

Recent Trends in Range Improvement on California Foothill Ranges

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THE foothill range lands of California are located both in the Coast Ranges and in the Sierra Nevada-Cascade Mountains, comprising a discontinuous zone between the upper limits of the valley floors and the lower limits of those forests that produce commercial timber. For the most part they lie between elevations of 500 and 2,500 feet above sea level. Soils, climate, physiography and other conditions affecting plant growth, vary widely. The lower slopes of these foothills are rolling grasslands; there is a transition to oak-grass woodland and chaparral at higher elevations and on more rugged terrain. While the grassland is relatively distinct, the woodland and chaparral are much intermingled (Fig. 1).

This foothill area produces a forage crop that is mainly annual plants, both forbs and grasses, many having been introduced from other lands. About 30 million acres—thirty percent of the state's area—are in this sort of country (Sampson and Burcham, 1954). These foothill ranges are important to the California livestock industry for at least two reasons: they are well-suited for economical production of feeder livestock; and they are favorably located with respect to local markets.

The grazing capacity of these ranges has decreased during the period of their use by domestic livestock, probably by as much as 25 to 50 percent. This decrease has been brought about by a number of causes that have affected primarily the herbaceous elements which constituted desirable forage in the

grassland and woodland associations. Deterioration of the native herbaceous vegetation has favored an increase in weedy herbs and of brush in the grassland and woodland covers. The brush—commonly called chaparral—consists of shrubby, mostly evergreen plants with simple, leathery leaves, dwarfed habit, an extensive root system and the capacity to endure long, hot and essentially rainless summers. Control of this brush constitutes an important problem in range improvement, because herbaceous forage plants cannot compete successfully once the deeper-rooted and more aggressive shrubs become established on the range.

The problem of undesirable woody vegetation on the foothill ranges centers in some 20 million acres of land, outside of the commercial timber zone and comprising

about two-thirds of the total foothill range area (Wieslander and Gleason, 1954). About 55 percent (11 million acres) of this problem area is dominated by a plant cover of brush, while the remaining 45 percent (9 million acres) is dominated by mixtures of noncommercial hardwoods, minor conifers, brush and herbs. It is probable that range improvement may be feasible on not more than about nine million acres of this problem area, when both its suitability for range use and the possibility of an economic return on investment required are taken into consideration (Sampson and Burcham, 1954).

Workers on the foothill ranges have generally subscribed to the idea that there are four related, integrated steps to solution of this range brush problem:

1. *Selection of site.* Careful consideration must be given to soil, precipitation, topography and other factors that affect plant growth and range use.

2. *Preparation of site.* The undesirable woody cover must be effectively removed and a seedbed prepared.

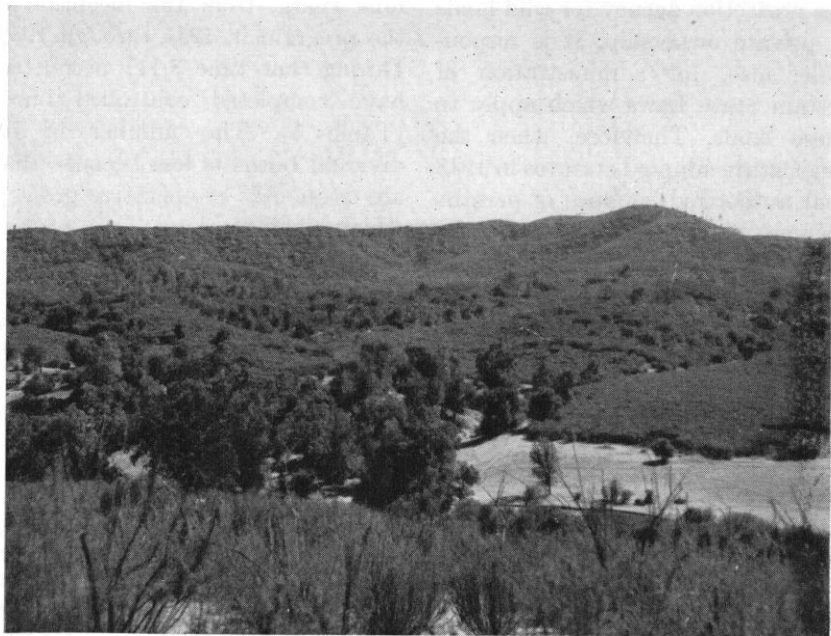


FIGURE 1. Representative foothill range with intermingled woodland and chaparral.

3. *Revegetation.* A cover of desirable forage plants must be established on the cleared area, by either natural succession or artificial reseeding.

4. *Management of the range.* Grazing must be controlled and live-stock managed to perpetuate the desirable plant cover and maintain productivity of the site. All these steps are essential; none may be omitted if the result is to be successful.

The Range Improvement Program of the California Division of Forestry

The California Division of Forestry has been engaged in a program of Range Improvement since 1945, as one phase of its work in protection and management of natural resources. It is one of a considerable number of agencies—including local, state and federal governments as well as private enterprise—with a direct and active interest in the foothill range problem.

The Division of Forestry—charged with protection of approximately 42 million acres in the state—can be regarded as the primary fire protection agency for wild lands in private ownership. It is responsible, also, for administration of certain State Laws which apply to these lands. Therefore, when the Legislature adopted statutes in 1945 that authorized issuance of permits for controlled burning of brush for range improvement, the Division was assigned responsibility for administering these permits (Calif. Division of Forestry, 1953). At the same time the Legislature directed the Division to engage in a program of experimental land clearance and revegetation on the foothill ranges to determine the effectiveness of various methods of clearing and the economic value of the cleared lands for forage production and range use. Thus, the Division of Forestry probably is unique among public

agencies in having a mandatory directive to do research on the range problems of the California foothills.

From the foregoing it is evident that our work in Range Improvement consists of an administrative phase, dealing with permits for rancher projects; and a research phase, which embodies experimental studies in land clearance and revegetation.

Administration of Permits for Controlled Burning

Activity in controlled burning is a rancher program. The projects are carried out on lands under control of private individuals; planning, preparation and execution of controlled burns are done by ranchers at their own expense. The Division of Forestry acts in an administrative capacity to regulate the use of fire in range improvement for protection of the interest of the general public. Although it does not do burning for ranchers, the Division provides stand-by service—properly equipped and trained fire suppression crews—for protection of adjacent property during burning.

Our records of this activity cover nine years—from the inception of the program in 1945 through 1953. During that time 3,117 permittees have completed controlled burns (Table 1). The number of individual burns is less because they are frequently co-operative projects which include lands of several ranchers. The yearly number of permittees has varied considerably (Fig. 2). These controlled burns have been applied on a net area of

838,602 acres (Table 1), with the annual acreage ranging from 31,248 acres in 1948, to 190,813 acres in 1952. During the early years the average size of controlled burn varied from 150 to 250 acres; it has increased gradually to between 400 and 450 acres for the last three years. However, a large majority of burns is smaller than the average size (Fig. 2).

An analysis of controlled burns in northern California showed the cost of burning small areas was highest (Sampson and Burcham, 1954). Burns averaging 40 acres in size cost \$3.65 per acre. The cost per acre decreased to 60¢ for burns averaging 440 acres and then increased to \$1.20 per acre for those of 640 acres. There is an indication that the cost per acre decreases again for areas larger than 640 acres, but there was not a sufficient number of larger burns available for study to firmly establish this. Since costs of burning are measurably lower per acre on areas larger than about 300 acres, co-operative controlled burns on lands of adjoining owners would reduce the per-acre cost. Size is only one of many factors which may influence costs of a controlled burning project.

On the better sites, use of fire may be limited to a single treatment to remove the mature stand of brush and subsequent regrowth controlled by chemicals or other means. In some cases one or two reburns may be made, to control sprouts and seedlings, at intervals of two to four years after the first treatment. In any event, where fire is used in range improvement it should be considered as but one step—and frequently the least important—in a carefully integrated and executed plan of natural resources development.

But the interest of our ranchers in range improvement is not limited to use of fire alone. Nearly 78,000 acres have been cleared for range purposes by use of mechanical

Table 1. Summary of range improvement activity in California, 1945-1953

Activity	Totals
Number of applications.....	3,666
Number of permittees.....	3,117
Burned under permit, acres...	925,734
Less: Area reburned, acres...	87,132
Net area treated, acres.....	838,602
Area reseeded, acres.....	274,539

equipment, including bulldozing, discing and various other appliances. Today equipment is widely used, also, for preparation of brush for controlled burning. A method that is finding increasing favor among ranchers is to break down the brush by using a bull-dozer with the blade raised about a foot above the ground surface, or by dragging heavy rails, anchor chains or similar devices over the brush which then is left to dry for six months or more before burning.

The use of chemicals is receiving considerable attention by ranchers. This method is not yet recommended on mature stands of chaparral except where coyote brush (*Baccharis pilularis*) and California sagebrush (*Artemisia californica*) are dominant. Chemicals do have a significant place in follow-up treatment to control sprouts and seedlings which come in after the original clearing operation (Leonard, 1953).

About 274,000 acres (29.6 percent) of the treated area have been seeded to forage plants. The proportion of area seeded each year has varied from a low of 23 percent to as high as 48.3 percent. Brush forms a discontinuous stand on much of the foothill range. Openings are dominated by annual plants which may provide from 400 to 1,600 pounds of seed per acre; under these conditions it is useless to seed at rates ordinarily used on the range. In dense stands of brush with a very sparse understory of herbs it is important that seeding be done to form a protective soil cover, and to provide competition with brush seedlings and sprouts, as well as for forage production. It appears that seeding should be done on an average of some 40 to 50 percent of the total area treated each year.

Ranchers are giving increased emphasis to managing treated brushland to maintain gains in grazing capacity, and appropriate follow-up work is being done after

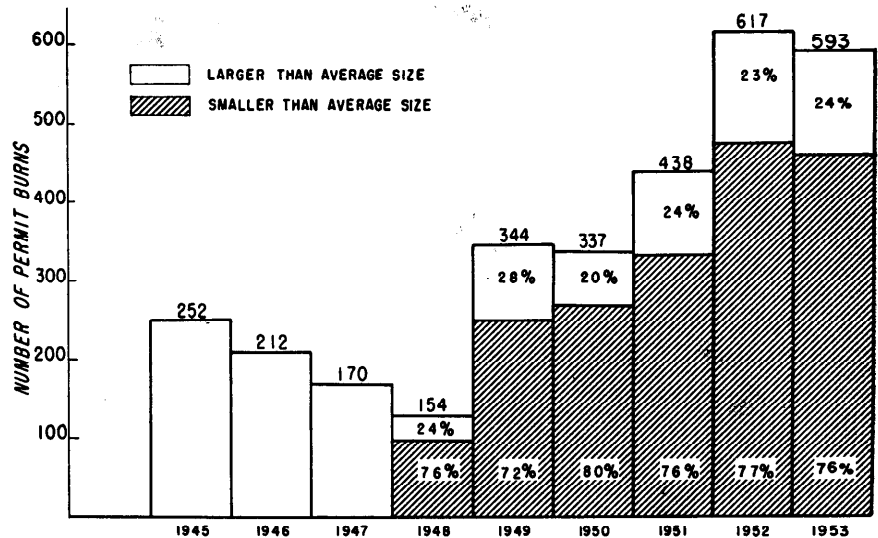


FIGURE 2. Number and relative size of controlled burns, 1945-1953, under permit from the California Division of Forestry.

the initial treatment. Preliminary results of a recent study—consisting of 94 cases in which 23,506 acres of land were treated—showed that follow-up work was done in 57 percent of the cases and on 69 percent of the acreage. In 21 percent of the cases, and on 26 percent of the area, there had been two or more follow-up treatments. These treatments included use of equipment for removal of brush snags after burning; use of chemicals on brush sprouts and seedlings; browsing by goats; reburning; and additional reseedling.

Results of these range improvement projects—measured in terms of grazing capacity—have varied widely. In some instances they are very poor; in others, they have been highly successful. The above study showed that in about 15 percent of the cases grazing capacity was essentially zero both when the project was started and when it was examined in 1953; thus, any gain made was not sustained. At the other extreme, represented by nearly 13 percent of the cases, from 15 to 30 acres were required per animal unit month before treatment; the requirement for the 1953 season was from one to three acres per animal unit month. While the average level

of success is highly encouraging, the frequency of poor results underscores the need for more basic information and its application.

Field Studies in Range Improvement

The Division of Forestry has engaged in experimental work in brush control on foothill ranges since 1948. A review of the research completed by other agencies at that time, or in progress, brought the realization that the "prescriptions" written for conversion of chaparral areas into forage-producing ranges, had been based on small-scale plot work. We could not find a single area of sufficient size to graze a sheep or a cow, where such a prescription was being applied under controlled conditions. This fact offered an obvious challenge, while at the same time it afforded an opportunity to engage in research which would neither duplicate, nor conflict with, work being undertaken by any other agency. We planned a series of field studies on areas of 150 to 450 acres in size, on which methods of clearing, reseedling and grazing management could be incorporated as an integral part of the study. They were set up on private land under written



FIGURE 3. Reseeding of controlled burns provides definite advantages in forage yields.

agreement with the rancher which gave us full control of all operations, including grazing. Most studies are co-operative with the Agricultural Extension Service of the county in which they are located.

The Rescue Range Study begun in 1949 is an example of these projects. This 160-acre tract is located in the foothills of the Sierra, about 50 miles east of Sacramento. Its Sierra stony clay loam soil is commonly associated with a chaparral cover and is only fair for range forage production on account of its shallow depth, stoniness and somewhat restricted sub-drainage. Cleared areas, with a cover of resident annual forage plants, require three to four acres per animal unit-month on ranges in good condition. This tract had not been cleared and had no recent history of wild fire. Chamise (*Adenostoma fasciculatum*) and manzanita (*Arctostaphylos* sp.) dominated the ridges; dense thickets of interior live oak (*Quercus wislizenii*) and California black oak (*Q. kelloggii*), six to 10 inches in diameter and 20 to 30 feet tall, occupied the swales. Annual precipitation averages about 35 inches.

Four plots of 20 to 30 acres each were laid out on this study area in

1950. Brush treatments consisted of (1) complete clearing with a bulldozer; (2) controlled burning without preparation (other than fire-breaks); and (3) controlled burning after the brush was crushed and dried. On some portions it was planned to control sprouts and seedlings by periodic reburning, while on others chemicals would be used. Most of the area was seeded, using both annuals and perennials in a number of combinations; approximately 20 acres were left unseeded, to revegetate naturally. Seeding was done in strips at right angles to the brush treatments to give a number of replications.

Conditions for growth—especially temperatures and distribution of precipitation—were favorable during the season after seeding so that an excellent stand of all species was obtained. During the first season after treatment (1951), light grazing yielded 1.6 animal unit months of use per acre for the plots receiving mechanical treatment in addition to burning and seeding—nearly six times the usual grazing capacity of ranges on this soil. In subsequent seasons the grazing capacity of these plots has been approximately 2.5 animal unit months per acre with an ample residue remaining.

Forage production for three seasons, based on clippings from ungrazed sample plots, is partly summarized in Table 2, to indicate results obtained by the different treatments. Highest yields have been obtained on plots where the brush was broken down and permitted to dry before burning (Fig. 3). Where brush was burned with no prior treatment, as in the usual controlled burn, only one-third to two-fifths as much forage has been produced—apparently due to the poor seedbed provided and to competition from regrowth of brush. The unseeded portion of the controlled burn has yielded only from 100 to 300 pounds of forage per acre each season. The combined use of equipment and fire has been more effective in brush removal, and has an additional advantage of not being followed by as heavy a growth of sprouts and seedlings as usually follows an ordinary burn. Sampling during 1951 indicated that areas which had been mechanically treated had 13,600 brush seedlings per acre; the area controlled burned and seeded had $2\frac{1}{3}$ times as many—31,800 seedlings per acre; while the area which had been burned and not seeded had nearly $4\frac{1}{2}$ times as many—an average of 57,200 brush seedlings per acre. The regrowth in subsequent years, from both sprouts and seedlings, has followed substantially this pattern, on those parts where

Table 2. Forage production, Rescue Range Study, Eldorado County, 1951-1953

Treatment	Air-dry Forage (pounds per acre)		
	1951	1952	1953
Brush crushed and burned; seeded	1,500	1,900	2,000
Controlled burned; seeded	500	800	800
Controlled burned; not seeded	100	200	300

no additional control measures have been used.

Mechanical treatment of brush prior to burning required an average of 1.1 hours per acre, using an HD-7 tractor. The equipment-use time varied according to the brush cover—from about 0.5 hour per acre in chamise to as much as 1.78 hours per acre for live oak thickets. The additional forage produced and the more effective control of brush make it profitable for the rancher to invest in the mechanical treatment on his better brushland sites.

The use of chemicals for controlling brush seedlings and sprouts was incorporated into this study in co-operation with Dr. O. A. Leonard, of the University of California at Davis. A broadcast spray was applied on April 17, 1952, using the propylene glycol butyl ether ester of 2,4-D in two gallons of diesel oil and 37½ gallons of water per acre (Leonard, 1953). Forage production was determined in July, 1953. The control plots produced 639 pounds of air-dry forage per acre. Where one pound of 2,4-D was applied per acre, the yield of forage was twice as much—1,378 pounds per acre—and 50 percent of the brush sprouts were killed. Where two pounds of 2,4-D were used per acre the forage production was nearly three times as great as on the controls—1,771 pounds per acre—while the kill of sprouts increased to 87 percent (Leonard, 1953).

As in range improvement projects of ranchers, our studies show a direct relationship between forage yield and intensity of effort in clearing, seed-bed preparation, re-seeding and management, as well as with site quality and conditions affecting plant growth.

The total costs for range improvement projects are highly variable. Some indication of the costs of burning has been given. In crushing brush in preparation for burning, ranchers have utilized a number of devices to increase effective width of their equipment such as rails, anchor chain, or even a small tree, in lieu of, or in addition to, a bulldozer blade. These devices reduce equipment-use time and costs appreciably. The average time required for crushing chamise or mixed chaparral is about one-half hour per acre, but on one area with slopes less than 20 percent, a rancher crushed 40 acres of chamise in five hours, an average of only 0.125 hour per acre. The cost of seed has ranged from \$1.00 per acre for ryegrass at 5 pounds per acre to about \$5.00 per acre when more expensive perennial grasses are used. In typical cases, cost of seed usually has varied from about \$1.80 to \$2.50 per acre. The cost of applying seed—fixed-wing aircraft are used most commonly—depends on size of the area to be seeded, distance from landing fields and similar factors. In general, there has been a downward trend in this cost during the last five years and in most localities it is now possible to apply seed on tracts of about 300 acres and upwards for 45 to 60¢ per acre. The total initial cost per acre for a range improvement project which includes crushing brush and seeding following controlled burning, may be \$9.00 to \$12.00, or even considerably more. To this must be added the cost of subsequent measures to control regrowth from sprouts and seedlings—reburning, chemical treatment or other methods.

Summary

The brush problem of the California foothill ranges encompasses a gross area of about 20 million acres. Areas with good soils, suitable topographic position and favorable climatic conditions may be improved for range use, if sites are carefully selected, brush is effectively removed, the area is seeded to forage plants as necessary and then properly managed.

During the past nine years range improvement work has been done on approximately 925,000 acres of this foothill range land. While controlled burning has been employed most extensively, the use of fire may be the least important step in range improvement in California. Increased attention is being given to mechanical clearing and use of chemicals, as well as to proper management. It is essential to follow the initial clearing with appropriate management and control measures. With an intensive job of range improvement the rancher may recover a fairly high per acre investment in from three to five years; ordinary controlled burning, without seeding or follow-up, may not repay the cash outlay.

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