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IMPROVING CALIFORNIA RANGES

BURLE J. JONES and R. M. LOVE

Supplementing range forage with irrigated pasture and concentrates.

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THE COLLEGE OF AGRICULTURE
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BURLE J. JONES[1] AND R. M. LOVE[2]

INTRODUCTION

THE PROBLEM of range feed resources that California range operators are facing is neither new, nor for the most part, of their own making. Weediness, through the influx and spread of alien plants, continues; but overgrazing and actual range depletion are less prevalent and serious now than some years ago. The range was more heavily stocked in 1876, when there were over 7½ million sheep and 1 million cattle, than in 1940, when there were about 3 million sheep and 1½ million cattle. As early as 1865, the problems of overgrazing, weediness, shortage of stored feed reserve, and the poor quality of range animals were discussed with concern by agricultural leaders.[3]

California livestock men early developed a routine of wintering their stock on home ranches, and summering them at high elevation. But after the national forests were organized, the United States Forest Service found that the livestock numbers on the higher ranges must be reduced for the sake of maintaining the yield level of pasturable plants. The history of these adjustments (showing a peak during World War I) is about as follows:

	1910–1913	1918–1921	1934–1937
Cattle and horses.....	175,000	210,000	140,000
Sheep and goats	425,000	560,000	340,000

The stringent reduction necessary after the first world war seemed a serious menace to the range-livestock interest. Eventually, however, it will doubtless prove a benefit, both to the higher ranges and to the livestock men themselves. Thrown back on their own resources, the graziers are developing other sources of feed.

On many ranges satisfactory management practices have long been in effect, but the general movement toward planned and sustained improvement of private ranges has occurred during the past decade and is gathering impetus. The goal of any planned system of range management may be summed up as the highest possible yield of palatable and nutritious feed over the longest possible part of the year.

To assist range operators in achieving this end, the Agricultural Extension Service has been conducting state-wide tests, both on the suitability of plant species for artificial reseeding and on the management that will encourage desirable species. This circular reports general results of these tests; specific recommendations should be sought from the county farm advisors and from coöperating range men.

In 1943 the University of California Division of Agronomy at Davis conducted a test on adjusted grazing management to determine how far into the summer grazing can be extended, and what livestock loads can be carried in that part of the Sacramento Valley. The report on this test is included here.

[1] Assistant Professor of Agricultural Extension (Agronomy).

[2] Assistant Professor of Agronomy and Assistant Agronomist in the Experiment Station.

[3] See, for example: Bidwell, John. Annual address. California State Agr. Soc. Trans. 1864–65:212. 1866.

YEAR-ROUND LIVESTOCK-FEEDING PRACTICES

There are infinite variations in seasonal livestock management, but nearly all of the practices examined in twenty-two counties fall into one or more of eight classes:

1. Home ranch the year round, with or without protein supplements for the dry summer.

The most satisfactory year-round operations of this type are found in the north coast and semicoastal districts where rainfall is high, the dry season is comparatively short, and there is a reasonably good stand of perennial grasses. Even on some of these ranges the use of some protein concentrate (fig. 1), such as cottonseed cake, is often profitable in summer as a means of maintaining the weights of both mature and young animals. On many ranges an adequate supplement of protein has even aided in preserving perennial grasses, for these plants have often been depleted through persistent grazing by foraging animals in search of needed proteins furnished by the late green leaves.

Fig. 1.—Feeding protein concentrates to supplement dry summer ranges.

Many small enterprises in nearly every county do manage to get by without any feed other than that provided by the foothill ranges and some protein supplement. A very successful example was found in the foothills of Stanislaus County. On this ranch the area that is to be utilized during the dry summer is not grazed at all previously. When the cattle are turned on it in late May or early June it will contain a rather dense cover of the usual annual grasses plus a reasonably good population of bur-clover, filaree, and native clovers. These, with a supplement of cottonseed cake, not only maintain the cattle but even turn out fat steers. In the succeeding year another section of the range is used for this summer feed. By such rotation a good quality of annual feed is maintained; and there are at least sustained remnants of perennial grasses, chiefly stipas (needlegrasses), melics, bluegrasses, and squirreltails.

On some of the ranges studied there are dry stream beds and seeps where feed remains green rather late in the summer. Without a definite rotation grazing practice and supplemental protein, these areas gradually decline in both

quantity and quality of feed; but with them, these areas may be maintained at a rather high level of production.

2. Home ranch the year round with part of the range cut green and fed during the summer or fall, out of windrow or shock.

This type of utilization depends on having, in each range subdivision, some areas that can be mowed. The yield will vary markedly with the season. In years of low rainfall, conditions may be so severe that none of the feed will reach hay proportions. Where this method is practiced in rotation, however, such a problem seldom arises. To be most effective the mowing should be done before the dominant grasses have become fibrous through overmaturity. This means that they should be cut as near to blooming time as possible. There is a wide variation in the handling of this cut forage. Some operators leave it in rather small and loose windrows. Others rake it up promptly and compress it into large shocks, thus preserving as much as possible of the green color. The hay will be consumed in all cases during the dry season; but the greenest material will certainly contain the most protein and the best feed values. Cutting will help to reduce dense stands of ripgut grass and other undesirable species, if done before their seeds mature. The practice has spread markedly during the past six years. Even with this kind of feed available, most operators use some protein supplement.

3. Home ranch the year round, with a hay supplement in the summer.

The few cases of this practice encountered were in the foothills of the San Joaquin Valley, chiefly in Tulare County.

On some ranches baled alfalfa hay is brought in and fed to the livestock on dry range from about August until December (when green feed becomes available). On others green grain or wild-oat hay is cut with a chopper into large trailers. These trailers are unloaded into covered bunkers on the adjacent range, where the feed is available to the livestock. Both these methods appear feasible and economic. The ranges examined were in good condition, bearing good populations of bur-clover, filaree, soft chess, and perennial grasses.

4. Home ranch the year round, with Sudan grass for summer.

It is estimated that over 100,000 acres of Sudan grass are used in this way. This includes some acreage irrigated before seeding in the Imperial Valley and in the western San Joaquin Valley. On dry-farmed areas this practice centers in the Sacramento Valley and on or near the coast from Sonoma to San Diego.

No other grass available will produce so much feed with so little surface moisture as will Sudan, once a stand is secured. The trick is to retain the soil moisture until the soil is warm enough for seeding this crop. Sometimes the seed must be planted in a furrow (a practice called "listing") in order to get it down to adequate moisture. Where enough land is available so that a system of Sudan grass and fallow can be set up, this plan can be followed indefinitely. But where suitable land is so limited that the grass must be seeded in the same field each year, declining yields are almost sure to follow. In these situations some alternate crop, such as vetch, or vetch and oats, will probably have to aid in maintaining soil fertility, particularly nitrogen supplies. If this arrangement is not possible, then some substitute crop or practice must replace Sudan grass.

5. Home ranch part of the year, with summer range at high elevations.

This is the oldest and most natural routine in the range-livestock business. Usually the high range is in the national forests or is a combination of private land and public domain. Costs and hazards in this are governed by distance to and from the range, by losses in weight, and by livestock mortality through straying, predators, and poisoning. The United States Forest Service recognizes as most desirable those permittees who own or operate ranges near the forests, so that both hazards and costs may be kept at reasonable levels. This method of handling livestock usually fits reasonably well into the best season of use for the home range, but there is sometimes a gap between the return of stock from the mountains and the advent of pasturable green feed. When the

Fig. 2.—Typical mountain meadowland, a feed resource too valuable to be allowed to degenerate into less than full production.

home range is in good condition, this gap can be filled by the use of dry burclover and filaree, or by the use of feed that has been cut green and bunched for this purpose; in addition, protein supplements are desirable.

6. Home ranch part of the year, with summer feed on stubble, beet tops, and other crop residue.

Very few of California's 1,000,000 acres of barley, 700,000 acres of wheat, and 200,000 acres of oats do not use livestock for the cleanup after harvest. Crop residue therefore contributes much to the total livestock enterprise. In skillful hands it is a source of much good feed. Some operators overlook the fact that stubble begins to decline in feed production from the day feeding begins. They sometimes leave livestock on the residue until little is left, even of the straw. The invariable result is much costly loss in flesh, which must be regained when better feeds become available.

Beet tops are, as a rule, fully utilized. The common practice is to feed them off as they have fallen in the field. Recently some of these tops have been made into stacked silage. By this method maximum feed values are preserved.[4]

7. Home ranch with meadow aftermath, or with use of part of the meadow for summer pasture.

[4] Guilbert, H. R., W. M. Regan, and R. F. Miller. Utilization of sugar-beet tops. 4 p. California Agricultural Experiment Station, Berkeley, California. 1943. (Lithoprint.)

On most ranches at high elevations, the primary purpose of the meadows is to supply hay for winter feed. Here the aftermath, pastured, constitutes an important part of the fall feed supply. Often there has been a definite effort to improve the quality and tonnage of meadow output. The result usually is that hay supplies are increased to a point where there is a safe margin and where some of the former meadowland may be used for summer pasture. There may be a split operation in which the breeding herd or the weaners are kept at home while the rest of the herd or flock go to the high mountains for the summer.

Much work remains to be done on this phase of home-ranch development. According to recent studies, many mountain meadows have been markedly reduced in the character and quality of their production by a too liberal use of water: they are kept in a marshy condition throughout the summer, except while haying is in progress; and gradually excess water drives out the most valuable grasses and legumes, besides encouraging sedges and other poor types. Good meadowland (fig. 2) is too valuable to any livestock enterprise to be allowed to degenerate into anything less than full productive capacity. Proper water distribution, rotation, and adequate drainage will pay good dividends on these meadows.

8. Home range part of the year, with irrigated pastures for summer.

Of the 300,000 acres of irrigated pasture in California, about 100,000 are used for beef cattle and sheep. No other innovation in the livestock business has done so much to relieve the stress on overburdened ranges and to improve the quality of meat animals.

Irrigated pastures when properly handled will supplement foothill ranges at a ratio of about 10 to 1. Putting it another way, 100 acres of good irrigated pasture will summer for 6 to 7 months as many animals as 1,000 acres of range will properly support during the other 5 to 6 months. They may also be used to augment hay supplies. They give a livestock man an ideal opportunity to develop his foothill range up to its utmost carrying capacity by taking off the load during the critical dry summer.

Many operators who cannot provide irrigated pastures for their entire flocks or herds are developing or renting sufficient acreage to care for breeding herds, weaners, or animals being fattened. This practice, in turn, gives the home range some relief.

The value of any of the practices discussed above to a given livestock enterprise must be determined by comparative cost, by adaptation, by probable permanence, and by relation to improvement of the home range. An example of possible lack of permanence is the growing of Sudan grass where only a limited acreage is available for it.

One or more of these supplementary practices will be essential to round out the feed year of almost any foothill range, since the proper utilization of seasonal green feed will not leave enough residue, in bulk or in feed value, for the dry season. Judging, however, from existing practices in foothill-range management, the quality of the feed can be improved and the grazing season lengthened by the adoption of properly designed grazing rotations on any range whether for year-long or for part-year use.

GROWTH HABITS OF RANGE PLANTS

In order to plan an intelligent range-improvement program, the operator must know something about the species of range plants, annual and perennial, good, bad, and indifferent, that are living upon his range or near it. He needs only a practical working knowledge. He will wish to know why some plants survive and increase under grazing and plant competition whereas others fail to grow at all or disappear.

No one has yet been able to picture accurately the species and relative abundance of grasses and other forage plants that occupied California ranges before the advent of the white man. Early explorers have left us only a very imperfect and incomplete record of the original plant cover. American settlers in the Great Valley found bur-clover, filaree, and wild oats very prevalent. Yet, according to the most careful research, none of these is native to the state. The inevitable conclusion is that, during the century of Spanish occupation, seeds of these were brought here from Europe directly or by way of Mexico, since they are native to the Mediterranean.

The Medusa-head wild-rye, a weedy type of annual that is now invading the state, illustrates how rapidly these introduced species can spread. Less than ten years ago the Medusa-head was recorded only in northern Siskiyou County and near Los Gatos in Santa Clara County. It has now invaded many range areas of northern California. Another ten years will probably find it as widespread as soft chess, red brome, ripgut grass, and many other common annual grasses.

The bromegrasses, which are now the most common on California ranges, are represented by twenty-four species. But only four of these are native; and they are of limited distribution and importance, except California brome, one of the common bunch grasses.

Most of the weedy types of annuals now prevalent, such as ripgut grass, red brome, downy chess, foxtail barley and nitgrass, were introduced into this state. Along with them came a few now classed as desirable, such as bur-clover, filaree, and soft chess. These annuals found California a most congenial home, especially the valleys and lower foothills where the winters are not severe. Here they begin growth with the first fall rains and are able to ripen before the dry summer overtakes them. Since moisture is abundant in winter they require very little in volume or depth of roots to nourish them.

Perennial plants, on the other hand, must perpetuate themselves as individuals. As a rule they remain green later than the annuals; and often they are later in setting seed. Different species survive the long, dry summers by different means. Bunch grasses, such as the stipas, have a deep-penetrating system of fibrous roots that explore moisture zones far beyond the reach of annuals. Alfalfa, burnet, and similar plants have long taproots with numerous side branches that reach far and deep into the soil. Timothy, Harding grass, one form of tall oatgrass, and some of the native melics store plant food in swellings (corms) at the base of the culms.

Most plants propagate by means of seeds from previous crops. In addition to seed production some plants, such as quackgrass, beardless wild-rye, and bluestem, spread locally in colonies by means of underground runners, or

rhizomes. Others have aboveground runners, or stolons; in this group are Rhodes grass and kikuyu grass. Bermuda grass has both stolons and rhizomes.

Some species having each of these life habits do tolerate the California climate, and many perennials of each group have lived here successfully after being introduced. Judging from remnants found throughout the foothill ranges of the state, there was once a considerable population of perennial grasses. Among these were stipas, three-awns, squirreltail grasses, Junegrass, bluegrasses, fescues, bromegrasses, and melic grasses. Before these were destroyed or seriously depleted by summer grazing, they provided much green feed after the annuals had matured and died. In considering range improvement, then, one must determine whether or not these native perennials can be brought back in pasturable stands and whether a system of management can be devised to perpetuate them at a profitable grazing level.

In order to determine the most economical means of reducing undesirable species, of increasing desirable ones, and of introducing new ones, one must know something of their life cycles, their relative dates of maturity, their ability to associate with others, and their aggressiveness. Through observation one learns more about the resistance of each species to grazing, its recovery after grazing, and the comparative degree and season of stocking that will increase or reduce it. Some of the management practices that have been found effective are discussed in later sections.

Since this circular is intended for popular use there is no botanical description of the range plants. This information can be found in the references. Scientific names of species tested and of other species mentioned by common names in the text are listed on pages 44 to 46.

SPECIES RECOMMENDED FOR VARIOUS REGIONS

Since so many of our present range plants are introduced, it is reasonable to ask whether we can intentionally import others of better feed values and with a longer grazing season, get them established on our ranges, and secure profitable grazing from them.

The late P. B. Kennedy, after some years of rather desultory tests and discouraging experience, still believed this to be a promising field for research. He also visualized a time when seed of our best resident species would be propagated and harvested for artificial reseeding.

In 1937 the Agricultural Extension Service initiated the first organized project of this kind in the state. More than a hundred species were tested in a series of row nurseries and broadcast plot plantings (figs. 3 and 4). From 40 to 100 species were used in a single nursery. The plants tested are given by key numbers and common and botanical names on pages 44 and 45. There were 240 nurseries and broadcast plots in 40 counties of the state. The approximate locations are shown by dots in figure 5.

Records were made of these plantings for the following six years, including 1943. There were also observations on many seedings made in row nurseries or broadcast by the Soil Conservation Service in or near their projects or districts. These and the parent nurseries supplied seed of several species not available on the commercial market.

The recommendations on the following pages are based on the results of

these tests and on observations of acreage seeding made by farm advisors or by range coöperators.

The University of California Division of Agronomy is conducting extensive selection and breeding work on some of the more promising perennial and

Fig. 3.—A row nursery in Lassen County. This is typical of over 200 nurseries in 40 counties.

Fig. 4.—Plot seeding in San Diego County. Such seedings, usually of about 1/50 acre for each species, followed the nursery row tests.

annual range plants in an attempt to find or develop strains especially adapted to specific environmental conditions found in California rangelands. The preliminary selection work has dealt with the segregation and purification of the various plant types within a species. Some of the selections are now being tested, but the work has not progressed to the point where specific recommendations can be made, and seed is not yet available for commercial distribution.

Experience in Australia has demonstrated that seeded forage plants often

have rather narrow limits of tolerance with respect to soil, elevation, and rainfall. Soil deficiencies there are more marked than they are here; and apparently some of the other factors are more restrictive. Many of the California native and introduced species seem to have rather wide tolerance between the extremes of drought, moisture, heat, and cold, and are widely dispersed, especially over the intermediate zones.

The elevation, topography, precipitation, climate, and plant-life zones of California, or any one of them, cannot be accurately illustrated except on a complicated and confused map pattern. From Mount Shasta in the north to

Fig. 5.—General climatic regions of California. Dots indicate the location of range nurseries and broadcast plots.

Kern County in the south, the Cascade Range and the Sierra Nevada present an irregular but continuous pattern of high elevations, indented by canyons sloping up from the Great Valley. Here precipitation can generally be reckoned by altitude. On the west the coastal mountains present a more haphazard picture. Topography breaks suddenly, with rainfall belts of 40 inches or more spotting the map: beginning at Mt. Tamalpais on the north and extending southward in the Santa Cruz, Santa Lucia, San Gabriel, San Bernardino, San Jacinto, and Laguna mountains.

When the distribution of resident species and the successes and failures of the many plants used in the range-improvement project are studied, a general pattern emerges that coincides roughly with the climatic factors mentioned. This serves to divide the state into seven regions as shown on figure 5.

Many of the species used in the test plots are not discussed in the recommendations for these seven regions. Only those have been included that gave some economic measure of survival in a sufficient number of trials to be significant.

I. NORTH COAST

Rainfall in the north-coast region (fig. 5) varies from over 100 inches in the north to about 16 in the San Francisco Bay area. This higher rainfall, together with a longer rainy season, tends to increase the number of grass species that will survive. But it is generally less favorable for legumes. The recommended species for reseeding are: tall oatgrass (6),[5] California brome (7), tall fescue (8), California oatgrass (9), the ryegrasses (12, 13, 14, 89, 90) (fig. 6), birdsfoot trefoils (15, 16), melics (22, 23, 24), prairie grass (25), Harding grass (28), burnet (30), the stipas (33, 34, 35), hop clover (43), subterranean clover (56, 97, 98—especially 98, the late strain), and orchard grasses (63, 63A, 63B).

Fig. 6.—A ryegrass seeding in Mendocino County. Light seedings (such as that shown) will survive better than dense stands on dry range.

Humboldt and *Mendocino counties* are a natural grass country, the chief problems being competition with resident growth, the need of adapted legumes to enrich the feed and maintain nitrogen in the soil, and some difficulties in the hotter interior regions, especially on the poor and exposed slopes. Hop clover (43), subterranean clovers (56, 98), and sometimes two species of trefoils (15, 16, 65) have been found to meet the first requirement very well. Sufficient grass species have also emerged favorably from the tests wherever they could be so seeded and managed as to avoid serious competition the first year. On the less favorable areas the greatest gains will come from the gradual adoption of grazing practices that will foster the return of such native perennials as California and timber oatgrasses, stipas, purple reedgrass, Junegrass, and the two perennial bromes *Bromus carinatus* (California brome), and *B. laevipes*. Further work is planned with hop clover (43), shamrock clover, subterranean clovers (56, 97, 98), trefoils (15, 16, 65), and such other legumes as are found to succeed, in order to bring up the legume content of the forage. Seeding operations are very promising in the many small valleys when conditions permit some seedbed preparation. In Mendocino County many acres

[5] Figures in parentheses refer to key numbers in the list on pages 44 and 45.

have been planted to Harding grass and other species under the well-organized program of the farm advisor.

As a result of the tests many acreage plantings have been made in Humboldt County. Most of the sites selected have been on land previously in oats for hay, or in some cultivated crop. Here the recommendations of the farm advisor have served a double purpose: the operator has had hay supplies practically equal in volume and feed value to his former grain crops without the necessity of annual seeding (fig. 7); and he has had a much greater aftermath of pasture, of better quality, than was formerly possible. The project has thus become very useful to many coöperators in Humboldt County.

Fig. 7.—Former grain-hay land on the north coast reseeded with permanent hay and pasture mixture.

None of the subterranean clovers (56, 97, 98) has been very successful in any of the plantings in *Lake County*. Inoculation with and without phosphorus should be tested before the species is abandoned here, since it seems to fit well into the soil and rainfall conditions of this county.

Reseeding results in the nurseries and in large-acreage seedings on the Guenoc, Witter Springs, and Kiethly ranges of Lake County have indicated that domestic ryegrass (13) and bur-clover (20) could be used on thin and somewhat poor soils. On the deeper and better soils tall fescue (8), Harding grass (28), burnet (30), alfalfa (17), and orchard grass (63) could be added, especially after brush burning or after some seedbed preparation.

One nursery in *Napa County* was seeded in a burn of brush and timber slash. By the third year manzanita seedlings had encroached upon it. It was hoped that data could be secured relative to the effect of a second burning on the stand of annual and of seeded plants and on the brush cover. Unfortunately, efforts to bring about a safe reburn were not successful.

Forage conditions in Napa County can be much improved through reseeding of the richer and flatter slopes and the bottomlands of the many valleys. Many brush fields where slash is burned or where accidental fires occur could also be seeded profitably. On the rougher and steeper topography, regulated

grazing management is essential to restore good stands of desirable resident annual and perennial plants of good forage value.

Before the inception of this project, many test plantings of various species had been made in *Sonoma County*. Harding grass (28) and burnet (30) have been very durable and good producers of summer green feed. Many other species have also been widely used and generally successful. Recent tests indidate that birdsfoot trefoil (16) will thrive on many dry-land pastures. Subterranean clover (56, 97, 98) has also become established on many sites, though it did not survive in the nursery. Some additional work is desirable to determine whether inoculation or the application of phosphorus will make this plant more useful. The spreading of animal manures has been found to increase forage production here. Phosphorus has markedly stimulated the growth of bur-clover (20).

Most of the foothills of Sonoma County are used in dairying rather than in beef and sheep production. Dairying calls for a high per-acre forage yield and a green forage that will extend throughout the summer. The range plants tested there have not fully accomplished these purposes under the seeding and management practices applied. Sudan grass has been extensively used and has served very well. The one serious disadvantage is the need of annual soil preparation and sowing for the production of this crop. Perhaps some coöperator can be found who has cropped to Sudan grass or small grains until his land has become rather free of competing resident plants. On such land a good seeding of the most productive and promising perennials could be made, to serve as a test of total annual yield and net income as compared with Sudan grass. The continuous grazing that has been applied to these hills has seriously depleted and, in many cases, destroyed the California oatgrass (9) that is native there. Reseeding this valuable perennial would be helpful. Subsequent grazing rotations that would serve to perpetuate it would doubtless be adequate for any other seeded species.

Range reseeding has now become a common practice in *Marin County*. Where these plantings are on land that has been in grain hay, or some cultivated crop such as artichokes, the results have been excellent. Where native sod is plowed out and seeded at once, competition is frequently too severe for the best results. The farm advisor recommends, therefore, that reseeding should follow vetch and oats, Sudan grass, or some similar crop. Subterranean clovers (56, 97, 98) have found a permanent place here and are almost invariably used, though the problem of which of the strains is best adapted to given restricted areas remains unsolved. Both inoculation and phosphorus treatments are being tested.

Birdsfoot trefoil (16) is growing thriftily in a mixture of planted grasses on the Heims ranch near Inverness. Near the coast, therefore, this legume may enhance pasture carrying capacity and prolong green feed far into the summer. When grown in a mixture with the taller grasses, it promises to provide an adequate hay crop, which has previously come from annually seeded cereals, mostly oats. This permanent crop will save the annual cost of soil preparation and seeding while defending the slopes against erosion. The trefoil will enrich the hay and pasture and furnish soil nitrogen, which should improve the growth of grass species.

II. CENTRAL COAST

Rainfall of 40 inches occurs in this region in Santa Cruz, western Monterey, western San Luis Obispo, and central Santa Barbara counties. In eastern San Luis Obispo County it is less than 10 inches. The foothills of the Salinas Valley are also low in rainfall (10 to 20 inches), especially those of the east side. The following list of recommended species covers mainly the more favorable coastal areas: tall oatgrass (6), California brome (7), tall fescue (8), California oatgrass (9), ryegrasses (12, 13, 14, 89, 90), birdsfoot trefoils (15, 16), alfalfas (17, 18, 96), melics (22, 23), prairie grass (25), Harding grass (28), burnet (30), stipas (33, 34, 35), subterranean clovers (56, 97, 98), orchard grasses (63, 63A, 63B), Rhodes grass (67), perennial veldt grass (91).

Particularly significant in two nurseries near Livermore, *Alameda County,* was the outstanding thrift of California oatgrass (9). This very palatable and long-season grass, doubtless once native and abundant in the region, has now been practically eliminated by farming and overgrazing. Through reseeding and proper management it could doubtless be restored and maintained at profitable grazing levels. Similar management and reseeding results could be expected to apply in Contra Costa, Solano, Marin, and other counties adjacent to the San Francisco Bay area.

The two nurseries seeded in *Contra Costa County* suffered from intense competition with resident annuals. Judging from experience in this county, and in similar coastal and semicoastal areas, seeding on range sod cannot be expected to produce satisfactory stands. Because the competition with resident growth is too keen, seeded species cannot make adequate root or top development to survive the first summer.

The grazing of cattle on the ranch where the one experimental planting is located in *Santa Clara County* has been regulated, after some years of careful observation, to meet the needs of the various range subdivisions from year to year. Such management has markedly increased the stands of California oatgrass (9), stipas (34, 35), and other perennial grasses and the better types of annual forage. The range was therefore not seriously in need of increased or improved pasturage. Livestock are fed chopped grain hay during the winter. The plots were seeded in the hope of finding suitable plants to provide this hay, with some aftermath of pasture, and thus avoid farming for grain hay. Although this objective has not been fully attained, the evidence justifies seeding on some land fallowed as in preparation for a crop of grain hay.

Forage conditions vary markedly in *San Benito County.* Toward the west, rainfall and general growth conditions are favorable. This condition prevails to and somewhat east of the summit of the Diablo Range in the 20- to 30-inch rainfall belt. Here a number of perennial grasses are prevalent, including California oatgrass (9), and the general range problem is to divert some erodible farming lands to a stable cover of pasturable feed. The extreme south east portion of the county is similar to the west side of the San Joaquin Valley and comes under the discussion of the south central valley (p. 21).

Besides having range test plots, the San Benito County farm advisor has done much experimental work to promote better feed conditions in the Bolsa, a large flat area of heavy and somewhat alkaline land extending from near

Hollister to the Pajaro River near Gilroy. Irrigation water is available by pump at comparatively low cost. Ryegrasses (13, 14) thrive without irrigation over all but the most saline parts of this land. In tests, even with intermittent irrigation, a high production of hay and pasture has been secured with seeded legumes and grasses. The production of vegetables is encroaching more and more on this Bolsa under war stress. Most likely, however, the area will eventually be converted into irrigated pastures as a summer supplement to the foothill ranges.

On the Haldorn ranch located in Carmel Valley and the Tularcitos ranch, both in *Monterey County,* considerable acreages of grain-hay land have been seeded to ryegrasses (13, 14), orchard grass (63), tall fescue (8), and common alfalfa (17). These are mowed annually to produce hay and keep down weeds. They provide excellent pasture. Another notable conversion of marginal grainland is found on the Trescony ranch near San Lucas. Ryegrasses (13, 14), common alfalfa (17), tall fescue (8), and bur-clover (20), make up the mixture. These are broadcast in barley stubble and harrowed in. The fields are mowed in the spring to reduce competition, conserve moisture, and produce hay. But the chief value lies in the production of green pasture during the summer. Grazing is so applied as to give adequate utilization of the seeded species without depleting them. Methods and results in this area of low rainfall could well be applied in many counties where similar, or more favorable, climatic and soil conditions prevail.

In the coastal and semicoastal areas of *San Luis Obispo County,* where atmospheric and rainfall conditions are favorable, a number of seeded species appear likely to prove valuable for hay and forage production if measures are taken to reduce resident competition. Toward the east the rainfall declines, and summer temperatures rise. Here fewer species can be used, and the more favorable sites must be selected for successful reseeding.

A program of range reseeding is well under way in *Santa Barbara County* and is showing material results. This has consisted largely of converting erodible farming lands over to hay and pasture uses. On the Parma (Los Alamos) ranch, all erodible slopes are gradually being withdrawn from bean and grain production and are being seeded with permanent-pasture mixtures. On the north slopes and less eroded soils, growth is excellent, and the stands appear permanent. On exposed and eroded slopes more patience will be essential to establish a profitable stand of grass and legumes.

On a large area extending west from Los Alamos to Lompoc and north to Santa Maria, the soil is very unstable, and serious erosion occurs when any degree of slope is farmed to grain or cultivated crops. Further tests should reveal that this land can be returned to a permanent hay and pasture cover.

Santa Barbara County is on the borderline between the central and south coast regions. For the southern portion of the county, the recommendations for the south coast region would be more applicable.

In all of this district the poorer soils of the hills that have been farmed out and the steeper slopes where grain farming is expensive and hazardous would doubtless be more profitable over a long term in seeded permanent pasture (and hay) crops than in grain. Seeding should follow farming so that competition would be reduced the first year. (See "Reseeding Practices," p. 41.)

III. SOUTH COAST

The high mountains of interior southern California create a rather wide rainfall belt rising to over 40 inches on the summits, with a variation of from 15 to 30 inches elsewhere. Adapted species are fewer here than in the north, but this is partly compensated for by certain more tropical plants such as smilo, perennial veldt, Rhodes, molasses, and elephant grasses, which apparently thrive here. Tested species that are recommended are as follows: tall fescue (8), ryegrasses (12, 13, 14, 89, 90), birdsfoot trefoils (15, 16), alfalfas (17, 96), prairie grass (25), Harding grass (28), burnet (30), stipas (33, 34, 35), subterranean clovers (56, 97, 98—especially 97, the early strain), orchard grasses (63, 63A, 63B), Rhodes grass (67), Dallis grass (68), perennial veldt grass (91).

There is much experience on a large scale to prove that wide areas of very erodible hillside land in *Ventura County* could well be converted from grains and cultivated crops to hay and pasture. Many such areas have already been seeded to pasture mixtures and have made profitable returns in hay and pasture. Burnet (30), Harding grass (28), Rhodes grass (67), and perennial veldt grass (91), are especially promising for this useful purpose, in addition to alfalfa (17), subterranean clovers (56, 97, 98), and the ryegrasses (13, 14). Such plantings, when cut and pastured in rotation, provide green feed on almost a year-round basis. Successful practices now in operation on the Berylwood, Scholle, and other ranches should serve as a guide to future operations. The Ventura County farm advisor has issued a leaflet covering reseeding and other essential practices in range improvement.

In Leona Valley and near Pomona, *Los Angeles County,* acreage seedings were made of those species most promising in the nurseries. These are being studied with respect to plant survival and the livestock management essential to their success. Except in the foothill and mountain area extending from Saugus to Lebec, the Los Angeles County farm advisor has been able to recommend procedures in range reseeding that will be likely to succeed in the various sections of the county.

In one nursery in sandy soil near the coast in *Orange County,* Dallis grass (68) survived the dry summers without irrigation. This, and some success with other species, led to the preparation and seeding of 4 acres to a mixture of ryegrasses (13, 14), tall fescue (8), nodding and purple stipas (34, 35), Rhodes grass (67), Dallis grass, and perennial veldt grass (91). The initial stand was satisfactory, but this seeding is still too recent for results to be significant.

Most of *San Bernardino County* falls in the mountain and desert regions (see p. 25), but several nurseries were planted in the southwest portion, which falls in the south-coast region, so that the recommendations for the latter region may be expected to hold for this area.

Though much of *Riverside County* falls in the desert region, all the nurseries planted in this county were in the western part, where conditions resemble the south-coast region. Three interesting aspects of reseeding were developed in nurseries here. One of these, in Reed Valley near Sage, is on a Ramona sandy loam soil previously farmed to grain hay. The elevation is about 3,000

feet, and the average rainfall about 15 inches. The plot was disked before seeding. Growth responses were never good. By the third year all seeded species were gone except California brome (7), two stipas (34, 35), and Michel's grass (99).

The second, in Parks Valley near Anza, is also a Ramona sandy loam soil at about 3,500 feet, with 15 inches of rain. But this nursery was seeded on fallow grainland; and growth was good from the first, with an excellent survival of species. Evidently the reserves of nitrogen made available through fallowing are as essential to a good growth of forage plants as they are to the growing of grain.

The third nursery, on the Pauba ranch near Temecula, is again on Ramona sandy loam soil. The elevation is about 1,100 feet, the rainfall about 13 inches. The land on which the nursery was planted had been farmed to grain from about 1900 to 1934, after being cleared of wild buckwheat and chamise. The topography is steep, and the soil very erodible. The land had become so badly depleted and so severely gullied by erosion that it could no longer be farmed. Growth responses from the 1939 seeding of range plants were generally poor. The center segments of each row seeded in 1940 were fertilized with nitrogen and phosphorus, and growth here was much improved. Soil conditions had improved sufficiently, however, so that all of the plants seeded in 1940 were more sturdy. At the last reading thirteen species were found to have survived from a seeded total of 47.

Because of its comparatively low coastal topography and high interior elevations, *San Diego County* is adapted to a rather favorable production of range feed. But a high per-acre carrying capacity should not be anticipated. Much precarious dry-farming on both coastal and intermediate areas that are rapidly eroded and depleted of surface fertility could well be converted to a permanent grass cover. To do this work effectively will require a sustained program of development. A few examples are available, and more are desirable. On these the operator must realize that an impoverished soil will not at once produce a large crop of forage. The program should probably begin with the stubble of cereals. On steep slopes some artificial soil-saving practices, such as contours or basin listing, may be required. After soil cover is reëstablished, it will then be essential to adopt grazing and cutting practices calculated to reduce weedy annuals and promote better species. A few such demonstration areas might lead to a general program of conversion. In the extreme eastern part of this county, conditions resemble those of the desert region (p. 25).

IV. NORTH CENTRAL VALLEY AND FOOTHILLS

From Merced County north to Tehama County the annual rainfall averages 10 to 20 inches, merging into the 20- to 30-inch rain belt in some of the lower foothills. In addition, from Merced County north, October and November rains may occur to start early feed. Across the Sierra Nevada foothills, rainfall generally rises at the rate of about 10 inches to each 1,000 feet increase in elevation. This creates a more favorable range-plant environment in the eastern part of this region. Recommended species are: California brome (7), and tall fescue (8) where rainfall is above 15 inches; ryegrasses (12, 13, 14, 89,

90); birdsfoot trefoils (15, 16) on damp sites and deep loams; alfalfas (17, 18) on deep soils; bur-clover (20); melics (22, 23) in the foothills only; Harding grass (28); burnet (30); stipas (33, 34, 35); subterranean clovers (56, 97, 98—especially 56, the midseason strain); and orchard grasses (63, 63A, 63B) at 15 inches or more of rainfall.

Clearly, ryegrasses (13, 14) and subterranean clover (56, 97, 98) will succeed over wide areas of the plains and intermediate elevations of *Shasta County,* whereas Harding grass (28) and burnet (30) will thrive on favored slopes and soils. At higher elevations tall oatgrass (6), tall fescue (8), and orchard grass (63) can be added. For the higher elevations in this county, see p. 23.

According to results from two nurseries and many plot seedings made in *Tehama County,* domestic ryegrass (13), purple stipa (35), and subterranean clover (56, 97, 98) could be widely used on the shallow soils; whereas tall fescue (8), alfalfa (17), Harding grass (28), burnet (30), and orchard grass (63) could be expected to survive on the deeper soils and more favorable moisture sites.

Ladak alfalfa (18) was thriftier and more durable in Bear Valley, *Colusa County,* than common alfalfa. This is a small valley in the western hills.

Acreage seedings of domestic ryegrass (13) have been made on the Mason and Henneke ranches in Bear Valley with good results. On the Mason ranch over 600 acres of native sod were seeded with ryegrass, which has done well for four years on both hills and bottom lands. Under a rotation system of grazing by cattle, this grass has not only maintained a stand, but even increased markedly. Some later grazing now seems to be required to prevent the stand from becoming too dense for adequate growth under limited moisture conditions (fig. 6). These hills have an average rainfall of about 15 inches. The soil is generally heavy and has a high content of stone particles on the slopes.

Reseeding with ryegrass in the foothills of western Colusa County would seem to offer some promise when accompanied by a system of grazing that will permit a part of it to seed each year. On bottom lands where seedbed preparation is possible, Harding grass (28) will undoubtedly thrive.

Numerous test plantings have been made by the Colusa County farm advisor in some of the valley lands of present low use, generally classed as alkali land. These have been under irrigation. Their success has been marked, and this project has indicated that many acres of such land could find its way into profitable pasture use. Few of these soils, except where white-alkali crystals occur, have been found too saline for the general pasture mixture made up of Ladino clover (40), domestic and perennial ryegrasses (13, 14), and orchard grass (63). In the more alkaline areas, birdsfoot trefoil (16) succeeds very well. Dallis grass (68) is also sometimes added. This experience is summarized here chiefly because it was initiated as a part of the range-improvement project. If all this land, now practically idle, were seeded to demonstrated irrigated-pasture mixtures, the summer pressure of livestock on the western foothills would be much relieved.

In Yolo County, the Division of Agronomy has seeded several nurseries (fig. 8) made up of selections of nodding and purple stipas (34, 35) from the experimental plots at Davis and other grasses and legumes to determine

whether fallow grainlands can be converted to profitable grazing and whether seeding to range plants will serve to control such weeds as morning-glory and star thistle while maintaining soil fertility.

On Cache Creek near Capay is a small planting of Harding grass (28) about twenty years old. This grass, with ryegrasses (13, 14), dry-farmed alfalfa (17, 18), subterranean clover (56, 97, 98), and burnet (30) could probably be used in these foothills to redeem some sloping grainlands that are subject to sheet and gully erosion.

A mixture of birdsfoot trefoil (16) and grasses seems well suited to the revegetation of the subirrigated tidal lands in *Solano County*. Reseeding would greatly increase the forage production of large areas of potential pas-

Fig. 8.—A range test in Yolo County of selections of native grasses developed at Davis.

turelands around Suisun Bay and in similar sites elsewhere. This of course would have to follow removal of the present cover, and some soil preparation. A mixture of introduced trefoil and grasses occurs on Grizzly Island, where excellent hay crops and summer-long green pasture have for some years been produced.

Large areas of foothill, plain, and marshland in this county respond well to reseeding practices when accompanied by proper management to control weeds and preserve seeded plants. Some of the plains used for winter sheep pasture are now carrying dense natural stands of purple stipa (35). Moderate grazing on them could well be carried further into the summer months. The ryegrasses (13, 14) also thrive on the pasturelands of both plains and foothills.

Results in *Nevada County* indicate that feed conditions could be much improved in similar areas north and south in the Sierra Nevada foothills, through the reseeding of open vales, the deeper soils, and the less exposed slopes, especially on land that has been farmed to annual crops.

In 1939 there were fertilizer plots within a nursery enclosure in *Placer County* on native sod, and in 1940 a section of the nursery was fertilized. The response was very marked, the greatest increase in growth of both legumes

and grasses being derived from a mixture of nitrogen and phosporus. The general use, however, of commercial fertilizers on rangeland is not now recommended. But further tests may demonstrate that on some sites fertilization can be profitably practiced to build up plant cover and reëstablish pasturable plants.

Many square miles of the lower foothills in this county produce a high percentage of weedy annuals as a result of years of close and untimely grazing. Even its short-season feed values are not fully realized because of its depleted and weedy condition. To judge from the meager evidence now available, reseeding with ryegrasses (13, 14), bur-clover (20), where necessary, and possibly subterranean clover (56, 97, 98) might markedly improve the condition of these lower slopes. This would have to be accompanied by a rotation system of grazing calculated to reduce the weedy annuals and to permit the seeded species to seed freely every second or third year. One favorable factor on this area is that the competition of resident growth would not be severe.

Judging from the general experience in *El Dorado County,* reseeding may be successful on the northerly exposures and deeper soils, but little can be expected from seeding on south slopes and thin soils.

Conditions in the foothills of *Sacramento County* are intermediate between those in Placer County and those in El Dorado County. The soil is generally deeper and more fertile than that under grazing at Lincoln, and the rainfall is more favorable. Reseeding with ryegrasses (13, 14) and bur (20) and subterranean clovers (56, 97, 98) might be useful in redeeming dry-farmed grainland or severely depleted grazing land. In general, however, grazing management calculated to promote resident perennials and the most desirable of the annuals is probably best. The range operators where the nursery is located practice rotation grazing during late fall, winter, and spring, using high-elevation ranges for summer and early fall. Their home range is in good condition and is improving.

Beyond the seeding of ryegrass (13, 14) and bur-clover (20) as temporary pastures, there seems little encouragement for range reseeding in the eastern part of *San Joaquin County.* The western foothills resemble region V (fig. 5) ; see the recommendations for the south central valley and foothills (p. 21).

In *Stanislaus County* test plots indicate that ryegrasses (13, 14), Harding grass (28), stipas (33, 34, 35), and subterranean clover (56, 97, 98) could be used in range reseeding where forage improvement is called for. This should be chiefly on foothill farmland that will be converted to pasture.

V. SOUTH CENTRAL VALLEY AND FOOTHILLS

South of Merced County rains cannot be depended upon before January, and average less than 10 inches. This is below the tolerance of most perennial range plants, though nodding and purple stipas (34, 35), malpais bluegrass (48), and California brome (7) are found throughout this region except at the lowest elevations in the southern part of the Kern Basin.

The western and southern San Joaquin foothills, from Alameda County south and extending in an arc south and east of the Kern Basin, are not fully comparable with the remainder of this region. It is a low and short-season rainfall area. It produces a natural winter and early-spring pasture of bur-

clover, filaree, and annual grasses for thousands of sheep and many cattle. Some of this range often appears seriously denuded at the end of the pasture season. But the soil is of an Altamont type that is not easily eroded, and the feed has been returning abundantly every favorable year for more than half a century of such use. The full utilization of this resident short-season feed while it is green and nutritious seems therefore to constitute the best economy for this part of the foothills.

Only the ryegrasses (12, 13, 14, 89, 90) and bur-clover (20) should be used in seeding in the valley and the western foothills. In the eastern hills where rainfall is 15 inches or more the same species should be used as in region IV.

Merced County does not extend back into the foothills beyond the line of 20-inch rainfall. In general, grazing management to encourage bur-clover, filaree, the better resident annuals, and melics, stipas, bluegrass, squirreltail grasses, and three-awns would be the best means of range improvement. This practice is being very well illustrated by the Crocker-Huffman ranch, where the foothill ranges are grazed from November to April and the cattle are on irrigated pastures during the remainder of the year. Sometimes, when it becomes necessary to move a part of the herd to the foothills in September, no decline in flesh is reported. The explanation doubtless lies in the improvement of the range forage by previous management.

Range reseeding and management practices in *Madera County* have been influenced by experience at the San Joaquin Experimental Range. Plantings made some years ago at Ahwahnee by L. G. Goar of the University of California have also indicated what introduced range plants are suitable for higher elevations. Plantings of both purple and hairy vetches, so grazed as to permit seeding and volunteering, have also become popular through test and demonstration plots.

The ryegrasses (13, 14) and burnet (30) survived only two years in a nursery near Dunlap, *Fresno County,* in coarse granite soil. Subterranean clover (56) is doing well. The slope is to the south, and moisture conditions probably did not favor the survival of perennials or late-maturing annuals. Further tests are desirable on more favorable sites and soils. Some of the hardier perennials should survive in this general district where excessively grazed or abandoned farming lands are to be revegetated.

In the southeast corner of *San Benito County,* which is similar to the western part of Fresno County, the chief problem is to convert a rather rank growth of weedy annuals, with scattered plants of perennials, to a better forage with a longer grazing season.

Conditions in the lower foothills of *Kings County* closely resemble those described for the Kern Basin (p. 23). Both in and around Sunflower Valley and in the higher hills to the north and west there is an opportunity to develop grazing practices that will tend to improve the character and quality of the resident forage. This is normally rich in bur-clover, filaree, and soft chess, and contains some perennial grasses. Excessive stands of ripgut grass, red brome, foxtail barley, and foxtail fescue are frequent, but could be controlled by adjusted grazing management, as discussed in a later section.

The chief need in *Tulare County* is to return some of the steeper and less productive grainlands to pasture, or to have two years of fallow and pasture

between crops of small grains. In these practices domestic ryegrass (13) and bur- (20) and subterranean clovers (56, 97, 98) would be the safest, with tall oatgrass (6), tall fescue (8), Ladak alfalfa (18), Harding grass (28), burnet (30), and orchard grass (63) on favored soil, slope, and rainfall sites.

Two extreme conditions in *Kern County* do not yield to the usual reseeding procedure. In the Kern Basin the rainfall is too low to permit of any sustained success with the plants that have survived elsewhere at low elevations. The desert species used were apparently unable to survive because of a lack of the summer rainfall to which they are accustomed in Arizona and in other places where they are found. At the high elevations of Lebec and Rising Canyon, fall seeding is not successful because temperatures are extremely cold and early rains are rare. Soil-wetting rains do not usually come to this area until January. Spring seeding would probably do no better, since there are no dependable spring rains and since, even if adequate germination was secured, soil moisture would be depleted before there would be enough leafage on the young seedlings to promote deep rooting.

In normal years the natural cover of the Kern Basin provides a reasonably good amount of winter and early-spring feed. Apparently this cannot be improved upon in quality or in length of pasturage with any species that we now have. At the high elevations there are many perennial grasses such as the stipas, melics, three-awns, squirreltail grasses, bluegrasses, and Junegrass. The best general procedure in range improvement throughout this territory would appear to be the development and application of range-management practices that will best conserve and encourage the existing forage species.

VI. MOUNTAIN

The mountain region is a cold-winter, timber, bunchgrass area. It is composed of mountains in the south, and of mountains, high plateaus, and mountain valleys in the north and northeast. Rainfall is generally above 40 inches, except in a large area beyond the mountains on the east and north. Except these back portions, most of this is national forest, and grazing is regulated by the United States Forest Service. Only a few native and introduced species are common to this and the other zones. Those that have been most successfully reseeded are: wheatgrasses (1 and sometimes 2, 3, and 4), tall oatgrass (6), tall fescue (8), timber oatgrass (10), ryegrasses (13, 14) except at highest elevations, birdsfoot trefoils (15, 16), alfalfas (17, 18), black medick (19), yellow sweetclover (61), orchard grass (63), smooth brome (64), and Michel's grass (99).

In *Lassen County,* as in Modoc, Siskiyou, and eastern Shasta counties, severe winters prevail, with a rather light annual precipitation. Few range plants that succeed in the lower foothills will survive in this high, semiarid country. The wheatgrasses, particularly crested wheatgrass (1), seem to have the widest application for general range use. Many plantings of Michel's grass (99) have been made, with favorable results. This plant usually behaves as a perennial at this altitude, especially when grazed before heading. Livestock prefer it to cereal rye. Tall oatgrass (6) and smooth brome (64) are frequently used in reseeding on the better and heavier soils, especially on cereal-rye fields which the operators desire to retire from cultivation.

As a result of range test plots, hundreds of acres formerly used for producing cereal-rye hay have been seeded to crested wheatgrass. Success in this practice seems to hinge upon control of volunteer rye. Where early cutting is practiced to reduce the competition for moisture and sunlight, the chances of success are greatly enhanced.

At Norvell Flat in the Lassen National Forest northwest of Westwood, the Forest Service seeded an open sagebrush flat to crested wheatgrass and smooth brome. It was fenced against livestock, and both plants have succeeded well. How grazing should be managed to perpetuate these species is still a problem.

In accidental burns in the heavily forested areas, reseeding with resident and introduced northern species evidently can be made to hasten protective ground cover and provide some feed for livestock while the long process of timber reproduction is taking place.

In connection with his range-improvement program, the Lassen County farm advisor has promoted an active program of meadow improvement. Many of these meadows on the home ranches of livestock producers have become sod-bound with inferior and unproductive plants. To demonstrate methods of improvement, a series of nurseries was planted in these meadows. Many ranch operators have utilized the results in a program of meadow rejuvenation to increase hay supplies and home pasturage. Similar work has been done in Modoc, Siskiyou, and eastern Shasta counties.

Modoc County has not participated in the present range-improvement project, but the county farm advisor has for some years made range and meadow improvement one of his major concerns. Seeds of some species used in the project have been sent to him for use in his many nurseries and test plots. Some of his methods were also borrowed in developing a plan of work.

In eastern and northern *Shasta County,* conditions approach those described for Lassen County. Here crested wheatgrass (1) and sometimes bluestem, or western wheatgrass (2), bluebunch wheatgrass (3), slender wheatgrass (4), tall oatgrass (6), Ladak alfalfa (18), yellow sweetclover (61), and smooth brome (64) are most likely to survive the more severe winters.

The ridge tops in an extensive accidental burn on the Martin Brothers' ranch north of Weed, *Siskiyou County,* were seeded in the ash with perennial ryegrass (14), smooth brome (64), crested wheatgrass (1), and tall oatgrass (6). All these species have succeeded well and are spreading under winter and spring grazing (November to May) by cattle.

Another interesting project has been the seeding of Ladak alfalfa (18) on dry land in and adjacent to the Shasta Valley. As a result of test-plot work, there are now about 1,000 acres of this land in Ladak for hay and pasture.

East of Grenada in the Sheep Rock district, test-plot seedings were made in 1940. This is a light ashy soil in sagebrush association, with an annual rainfall of only 6 inches. Crested wheatgrass (1) and bluestem (2), tall oatgrass (6), tall fescue (8), Ladak alfalfa (18), and burnet (30) have been eminently successful, whereas domestic ryegrass (13) and smooth brome (64) have failed.

Another notable achievement in livestock feeding is found on the Hart ranch in Shasta Valley. The meadows here are maintained at a high level of hay and pasture production, chiefly through the sparing and judicious use of summer irrigation water.

VII. DESERT

In this region rainfall is generally below 5 inches, except in some of the higher mountains, where summer showers support gramagrasses and other desert perennials. The desert now accommodates as much grazing as its limited vegetation and stock-watering facilities will support. From seventeen nurseries planted with seed of desert species from Arizona and New Mexico there were only negative results.

Thirteen nurseries and many plot seedings were made and recorded in *San Bernardino County*. These covered four areas: (1) the southwestern portion of the county at elevations ranging from 1,200 to about 3,500 feet and with an average rainfall of 15 to 25 inches; (2) the alpine belt in the San Gabriel Mountains, where rainfall is 30 to 40 inches or more; (3) the New York and similar mountain ranges in the desert, where rainfall is 5 to 10 inches and occurs in part during the summer; (4) the desert floor, where rainfall is 5 inches or less. The first area has been mentioned under the south-coast region.

In the alpine belt, conditions resemble those described for the Tehachapi Mountains (Kern County), and this area is really a part of the mountain region rather than the desert. Fall planting does not result in adequate germination, because of the late occurrence of rain and the cold winters; and with spring planting the moisture is not adequate for a long enough period.

About 8,000 to 12,000 cattle are pastured the year round in the desert areas, mountain pasturage being utilized during the summer and the desert floor during the winter. In the New York and similar high desert mountains the scant summer rainfall promotes a good stand of gramas and other grasses found in like belts in Arizona and New Mexico. These require no treatment other than a grazing management that will perpetuate them. On the desert floor there are only desert species such as bush muhly, sacaton, big galleta, Indian ricegrass, and desert saltbushes. Desert species (69 to 88) were seeded in the desert floor and desert mountain areas, but none survived.

EFFECTS OF MOWING AND GRAZING ON ESTABLISHMENT OF SEEDED PERENNIALS

One important problem in the improvement of California ranges is the reëstablishment of perennial grasses. The slower growth of the seedlings of perennials is a marked handicap to their survival among a dense stand of resident annuals. As has been pointed out for certain districts, many of the perennials in range test plots suffered from the severe competition provided by the annuals. Lack of grazing at the proper time has perhaps been as common a cause of failures as overgrazing. To determine the effects of different management practices on freshly seeded perennials, two experiments were set up at Davis.

EARLY VERSUS LATE MOWING OF STIPAS

The first experiment was a set of 24 plots of stipa strains, 12×16 feet, in three series of 8 plots each, broadcast on summer fallow, December 15, 1942. Part of each plot was mowed March 31, 1943, and the cuttings removed. Figure 9, taken at that time, illustrates the severe competition provided by two common plants, filaree and buckthorn weed. On May 13, 1943, the total

area was again mowed; and mowing was repeated July 13 and November 12. Counts of stipa plants were made April 1, 1943, and January 11, 1944. The results are summarized in table 1.

The reduction of stand by January 11, 1944, on the area mowed March 31, 1943, indicates that the mowing might have been even more effective if done

Fig. 9.—Reseeding experiment at Davis. The area not mowed March 31, 1943, had only half as many stipa plants (January 11, 1944) as that part mowed early. (See fig. 10.) Note the heavy growth of filaree and buckthorn weed on the strip (right) not clipped. Photograph taken April 2, 1943, two days after mowing.

TABLE 1

NUMBER OF STIPA PLANTS IN 8 SQUARE FEET

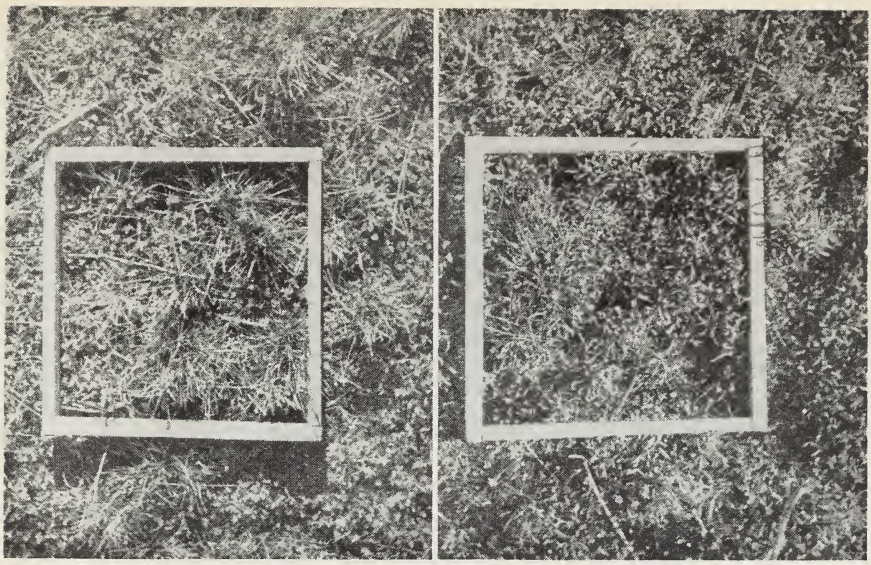
(One square foot from each plot or treatment)

Series	Initial stand, April 1, 1943	Stand of stipa plants January 11, 1944	
		On area mowed March 31, 1943	On area not mowed until May 13, 1943
1	90	70	18
2	80	49	32
3	62	46	19
Average	77	55	23

earlier. The illustration (fig. 9) bears this out. There can be little doubt, however, that the stipas on the areas not mowed until May 13 suffered, as was evidenced by reduction of the stand to less than one half (an average of 23 plants as compared with 55 on the area mowed early; see also fig. 10).

EARLY AND LATE GRAZING AND MOWING OF PERENNIALS

In the second experiment a 27-acre field was disked to a depth of 3 or 4 inches and, except for three areas reserved for plots, was seeded broadcast with a mixture of perennial ryegrass (14), 6 pounds per acre; domestic rye-



A *B*

Fig. 10.—Representative samples of the early-mowed (*A*) and late-mowed (*B*) areas in the reseeding experiment at Davis. The frame is 1 foot square. The difference in number and vigor of the stipa plants (those with long, narrow leaves) is evident. Photographs taken January 15, 1944.

TABLE 2

PLANT COUNTS, SEPTEMBER 23, 1943, AFTER EARLY AND LATE GRAZING AND LATE MOWING

Key number and common name of plant	Number of plants touching the line*		
	Early-grazed; south field	Late-grazed; middle field	Mowed; north field
Total for 2 plots in each field:			
6. Tall oatgrass	18	10	0
8. Tall fescue	31	19	4
13. Domestic ryegrass	Matured	Matured	Matured
14. Perennial ryegrass	23	11	2
16. Birdsfoot trefoil	97	67	44
30. Burnet	30	11	11
34. Nodding stipa	50	5	5
35. Purple stipa	23	3	1
42. Persian clover	Matured	Matured	Matured
56. Subterranean clover, Mt. Barker variety	Matured	Matured	Matured
61. Yellow sweetclover	69	20	23
63. Orchard grass	13	8	0
67. Rhodes grass	0	0	0
74. Dallis grass	4	1	0
91. Perennial veldt grass	10	3	0
95. Barrel clover	Matured	Matured	Matured
32. *Agropryon* × wheat hybrid	2	4	2
Total for 17 plots in each field:			
34. Nodding stipa	228	24	18
35. Purple stipa	111	23	6
Total, 34 plots in each field	609	209	116

* Count made by stretching a tape measure diagonally across the plot and recording the number of plants touching the line.

Fig. 11.—Field at right of fence grazed April 2 to April 20; the volunteer cereals have been eaten down before all available moisture was exhausted. At left of fence is field into which the sheep were turned April 20; note the heavy volunteer growth of cereals; compare with figure 12. Photograph taken April 18, 1943.

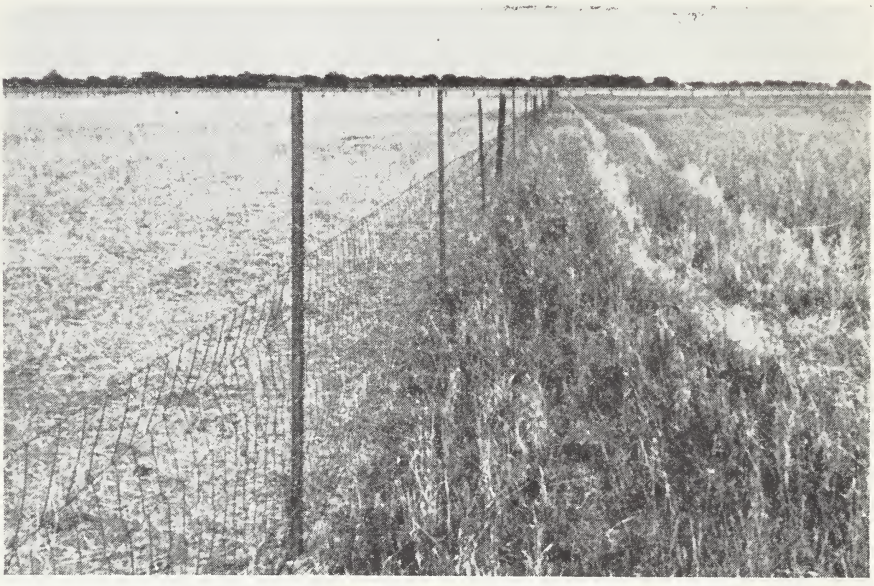


Fig. 12.—Right, recovery in the early-grazed field after April 20; the volunteer cereals, ryegrasses, and bur-clover set abundant seed from the secondary growth. Left, the late-grazed field, very well cleaned up. (Compare with fig. 11.) Photograph taken June 20, 1943.

grass (13), 3 pounds; and bur-clover (20), 10 pounds. In addition, over the field (including the plots) was a volunteer seeding of wheat, oats, and barley estimated to be at the rate of 25 to 45 pounds per acre. Rain beat in the seed.

In the reserved areas three sets of 34 plots, each plot measuring 10.0×43.5 feet (about 0.01 acre), were seeded broadcast November 23 to five legumes, burnet (30), a member of the rose family, and eleven grasses, including nodding and purple stipas (34, 35). In each set, 17 plots were seeded with nodding stipa, and a parallel set of 17 with purple stipa, at the rate of 6¼ pounds per acre (12½ pounds where stipa plots were superimposed). One other grass or legume was seeded on each plot at the same rate. The species used are listed in table 2. In March, 1943, before any grazing occurred, the area was divided into three fields of 9 acres each. Each field contained one set of 34 plots.

Three different management practices were pursued the first year after seeding:

1. Early grazing: The three 9-acre fields received the same treatment until April 2, 1943, when 275 ewes and lambs were turned into the south field. At that time there was a fair-to-good stand of most of the seeded species in all fields, the cereals were 12 to 18 inches high, the bur-clover was flowering, but the perennial grasses were still small seedlings 1 to 2 inches high. Grazing in the south field was continued until April 20, by which time the cereals had been grazed to a fairly uniform height of 4 to 6 inches (fig. 11) and the bur-clover and wild morning-glory had been closely cropped. The slower-growing perennials were not grazed to any appreciable extent. The stand of the seeded species in the plots was fair to good at this time; they varied in height from 4 to 8 inches. By July 5, however, they varied in height from 6 to 30 inches, and most perennials were setting seed.

On July 27, when 83 ewe lambs were turned back into the south field, all the perennials and the secondary growth of volunteer cereals, bur-clover, and ryegrasses had matured seed. The field was well cleaned up by August 24, when the lambs were removed.

2. Late grazing: On April 20, when 264 ewes and lambs were turned into the middle field, the volunteer wheat and barley were about 3 feet high and in the dough stage (fig. 11); wild morning-glory, bur-clover, and ryegrasses had set seed; the stand of seeded perennials varied from fair to good, and their height was 3 to 6 inches. The flock was removed from this field May 21. To clean up more of the straw, 83 dry ewes were put in and kept there until June 16 (fig. 12). One noticeable result, in contrast to the early-grazed field, was the almost complete destruction of the yellow star thistle (fig. 13) by the grazing. Observations July 5 showed a poor-to-fair stand of the seeded perennials, which were still only 3 to 8 inches high and had not yet reached the flowering stage.

3. Mowing: It was originally planned to mow the north field April 2, when the animals were turned into the south one; the aim was to compare early mowing with early grazing. Because of the labor situation it was not mowed until April 16, so that the results are not a fair comparison of early mowing versus early grazing. The hay was removed from the field. On April 22 the stand and growth of the seeded perennials was essentially the same in the late-grazed and mowed fields. On June 17, when 68 ewes were placed in the north field, the cereals, ryegrasses, and bur-clover had recovered from the mowing. Wild

morning-glory, of course, was not affected and provided severe competition for the perennials in the plots. The ewes were removed July 27. The July 5 observations showed a poor to fairly good stand of the perennials, which varied from 3 to 8 inches in height. The plants were weak for the most part.

Counts were made on the plots in all fields September 23, 1943, to obtain a fairly accurate picture of the results of the different management treatments on the establishment of the various grasses and legumes. A tape measure was stretched diagonally across each plot, and each plant touching the line was recorded. The results are given in table 2.

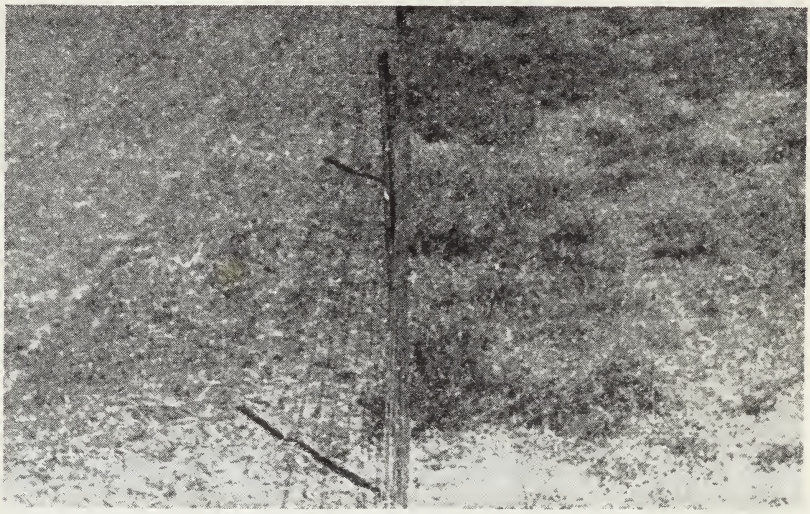


Fig. 13.—Right, star thistle in the early-grazed field. Left, although the late and prolonged grazing in the middle field was harmful to the perennial stand, this treatment was fairly effective in reducing the stand of star thistle. Photograph taken August 25, 1943.

Except for a few species that are obviously not adapted to dry-farming conditions and therefore did not succeed in any field, the trend of establishment success was remarkably uniform. The perennial legumes and burnet did the best in all fields. Even with them, however, a better stand was obtained in the field that had the early, intensive grazing. For the perennial grasses, which are slower growing, the differences in response to the three grazing treatments were even more marked. Apart from actual numbers, the plants themselves differed markedly in vigor in the three fields. Those in the early-grazed field were healthy and vigorous, whereas those in the late-grazed and mowed fields were poorly established, with very weak root systems barely holding the crowns in contact with the soil.

In this experiment on good soil with a very high water-holding capacity, proper management has proved helpful to the successful establishment of perennials. Yet the fields have produced a profitable amount of grazing, a good increase in livestock weight, and some off-season pasturage that could not be provided by annuals alone. This became even more evident during the second season. On poorer soils with a low water-holding capacity, such management would be absolutely necessary.

OBSERVATIONS ON MANAGEMENT OF BRUSH FIELDS

The situation with respect to the controversial subject of brush fields is probably more hopeful than in the past. New policies and practices are being shaped with each passing year and are almost sure to develop rapidly when men, machinery, and materials return to their normal functions. Clearly, whatever the future may hold, California must readjust and utilize to fullest capacity her feed- and food-producing resources in order to meet the requirements of a rapidly expanding population. Among other things, there must come a careful and intelligent analysis of the brush fields that now encroach upon potential pasture lands.

During the six years of the present study consecutive annual observations have been made on as many sites as possible, and as many aspects of this problem have been studied as time would permit.

Several accidental brush burns have been observed in the hills of western Colusa County. These have not been accompanied by reseeding nor by any considered system of grazing. The results have not been promising in increased feed production. Much of the brush is chamise, which occupies the steep, thin soils not well adapted to feed production. Some of the other brush types might be attacked more hopefully where the slope is not too steep or the exposure too severe. Such a breakup of brush lands would require very careful control when fire is used.

In El Dorado County some excellent stands of both seeded and natural pasture plants have followed brush burning on northerly slopes and deeper soils. In shallow soils and more severe exposures an adequate yield of feed has not usually followed brush removal.

On one range in Lake County a program of controlled burning has been under way for five years. This is a typical chamise area with steep slopes and a thin, poor soil. Designated areas are burned each year, and domestic ryegrass (13) is seeded in the fresh ash. At the end of five years the stand of ryegrass is still very good, and there has been no appreciable erosion. Sheep are pastured on this range in June, July, and September. They browse the young sprouts of chamise and crop the matured ryegrass, trampling the grass seed into the soil. Although this browsing is materially retarding the chamise sprouts, the brush may perhaps eventually retake the land unless it is reburned. Such burning will destroy the grass litter that has improved the soil somewhat. It is impossible to predict what the end product will be. Thus far, however, the operation has been profitable, not only because of increased forage in former brush fields, but also because burning them out has served to make open parks with a cover of native stipa more accessible to the stock. The most interesting feature is that by present grazing practices the area provides feed during the critical summer months. Slopes, soil, and cover here are certainly not what have been considered as favorable for brush removal; the success so far attained must be credited to reseeding followed by grazing after the grass seed is mature.

On another range in Lake County, also in chamise but with somewhat more favorable soils and slopes, a more exact program is followed. In the spring a tractor is driven around the area to be burned. The brush crushed by the

tractor is burned out in the spring at a time when only the broken brush will burn. This provides an excellent firebreak for burning out the encircled brush field in the summer, when a good kill can be attained. The burned areas are not pastured during the first year after burning. On some of the burns, reseeding has been practiced in the fresh ash. Domestic ryegrass (13) does well on all exposures, and Harding (28) and orchard grasses (63) succeed on the north slopes.

In Marin County some interesting work has been done in removing brush with a heavy plow designed for that purpose. The plowing was done on the contour, and the brush practically covered. In the fall the entire area was seeded to ryegrass and orchard grass. Good stands were secured and have provided excellent hay and pasture crops.

In Mendocino County coöperative brush burning is extensively practiced. Consecutive observations have been made on only two of the ranges involved. These were in the foothills near Hopland, where chamise, toyon, cascara, manzanita, and scrub oak predominate. Perennial grasses found in the burns consisted of purple reedgrass, foothill and purple stipas (33, 35), California melic (23), *Bromus laevipes,* blue wild-rye, and red fescue. There was a wide variation in the grazing management after burning. One 3,000-acre range was fenced into seven subdivisions. Not over 100 acres was burned at a time, and the land was not pastured the year after burning. Rotation grazing with sheep was then practiced. After five years of such management, the 3,000 acres now carries a flock of 950 ewes, with their lambs, on a year-round basis. One section of this range was burned in 1936 and reburned in 1941. Upon examination in 1942 it appeared that the second burn had fully destroyed the brush; the area bore an excellent mixture of annual and perennial grasses.

The other range observed had not been subdivided and was pastured on a more continuous basis. On much of the burned area there was an excellent stand of perennial grasses, but these had the appearance of being considerably weakened. At the same time the better annuals were being depleted.

On one foothill range observed in Orange County, spring burning had been attempted. The burn was very patchy. While many annual and perennial grasses were present, the cover on the burned sections consisted largely of turkey-mullein and other summer weeds. During the summer several hundred acres of adjacent range were swept by an accidental fire, which did a much more complete job, except for occasional colonies of cactus. On this area there was an excellent stand of perennial grasses, chiefly foothill and nodding stipas, and of pasturable annuals. Since there had been no previous examination of the brush fields, it is not known whether the resident plants within these two areas were identical; but the difference in the cover after burning was striking. This detail merits further study. Time of burning may be a vital factor in the character of plant recovery. Artificial reseeding would certainly be more successful after a summer or fall burn than after a spring burn.

On the Pauba ranch in Riverside County, an area of the range near a nursery was accidentally burned in the summer of 1941. The topography resembles that described for the nursery (p. 18); the soil is somewhat more fertile but no less erodible. In 1942, pasturable forage on the burned area was estimated to be twice as great as on the unburned areas adjacent; and there was no

erosion, even though in one January storm over 6 inches of water fell in 12 hours. The brush is wild buckwheat and chamise. Unlike the field where the nursery was located, this area had not been exposed to depletion by grain farming and erosion.

Since conditions here are typical of thousands of acres in that part of the state, the area provides a possible answer to two problems confronting the livestock men of this and similar foothill areas in southern California: (1) turning steep, erodible, and marginal grainlands back to more permanent and less destructive grazing use and (2) converting brush fields directly to pasture and using them to withstand and prevent erosion. The first phase of this problem has been discussed in the section on artificial reseeding.

The conversion of brush fields directly to grazing by brush removal should be approached with extreme caution. The absence of erosion on the Pauba burn might not always follow, though the experience would seem to suffice for further clearing there. On other sites there might not be enough natural return of grass cover to defend the land against erosion. In any program of brush removal on those erodible lands, strip cropping would appear to offer the safest approach. There is not enough evidence at hand to determine whether artificial reseeding would be helpful. Experience in San Bernardino and Riverside counties indicates, however, that the less expensive seeds, such as ryegrass and bur-clover, could be profitably sown. Further experience here is essential to determine how stands of perennials, such as tall fescue, smilo, Harding, stipas, orchard, and perennial veldt grasses, can best be secured.

These two problems are vital to wide areas in Riverside, San Bernardino, San Diego, Los Angeles, Orange, and Ventura counties. Some definite program of experimental procedure should be devised and put into practice there.

On some of the mesalands of the Redlands-Yucaipa district of San Bernardino County excellent work has been done in brush removal. Both mechanical methods and fire were used. A wide strip was plowed out around the periphery with a tractor and a heavy four-bottom plow. The brush was left largely on the surface to prevent erosion. The center was then burned out. After these operations the entire area was seeded with domestic ryegrass (13) and bur-clover (20). Sheep were pastured on it during late winter and until April. Both plant species seeded freely and have persisted. The stand was much better on the plowed land and on a heavy brush burn than on the sod, where there had been only a grass fire. No erosion or other harmful effects were noted except where the fire had been allowed to run down steep south slopes into a ravine that created a natural firebreak. Here there was some soil erosion, and the grass cover was too scant to be of value.

In San Luis Obispo County, observations were made on a range in the Adelaida district. Here the brush was cut and piled in conjunction with wood-cutting operations. After the first fall rains this was burned and the area seeded with domestic ryegrass (13), Harding grass (28), alfalfa (17), and bur-clover (20). The salvage of wood for fuel saved this operation from prohibitive costs. A marked return of brush is taking place by means of seedlings and rootsprouts. Unless goats are used to control this growth by browsing, reclearing will be necessary within a few years. The stand of seeded plants varies markedly, but in general is satisfactory.

During 1943, bulldozing operations were observed on a new livestock enterprise near Fern in Shasta County. The topography is rough, and the land a stony red clay. The cover was manzanita, ceanothus, oak, and pine. The operation cost about $15 an acre. Apparently a good cover of forage plants cannot be expected without artificial reseeding. Where the bulldozing was done during the summer, the machines left a good seedbed condition. Where the land was cleared during the spring, the soil was very hard and impervious. The brush and timber were pushed into large piles and windrows to be burned after the first fall rains. Results cannot be forecast, but some years of carefully controlled grazing will apparently be necessary to liquidate the investment. It also seems probable that manzanita seedlings will require further clearing within two or three years.

Fig. 14.—A good stand of resident perennial grasses in San Diego County after a brush burn. Photographed first year after the burn.

In Siskiyou County artificial seeding after an accidental burn in 1939 has saved the situation from a feed standpoint. Removal of the stock in May allows both sown and resident species to seed freely. The stands are thickening and spreading downward into unseeded slopes and flats. So far the return of brush has been very slight.

Probably the greatest objection to the firing of brush fields is that it often includes slopes, soils, and exposures which do not yield a profitable return in feed and on which the result may be actually harmful. The boundaries of a burn are generally fixed by natural barriers where the fire can be stopped by roads or trails, or where a firebreak can easily be created by backfiring. By mechanical means, one can confine brush removal to areas capable of producing feed.

In a combination of methods, one can use a bulldozer or brush plow around the outside of the area to clear a break so that the inside can be safely burned. The cost of the operation will then be less than if the whole job were done by machinery; and yet the fires will be confined to pasturable areas.

As a rule, except where perennial grasses are prevalent among the brush,

the stirring of the soil by plow or bulldozer markedly improves the growth of vegetation, particularly bur-clover and filaree. Reseeding is also usually more successful on these stirred soils than on soils that are cleared by fire only.

When a stand of brush is dense, the stand of grass after its removal is likely to be sparser than that which follows a sparse brush cover. Some areas have an excellent stand of perennial grasses soon after burning (fig. 14). Others, however, are almost totally devoid of vegetation after brush removal. When brush is removed, it is important that the soil should be covered by grass and other pasturable vegetation with the advent of the first rainy season.

One objective should be to determine before brush removal what will be the character and density of the cover that will come in naturally. Presumably this could be determined only from remnants of plants and from seeds found within the brush fields. If an adequate cover will not naturally clothe the area the first year, then reseeding should be resorted to. This work might entail the production of commercial supplies of seed of those native or resident species that promise to succeed on the site, such as soft chess, filaree, bur-clover (20), stipas (33, 34), and California oatgrass (9).

SEASONAL MANAGEMENT OF LIVESTOCK

Regardless of whether the range operator contemplates brush removal, artificial seeding, or any other phase of range improvement, the ultimate key to his success will lie in the seasonal management of his livestock on the area under treatment.

At high elevation the season of pasturable growth is short, but continuous close cropping is recognized as detrimental to the feed. At lower elevations year-round use is possible, but is also damaging under continuous grazing. A planned grazing practice is therefore essential on all rangelands.

Some investigators have attempted to define the geography of what they term the "annual type" range in California. Within these defined limits the ranges, they believe, are and must remain of this type. But all the grass ranges of California could be converted to the annual type if they were subjected to continuous close grazing from the first pasturable growth to full maturity. Stands of undisturbed perennial grasses are as dense on some of the valley areas ("annual type") as they are at any of the high elevations. Conversely, when a range at high elevation is abused by habitual, untimely, and excessive grazing, the perennial grasses gradually give way to such annuals as downy chess. Type of range in this respect, then, would seem to depend more upon previous use or abuse than upon any definable geographical limits.

All admit that the decline of perennial grasses throughout the state has resulted from their abuse during the summer after the annuals have dried. At this time, grazing animals seek their green leaves as a means of replenishing a declining ratio of protein in the diet. Summer overgrazing, then, resulting in summer depletion, is more prevalent and more in need of correction than the reduction of all cover that is usually implied in the loose term "depleted ranges." Grazing management, in general, should take account of this fact and should seek a system of rotation, plus supplemental summer feeds of high protein content, that will reëstablish on each site the most nutritious cover that it will support, with the longest attainable season of green feed.

The average range operator needs to fix a specific goal toward which to strive in a program of improvement. So far as resident species are concerned, one can best determine this goal by appraising the remnants that are to be found on the range. If perennial grasses are present, one may assume that they are not accidental or unusual, but that they represent a remnant of previous cover. These, and the best of the annuals, are the species the operator should try to encourage.

To determine his goal, the range operator may well make a thorough survey of the range with someone who can identify the plants in the cover. This survey should catalog, and, if possible, map the percentages of each plant prevalent, including especially the comparative density and thrift of the most desirable ones such as bur-clover, native clovers, filaree, soft chess, and the remnants of perennial grasses. It should also locate and map the areas where weedy species dominate. The long-time objective should then be to reduce the weedy plants and increase the more desirable ones. With the original survey in mind, the cattleman or sheepman can make observations each year, during his normal and necessary contacts with the stock and the range, to determine the amount of progress being made toward the objective. Seasonal rainfall and temperatures will exert a marked temporary effect upon the plant population of any range, and this effect must be taken into account.

The operator who desires to initiate a range-improvement program will probably desire to rectify one or a combination of two conditions: (1) a really depleted range or (2) a range foul with weedy species that should be reduced and replaced with better feed.

A depleted range is one on which overgrazing has practically eliminated the perennial grasses, weakened the annuals, and exposed the soil to sun glare, rain impaction, and erosion until a condition approaching sterility exists. The first step in dealing with such a condition is to give the area a good rest. Plant recovery is essential to shield the soil and begin the restoration of fertility through the decay of organic matter. The operator should not be too critical of the character of growth that starts this recovery. A full year of rest will not to be too much, and it may be even longer before any grazing can be allowed. This would be a good time to reduce the herd or flock by a rigid culling of the poorer types. Other feeds should, furthermore, be sought until the recovery of the range is well under way. Grazing practices must then be gauged by their tendency toward the improvement that the grazier has in mind. Some degree of progress should be the object of each year's operations.

A range foul with weedy or undesirable growth needs an immediate grazing program to reduce the percentage of such plants in the cover. In other words, the standard management plan shown in figure 16 and discussed on page 39, or some suitable modification of it, can be put into immediate practice.

The great economic question confronting a range operator in any grazing plan is whether or not his range, once improved by a greater density or a better quality of feed, will support enough animals to maintain his business. The question might be put as follows: Assume that a given range, even though "depleted," has become stabilized at a given livestock-carrying capacity and will not deteriorate further. If the level of feed is brought up in value and abundance by a reduction in livestock numbers or by adjusted grazing prac-

tices, will the range then maintain that higher level of feed values and produce higher livestock gains than when in the original depleted condition? According to experience in Arizona, dating back to 1904, grazing management can be so adjusted that carrying capacity can be not only maintained, but actually increased. To be sure, Arizona has summer rains to promote summer green feed. But those rains are generally very scant, and plants have similar annual life cycles everywhere regardless of the season at which they are green. Re-

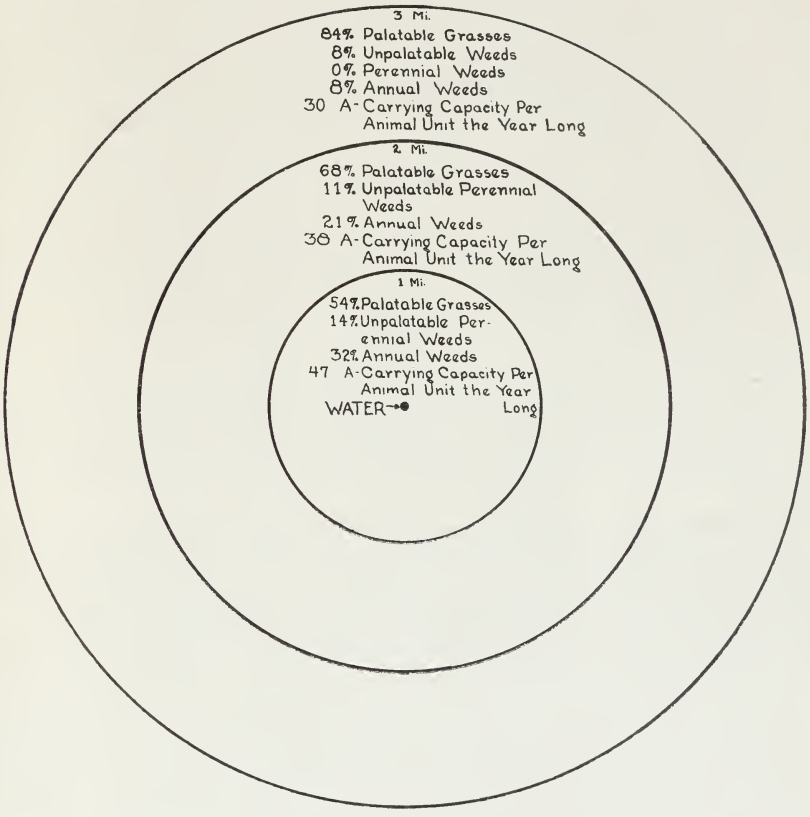


Fig. 15.—Effect of convenience of stock water on range utilization in the Great Plains area. In California, range livestock should not have to travel more than 2½ miles to water on flat or rolling ranges, nor more than 1 mile in rough topography or heavy brush or timber. (Adapted from United States Department of Agriculture Miscellaneous Publication 410.)

sponses in California should be as favorable. Indeed, experience of many graziers has demonstrated that they can be, though the present study has revealed no consecutive experience of such long duration as that reported from Arizona. Range surveys during the past six years have included all parts of California. The various ranges exemplified every degree of transition from the better species toward the poorer and from the poorer toward the better. In every case the trend upward or downward in grazing values has been the direct result of practices applied. Where livestock are grazed on a given range only while the plants are green and growing and are removed before soil moisture

becomes inadequate for maturing the better annuals and the perennials, the transition toward better feed proceeds more rapidly, provided the livestock load is habitually neither excessive nor yet too light. Where a range is used on a year-round basis the transition is less simple. But there is much evidence that it can be made without reducing livestock numbers, except where serious overstocking has prevailed. In the foothill ranges it will not come about through deferred grazing or decreased rate of stocking alone. It can be accomplished only by some application of rotation grazing.

The first requirement of any adequate system of grazing management is that there be enough subdivisions of the range, each with convenient water for the stock. The injurious effects of inadequate and poorly distributed stock water are shown in figure 15. If water were provided in each mile of the area shown within the circles on the graph, one might expect the entire range to have the carrying capacity of the center segment, 38 acres per animal unit instead of the 47 acres required on the overgrazed mile adjacent to water. Experience in this state has demonstrated that on flat or rolling ranges neither cattle nor sheep should travel more than 2½ miles to water. In rough topography, or heavy brush or timber, water should be available within each mile of range.

The agricultural conservation program has performed an excellent service in promoting the subdivision of private ranges and the development of stock water. With these improvements completed, it becomes essential to develop the type and season of rotation most suitable for each subdivision and each general site.

No large range that is to be grazed for a continuous period of 90 days or more can be best utilized by constant pasturing of the entire area. Subdivisions are essential to enable the operator to increase or decrease the livestock pressure on specific areas at certain seasons for maximum feed production.

The condition of the plants is itself an indicator of the natural succession of feed and of the time to graze to secure maximum production. Practically all grasses are most palatable and nutritious while green and before the seed matures.[6] Such annuals as foxtail barley and ripgut grass are very good feed while green, but have little or no feed value and are actually harmful after drying. Most perennial grasses retain green leafage even after the seeds have ripened. Bur-clover (20) and filaree are excellent feeds when dead and dry. Clearly any palatable species, whether annual or perennial, can be encouraged or discouraged by the time and the severity of the grazing applied to it. If it is an undesirable species it should be discouraged from seeding for reproduction or, if a perennial, from nourishing itself as an individual. If it is a species to be encouraged, then it should be allowed to nourish itself and to seed.

California oatgrass and the stipas, the most prevalent perennial grasses in the state, seem about equally sensitive to overgrazing. Both have been reduced to sparse remnants over wide areas by persistent overuse. Yet some graziers have been able to maintain or to improve stands of them by regulated seasonal grazing. Both always occur in the presence of numerous annuals. In the season when these annuals are green and most nutritious, the perennials are not

[6] Guilbert, H. R., and R. F. Miller. Feeding cattle and sheep on the range. California Agr. Ext. Cir. 70:1–28. 1932. (Out of print.)

damaged by reasonably heavy grazing; during this period, in fact, they are generally shunned in favor of the annuals. After the annuals have dried, grazing must be regulated more carefully. While the stand of perennials is being increased, the best practice is to allow little or no early-summer grazing. The next best is a rotation system by which they can be allowed to nourish themselves fully once in each cycle of two, three, or four years. Under this method, many ranges will carry a moderate load of livestock well into and sometimes throughout the summer when the green blades of perennial grasses are most in demand. This observation seems to agree with the experience in the high bunchgrass country, where rotation and decreased rate of stocking, on a short-season basis, have proved essential to the perpetuation of perennial grasses that must be grazed during the critical period of reproduction.

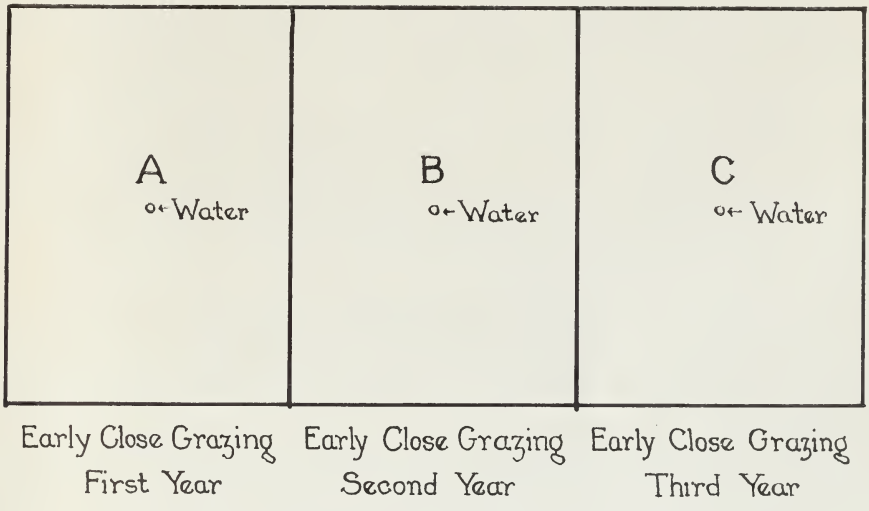


Fig. 16.—Standard plan for grazing foothill ranges.

Piecing these details together, one sees that stock should be concentrated on those portions of the range that are foulest with ripgut grass, red brome, foxtail barley, and foxtail fescue while the growth is young, green, and most palatable and nutritious. Thus the plants are utilized while they are most valuable and are prevented from seeding excessively, so that they are gradually reduced in percentage of plant population. This means that the foulest areas should be stocked heavily enough to prevent selective grazing and to insure close cropping. A range appraised shortly after this treatment might appear overgrazed. But if examined in later years after a series of rotations, it should appear to be improving. Whether the use is year-round or only seasonal, some adaptation of this practice as a phase of rotation grazing will be found to improve the quality of the feed and eventually to lengthen the grazing season.

The suggested plan for grazing foothill ranges here illustrated (fig. 16) and described is designed for average conditions. It rests on the assumption, verified on a number of ranges, that both perennials and desirable annuals will survive and do well if allowed to nourish themselves once in each cycle of

three years. As indicated elsewhere, much depends upon the severity of the treatment to which they are subjected in the other two years of the cycle. Their condition will, in turn, affect the length of the cycle necessary for the successful application of such a rotation. One must study such factors each year to determine the progress being made in range improvement.

The range subdivision that is foulest with weedy annuals, such as ripgut grass, red brome, or foxtail barley, should be first used in the suggested plan of rotation. This rotation consists in placing sufficient livestock in that field to graze it down closely while the resident annuals are green and palatable and before the seed heads are formed. The livestock load should be sufficient to prevent selective grazing and to insure an even and close cropping of the cover. The animals should be removed early enough so that soil moisture will be adequate to mature bur-clover, filaree, soft chess, and such perennials as are present. In the south this may be as early as March 15; in the north as late at May 15—or on the north coast even as late as June. Seasonal climatic conditions must be considered in determining both the beginning and the end of this grazing period. Soft chess, bur-clover, filaree, and the perennial grasses all mature later than most of the weedy annuals. Nitgrass, Medusa-head wild-rye, and goatgrass are notable exceptions, being weedy annuals that mature late. A moderate grazing may be applied again if necessary after the plants have matured. But this early grazing and comparatively early resting will have several notable effects:

1. The early weedy annuals will be prevented from producing a normal seed crop and will be reduced in the ensuing plant population.

2. Good use will be made of foxtail barley and ripgut grass, since they are excellent pasture plants while green and leafy, but useless and even harmful when mature.

3. Plants that are being cropped tend to put out new leaves and stems, thus remaining green longer than when allowed to mature. Cropped plants extract less soil moisture than when allowed to produce full leafage. Because of these two influences, the cropped fields remain green longer than those grazed less severely.

4. As the population of weedy annuals is reduced by this early grazing, there will be an increase in the more desirable species. This will not be an immediate result, but will be the end product that the operator seeks to attain.

If this early grazing has been applied to one field the first year, then it should be transferred to another for the second year and to the remaining subdivision the third, returning to the original one in the fourth. Meantime, the subdivisions not grazed early should receive as nearly normal grazing as the readjustment of livestock will permit. This system may need adjustment to suit local conditions. On some sites one can effect a more rapid improvement by creating a two-year rotation, if such a plan can be economically put into operation. Again, a four-year rotation may suffice. Some sheepmen, where enough pasture subdivisions are available, find it feasible to use a more frequent on-and-off rotation. Smaller enclosures are conducive to more intensive grazing. But the owners of large herds, especially of cattle, do not like to shift their stock too frequently. These details can best be determined by experience on each range where rotation grazing is put into practice.

SUMMARY OF RECOMMENDATIONS

RESEEDING PRACTICES

Few species will give any satisfactory degree of germination and growth when seeded on range sod without any soil preparation. Those that will should be sown in the fall so that they can have full advantage of the rainy season; seeding should be preceded by rather close grazing in order that the seed can come in contact with the soil. Those species, then, that will generally give a reasonably good stand are domestic and perennial ryegrasses (13, 14), burclover (20), subterranean clovers (56, 97, 98), filaree, and burnet. Recommendations by regions are given on pages 15 to 25.

The species mentioned and a number of others will succeed well when sown in a fresh brush burn (fig. 17) or in a prepared seedbed against a firm bottom. The ash of a grass burn seems to possess little in the way of nutritive or protective values.

Seeded perennials will not survive the first year satisfactorily where dense stands of resident annuals are present to compete for moisture and sunlight (fig. 18). This competition can often be reduced sufficiently by cutting the annuals before they mature and while soil moisture remains near the surface.

No matter what species are used in seeding or how well they germinate and grow, one cannot expect that they will survive or that a general range improvement will follow unless grazing practices are regulated to accomplish these ends. The ryegrasses have been widely seeded on comparatively small areas almost throughout the state and have started and grown very well. Often, however, they have not survived more than one or two years because the grazing has been so close and continuous that they could not produce seed. Occasionally, where larger acreages have been sown and regulated grazing has been applied, the stands are denser after four or five years than during the first year. Domestic ryegrass is an annual, on the range. It is green later than most resident annuals, but will not persist unless it can produce at least a partial crop of seed. Areas seeded to it, or to any other annual or perennial species, should be large enough to provide for a rotation of stock, or should be rested before plant maturity.

Reseeding is recommended chiefly on marginal or erodible farming land that is more likely to be profitable in a permanent cover than in precarious annual seed crops. Seeding such land in the stubble of the previous crop is better than plowing the stubble out and seeding in soft, loose soil. Seeding after a year of fallow is still better.

When land is too seriously depleted or eroded to produce profitable yields of grain, beans, or other dry-land crops, it should not be expected to produce at once a luxuriant growth of forage plants. The cereal grains are grasses, and their reaction to soil depletion is similar to that of forage plants. Patience is essential in establishing permanent forage on any land that has been abandoned for farming because of erosion or depletion of fertility.

In tests by A. W. Sampson[7] and others, the nitrogen content of the surface soil has proved to be higher after burning slash or brush than it was before. In

[7] Sampson, A. W. Plant succession on burned chaparral lands in northern California. California Agr. Exp. Sta. Bul. 685:1–144. 1944.

dry-farming, the chief purpose of fallowing is to accumulate some free nitrogen in the soil for the benefit of the crop to be grown during the next rainy season. In the present range-test plots both brush burning and fallow have proved conducive to a good growth of seeded plants.

Fig. 17.—Thriving stand of Harding grass sown in a fresh brush burn, Mendocino County.

Fig. 18.—Dense mat of resident grasses. Such competition often inhibits a good stand of seeded grasses. Early clipping or grazing is helpful.

After alfalfa, burnet, or other taprooted plants are established, gophers must be effectively controlled. A rapid increase in the population of these rodents can be expected, and they will soon destroy much of the stand.

Tests by Sampson (cited above) also show that in burns annual plants are usually weaker in growth the second year after brush burning. In the present work perennials did not show this behavior. Any perennial plant that makes a sturdy growth the first year has a much better chance of survival than one

that starts slowly and feebly. The explanation, apparently, is that when the top is strong the roots penetrate deep into the soil and extract moisture and fertility beyond the reach of the annuals.

BRUSH MANAGEMENT

Soils and slopes known to be erodible should not be denuded of their native cover unless adequate provision can be made to prevent sheet or gully erosion.

Some soils and slopes are not adapted to the production of good forage after the brush is removed. Detailed surveys to delineate these areas are needed.

In general, the soils of steep south and southwest exposures are too shallow and too much exposed to weathering to justify burning the brush from them.

Even under the most favorable conditions, maximum results cannot be achieved unless the areas burned are restricted to an acreage that can be properly managed with respect to the grazing of shrub sprouts, the seeded or natural forage plants being meanwhile preserved.

The burning of brush or grass, when properly timed, does not kill out any considerable proportion of the perennial grasses present.

Wherever feasible the use of heavy machinery to outline the areas to be burned is recommended as a means of protection and of limiting fires to areas that can be profitably burned.

Close coöperation of graziers is essential to a coördinated and effective program. This coöperation should include help not only in defining the areas to be treated and controlling fires, but also in the grazing management that is to follow. Increased pasture acreage should not mean more depleted ranges.

When artificial seeding is to follow the burning of brush, it should be done before the fall rains. The ash is useful as a cover for the seed, and early germination helps the seeded species to compete with native growth. More reseeding experience is needed.

Both accidentally and intentionally brush-denuded areas should be used for experimental and test-plot work on all phases of this problem.

GRAZING MANAGEMENT

Planned grazing management is essential to range improvement regardless of any other practices applied, such as reseeding and brush removal.

An appraisal of existing and potential plant populations is a desirable means of establishing a goal for improvement.

Excessive late-spring and summer grazing is damaging to perennial grasses and the more desirable annual plants.

A range depleted by past abuse will require a rest followed by adjusted grazing practices. A range foul with ripgut grass, red brome, foxtail barley, and some other annual species can be improved by early cropping to reduce seed production; stock should be removed early enough in the spring so that soil moisture will be adequate to permit the perennials and the better annuals to mature seed.

Sufficient range subdivisions and adequate and convenient water for stock are essential to the practice of rotation grazing.

A three-year grazing rotation is recommended for the ordinary range situation. Shorter rotations may be desirable to hasten improvement. Longer rotations may be necessary to meet individual requirements.

COMMON AND SCIENTIFIC NAMES OF PLANTS MENTIONED IN THIS CIRCULAR

PLANTS TESTED IN RANGE NURSERIES, BY KEY NUMBERS

1. Crested wheatgrass, *Agropyron cristatum* (L.) Beauv.
2. Bluestem (western wheatgrass), *Agropyron Smithii* Rydb.
3. Bluebunch wheatgrass, *Agropyron spicatum* (Pursh) Scribn. and Smith
4. Slender wheatgrass, *Agropyron pauciflorum* (Schwein.) Hitchc.
5. Australian saltbush, *Atriplex semibaccata* R. Br.
6. Tall oatgrass, *Arrhenatherum elatius* (L.) Mert. and Koch
7. California brome (mountain brome), *Bromus carinatus* Hook. and Arn.
8. Tall fescue (alta fescue), *Festuca elatior* L. 29366, a selection of meadow fescue
9. California oatgrass, *Danthonia californica* Boland.
10. Timber oatgrass, *Danthonia intermedia* Vasey
11. Red fescue, *Festuca rubra* L.
12. Short-rotation ryegrass, *Lolium perenne* L., a selection of perennial ryegrass
13. Domestic ryegrass, *Lolium multiflorum* Lam.
14. Perennial ryegrass, *Lolium perenne* L.
15. Birdsfoot trefoil, *Lotus corniculatus* L., erect type
16. Birdsfoot trefoil, *Lotus corniculatus* L., prostrate type
17. Alfalfa, *Medicago sativa* L., common or Chilean variety
18. Alfalfa, *Medicago sativa* L., Ladak variety
19. Black medick, *Medicago lupulina* L.
20. Bur-clover, *Medicago hispida* Gaertn.
21. Spotted medick (spotted bur-clover), *Medicago arabica* All.
22. *Melica californica* Scribn.
23. California melic, *Melica imperfecta* Trin.
24. Bearded melic, *Melica aristata* Thurb.
25. Prairie grass, *Bromus catharticus* Vahl., a perennial form of rescue grass
26. Smilo (San Diego grass), *Oryzopsis miliacea* (L.) Benth. and Hook.
27. Indian ricegrass (sandgrass), *Oryzopsis hymenoides* (Roem. and Schult.) Ricker
28. Harding grass, *Phalaris tuberosa* L. var. *stenoptera* (Hack.) Hitchc.
29. Creeping rooted alfalfa, *Medicago* sp.
30. Burnet, *Sanguisorba minor* Scop. (*Poterium Sanguisorba*)
31. Idaho fescue (blue bunchgrass), *Festuca idahoensis* Elmer
32. *Agropyron* × *Triticum*, a cross of wheatgrass and wheat
33. Foothill stipa (foothill needlegrass), *Stipa lepida* Hitchc.
34. Nodding stipa (nodding needlegrass), *Stipa cernua* Stebbins and Love
35. Purple stipa (purple needlegrass), *Stipa pulchra* Hitchc.
36. Meadow foxtail, *Alopecurus pratensis* L.
37. Bulbous barley, *Hordeum bulbosum* L.
38. American vetch, *Vicia americana* Muhl.
39. Purple vetch, *Vicia atropurpurea* Desf.
40. Ladino clover, *Trifolium repens* L.
41. Cluster clover (McNeill clover), *Trifolium glomeratum* L.
42. Persian clover, *Trifolium resupinatum* L.
43. Hop clover, *Trifolium procumbens* L.
44. Thingrass (leafy redtop), *Agrostis diegoensis* Vasey
45. Hall's bentgrass, *Agrostis Hallii* Vasey
46. Lemmon stipa (Lemmon needlegrass), *Stipa Lemmoni* (Vasey) Scribn.
47. Junegrass, *Koeleria cristata* (L.) Pers.
48. Malpais bluegrass, *Poa scabrella* (Thurb.) Benth.
49. Sandberg bluegrass, *Poa secunda* Presl.
50. *Medicago hispida* Gaertn. var. *sardoa* (variety not verified)
51. *Medicago muricata* All.
52. Tifton bur clover (Tifton medick), *Medicago rigidula* Desr.
53. Snail clover (snail medick), *Medicago scutellata* Mill.

54. Tubercled clover (cogwheel medick), *Medicago tuberculata* Willd.
55. *Medicago turbinata* Willd.
56. Subterranean clover, *Trifolium subterraneum* L., Mt. Barker variety (midseason)
57. Horned trigonella, *Trigonella corniculata* L.
58. *Trigonella Balansae* Boiss. and Reut.
59. White lupine, *Lupinus albus* Linn.
60. Yellow sweet lupine, *Lupinus luteus* Linn.
61. Yellow sweetclover, *Melilotus officinalis* Lam.
62. *Melilotus* sp., a selection of yellow sweetclover of low cumarin content
63. Orchard grass, *Dactylis glomerata* L.
    63A. Orchard grass, *Dactylis glomerata* L., Akaroa variety
    63B. Orchard grass, *Dactylis glomerata* L., C-23 selection
64. Smooth brome, *Bromus inermis* Leyss.
65. Big trefoil, *Lotus major* Scop.
66. Strawberry clover, *Trifolium fragiferum* L.
67. Rhodes grass, *Chloris Gayana* Kunth.
68. Dallis grass, *Paspalum dilatatum* Poir.
69. Feathertop, *Pennisetum villosum* R. Br.
70. Capegrass (weeping lovegrass), *Eragrostis curvula* (Schrad.) Nees
71. *Eragrostis Lehmanniana* Nees
72. Gray saltbush (Mediterranean saltbush), *Atriplex Halimus* L.
73. Karroo bush, *Pentzia virgata* Less., possibly synonymous with *P. incana*
74. Karroo bush, *Pentzia incana* Ktze.
75. Giant panicgrass (blue panicum), *Panicum antidotale* Retz.
76. *Euryops multifidis* DC.
77. Plains bristlegrass, *Setaria macrostachya* H.B.K.
78. Blue grama, *Bouteloua gracilis* (H.B.K.) Lag.
79. Side-oats grama, *Bouteloua curtipendula* (Michx.) Torr.
80. Rothrock grama, *Bouteloua Rothrockii* Vasey
81. Mediterranean grass, *Schismus barbatus* (L.) Chase
82. Cottontop, *Trichachne californica* (Benth.) Chase
83. *Tripteris pachyteris* Harv.
84. Plantain (Indian wheat), *Plantago xerodea* (Morris)
85. Broom menodora, *Menodora scoparia* Engelm.
86. Rough menodora, *Menodora scabra* Gray
87. Tobosa grass, *Hilaria mutica* (Buckl.) Benth.
88. *Enchylaena tomentosa* R. Br.
89. Wimmera ryegrass, *Lolium rigidum* var. *strictum*. (Presl.) Jansen, annual
90. Perennial ryegrass, *Lolium perenne* L., Clune's variety
91. Perennial veldt grass, *Ehrharta calycina* Sm.
92. Carpet grass, *Axonopus compressus* (Swartz) Beauv.
93. Mitchell grass, *Astrebla triticoides* F.v.M.
94. Australian canary grass, *Phalaris tuberosa* L.
95. Barrel clover (barrel medick), *Medicago tribuloides* Desr.
96. Alfalfa, *Medicago sativa* L., Pilca Butta variety
97. Subterranean clover, *Trifolium subterraneum* L., Dwalganup variety (early)
98. Subterranean clover, *Trifolium subterraneum* L., Tallarook variety (late)
99. Michel's grass, or Michel's hybrid (species undetermined)

PLANTS TESTED ONE OR MORE YEARS BUT ABANDONED AS UNPROMISING

Alkali sacaton, *Sporobolus airoides* (Torr.) Torr.
Blue wild-rye, *Elymus glaucus* Buckl.
Bluejoint turkeyfoot, *Andropogon furcatus* Muhl.
Bush muhly, *Muhlenbergia Porteri* Scribn.
Chewings fescue, *Festuca rubra* L. var. *commutata* Gaud.
Columbia stipa (Columbia needlegrass), *Stipa columbiana* Macoun
Danthonia californica Boland. var. *americana* (Scribn.) Hitchc.

Desert stipa (desert needlegrass), *Stipa speciosa* Trin. and Rupr.
Masolo, *Astragalus Rubyi* (species description not yet published)
Pacific reedgrass, *Calamagrostis nutkaensis* (Presl.) Steud.
Prairie beardgrass, *Andropogon scoparius* Michx.
Sainfoin (esparcette, holy clover), *Onobrychis viciaefolia* Scop.
Saltbush, *Atriplex nummularia* Lindl.
Silver beardgrass, *Andropogon saccharoides* Swartz
Sulla, *Hedysarum coronarium* L.
Western stipa (western needlegrass), *Stipa occidentalis* Thurb.
Zawadke alkaligrass, *Puccinellia Nuttalliana* (Schult.) Hitchc., a cultivated form of Nuttall alkaligrass.

OTHER PLANTS MENTIONED IN THE TEXT

Barb goatgrass, *Aegilops triuncialis* L.
Beardless wild-rye, *Elymus triticoides* Buckl.
Bermuda grass, *Cynodon Dactylon* (L.) Pers.
Big galleta, *Hilaria rigida* (Thurb.) Benth.
Bromus laevipes Shear
Buckthorn weed (fiddleneck), *Amsinckia Douglasiana* DC.
Downy chess, *Bromus tectorum* L.
Desert saltbushes, *Atriplex* spp.
Elephant grass, *Pennisetum purpureum*
Filaree (alfilaria), *Erodium* spp.
Foxtail barley, *Hordeum jubatum* L.
Foxtail fescue, *Festuca megalura* Nutt.
Kikuyu grass, *Pennisetum clandestinum* Hochst.
Medusa-head, *Elymus Caput-Medusae* L.
Molasses grass, *Melinis minutiflora* Beauv.
Nitgrass, *Gastridium ventricosum* (Gouan) Schinz and Thell.
Purple reedgrass, *Calamagrostis purpurascens* R. Br.
Quackgrass, *Agropyron repens* (L.) Beauv.
Red brome, *Bromus rubens* L.
Reed canary grass, *Phalaris arundinacea* L.
Ripgut grass, *Bromus rigidus* Roth
Shamrock clover, *Trifolium dubium* Sibth.
Slender wild oats, *Avena barbata* Brot.
Soft chess, *Bromus mollis* L.
Squirreltail grasses, *Sitanion* spp.
Sudan grass, *Sorghum vulgare* var. *sudanense* (Piper) Hitchc.
Three-awns, *Aristida* spp.
Timothy, *Phleum pratense* L.
Turkey-mullein, *Eremocarpus setigerus* Benth.
Wild buckwheat, *Eriogonum fasciculatum* Benth.
Wild oats, *Avena fatua* L.

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