MANAGEMENT OF CHAMISE BRUSHLANDS FOR GAME IN THE NORTH COAST REGION OF CALIFORNIA[1]

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INTRODUCTION

This study was begun in the spring of 1948 to investigate the possibility of managing chamise brushlands for game, the primary purpose being to determine whether game populations will build up under brushland management, and, if so, the most satisfactory way of manipulating the cover to increase game production. The investigations have centered mainly in Lake County, but have not been entirely limited to that area. In California, there are about 7,300,000 acres of chamise brushlands (Sampson, 1944). They are important in the interior Coast Range from Trinity and Shasta Counties south to San Francisco Bay. The chief center of their distribution, however, is in the southern Coast Range; smaller isolated units are found in the Sierra Nevada foothills. The chamise brushlands have been looked upon chiefly as valuable for game and watershed but little has been done in the way of management for either purpose. The rapid increase in population of the State, producing a corresponding increase in water demands, results in a greater need for good watershed management. Also more productive game areas are needed because there are more hunters and a greater need for meat, and as well a greater amount of time to be spent in recreation.

This paper should be looked upon as a progress report since the study is still under way and the results may change with a greater accumulation of data. It is recognized that more data are needed on nearly every phase of the project. The investigations are being carried on cooperatively between the University of California and the California Department of Fish and Game with funds provided by federal aid in Wildlife Restoration Act, Project California 31-R. Most of the wild life studies were made by R. D. Taber, the plant studies by the other investigators.

The authors express gratitude to the many persons who assisted in various ways on the project. The studies were suggested by Ben Glading, Chief of the Bureau of Game Conservation, California Department of Fish and Game. He foresaw a need for information of this sort in developing sound game management policies for the Bureau of Game Conservation. Dan Tillotson, also of the California Department of Fish and Game, has been in general charge of Pittman-Robertson projects and helped in many ways. Many students in the University of California helped at various times. Professor R. E. Storie of the university examined the soils, and Dr. J. Vlamis made the soil fertility tests. The food analyses of deer stomachs were made by Carol Ferrel and Howard Leach of the fish and game

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laboratory in Berkeley. Merton Rosen, Arthur Bischoff, John Azevedo, and Alvin Hightower assisted in collecting the deer and making parasite examinations. Gratitude is expressed also to ranchers in the area for their generous cooperation, and especially to Glen Keithly for the benefit of his keen observation and the information he gave on brushland management. He is a pioneer in this work, having started a program of brush control for sheep and deer years earlier. Much of the work presented here was done on Keithly's ranch.

Appreciation is expressed to the following who critically read the manuscript: Keith Arnold, H. F. Heady, W. E. Howard, A. S. Leopold, W. M. Longhurst, R. M. Love, A. W. Sampson, K. W. Wagnon, University of California; W. P. Dasmann, Ben Glading, Dan Tillotson, Department of Fish and Game; L. T. Burcham, State Division of Forestry; F. P. Cronemiller, M. W. Talbot, U. S. Forest Service; R. M. Bond, Soil Conservation Service; G. H. Sharrer, Bureau of Land Management; E. N. Dye, Ralph Leavers, California Farm Bureau; N. M. Hughes, Associated Sportsmen; Glen Keithly, rancher.

DESCRIPTION OF CHAMISE BRUSHLANDS

The brushlands studied are typical of western Lake County and much of the North Coast ranges. Data on vegetation, soils, and climate are taken from the study areas, or nearby, but are applicable to a much greater range.

Vegetation

In general the chamise brushlands in Lake County comprise two cover types, those in which chamise (*Adenostema fasciculatum*) predominates and those which contain a mixture of broad-sclerophyll shrubs and small

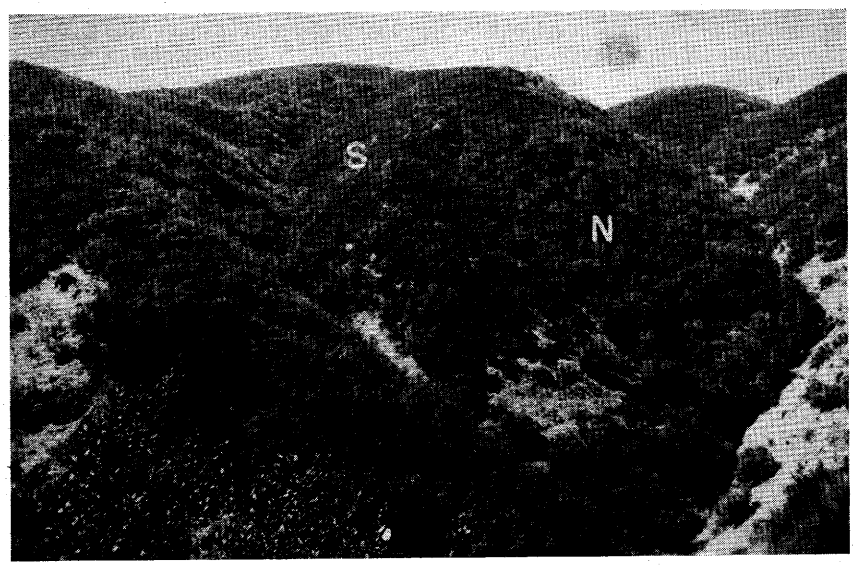

FIGURE 1. Close view of chamise brushland in Lake County. Chamise predominates on the south-facing (S) exposures while a mixture of taller broad-sclerophyll shrubs and small trees are found on the north-facing (N) slopes. Lake County brushlands have long been famous deer hunting grounds. Water from springs is well distributed in the ravines.

trees. The chamise occurs mainly on south-facing slopes and drier sites while the mixed chaparral is found on the more mesic north exposures and in ravines (Figure 1). This intermixture of chamise and mixed chaparral is especially favorable for deer. A majority of the shrubs and small trees are good or excellent browse species. The intermixture of browse plants in Lake County is probably as favorable for deer as most chamise brushlands in other portions of the State. Some brushlands are so nearly pure chamise that they furnish relatively poor browse.

On south exposures in Lake County chamise often occurs in relatively pure stands, depending primarily upon the age of the stand and fire history, but usually it occurs with admixtures of lesser amounts of wedgeleaf ceanothus (*Ceanothus cuneatus*), wavyleaf ceanothus (*C. foliosus*), Stanford manzanita (*Arctostaphylos stanfordiana*), poison oak (*Rhus diversiloba*), yerba santa (*Eriodictyon californicum*), and others. The ceanothus species above, which are nonsprouters, are in greater abundance in young or recently burned chamise stands that have not been repeatedly burned in close succession.

The north-facing slopes are vegetated chiefly by interior live oak (*Quercus wislizenii*), scrub oak (*Q. dumosa*), Eastwood manzanita (*Arctostaphylos glandulosa*), California laurel (*Umbellularia californica*), toyon (*Photinia arbutifolia*), birchleaf mahogany (*Cercocarpus betuloides*), deerbrush (*Ceanothus integerrimus*), chamise, and others, roughly in that order of abundance. Interior live oak frequently makes up half of the cover.

Other species may predominate or become more important in special sites. In wetter situations, madrone (*Arbutus menziesii*) and canyon live oak (*Quercus chrysolepis*) are common. Knob-cone pine (*Pinus tuberculata*) is frequent on certain soil types. On ridgetops chaparral pea (*Pickeringia montana*) is more abundant than on either north- or south-facing slopes.

The brush canopy on all sites is usually so complete as to preclude much herbaceous vegetation as understory.

Soils

The soils on south exposures where chamise occurs in the study areas are derived from consolidated sedimentary rocks. The shallower and least productive ones have developed on parent materials which have undergone the least metamorphosis. The Maymen series is typical of this group and occurs most extensively. These soils are less than 12 inches deep and are light brown in color, moderately acid, and vary from clay to clay loam in texture. They are relatively low in fertility. Soils of the Dorado series, which usually occupy the lower edge of the chamise slopes, are formed on sediments having undergone an intermediate amount of metamorphosis. They are deeper than the Maymen, 12 to 18 inches, less acid, and light reddish-brown in color.

On north exposures the soils are generally deeper and darker in color than those on south exposures. Some are a deeper phase of Maymen, ranging in depth from 12 to 24 inches. The Los Gatos series, intermingled with the Maymen and usually supporting a mixed stand of brush with occasional knob-cone pine trees, are soils developed on the more highly metamorphosed sediments and are general underlain by more

massive rocks. They are 18 to 24 inches in depth, moderately acid on the surface, and are reddish-brown in color. Laughlin soils may occur where chamise contacts or invades into woodland-grass. This series is characterized by depths of 24 to 30 inches, medium to fine texture, and slight acidity. The soils are light brown to light reddish-brown in color and are formed on residual parent material. They are relatively fertile soils and support fairly heavy stands of herbaceous vegetation where the brush is removed or thinned out.

Soils from the study areas were tested for fertility by using pot tests conducted in the greenhouse by the Soils Division of the University of

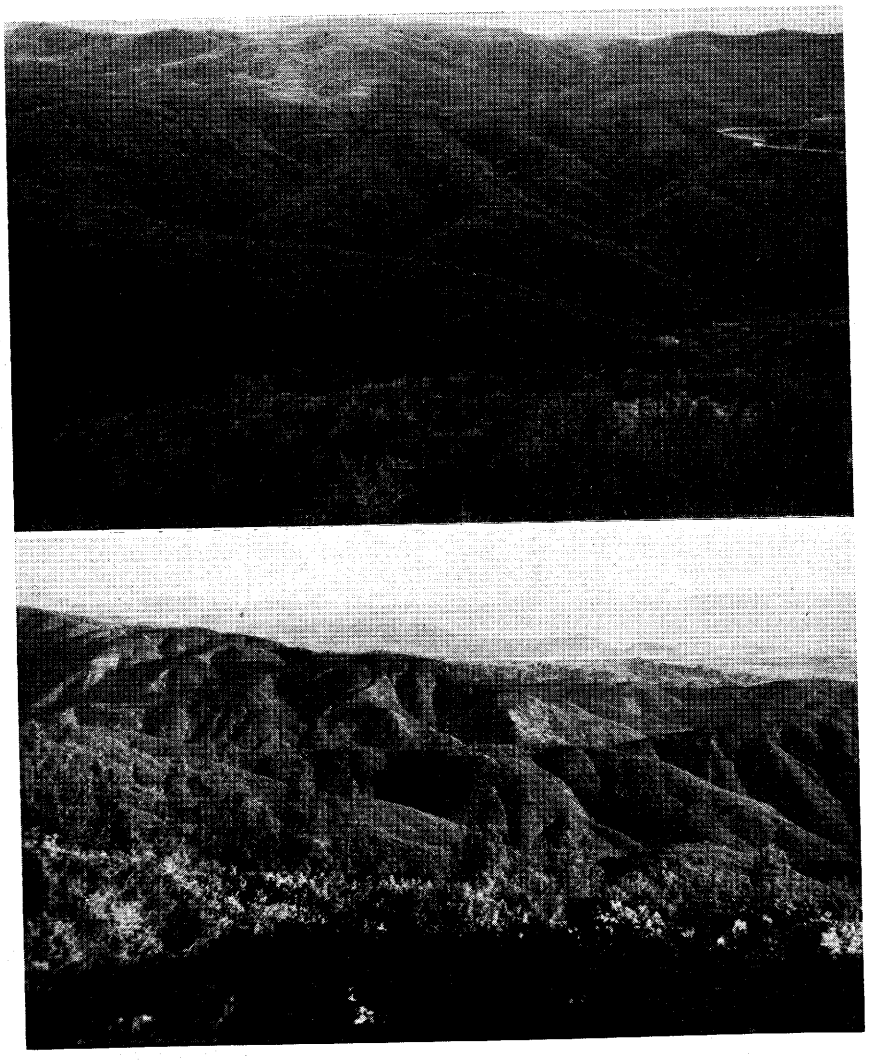

FIGURE 2. Chamise brushlands in Lake County. Some are not excessively steep while others are rugged and somewhat inaccessible.

California at Berkeley. Results of these tests indicate that chamise-covered soils are generally low in nitrogen even when the woody vegetation has not been disturbed over a long period of time.

It is generally recognized that a majority of chamise brushland soils are low in fertility. On the study areas the Maymen soil was the most extensive and least productive; perhaps it forms a larger area than any other chamise brushland soil in California. Probably the second most extensive chamise brushland soil in California is Los Gatos. This is considered more productive than Maymen. Another frequently occurring chamise soil, perhaps the third in rank, has not yet been named but contains a large amount of granitic material. The fertility of the latter soil is considered about the same as that of Maymen. Serpentine soils are about the poorest of all. Chamise also occurs on several other soils, a majority of which are more fertile than those named above. Some are relatively deep and have been cleared for agricultural crops.

Slopes where chamise occurs are generally rather steep (Figure 2). On the study areas in Lake County they averaged about 20 to 25 degrees. In some chamise brushlands the average slope is greater.

Climate

The weather station nearest to the study areas is at Lakeport, on the west shore of Clear Lake, about three to eight miles away. The mean annual temperature recorded there is 57 degrees F., the extremes varying generally from about 20 degrees to 110 degrees.

Mean annual precipitation, based on a 30-year average, is 28 inches. Practically all of this comes as rain between late September and April, inclusive; consequently, the summer months are extremely dry. Since the vegetation becomes very dry during summer, the possibility of large acreages of brush being destroyed by fire is high. Water becomes less abundant along drainage ways as the dry season advances but many of the springs maintain their flow throughout the summer.

The same general pattern of temperatures and rainfall characterizes all chamise brushlands in California. The brushlands usually occur where the precipitation is between 14 and 40 inches. Where rainfall is 14 inches and below the chamise becomes open and desert-like in appearance and above 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.

PRESENT LAND MANAGEMENT PATTERN

Chamise brushlands have been generally looked upon as valuable for game and as watersheds. Some are used in sheep production. They are more suitable for sheep than cattle because of steepness of slopes and the predominance of browse. Poisonous plants occur on many chamise brushlands. Little effort has been made to manage these lands.

Usually the intention of public agencies has been to protect chamise brushlands from fire, but, in spite of this, wildfires occur frequently (Figure 3). Some of the wildfires have been large and destructive (Figure 4). Some people wonder if large fires are not to be expected where total protection is attempted. As a result of protection the brush is permitted

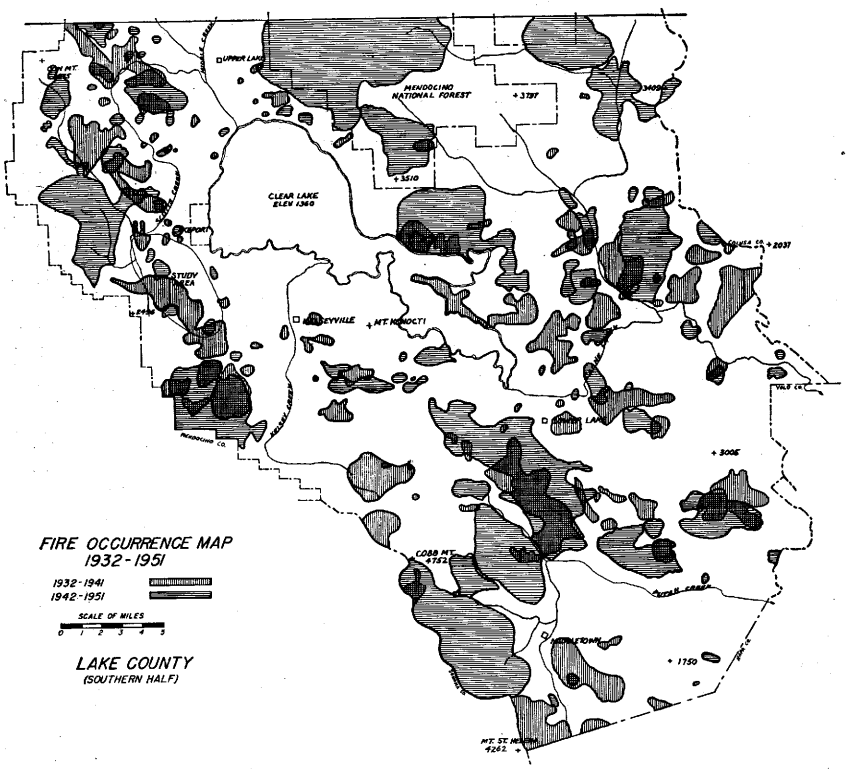

FIGURE 3. The shaded portions indicate areas burned by wildfires. Much of the unshaded portion is agricultural land. It appears that a majority of the brushlands in the southern half of Lake County burn at least one time in each 20 years. Fire records were furnished by the State Division of Forestry. The map does not show all of the fires but attempts to show all the area burned at least once by wildfires in each of the 10-year periods.

to grow up uniformly and within about 25 years much of it becomes dead fuel; this material greatly increases the fire hazard. When fires are started in this kind of cover they are difficult to control and are likely to be large and destructive. Limited "spot burning" in the spring months has been suggested as a means of reducing the hazard of such fires. In fact, burning of this nature was initiated in Lake County in 1950-1951 by personnel of the county board of supervisors, State Division of Forestry, county farm advisor, Fish and Game, and private landowners. Plans call for limited burning in the spring to reduce fire hazard around cultural developments and also to decrease the possibility that large wildfires will occur during summer. Another purpose of spot burning is to improve conditions for game.

Areas burned by wildfires are usually not reseeded and the soil is nearly bare the following winter. In the second winter the soil is fairly well covered with sprouts and brush seedlings. Then within 8 to 12 years the brush stand is well developed and becomes nearly impenetrable. During these years little dead wood or litter is produced and fire presents no particular problem (Buck, 1951). If it were not for this period of

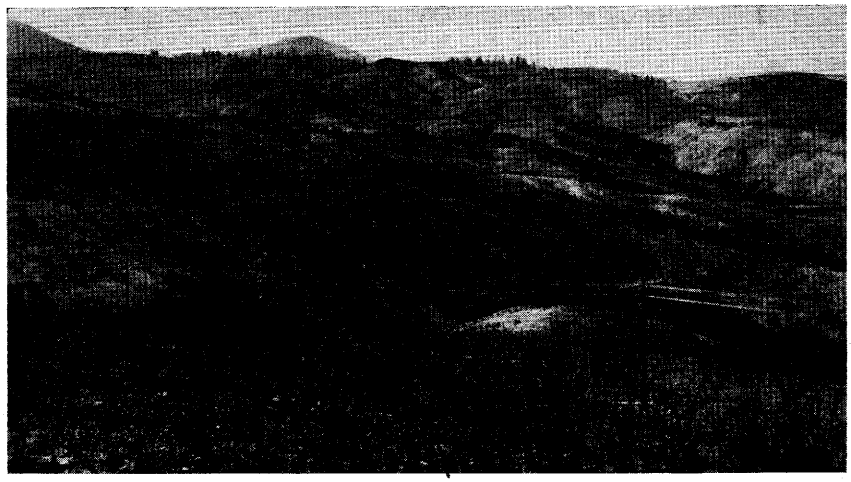

FIGURE 4. Wildfire burned area of 6,000 acres in Lake County. Wildfires are frequent and often large and destructive. In this case the fire burned so intensely that insufficient unburned brush remained as cover for game.

reduced fuel following wildfire burns in dense brush, fires would probably occur more frequently than at present and would also be larger and more uniform in intensity.

Game populations in or around wildfire burns usually build up while the brush is young and palatable but then decrease or move out when the brush grows up. Of recent date controlled burning and other manipulation of brush to improve conditions for game has gained popularity. Some areas are reseeded to herbaceous plants and managed following brush removal; some are not.

There has been some question as to watershed conditions under chamise brush and the effects of fire on erosion. Investigations by Veihmeyer (1951) have shown that small plots burned annually convert largely to grass and in this condition there is less erosion than from undisturbed areas of chamise. Studies by Colman (1951) and others have shown that erosion accelerates following occasional brush fires in chamise and may continue for at least eight years. The latter studies were in areas not reseeded to grasses, where little herbaceous vegetation occurred. Both sets of studies would indicate that chamise is a relatively poor watershed cover, especially since such brushlands burn frequently. More studies are needed on the feasibility of converting chamise brushlands to a cover better adapted to prevent erosion. Both grass and trees offer considerable promise for this purpose but studies on the possibilities of manipulating vegetation to improve watershed conditions have scarcely begun in California.

It has been observed many times that the surface soil is loose following fires in dense brush and is easily moved downhill by deer feeding over slopes. On steep slopes considerable soil may gradually be moved to the bottoms of drainageways. This is washed away during winter storms. On the other hand, the soil is usually firm in areas of burned grass and little movement takes place. Again, the observations indicate that grass shows

promise of lessening soil erosion in the presence of fires. Differences between grass and brush covers may be summarized as follows: Fires in grass are less intense than those in brush; the grass seeds and residue are not all destroyed; the grass begins growth following fall rains and soon covers the soil; the soil is firm following fire. In dense brush, on the other hand, the fires are intense; the soil is loose and bare the following winter; the shrubby vegetation recovers slowly.

GAME POPULATIONS AS RELATED TO BRUSHLAND MANAGEMENT

Game populations were studied in Lake County under three different conditions of chamise brushland: (1) Heavy brush cover protected from fire; (2) Wildfire burn, in which there were a few unburned islands the first winter, followed by the presence of brush sprouts, seedlings, and a small quantity of herbaceous cover the second year; (3) Opened brush, consisting of small burned patches within dense brush seeded to suitable herbaceous plants (Figure 5). Area of each condition was about 1,000 acres.

Detailed investigations were made on the Columbian blacktailed deer (*Odocoileus hemionus columbianus*). During the course of this work observations were made of the California jackrabbit (*Lepus californicus*), brush rabbit (*Sylvilagus bachmani*), mountain quail (*Oreortryx picta*), valley quail (*Lophortyx californica*), and mourning dove (*Zenaidura macroura*).

Deer Populations

The deer of this region are resident rather than migratory, but they do make short seasonal movements which depend on weather conditions and food supplies. Population densities were determined by pellet censuses checked by sight records. The number of deer on the study areas in heavy brush ranged from averages of 10 to 30 to the square mile, in the wildfire burns from 5 to 160, and in the opened brush from 40 to 110. Where surrounding food conditions are poor, a wildfire burn of newly sprouting brush will attract large numbers of deer. However, all of these deer may move to better cover in bad weather; also, the burned area loses its attractiveness very rapidly as the sprouts grow up and become less palatable. Over a period of years extensive wildfire burns support lower average deer populations than opened brush because there may not be enough deer to keep the sprout growth in a palatable stage.

Search for basic factors governing deer population densities in the different brush covers included the investigation of fawn production, the weights or relative condition of individual deer on the three study areas, and food habits and comparative nutrition.

Fawn Production

Studies on collected does indicate that fawn production is governed largely by ovulation rate. Ovulation rates in adult does (18 months and older) were approximately as follows: In heavy brush, 84 percent; on wildfire burn, 116 percent; in opened brush, 147 percent (Taber, 1953). Although the doe collection consisted of only 42 individuals, reliance on these figures is strengthened by the fact that they correspond closely to

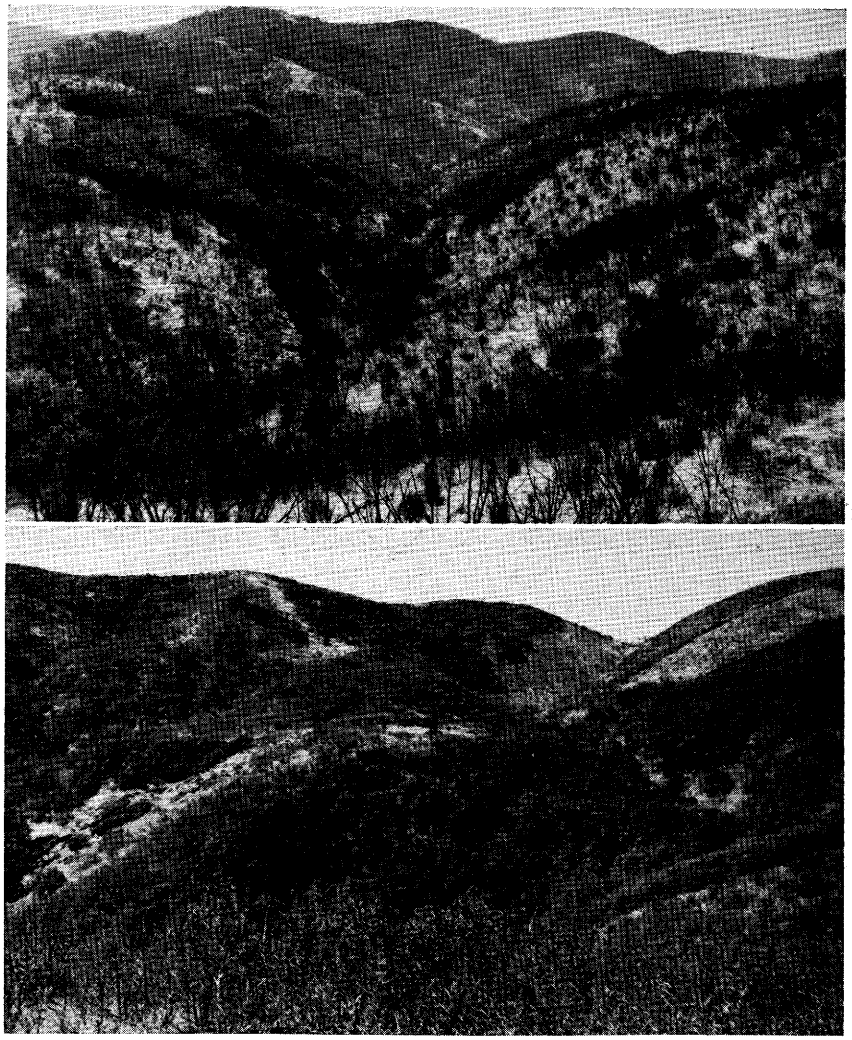

FIGURE 5. Areas of opened brush produced by spot burning. The interspersion of grass and brush forms a favorable habitat for deer. During late winter and early spring the deer graze heavily on the grasses. The spots of dense brush form necessary cover.

the ratio of fawns to 100 adult does following the rut. This ratio varies somewhat from year to year, but the following values seem to be representative for the areas under study: in heavy brush, about 60 to 85 fawns per 100 adult does; on the wildfire burn about 100 to 110 fawns per 100 adult does; in opened brush, about 115 to 140 fawns per 100 adult does. A change in the fawn: doe ratio between the fawn drop and the rut obviously may be brought about by either fawn or doe mortality. Therefore the ratios do not necessarily represent an extremely high fawn survival. Actually there is evidence of some mortality among both does and fawns during the summer.

Deer Weights

Skeletal size differences between deer of the same age for the different brush cover conditions seem to be either small or absent. Therefore, comparing weights of deer of the same age gives an indication of relative condition rather than comparative size.

The weights of 23 bucks taken from the heavy brush and the opened brush during the hunting season are compared in Table 1. The bucks are grouped by antler beam diameter, the first class (15-19 mm.) containing mostly young bucks and the second class (19.1-23 mm.) containing those of medium age. Weights were obtained with the paunch out but all other organs present.

TABLE 1

Field-dressed Weights of 23 Bucks From Two Conditions of Brush Cover, 1949 (.2 Level of Significance)

Beam diameter	Heavy brush		Opened brush	
	Weight, pounds	Number of deer	Weight, pounds	Number of deer
15-19 mm.	66.0±3.73	9	75.5±4.99	6
19.1-23 mm.	81.0±7.7	5	86.5±6.66	3

Bucks from opened brush tend to be heavier than those from heavy brush with this tendency being greater in young than in medium-aged deer. The bucks from a recent wildfire burn tend to be about as heavy as those of similar age from opened brush. They also tend to have more massive antlers.

A sample of does taken in late winter and early spring indicates that those from opened brush tend to be in the best condition, those from the wildfire burn intermediate, and those from heavy brush poorest. This difference is most distinct in yearling and very old does and less so in those of medium age.

Food Habits and Nutrition

The deer in opened brush have access to much more herbaceous forage than those in the wildfire burns or those in the heavy brush, and their diet consists largely of herbs in the late winter and early spring.

In the interpretation of results, it should be remembered that the browse species start rapid spring growth in April, putting forth many succulent sprouts. In the opened brush it may be seen that herbaceous forage was preferred during February and March, and that browse consumption rose during April and herbaceous species were taken heavily again in May. Thus where the deer had both woody and herbaceous plants available they seemed to prefer the more succulent forage. In the wildfire burn, where there was much less herbaceous forage, the deer tended to take herbs whenever available except in April when the tender brush sprouts were emerging. In the heavy brush, herbaceous material was practically absent and the deer had to subsist on browse, regardless of preference. These findings illustrate that herbaceous plants are heavily

TABLE 2

Summary of the Food Habits on Each Area for the Late Winter and Early Spring Months

	Brush type											
	Heavy brush				18-month-old wildfire burn				Opened brush			
Month	Feb.	Mar.	Apr.	May	Feb.	Mar.	Apr.	May	Feb.	Mar.	Apr.	May
Number of deer	3	3	3	10	5	4	6	1	5	4	5	3
Percent volume Herbaceous	2	3	1	5	1	41	1	65	70	97	50	86
Browse*	98	97	99	95	99	59	99	35	30	3	50	14

* Including acorns.

utilized during late winter and spring when most succulent. The nutritional intake of deer which have abundant herbaceous forage appears to be highest. Mature browse is of low nutrient value compared to growing herbs, except for a short spring period of rapid growth (Gordon and Sampson, 1939). This is especially true of nondeciduous browse species such as chamise, interior live oak and wedgeleaf ceanothus, which were among the staple browse plants in the study areas. During late summer and fall the deer on all areas subsist largely on browse. Analyses have shown that crown-sprouts of chamise on burns have a higher nutritional content than older growth stages of the same plants (Reynolds and Sampson, 1943).

While the whole question of nutrition has not yet been thoroughly explored, there is evidence to indicate that the opened brush and the heavy brush may be compared for annual diet in the following manner: In the opened brush, the deer have available an excellent diet during four months of the year, foraging on abundant herbs and new sprouts (February-May), a good diet for another four months (November, December, January, June) when some green herbs are available and sprouts are still growing in the spring and early summer, and a poor diet during the remaining four months (July-October) when the herbs are dry and the browse plants are more or less dormant. In the heavy brush the deer have access to an excellent diet only two months of the year (April, May) when the brush is growing rapidly, a good diet during two months (March and June) when there is some shrub growth, and a poor diet for eight months (July-February) when there is little growth and the shrubs are largely dormant. In a wildfire burn the amount of succulent browse available in winter depends on when the area burned. If the fire is very late in the season there will be practically no crown sprouting until the following spring.

The difference in nutritional planes is probably based on adequacy of assimilable protein and phosphorous in the opened brush and a lack of these elements in the heavy brush. The basis for the differences in population density, fawn production, and condition of individual deer among the various brush cover conditions is probably to be found in differences in nutrition of these cover types.

Resident Small Game Populations

The small game population density estimates given below are based on strip-counts and observations for the quail, pellet counts for the jackrabbit, and general observations for the other species.

Valley Quail. In the heavy brush and in wildfire burns the valley quail population density in late summer seems to be about 100 birds per square mile at altitudes of 1,500-2,000 feet. At higher altitudes (2,000-2,500 feet) the population density is lower, perhaps as low as 40 per square mile. In the opened brush (1,500-2,000 feet) late summer populations of 250 per square mile have been observed. Opening the brush definitely encourages valley quail.

Mountain Quail. In heavy brush and in wildfire burns the mountain quail population density in late summer appears to be between 50 and 80 birds per square mile at altitudes of 1,500-2,000 feet. At 2,000-2,500 feet the late summer density is higher, perhaps 160 birds per square mile. In the opened brush at altitudes of 1,500-2,000 feet as many as 140 to 150 birds per square mile have been observed in late summer. While these findings seem to indicate that opening the brush encourages mountain quail, the secretive habits of these birds may lead to error. It is possible that the apparent higher densities in open brush are due to the better visibility there. This is supported by the opinion of Mr. Keithly, who believes that during the decade that he has been opening his brush the mountain quail population has not increased at all, even under complete protection.

California Jackrabbit. In the heavy brush the density is very low, about one jackrabbit per square mile. In the wildfire burns it is from 5 to 10 per square mile. In the opened brush the jackrabbits reached the greatest density found, fluctuating between 10 and 45 per square mile. The highest counts were made in summer.

Brush Rabbit. Brush rabbits are numerous in the heavy brush and in and around islands of heavy brush in wildfire or opened brush areas.

Mourning Dove. Dove populations in the heavy brush are low. They are higher in the wildfire burns and highest in the opened brush. This refers to breeding density.

It seems evident that 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 (cf. Burcham, 1950). In the opened brush are found not only the densest populations of most small game, but also cover which is most suitable for upland hunting. Even species such as the brush rabbit and mountain quail, which seem to be more numerous in the heavy brush than in the opened brush, may be hunted more successfully in the latter areas. It is almost impossible to hunt small game in heavy brush, especially after the first fall rains.

STUDIES ON METHODS OF OPENING CHAMISE BRUSHLANDS

Based on 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, introduce herbaceous species where needed, and keep the browse plants in a productive condition. Opening dense chamise brushland provides a desirable interspersion of food and cover. If herbaceous species that are naturally or artifically seeded become abundant

in opened brushlands they help to stabilize the soil and markedly improve the forage for game animals. When grazed properly the good browse plants can be maintained in a productive condition over a long period of time. Once chamise brushlands are properly opened and the growth of herbaceous species is encouraged, good management should keep them productive with a minimum of further disturbance.

Methods studied in opening chamise brushlands are burning and grazing, mechanical means, and chemical treatment. Seeding of desirable forage plants should generally be combined with any of these methods to increase chances of establishment of 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 burning and grazing. Although 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

Season of Burning

From the standpoint of game management, either spring or late fall burning has proven satisfactory in opening chamise. Spring burning, before the grasses outside of the brush areas become dry, has been relatively easy with reasonably good success in 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 with the result that it will burn uphill (Figure 6). Usually the fire will not spread to the sides and will go out at the top of the slope. Areas of decadent brush, containing considerable dead material, will burn easiest and here firing should be started when the humidity is relatively high. Late fall burning is slightly more hazardous than spring burning. Usually more elaborate preparations are needed for fall burning than for spring burning. Information on techniques in burning may be obtained by reading *Use of Fire in Land Clearing* by 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. The inexperienced should start under the instruction of someone competent in the proper use of fire. Manipulating brush by fire is not easy. It requires considerable planning, care, effort, and patience to do a good job.

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

Studies have not yet 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 of burning 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 months. However, studies thus far indicate that few brush seedlings appear on spring burns. This would mean that sprouting species, such as chamise, are favored over nonsprouters, such as wedgeleaf ceanothus. If this is borne out by further studies on burns made before seed maturity, the composition of the brush cover for deer may be adversely affected by spring burning. Some fall burning may be necessary then to provide

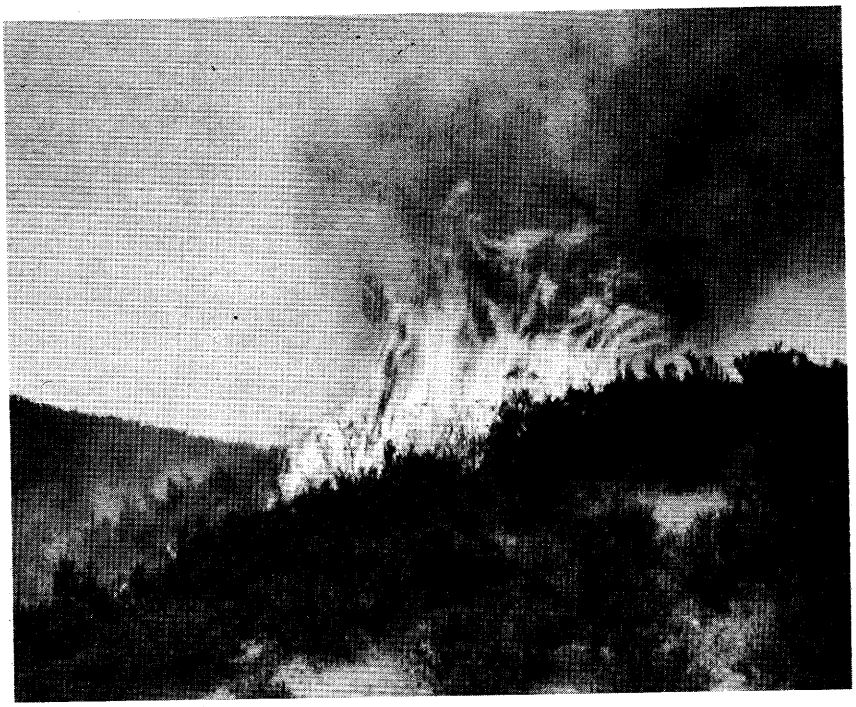

FIGURE 6. Controlled "spot" burning in May in chamise. The fire was lit at the base of the slope with the result that it burned uphill. It did not spread to the sides and went out at the top of the slope. The burning was done on a clear day when the humidity was about 27 percent. Grasses outside of the brush area were still green.

young plants of wavyleaf ceanothus, wedgeleaf ceanothus, and other valuable nonsprouting browse plants. Further studies are needed on this phase of brushland management.

Control of Sprouts

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 one of the most effective tools for this purpose 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, interior live oak 30 to 40 inches (Figure 7). Thus, unless the sprouts are browsed they soon become so large as to be more or less useless as food for game. Deer and sheep are effective in controlling sprouts by suppressing height growth and by killing some of the plants the first season following burning (Figures 8, 9, 10). Failures in brush control and reseeding in chamise brushlands occur often due to lack of sprout control. The sprouts must be suppressed if brush control and reseeding are to be successful in such brushlands. Not enough attention has been given to this phase of management.

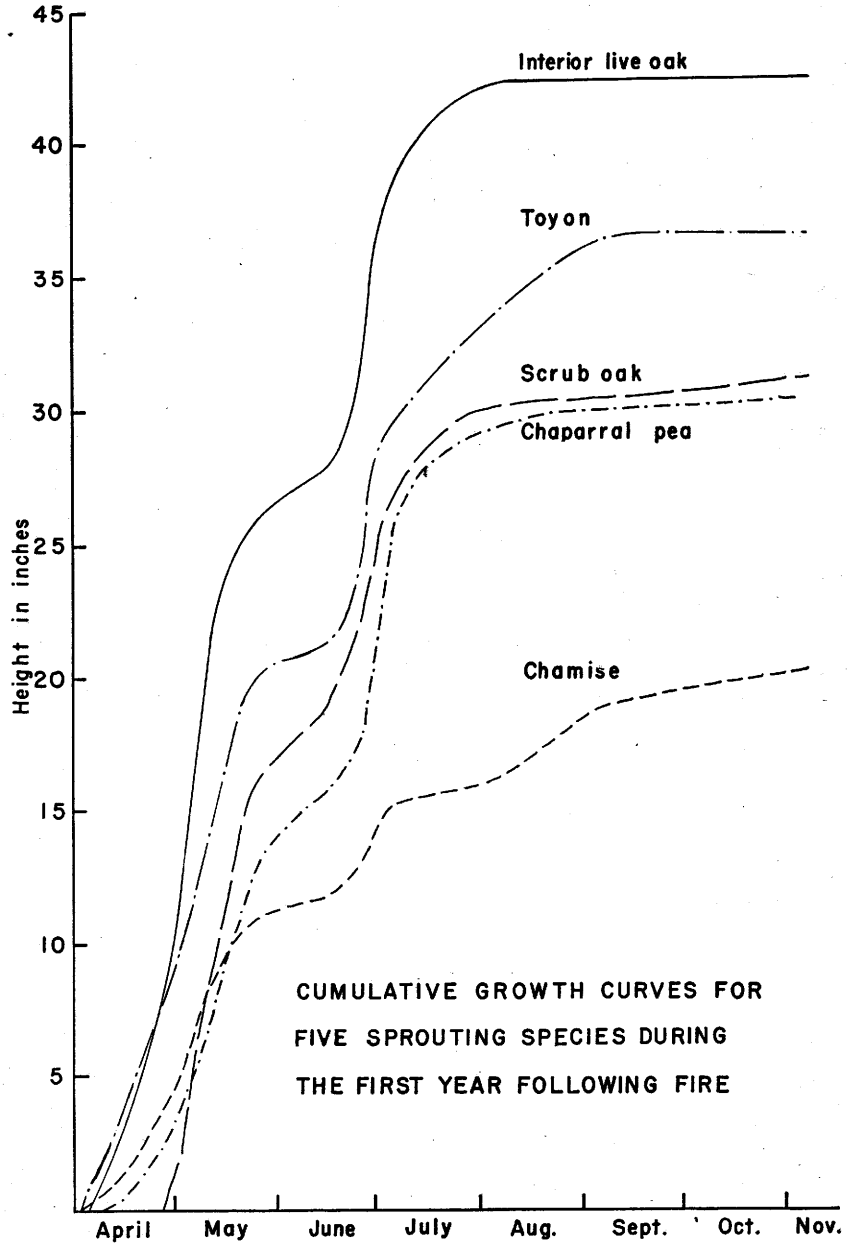

FIGURE 7. Sprout growth control is an essential step in opening chamise brushlands. Without utilization the sprouts grow rapidly, soon become unpalatable and of little use as food to deer. Curves represent growth in one year of several important browse species in the absence of grazing.

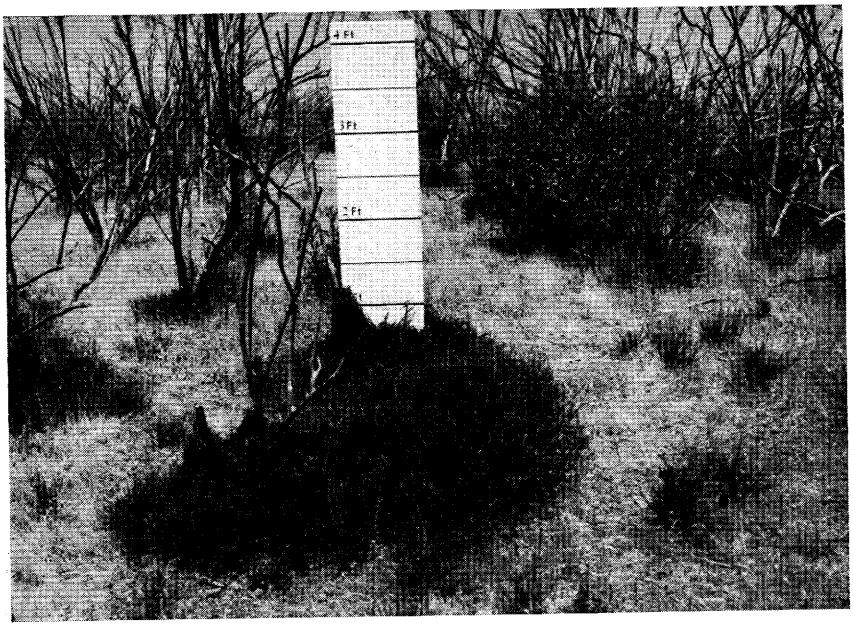

FIGURE 8. On this south-facing slope, burned in 1945, a large population of deer has kept the sprouts (large plants) and seedlings (small plants) browsed down and in productive condition. The deer also made good use of the grass. Photo taken in 1951.

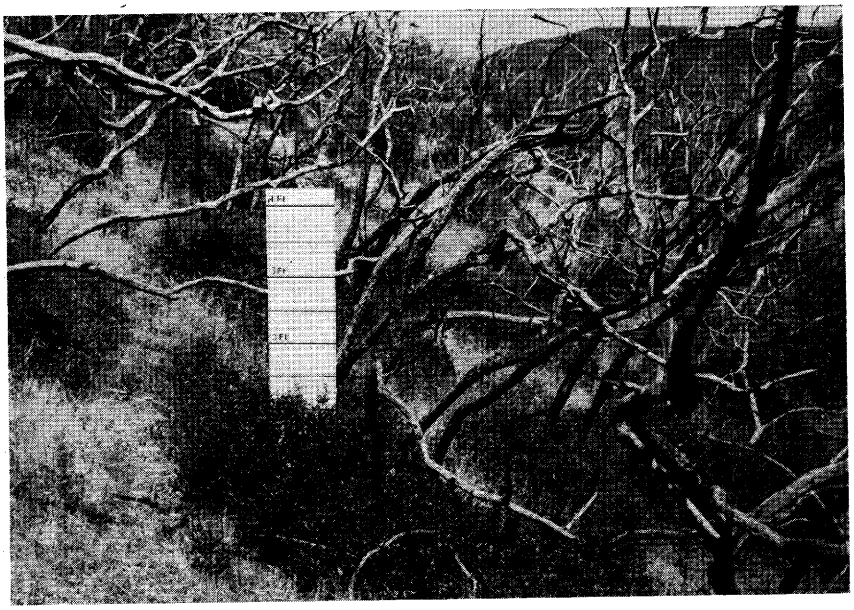

FIGURE 9. This north-facing exposure of mixed chaparral was burned in 1945. Heavy browsing by deer has kept the brush low and productive. Photo taken in summer, 1951.

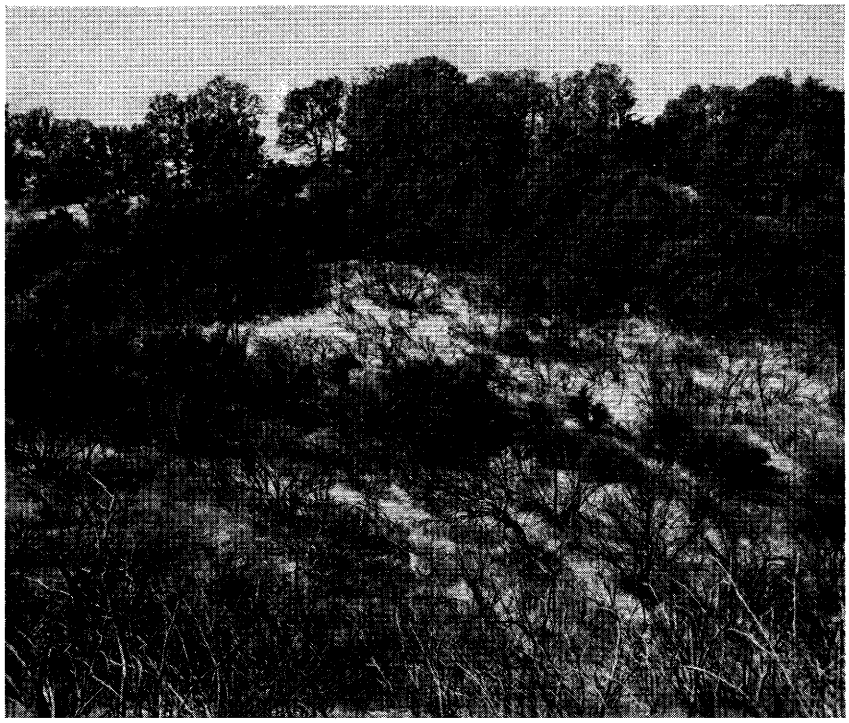

FIGURE 10. Very heavy browsing by deer the first year after burning killed most of the sprouts, but seedlings survived and will continue to furnish browse. Grassy spots in brush furnish valuable forage for deer in late winter and early spring when the herbage is green and succulent.

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 (Figure 11). Even light browsing by deer considerably suppresses 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.

Heavy utilization from year to year will continue to suppress sprout growth (Figure 12). A majority of plants browsed heavily for five years averaged only 17 inches in height while plants protected from browsing averaged between 22 and 32 inches in only two years. Sprouts protected entirely from browsing for five years were not available for comparison.

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 six to eight inches tall the stiff stems prevent the deer from grazing so close as to kill the plants. On a seven-year-old burn no plants of chamise were killed by heavy browsing in the past two years.

In August, 1948, about 25 acres of old brush burned along with some 300 acres that had burned in 1945. This area supported an estimated 100

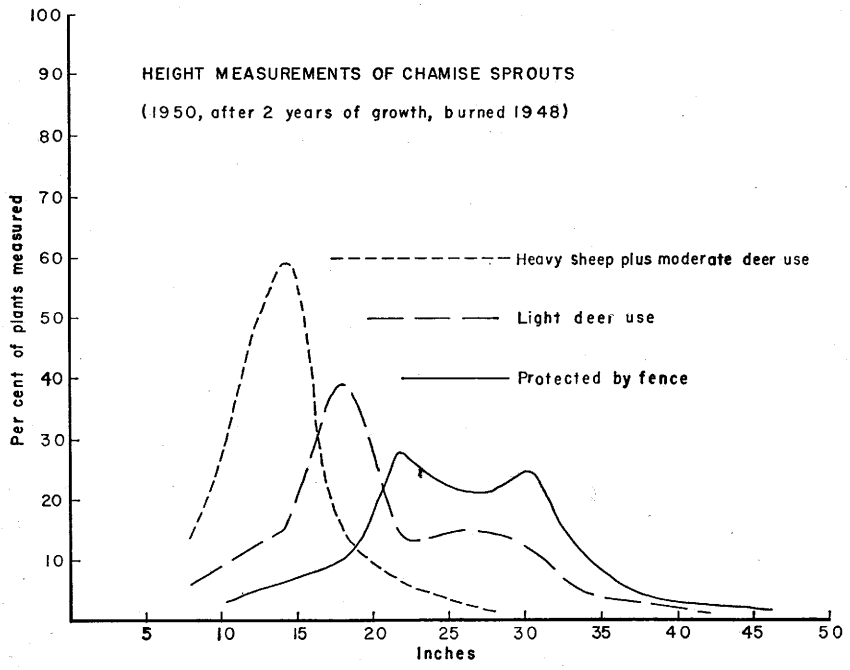

FIGURE 11. Curves showing the effect of browsing in retarding sprout growth. Most of the plants heavily browsed by sheep plus deer measured 14 inches while most of those protected from deer and sheep average between 22 and 32 inches. Light use by deer also considerably retarded height growth of sprouts.

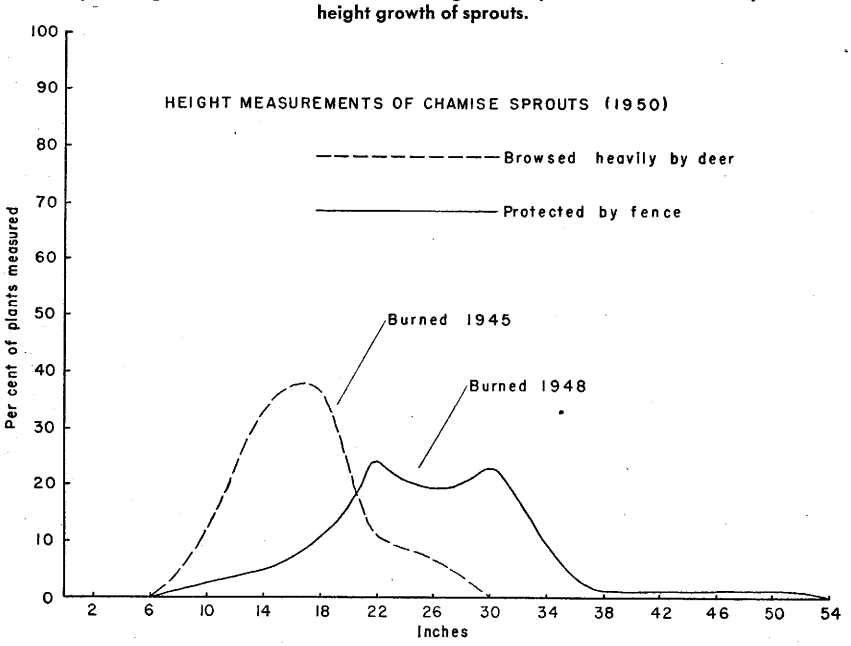

FIGURE 12. This graph indicates the effect of heavy deer browsing in retarding sprout growth. The sprouts browsed closely by deer averaged about 17 inches in height after five years while most of those protected from deer and sheep were between 22 and 32 inches in only two years.

or more mature deer per square mile. On the 25 acres of new burn, close browsing by the large deer population took place as soon as sprouting began. As no additional burns had been made here since 1948, sampling in 1950 furnished a measure of the effectiveness of two seasons of heavy deer browsing in opening dense chamise. Both northwest and southeast exposures were represented in the 25-acre area; these were sampled separately to determine the correlation between composition of the plant cover and the effect of deer browsing on brush recovery. The northwest exposure had chamise mixed with toyon, Eastwood manzanita, scrub oak, and poison oak; the southeast exposure was principally chamise with some wedgeleaf ceanothus.

Figures were obtained on number of brush plants alive, number killed by fire, number killed by browsing, and the average height of the brush sprouts from browsed and unbrowsed plants (Table 3).

TABLE 3

The Results of Close Browsing by Deer Following Fire. The Effect of Close Deer Browsing Was to Open the Dense Stand of Brush by Killing Many of the Sprouts

Exposure	Species	Number of plots	Plants alive (percent)	Plants killed		Average height of sprouts	
				By fire (percent)	By grazing (percent)	Browsed (inches)	Unbrowsed (inches)
NW	Chamise	24	19.7	26.0	54.3	4.8	20.1
	Eastwood manzanita	12	50.0	25.0	25.0	6.8	23.0
	Toyon	9	88.4	0.0	11.6	7.7	36.8
	Scrub oak	3	100.0	0.0	0.0	4.0	32.1
SE	Chamise	30	30.7	31.9	37.4	4.8	20.1
	Toyon	3	100.0	0.0	0.0	7.3	36.8

On the northwest exposure over one-half of the sprouting chamise plants were killed by deer browsing. It is significant that 25 percent of the Eastwood manzanita plants were also killed by browsing for these sprouts are usually eaten only lightly by deer. Among the sprouting species, scrub oak seemed most resistant to the effects of heavy browsing even though the sprouts on it were eaten to a lower average height than on any of the other species. Observations indicated that the weakened plants usually died in winter following heavy browsing in summer.

On the southeast exposure fewer sprouted plants were killed by deer browsing than on the northwest exposure, probably because of lighter use there in the winter and early spring months. In both areas, however, the effect of close deer browsing was to open the dense stand of brush by killing many of the sprouts.

It was found also that close grazing by sheep in addition to light deer use is an effective way of opening areas of dense chamise brush following fire. Results of sampling on an area browsed heavily by sheep in addition to light use by deer are summarized in Table 4.

TABLE 4

Results of Light Utilization by Deer Compared to Heavy Utilization by Sheep Plus Deer in Opening Chamise Brush Following Fire

Date of sampling	Number of plots (mil-acre)	Mature chamise plants killed	
		By fire (percent)	By grazing (percent)
Area utilized lightly by deer only			
7/20/48	64	25.0	
12/21/48	45		0.7
6/29/49	45		0.0
Area used heavily by sheep from March to July 10, 1948, and lightly by deer			
7/21/48	40	27.0	
12/21/48	50		22.0
6/14/49	45		42.0

In both areas approximately one-fourth of the mature plants were killed by fairly intense fire, which is about normal as indicated by sampling in many places. In the area where deer utilization was light, less than 1 percent of the plants died the first year after the fire and none in the second year. However, in the other area, heavy use from a combination of sheep and deer killed 64 percent of the plants in addition to the 27 percent killed by the fire. Opening to this extent might not always be desirable. But in suitable places where burned areas are so large that deer cannot effectively suppress sprout growth, sheep can be used to good advantage in opening the brush and prolonging use by deer.

Size and Amount of Area to Burn

Burned spots should usually be small, 5 to 10 acres or so in size, in order to form as much edge as possible. The acreage to be burned should be decided 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 five 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 on top of the brush sprouts. 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, it would be desirable to proceed slowly. This procedure should continue until the desired amount of opening has been accomplished.

Mechanical Control of Brush

In suitable areas chamise brushlands may be opened by mechanical means such as heavy disking or by pushing the brush over with a bulldozer, holding the blade about six inches above the soil (Figure 13).

FIGURE 13. Chamise brush pushed over with bulldozer blade about six inches above the soil. The plants that are not totally destroyed grow sprouts and furnish abundant browse for deer.

FIGURE 14. Pattern of opened brush obtained by using heavy disk. The grassy areas were disked, the brush strips were not. This work was done by the U. S. Forest Service on the Mendocino National Forest. Photo taken May 28, 1951.

Pushed-over brush need not be burned. There are several advantages in mechanically opening chamise brushlands. In the first place, a residue is left on the soil which is helpful in erosion control. The residue also gives reseeded grasses protection against frost heaving and intense heat and drying from the sun. If pushing over brush along ridge tops enables one to start herbaceous vegetation more easily than otherwise, 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 insurance of a continuing seed supply is invaluable. There is evidence that a more favorable composition of brush cover for deer can be maintained by mechanical means than by using fire. Mechanical means can be used in areas where it is too dangerous to attempt burning. Another advantage in mechanical control is that patterns of interspersion of brush and grass can be obtained without difficulty (Figure 14).

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 in the soil and the fire hazard is not high from this practice. The U. S. Forest Service has pioneered in the use of the heavy disk in chamise brushlands.

Chemical Control of Brush

Studies on the use of hormone sprays in opening brush for game were limited to treatment of seedlings and sprouts following burning and grazing. The effectiveness of the method seems to be correlated with the vigor of plants which, in turn, is affected by grass competition and intensity of grazing. In view of the expense of hormone sprays, other methods of opening the brush for game appear more practical at this time. Further studies are needed to determine how chemicals can be used to control composition of the stand to reduce the nondesirable species and favor the more desirable ones.

RESEEDING OF CHAMISE BRUSHLANDS

Where chamise brush has been removed, it is desirable to reseed to suitable forage species in order to establish a plant cover as quickly as possible.

Three years of study on reseeding of such brushlands in Lake County have indicated the importance of several factors affecting successful revegetation. These are: species used, dates and rates of reseeding, frost heaving, grazing preference by game animals, and competitive relationship between reseeded grasses and brush plants.

Species Used

Several annual and perennial species were used in the reseeding trials. Annuals included soft chess, red brome, domestic ryegrass, rose clover and bur clover; perennials included hardinggrass, orchardgrass, perennial ryegrass, smilo, tall fescue, burnet, and sweet clover.

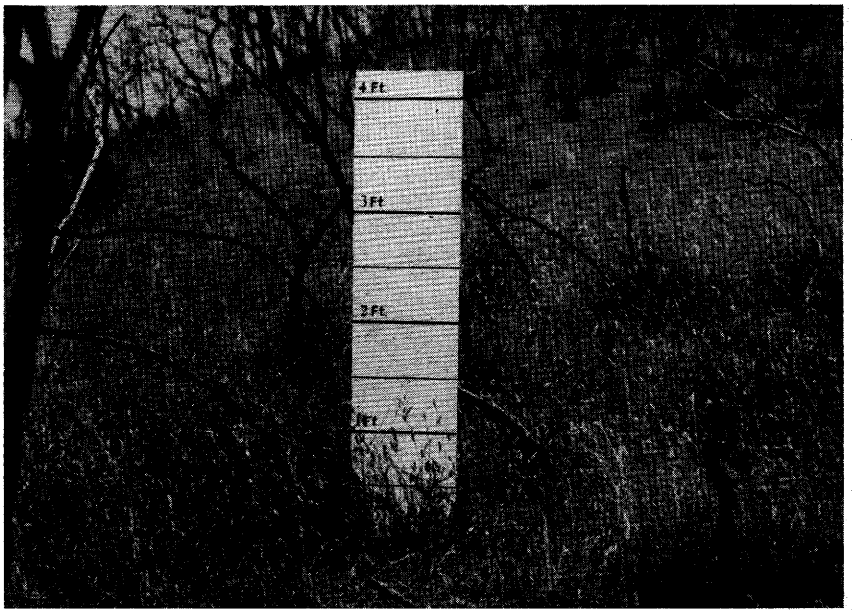

FIGURE 15. Area of chamise brush reseeded to soft chess after controlled burning. This species is well adapted to reseeding of poor chamise brushlands. It is well liked by deer in spring when green but is not liked after it is dry. Photo taken in July after the grass was dry.

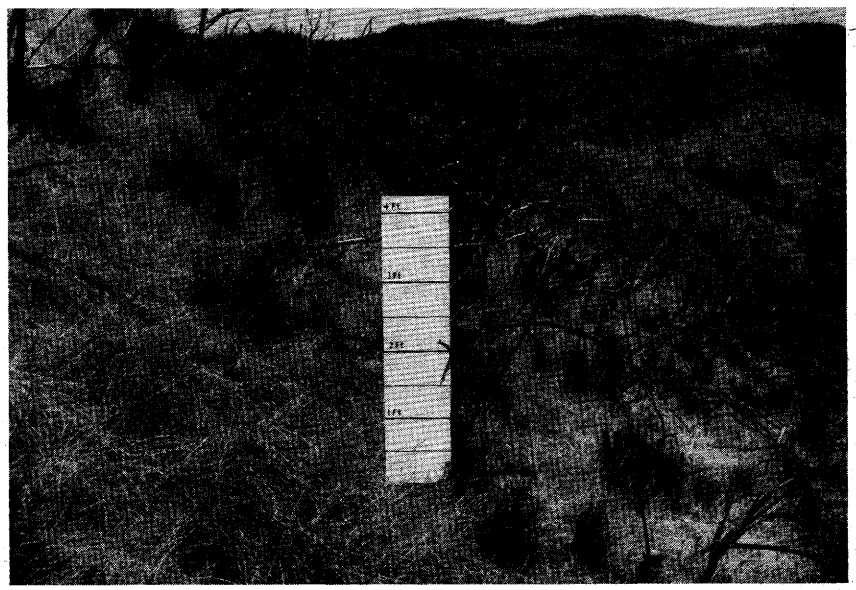

FIGURE 16. Area of chamise brushland reseeded to domestic rye-grass following controlled burning. This grass has done moderately well on chamise brushlands. Photo taken in July after the grass was dry.

Over a period of three years, which included both good and poor climatic conditions for establishment of herbaceous vegetation, soft chess proved to be the most satisfactory of the annuals (Figure 15). Although seed of this species is not easily available at present it can be recommended for reseeding of relatively poor chamise brushlands. Red brome did as well as soft chess but is inferior as a forage plant. Domestic ryegrass did fairly well in most instances when planted before the start of fall rains (Figure 16). Rose clover appears to be a promising legume for reseeding chamise brushlands (Love and Jones, 1952). It is a new introduction and was tested in these studies only one year. Bur clover did not give satisfactory results.

Perennials generally did better at about 2,400 feet elevation than they did at about 1,500 feet. At the lower elevation, annuals were generally more satisfactory. Perennials that did fairly well include hardinggrass, orchardgrass, smilo, burnet and tall fescue.

Date and Rate of Reseeding

In general, seedings made about the middle or latter part of September shortly before the start of fall rains, have been the most successful. Seedings made in the spring or summer after spring burns have not been as successful as those made in late summer or early fall. December plantings did fairly well but did not make as much growth as the early fall seedings. Seedings made in February were complete failures.

Results with rates of reseeding varied somewhat with weather conditions. In favorable years fewer pounds of seed were needed for a satisfactory stand than in poor years, perhaps due to better germination. About two pounds of soft chess per acre appeared to be nearly as satisfactory as four pounds. Stands of domestic ryegrass improved regularly with increase in the seeding rate up to 10 pounds per acre. Hardinggrass and tall fescue gave satisfactory germination with four pounds per acre. Smilo, a small-seeded species, required two pounds. However, the heavier seedings of all species produced stands more effective in competing with brush seedlings.

Frost Heaving

Frost heaving was the most adverse factor affecting the establishment of reseeded species in burned chamise brushlands in Lake County, especially at elevations around 1,500 to 2,400 feet. In each of three seasons of study, 1948 to 1951, frost heaving has been appreciable. In the winter of 1948-1949 severe cold in December heaved out 99 percent of the newly germinated seedlings of domestic ryegrass, hardinggrass and orchardgrass. In 1949-1950 approximately 80 percent of the seedlings of several species on north exposures were heaved out, and about 15 percent of those on south exposures. In the winter of 1950-1951, which was mild, about 35 percent of the smilo seedlings on a southeast exposure were lost and about 65 percent of those on a northwest slope. Hardinggrass and annual species, however, were not so adversely affected in 1950-51. From observations of excavated root systems those species with many fine roots, such as smilo, were more susceptible to frost heaving

than those with fewer, coarser ones, such as hardinggrass. Once domestic ryegrass roots penetrate below the frost line there is little danger from heaving. In the winter of 1950-1951 the annual species, especially resident ones, were not noticeably damaged by the action of frosts. This is one reason why resident annuals have done better in seeding chamise brushlands in this area than many of the introduced species. Frost heaving appeared to be more severe around 1,500 to 2,400 feet than higher where there was less daily freezing and thawing. Also, frost heaving was more severe in loose soils than in those tending to have a tight structure.

Preference by Grazing Animals

Deer make their greatest use of reseeded grasses in the early spring before brush sprouts become available on newly burned areas. In studies of comparative grazing use in the spring, domestic ryegrass and soft chess were heavily grazed by deer while hardinggrass and smilo were only lightly used. After the annuals are dry, the hardinggrass and smilo are heavily used. All of the grasses seeded have been grazed to some extent and are an important source of feed on burned areas. In some instances deer did damage to newly seeded stands by close grazing and trampling. Damage was greatest in small plots where less than 10 acres were seeded and the concentration of deer was high. In large seedings or a number of small ones, deer were responsible for little or no damage. Moderate grazing of domestic ryegrass and soft chess by deer might be helpful in causing the grasses to tiller and increase in density.

California jackrabbits made much use of reseeded species. They were next to frost heaving in causing damage. All of the perennial species and also domestic ryegrass were heavily used. The latter was heavily grazed after it was dry, but soft chess nearby was little used. In areas where there is no ryegrass, stomach analyses show that soft chess seeds are readily taken during the summer. Perennial species were heavily used by jackrabbits during summer and severely damaged in many cases.

Competition Between Reseeded Species and Brush Seedlings

The importance of a good stand of grass in suppressing the growth and establishment of brush seedlings was noted soon after the studies were started in 1948. Sampling over a three-year period shows a very high negative correlation between the density of herbaceous cover and number of brush seedlings on seeded chamise brushlands in Lake County (Figure 17). In very dense stands of domestic ryegrass, few brush seedlings emerged and none survived. Brush seedlings appeared in thin stands of domestic ryegrass and in perennial stands but many of these died during the summer. The close relation between density of herbaceous cover and number of brush seedlings increases the need for a fairly dense cover of grasses the first year after burning. Dense stands of domestic ryegrass had only little retarding effect on the sprouts from chamise root crowns. Some grasses offer more competition than others; for example, domestic ryegrass is stronger than the perennials (Schultz and Biswell, 1952).

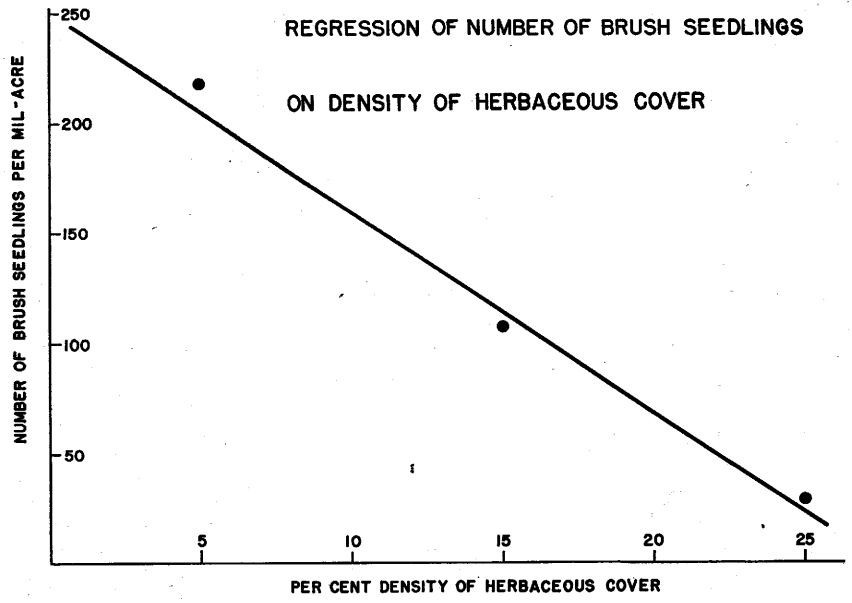

FIGURE 17. The line shows the negative correlation between number of brush seedlings and density of herbaceous cover. The plotted points are based on figures from four replications for each density class. As the grass density increased the number of brush seedlings decreased. The measurements were made late in the summer. The close relationship between grass density and brush seedlings increases the need for a fairly dense cover of grasses the first year in opening chamise brush.

STEPS IN OPENING CHAMISE BRUSHLAND

Several steps in the operation of opening chamise brushland are now well understood on the basis of experiments and are outlined below. It is logical to assume that the more nearly the areas in question resemble the general area studied in Lake County, the more closely these steps will apply. Knowledge of both the game population and the plant population in the brush area to be manipulated and managed is essential.

1. *Location of Deer and Their Approximate Density.* The success of opening chamise brushlands is dependent upon the presence of at least a few deer in the general locality. There is small possibility of luring deer long distances to areas of low concentration simply by opening the brush. A total absence of deer may indicate a lack of water or some other limiting factor; in this case opening of the brush may be of little or no benefit.

Information about the number of deer and their location may be gained accurately enough by reconnaissance through the area, or by noting kill of bucks during past hunting seasons, or by testimony of local residents and sportsmen.

2. *Selection of Areas.* Chamise brushlands vary widely in such features as soils and topography. Some are better adapted to growing grasses than others. In beginning a program of managing brush, the more productive areas should be selected first, areas where there is reasonable

assurance that grasses will grow abundantly. Usually this can be determined by observation of abundance of grasses in such places as wildfire burns and in clearings along power lines. Soil examination and surveys should prove helpful, and luxuriance of the brush often indicates the quality of the site. Scattered grasses in brush are a good indication that they will increase if the brush is opened and competition decreased.

3. *Methods of Opening the Area.* Whether fire or mechanical means are used in opening the brush depends largely on the risk of using fire, brush cover conditions, and type of terrain (Figure 18). Where the

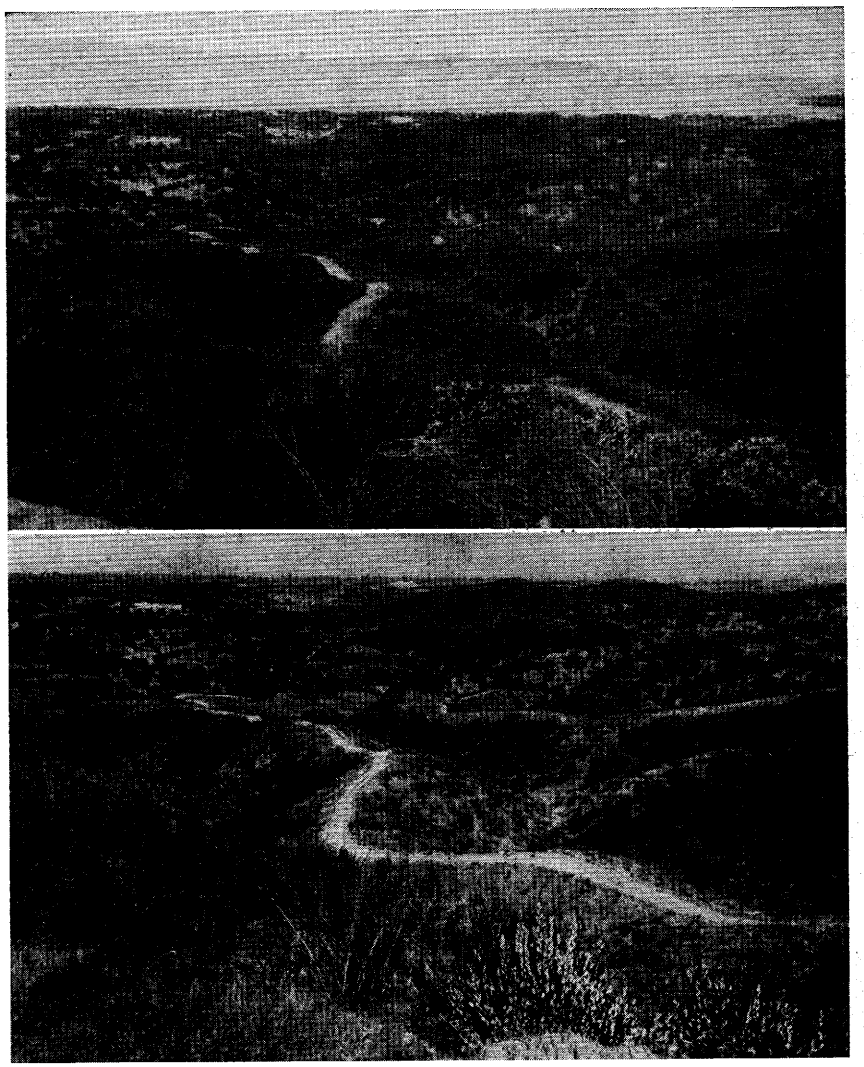

FIGURE 18. Views of an area in Lake County before and after the chamise brushland was opened by controlled burning and reseeding. Upper photo taken in 1949; lower, 1951.

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 top and ordinarily no more area will be burned than the length of the slope by the distance fired along the bottom. 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 chamise brush occupies all exposures, and is of uniform density, the risk of using fire is greater than where the type of brush varies with exposure. With a uniform brush cover, the fire is more likely to spread because conditions for burning are more uniform also. 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. One should be familiar with the state fire laws and obtain a fire permit from the local forest ranger during the fire season.

Where conditions for burning are too hazardous, and the terrain is not too steep, mechanical means may be used to open the brush.

4. *Extent to Which Area Should Be Opened.* 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 10 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 are 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 30 percent of the area should be left in well distributed dense brush as cover for game. In a few years the deer population will build up to the carrying capacity of the range. When this point is reached it will be necessary to control the deer population to maintain this balance.

5. *Reseeding to Adapted Forage Species.* All areas cleared of brush should be reseeded to adapted forage plants before the first fall rains. If the reseeding is not done by this 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. These are not known for all cases and will vary with locality; some testing should be done in all areas.

6. *Reburning.* 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 will carry the fire. In general, however, as little reburning as possible should be done for this tends to eliminate certain of the valuable nonsprouting species, and may also result in

opening the brush too much. Insofar as possible, sprout growth should be retarded by deer browsing and areas maintained in open condition this way. When areas are properly opened every care should be taken to avoid wildfires for these are likely to upset the proper interspersion of brush and herbaceous plants and may not leave enough dense brush cover for deer. After an area is opened and the proper balance between dense brush and opened area is attained, it may prove more desirable, where feasible, to maintain this condition by mechanical means than by fire.

7. *Grazing Management.* 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 (Figure 19). 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 quite similar to that by deer; where both kinds of animals use the range, proper allowance must be made for each. In some cases, jackrabbits may become sufficiently abundant to justify reducing their number.

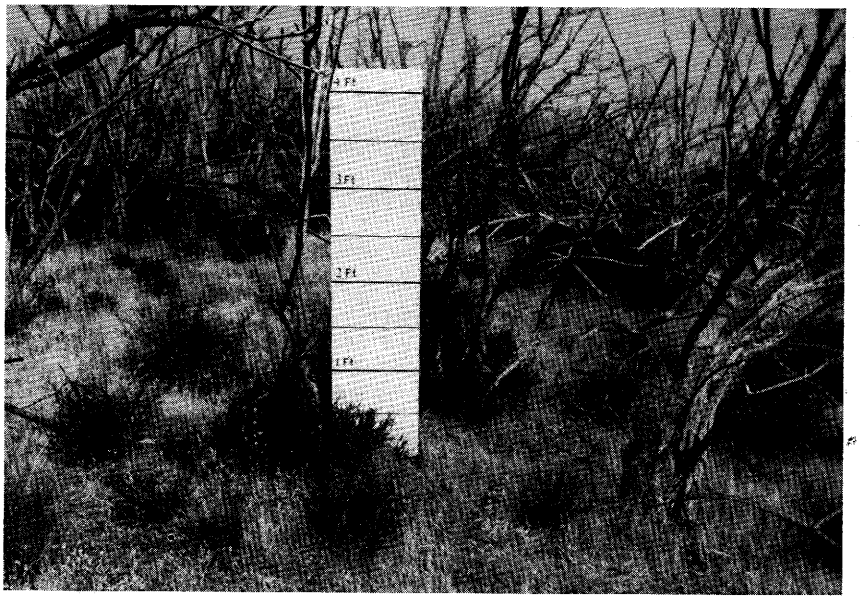

FIGURE 19. View of area burned in 1945 and used only by deer for six years. Both the browse and grass show about proper utilization. Photo was taken September 13, 1951, near the end of the dry forage period. If used also by other kinds of animals adjustments should be made for proper utilization of the grass, always leaving enough for an effective watershed cover.

SUMMARY

1. Studies on the management of chamise brushlands for game were made in Lake County, California, from 1948 to 1951. Brushlands on the study areas comprise two types: those in which chamise predominates on south exposures and those where broad-sclerophyll shrubs and trees predominate on north-facing exposures. The dominant shrubs and trees are chamise, interior live oak, Eastwood manzanita, scrub oak, California laurel, toyon, wedgeleaf ceanothus, wavyleaf ceanothus, deerbrush, Stanford manzanita, yerba santa, poison oak, birchleaf mahogany and chaparral pea, approximately in that order of abundance.
2. Chamise occurs on a variety of soils in this area. The Maymen series is the most extensive. These soils are less than 12 inches deep. The more productive soils belong to the Dorado, Los Gatos, and Laughlin series. Chamise-covered soils are generally low in nitrogen even where the woody vegetation has not been disturbed over a long period of time.
3. Chamise brushlands have been generally looked upon as valuable for game and watersheds. However, little has been done to manage them for either except to attempt total fire exclusion. This has not been entirely successful since wildfires occur frequently; some are very large and destructive.
4. The primary purpose of this study was to determine whether game populations will build up under brushland management, and, if so, the most satisfactory way of managing chamise brushlands for game production.
5. Black-tailed deer populations were studied under three different conditions of chamise brushland: (1) Heavy brush cover, protected from fire; (2) Wildfire burn; (3) Opened brush, consisting of an interspersion of grass with patches of dense brush. Observations and less detailed studies were made of the valley quail, California jackrabbit, brush rabbit, mountain quail, and mourning dove.
   a. Number of deer in the heavy brush averaged 10 to 30 to the square mile; in the wildfire burn 5 to 160; and in the opened brush about 40 to 110. Populations in the heavy brush and opened brush were rather stable; but in the wildfire burn large numbers of deer moved in when the sprouts were young and tender and out during cold weather.
   b. In adult does the ovulation rates were: Heavy brush 84 percent; wildfire burn 116 percent; opened brush 147 percent. Ratios of fawns to 100 does following the rut were: Heavy brush about 60 to 85; wildfire burn 100 to 110; opened brush 115 to 140.
   c. Bucks from opened brush were heavier than those from heavy brush; this tendency was stronger in young deer than in medium-aged ones. Bucks from the wildfire burns tended to be as heavy as those from opened brush.
   d. Herbaceous plants when available and green are utilized heavily by deer. From February to May the deer in opened brush foraged largely on herbaceous plants, whereas those in the heavy brush foraged almost entirely on shrubs. In the wildfire burns herbaceous plants comprised about half of the forage in March and April.

e. Valley quail populations in late summer were about two and one-half times as great in opened brush as in heavy brush or in wildfire burns. Mountain quail were difficult to census but more were counted in opened brush than dense brush. Jackrabbits fluctuated from 10 to 45 per square mile in the opened brush but in heavy brush only about one was found per square mile. In wildfire burns they reached densities of 5 to 10 per square mile. Brush rabbits were numerous in the heavy brush. In wildfire burns and opened areas they existed largely in the remaining spots of heavy brush. Mourning doves were the most abundant in opened brush. They were found occasionally in wildfire burns but seldom in the heavy brush.

6. Methods studied in opening chamise brushlands to improve conditions for game were burning, grazing, mechanical means, and chemical treatment.
   a. Both spring and late fall burning proved satisfactory in opening chamise brush. Summer burning in chamise brushlands for game is not recommended because of difficulties and expense in fire control and the possibility that the area burned will be too large.
   b. Control of sprouts through browsing following initial brush removal is an essential step in the opening of dense chamise brushlands.
   c. Spot burns of about five acres evenly scattered are probably sufficient for initiating a program of managing chamise brushlands. Ultimately not more than 70 percent of a brush area should be treated and the remainder left in dense brush as cover for game.
   d. Some areas of chamise brushlands may be opened by mechanical means such as bulldozing or disking.
   e. Use of hormone sprays were limited to treatment of seedlings and sprouts. Other means of opening the brush for game appear more practical at this time.
7. Chamise lands should be seeded following brush removal to increase forage production, to lessen erosion, to offer competition to a potentially overdense stand of brush seedlings, and to furnish fuel for a reburn if necessary.
   a. The most promising species tested were soft chess, domestic ryegrass, hardinggrass, smilo, tall fescue, orchardgrass, rose clover and burnet. Seedings made shortly before the start of fall rains did best. However, those made shortly after the first rains have been successful. Most failures in reseeding were due to frost heaving and heavy use by jackrabbits.
   b. Deer make their greatest use of reseeded grasses in the early spring. At this season, soft chess and domestic ryegrass were more heavily grazed than others. But all reseeded species were used and can make up an important part of the deer diet.
   c. A negative correlation was found between density of reseeded grasses and survival of brush seedlings.
8. In opening new areas of chamise brushlands, steps to be considered are: Location of deer and their approximate density, selection of area, methods of opening the area, extent to which area should be opened, reseeding to adapted forage species, reburning, and grazing management.

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