation of chamise brushlands for game should be to reduce the brush cover in spots and introduce palatable herbaceous species for use in winter and early spring. Methods for doing this are controlled burning and grazing, mechanical means, such as bulldozing and disking, and chemical treatment. Usually a combination of these methods will serve best. Reseeding to desirable forage and watershed plants should follow in places where brush has been removed by burning and disking.

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