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INCREASING FORAGE AND LIVESTOCK PRODUCTION ON NORTHEASTERN CALIFORNIA MOUNTAIN SUMMER RANGES

By A. L. Horway, Range Conservationist, and

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INCREASING FORAGE AND LIVESTOCK PRODUCTION ON NORTHEASTERN CALIFORNIA MOUNTAIN SUMMER RANGES

By A. L. Hormay, Range Conservationist, and M. W. Talbot, formerly Associate Director,[1] California Forest and Range Experiment Station, Forest Service, U. S. Department of Agriculture[2]

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[2] Maintained at Berkeley, California, by the Forest Service, U. S. Department of Agriculture, in cooperation with the University of California.

INTRODUCTION

Much of the more productive and usable mountain rangelands in California lies in the northeast corner of the State. These ranges have premium value to the livestock industry because they furnish much-needed green forage for beef cattle and sheep during a 4- or 5-month period of the year when vegetation on most lower elevation ranges is dry and deficient in nutritive value. Many ranchers depend on these ranges to round out their yearly grazing operations.

Livestock grazing on mountain ranges in California affects the yield of many highly important products and values from these lands besides livestock. The dense vegetation cover and good soil conditions obtained under proper livestock grazing provide for better regulated flow of usable water from the mountain watersheds, reduce flood peaks and silting of streams, improve the food supply and habitat of wildlife, and enhance recreational values generally. Improper grazing thins and deteriorates the vegetation cover, causes soil erosion, and reduces these values. Proper management of livestock grazing on mountain ranges, therefore, has far reaching influence on the economy of the entire State.

Livestock grazing was started in the mountains of northeastern California about 1860. At that time most of these ranges were part of the public domain and open to grazing without cost. So stockmen grazed large numbers of livestock on the range for as long a time as possible each year. Such grazing prevailed for nearly 50 years without supervision and resulted in serious deterioration of the range (*11*, *22*)[3/]. The vegetation cover was thinned and soil

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3/ Italic numbers in parenthesis refer to Literature Cited, page 107.

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fertility reduced. Some of the better forage species were killed out and replaced by inferior ones. It is estimated that these changes reduced the productive capacity of the land by about half. Faulty management of livestock grazing was largely responsible for this loss.

Regulation of grazing on mountain ranges on a broad scale started with the establishment of the national forests in 1905 (16). Qualified stockmen were given grazing privileges on definite areas. Attention was given to controlling important grazing-management factors like stocking rate, season of grazing, and livestock distribution, so as to encourage range improvement. Yet as much as 30 years later it was apparent that fully satisfactory grazing management methods had not been developed. Even under what appeared to be proper stocking, suitable grazing seasons, and good livestock distribution, parts of the range continued to be heavily grazed and damaged.

In 1936 the California Forest and Range Experiment Station began research at the Burgess Spring Experimental Range in Lassen County, California, to develop practices which would provide for improvement and sustained high production from mountain livestock ranges. These studies were completed in 1951. The research demonstrated conclusively that periodic resting of the range from grazing is essential for increasing and maintaining grazing capacity and that some system of rest-rotation management is best for such ranges.

The idea of some resting of ranges for improvement is not new. A. W. Sampson reached this conclusion from studies started in the Wallowa Mountains of Oregon in 1907, and designed what is known as the deferred and rotation system of grazing (24). Many other investigators reported similar findings, including Craddock and Forsling (6), Frandsen (8), Hutchings and Stewart (14), McCarty (18), McCarty and Price (19), and Reid and Pickford (22). They all concluded that some rest from grazing is necessary for range improvement and maintenance.

Several tests have been made of deferred-rotation systems on western ranges to date (7, 12, 13, 15, 20, 23, 26). The systems used were compared with continuous grazing and evaluated in terms of livestock weight gains, livestock production per acre, and vegetation changes. In general, the comparisons showed that deferred-rotation grazing improved the range to some degree whereas continuous grazing tended to deteriorate the range. On the other hand, continuous grazing yielded greater livestock production over the periods tested.

All these tests, however, had some shortcomings. Several studies were not conducted for a long enough time to determine the merits of deferred-rotation grazing for improving and maintaining ranges. In some, resting was not geared closely with the growth habit of the vegetation so the benefits from deferring were offset in part or entirely by the harmful effects of grazing.

The studies reported here have indicated the need for longer rest periods than have been recommended by previous investigators. Not only deferment of grazing for part of the grazing season, but resting for entire growing seasons has been found necessary. Rest-rotation grazing, therefore, is recommended. Also, principles of grazing management that have application to perennial bunchgrass ranges throughout the West--to sheep ranges as well as cattle ranges, have been demonstrated.

THE MOUNTAIN RANGES OF NORTHEASTERN CALIFORNIA

Northeastern California is a semiarid plateau of volcanic origin ranging from 3,500 to 8,000 feet in altitude. It is covered by numerous lava flows and cinder cones and a few high peaks including Mt. Lassen and Mt. Shasta. Interspersed among the mountains are many plains and valleys, some of which are poorly drained. The weather of the region is characterized by wet, cold, snowy winters and comparatively dry, warm summers.

Summer livestock ranges lie mainly above an altitude of 4,000 feet and are grazed for 4 or 5 months between May and October. On the average about 3 percent range is grassland type, 3 percent broadleaved shrub and tree types (aspen, alder, oak), 14 percent sagebrush, 19 percent sagebrush-juniper, and 36 percent pine timber types (fig. 1). Nearly 25 percent of the area of these ranges is either barren or unusable dense timber or brush and therefore has little or no grazing value for livestock.

ALE-226

Figure 1.--Northeastern California mountain summer ranges support a composite of types--usually grasslands in valley bottoms, sagebrush on surrounding gentle slopes, and pine timber on the mountain sides.

GRASSLAND TYPE

The grassland type occupies a variety of sites from wet to dry. The more productive sites yield a ton or more herbage to the acre.

Closed Basin Site

In some valleys water stands from 6 to 36 inches deep on the soil surface for several weeks in the spring or even throughout the summer. Here the vegetation consists mainly of rhizome-forming species like common spikesedge[4/], silver sedge, wire rush, common

4/ Common and botanical names of the species mentioned in this bulletin are listed on page 105.

arrowhead, and hoaryleaf arnica. The soils are usually dark gray alluvial loams, clay loams, and clays that lie on impervious unrelated substrata. They are 36 to 60 inches deep.

ALE-226

Figure 1.--Northeastern California mountain summer ranges support a composite of types--usually grasslands in valley bottoms, sagebrush on surrounding gentle slopes, and pine timber on the mountain sides.

These sites are grazed moderately to heavily by cattle. They are in relatively good condition, however, because of the strong regenerative habit of the species. Many closed basins could be improved for grazing by better drainage.

Drained Basin Site

In some respects the drained basin site is similar to the closed basin site. The drainage is sluggish and the soils poorly aerated. However, desirable bunchgrasses, like tufted hairgrass, Nevada bluegrass, meadow barley, and bottlebrush squirreltail grow in the cover together with sod species. In many places these grasses have been reduced or killed out by grazing. Silver sagebrush often invades deteriorated parts of this site (fig. 2).

Figure 2.--A deteriorated, drained basin site that has been invaded by silver sagebrush. Wire rush and spikesedge comprise most of the cover in the shrub interspaces but a light stand of desirable and previously more abundant forage species like Nevada bluegrass and bottlebrush squirreltail, still grows under the protecting shrub crowns. ALH-788

Wet Meadow Site

Some grassland sites are well drained and kept most practically throughout the summer by fresh moving water from a spring or stream (fig. 3). These are the common mountain meadow. The site produces the greatest quantity of high value forage per acre of any of the grassland sites. Prominent species on areas in good condition include tufted hairgrass, Nevada bluegrass, Kentucky bluegrass, thin bentgrass, mat muhly, chamisso sedge, silver sedge, Oregon checkermallow, Northwest cinquefoil, and longstalk clover.

ALH-783

Figure 2.--A deteriorated, drained basin site that has been invaded by silver sagebrush. Wire rush and spikesedge comprise most of the cover in the shrub interspaces but a light stand of desirable and previously more abundant forage species like Nevada bluegrass and bottlebrush squirreltail, still grows under the protecting shrub crowns.

ALR-824

Figure 3.--The wet meadow is the most productive of the grassland sites, and is especially valuable for cattle grazing.

The site is usually heavily grazed and consequently in many places the vegetation has been greatly thinned and changed in composition and the soils gullied (fig. 4). Species commonly found on deteriorated areas include forbs like biscuitroot, plaintainleaf buttercup, western buttercup, low pussytoes, aster, water groundsel, cluster tarweed, and common camas and shrubs like big sagebrush, black sagebrush, and silver sagebrush.

ALR-826

Figure 4.--A wet meadow site where the forage cover has been greatly thinned and gully erosion started as a result of continuous close grazing.

The soils consist of brown or gray alluvial loams and clay loams. They lie on impervious unrelated substrata and are 17 to 60 inches deep.

Terrace Site

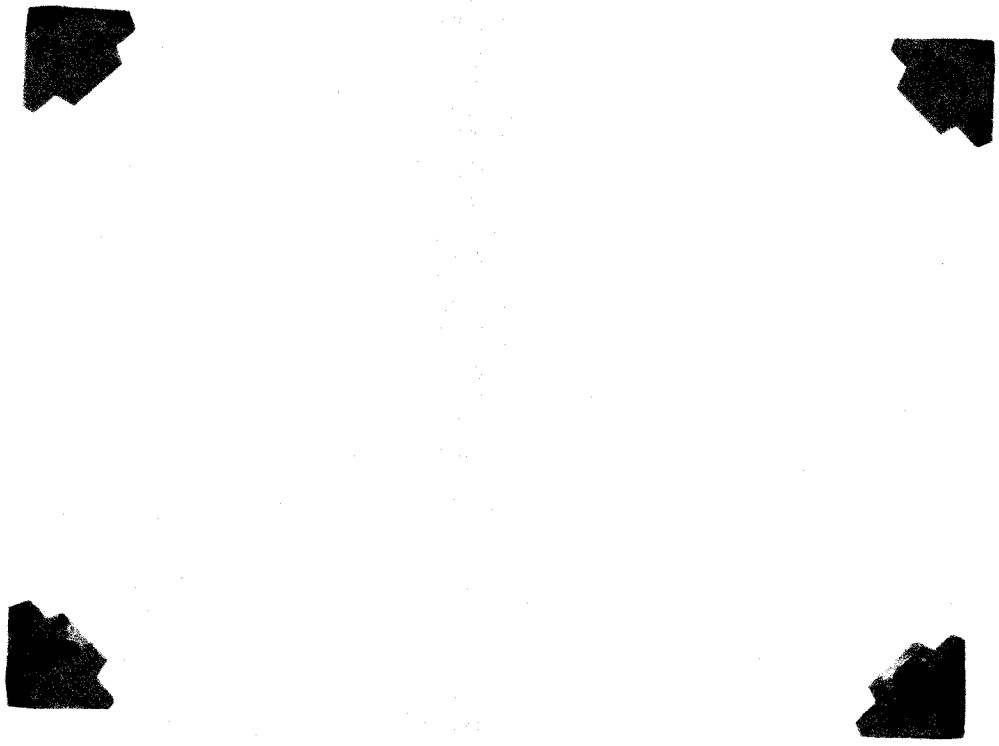
Some terraces, benches, and bottomlands in northeastern California at one time supported a dense stand of shorthair sedge which often included some Idaho fescue and Sandberg bluegrass. This cover has been disintegrated by heavy grazing (fig. 5) and invaded by inferior grazing species in many places.

ALR-913

Figure 5.--A disintegrating hair sedge stand. Here tarweed and other inferior annuals are growing on the areas of exposed soil. Plantainleaf buttercup is frequently found on such eroded sites.

AIM-824

Figure 3.--The wet meadow is the most productive of the grassland sites, and is especially valuable for cattle grazing.



ALE-826

Figure 4.--A wet meadow site where the forage cover has been greatly thinned and gully erosion started as a result of continuous close grazing.

ALM-913

Figure 5.--A disintegrating hair sedge stand. Here tarweed and other inferior annuals are growing on the areas of exposed soil. Plantainleaf buttercup is frequently found on such eroded sites.

The soils on terrace sites generally consist of brown or dark gray, gravelly or stony loams and clay loams. They range in depth from 12 to 36 inches and are usually underlain by an impervious clay pan or concretion layer. They are wet in spring but because of shallowness dry out rapidly in summer.

SAGEBRUSH TYPE

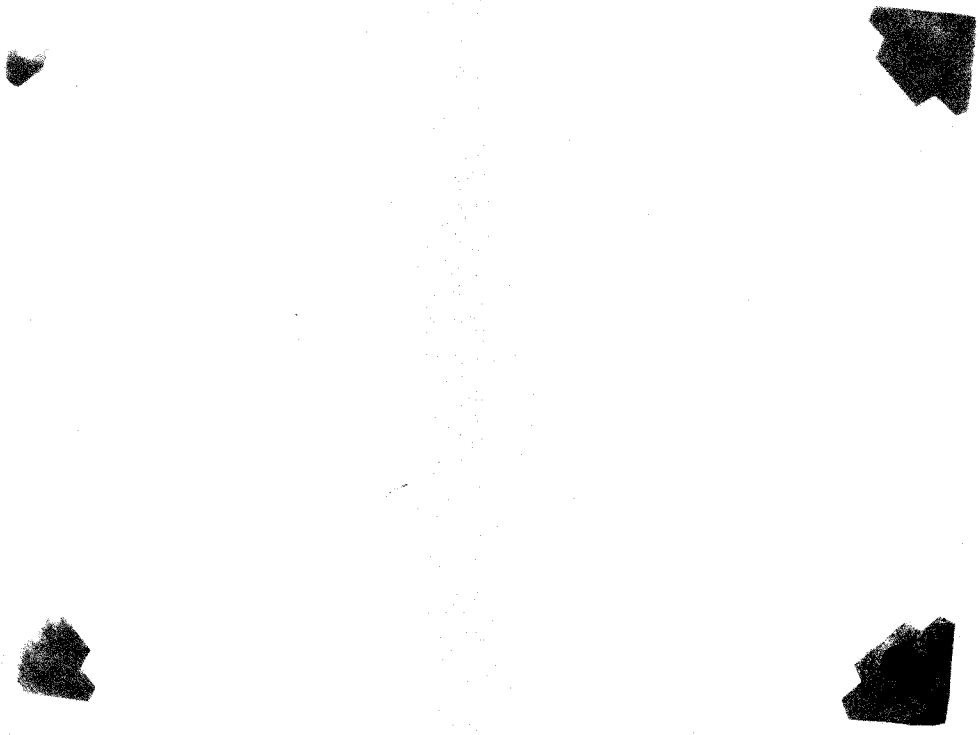
Three species of sagebrush--silver sagebrush, black sagebrush, and big sagebrush--grow widely throughout the region. Silver sagebrush is generally found on poorly drained sites (fig. 2). Black sagebrush occupies better drained sites and shallower, lighter soils comparable to those found on the terrace site (fig. 6). Big sagebrush on the other hand, grows on well drained soils on benchlands and mountain slopes in a zone between the black sagebrush type and the pine timber type (fig. 1). Species commonly associated with big sagebrush are Idaho fescue, bottlebrush squirreltail, western needlegrass, woolly mulesears, arrowleaf balsamroot, bloomer rabbitbrush, and bitterbrush.

ALH-1151

Figure 6.--Black sagebrush is usually found on shallow soils that have some drainage impairment, in the transition zone between the wetter bottom land sites and pine timber site.

SAGEBRUSH-JUNIPER TYPE

Sierra juniper characterizes the sagebrush-juniper type. In some places this species grows with black sagebrush and its associates and in other places with big sagebrush. Altitudinally the type generally lies between the sagebrush and the pine timber types. In most places it is heavily grazed and deteriorated. As a result of deterioration, the density of juniper has increased in many places.



ALH-1181

Figure 6.--Black sagebrush is usually found on shallow soils that have some drainage impairment, in the transition zone between the wetter bottom land sites and pine timber site.

PINE TIMBER TYPE

The pine timber type consists mainly of ponderosa and Jeffrey pines and pine-fir mixtures. Locally, white fir, California red fir, and incense-cedar are associated species. Only sites containing a high proportion of pine, generally those on benchlands and southerly mountain exposures, have appreciable grazing values.

The pine type generally occupies reddish brown, stony and sandy loams that are derived from underlying lava rock. These soils are well drained and range from 6 to 60 inches deep.

Typically, the pine forest is relatively open (fig. 7). The crowns of the larger trees are usually separated and reproduction occurs in groups. Considerable herbaceous vegetation of high grazing value grows in the understory. Some of the more abundant forage species are: Idaho fescue, bottlebrush squirreltail, Western needlegrass, Elmer needlegrass, Lemmon needlegrass, Sandberg bluegrass, Ross sedge, woolly mulesears, longspur lupine, and bitterbrush. Squawcarpet ceanothus and big sagebrush are also prominent in the type in many places. However they have relatively little grazing value for livestock.

ALM-1834

Figure 7.--Characteristic open structure of the pine forest. Idaho fescue is usually prominent in the understory.

ALE-1834

Figure 7.--Characteristic open structure of the pine forest. Idaho fescue is usually prominent in the understory.

The pine timber type has been grazed less heavily than most of the other types because it lies on less accessible topography and contains less stock water. Nevertheless the type has deteriorated around watering places and trailways and on margins adjoining the grassland and sagebrush types.

Northeastern California mountain ranges, it can be seen, are quite diverse in vegetation types, soils, and topography. In spite of this diversity, the problems of range management are very similar from place to place. They center around the improvement and maintenance of areas that support perennial bunchgrasses, tufted forbs, and non-sprouting shrubs. These plants reproduce from seed. More than 97 percent of the usable range area supports this type of vegetation. The remainder, restricted entirely to the wetter grassland sites, supports sod species which spread by rhizomes.

HOW THE PROBLEM WAS STUDIED

The studies were designed to get a clear picture of how grazing causes range deterioration and in this way to provide a basis for formulating grazing management practices that would prevent range deterioration under grazing use. Accordingly, the principal observations and measurements in these studies dealt with the character and growth of the vegetation, how the cattle grazed the vegetation, and how both the vegetation and cattle reacted to grazing.

EXPERIMENTAL LAYOUT

The studies were carried out in three fenced pastures (fig. 8) on representative areas of cut-over pine timber and grassland types. The timber pasture was located on rolling topography on the lower southeast slope of Harvey Mountain. The area was logged with tractors in the fall of 1934. About 80 percent of the merchantable trees, mainly ponderosa and Jeffrey pine, were cut. After logging, about 24 percent of the pasture area remained covered with trees 16 inches in diameter and larger, and 28 percent by pole size and smaller reproduction. About 48 percent was largely treeless.

Figure 8.--Experimental pasture layout at the Burgess Spring Experimental Range.

The grassland pastures were located on comparatively flat ground. They encompassed closed basin, drained basin, wet meadow, and terrace grassland sites.

Studies in the timber type were started in 1936 and in the grassland type in 1943. Most of the work was concentrated in the timber type where opportunities for studying bunchgrass type vegetation were best. The experimental program was carried on through 1951.

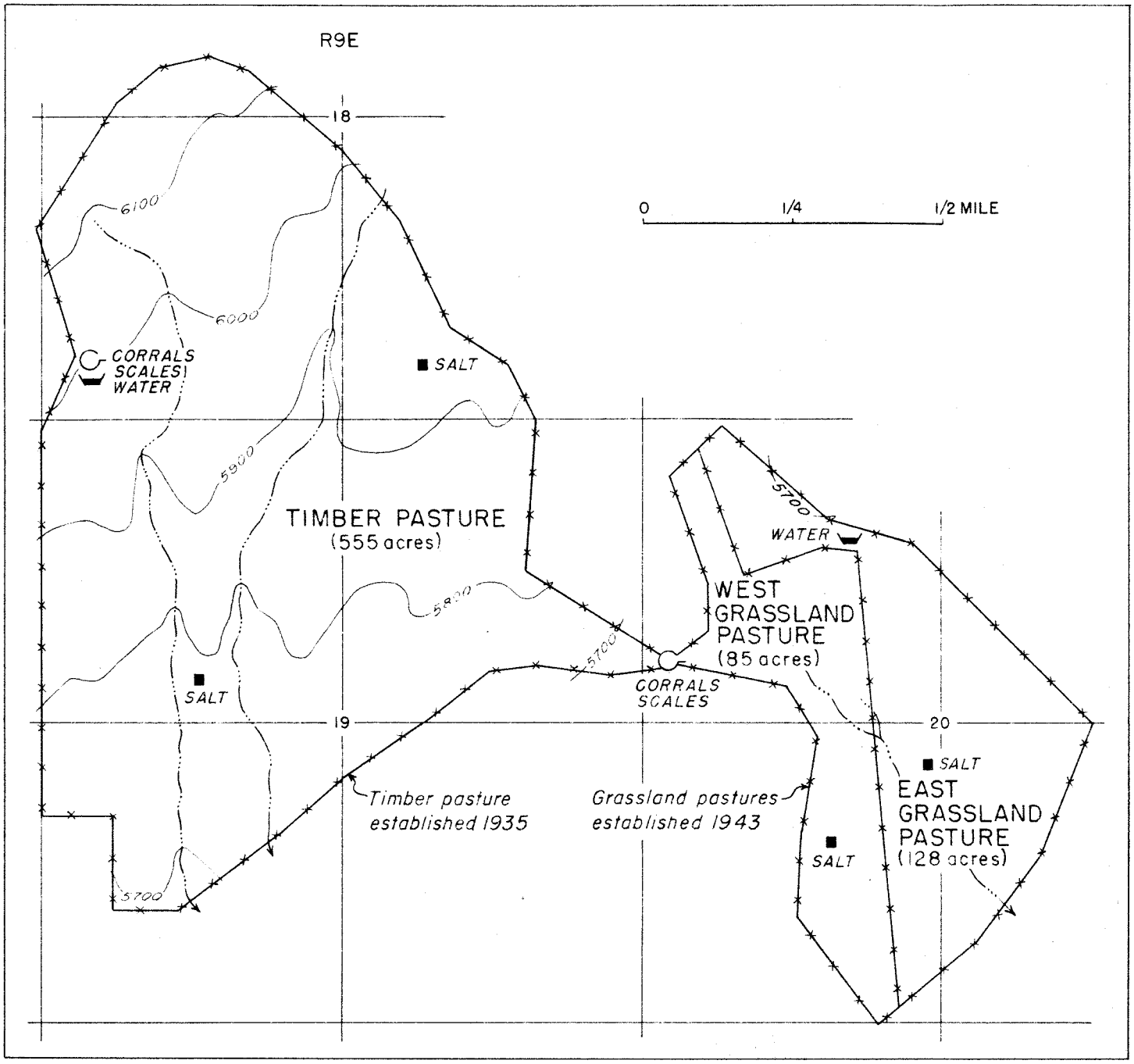


Figure 8.---Experimental pasture layout at the Burgess Spring Experimental Range.

VEGETATION RECORDS

Growth and development of the more abundant plant species were measured on staked plants in both types. Vegetation changes resulting from cattle grazing were measured only in the timber type. Here records were obtained on 855 one-fourth-milacre square quadrats laid out in a grid in the pasture. The quadrats were spaced 2.5 chains apart. Every other quadrat was protected from grazing by a rod-square, 4-strand barbwire exclosure. The effect of grazing on the vegetation was determined by comparing vegetation changes inside and outside these exclosures. In both the timber and grassland types, occular estimates were made of species utilization at the end of each grazing season.

Clipping experiments were conducted with Idaho fescue, bottlebrush squirreltail, longspur lupine, and woolly mulesears to help interpret the effects of grazing on these species. Groups of 10 plants of each species were clipped with a knife to a 1.5-inch stubble at different growth stages during the season.

The effect of logging on grazing capacity was measured on 300 one-fourth-milacre quadrats distributed on 6 1.5-acre plots. The basal area of perennial grasses and forbs and the crown area of shrubs were measured.

LIVESTOCK AND GRAZING RECORDS

From 1936 through 1938 information was obtained on how cattle grazed the vegetation in the timber type. Individual animals were followed on foot during daylight hours 2 or 3 days each week, and the number of bites taken of the various plant species was recorded. Cattle were different each year--in 1936 Hereford, Shorthorn, and Angus steers, in 1937 Hereford steers, heifers, and dry cows, and in 1938 all Hereford steers.

No cattle were grazed in the timber pasture from 1940 through 1942 and only incidental use was made of the pastures from 1939 thru 1943.

From 1944 thru 1948, after the grassland pastures were established, weight gains of cattle grazed in the timber and grassland types were measured. Similar yearling Hereford heifers were used in each of these years. The average weight of the animals ranged from 380 to 450 pounds in different years. All the cattle came onto the experimental range in fair condition of flesh and moderately shrunk.

In all years of the study, the experimental cattle were weighed at approximately 2-week intervals each grazing season. They were corralled between 4 and 6 o'clock in the afternoon and weighed the next morning between 7 and 9, after an overnight stand of 15 hours without food or water. This procedure was followed to minimize differences in fill in the animals from one weighing to the next and to provide more consistent weight records.

WEATHER DURING THE STUDY PERIOD

Precipitation, snow pack, and air temperature records from 1935 to 1951 were obtained at the Blacks Mountain Experimental Forest headquarters, 12 miles west of the Experimental Range. Annual precipitation, from September 1 to August 31, averaged 17.64 inches from 1935 to 1951 (table 1). The lowest precipitation was 9.09 inches in 1939, and the highest 29.24 inches in 1938. The winter snow pack averaged about 1.5 feet deep. A maximum pack of 6 feet was observed in 1951.

The coldest and wettest period during the year was from January thru March; the warmest and driest, from July thru September (fig. 9 and table 2). Seventy-four percent of the total precipitation fell during the 7 months from September 1 to April 1, mainly as snow. Twenty-two percent (3.90 inches) fell during the active vegetative growing season from April 1 through June. Less than 1 inch fell during July, August, and September.

Figure 9.--Precipitation and temperature at Blacks Mountain Experimental Forest headquarters.

Table 1.--Total annual precipitation, September 1 to August 31, Blacks Mountain Experimental Forest Headquarters, Lassen County, 1935-1951

Year	Inches	Percent of average
1935-36	16.50	94
1936-37	14.32	81
1937-38	29.24	166
1938-39	9.09	52
1939-40	18.91	107
1940-41	21.28	121
1941-42	20.13	114
1942-43	16.26	92
1943-44	13.69	78
1944-45	17.35	98
1945-46	15.42	87
1946-47	13.18	75
1947-48	23.95	136
1948-49	16.37	93
1949-50	17.28	98
1950-51	19.30	109
Average	17.64	100

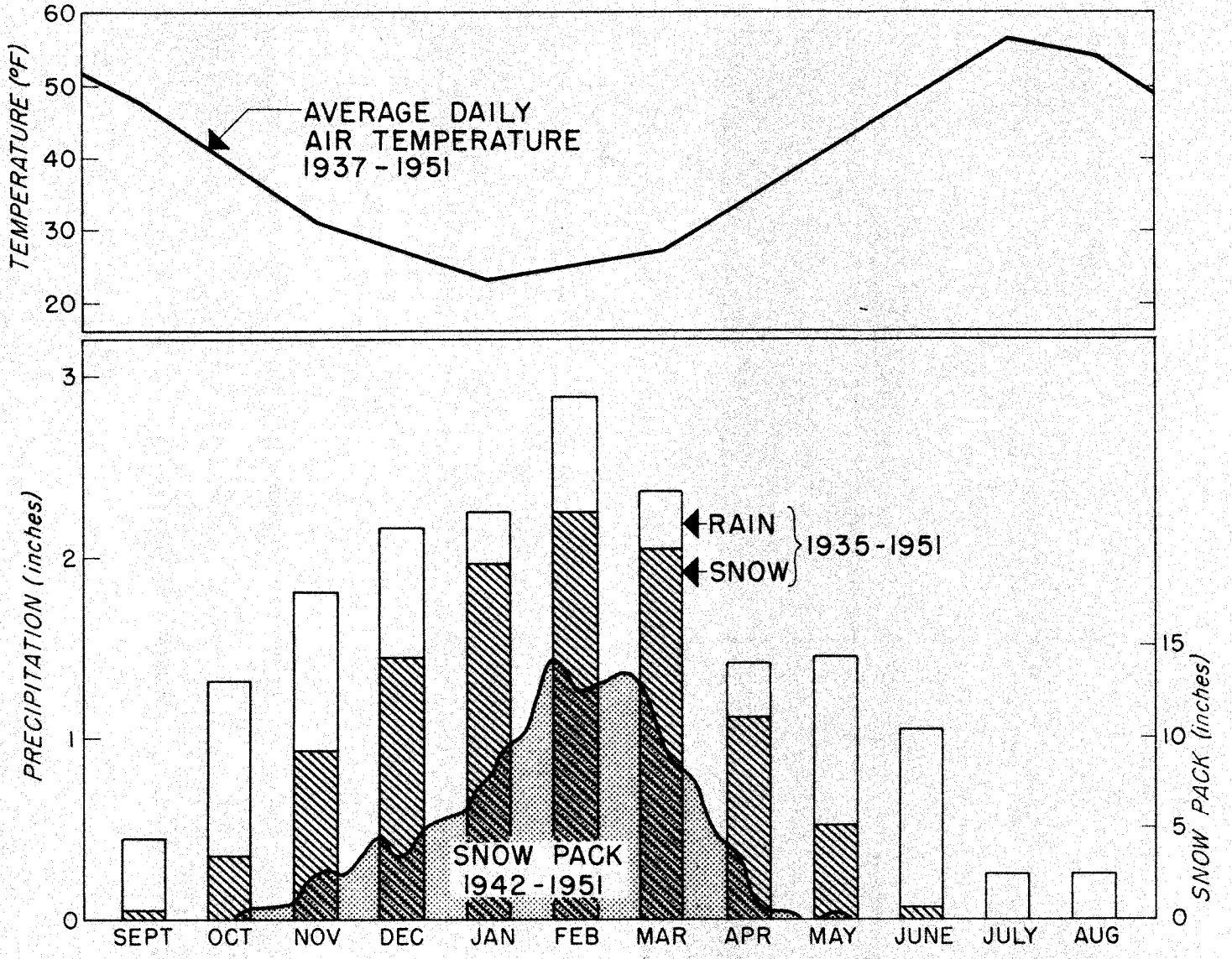


Figure 9.--Precipitation and temperature at Blacks Mountain Experimental Forest headquarters.

Table 2.--Monthly precipitation, Blacks Mountain Experimental Forest headquarters, Lassen County, 1935-1951

Month	Inches	Percent
September	0.44	2
October	1.34	8
November	1.79	10
December	2.20	13
January	2.23	13
February	2.87	16
March	2.37	14
April	1.40	8
May	1.44	8
June	1.06	6
July	0.24	1
August	0.26	1
Total	17.64	100

A comparison of the record at the Blacks Mountain headquarters with a long time record taken at Susanville, located 40 miles to the southeast, indicates that approximate extremes in precipitation were experienced during the study period.

Average daily air temperatures ranged below freezing from early December until mid-March, and up to 61°F. in July (table 3). The lowest temperature recorded was -27°F. in January 1937 and the highest 98°F. in July 1946. The frost-free period averaged only 33 days, starting in early July and ending in early August.

Table 3.--Monthly air temperature, Blacks Mountain Experimental Forest headquarters, 1937 to 1951

Month	Mean	Average maximum	Average minimum	15-year maximum	15-year minimum
	°F.	°F.	°F.	°F.	°F.
September	53	72	34	94	14
October	45	60	29	81	6
November	36	49	23	74	-5
December	1/ 31	1/ 43	20	66	-12
January	28	40	16	64	-27
February	30	41	18	73	-12
March	32	44	20	73	-8
April	39	53	25	79	5
May	46	62	30	85	2
June	53	71	35	94	20
July	61	82	40	98	27
August	59	81	37	96	25

1/ 14-year average.

GROWTH, DEVELOPMENT, AND UTILIZATION OF VEGETATION

Knowledge of plant growth and development is basic to proper management of grazing. The timing of many range practices is determined better in terms of plant growth stages than calendar dates. This is true for example in determining the start and length of the grazing season, and when livestock should be moved from one area to another for best results. Even more important, grazing must be timed in relation to plant growth stages to maintain the vigor of established plants and encourage natural reproduction. The timing of weed control and other cultural treatments on the range are also dependent on knowledge of plant growth and development.

GROWTH IN TIMBER TYPE

The seasonal development of the herbaceous vegetation in the timber type can be illustrated with Idaho fescue, whose pattern of growth is representative of the herbaceous vegetation as a whole (fig. 10). Sustained mainly by moisture stored in the soil during winter, growth began about April 1, immediately after the winter snow pack melted. Growth ended about 120 days later in early August with ripening of seed (fig. 11). Flower stalks started to show above the basal leaves of the plants near the end of May. Half the total seasonal yield of herbage was produced by this time. For the next 4 weeks the plants grew rapidly. They flowered and reached full height early in July. Maximum herbage yield was produced about a month later at seed-ripening time.

Figure 10.--Relation between the growth and development of Idaho fescue and 10 abundant forage species growing on the same area.

Figure 11.--Average seasonal growth and development of Idaho fescue.

The plants started to lose moisture and greenness in June, even before flowering time. They dried rapidly during the first half of August. By October, both greenness and moisture content reached a minimum of about 10 percent. In drying, the plants lost weight because of disintegration of leaves and stems and shedding of seed. Idaho fescue lost about 20 percent of its weight at maximum development by October 1.

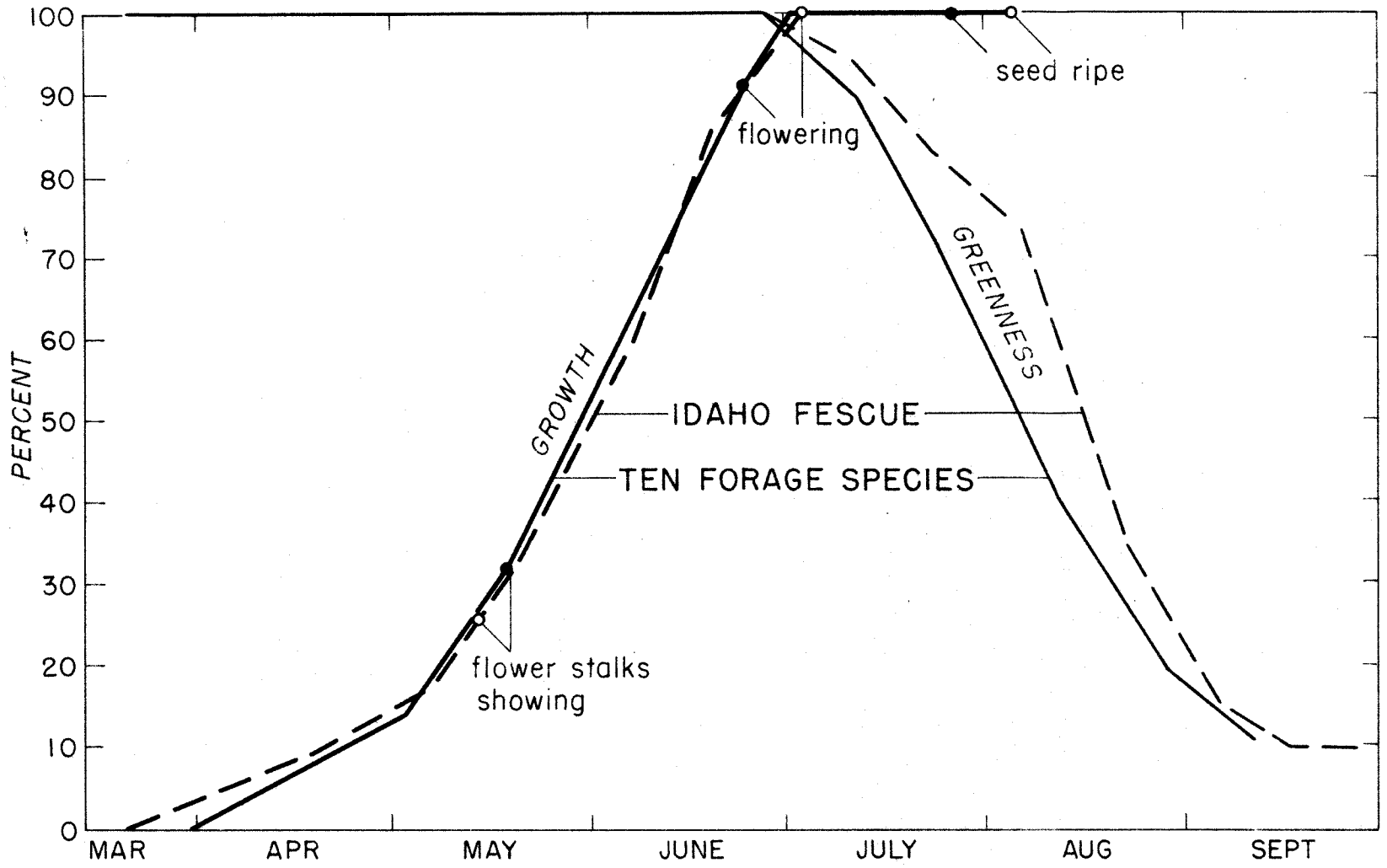


Figure 10.--Relation between the growth and development of Idaho fescue and 10 abundant forage species growing on the same area.

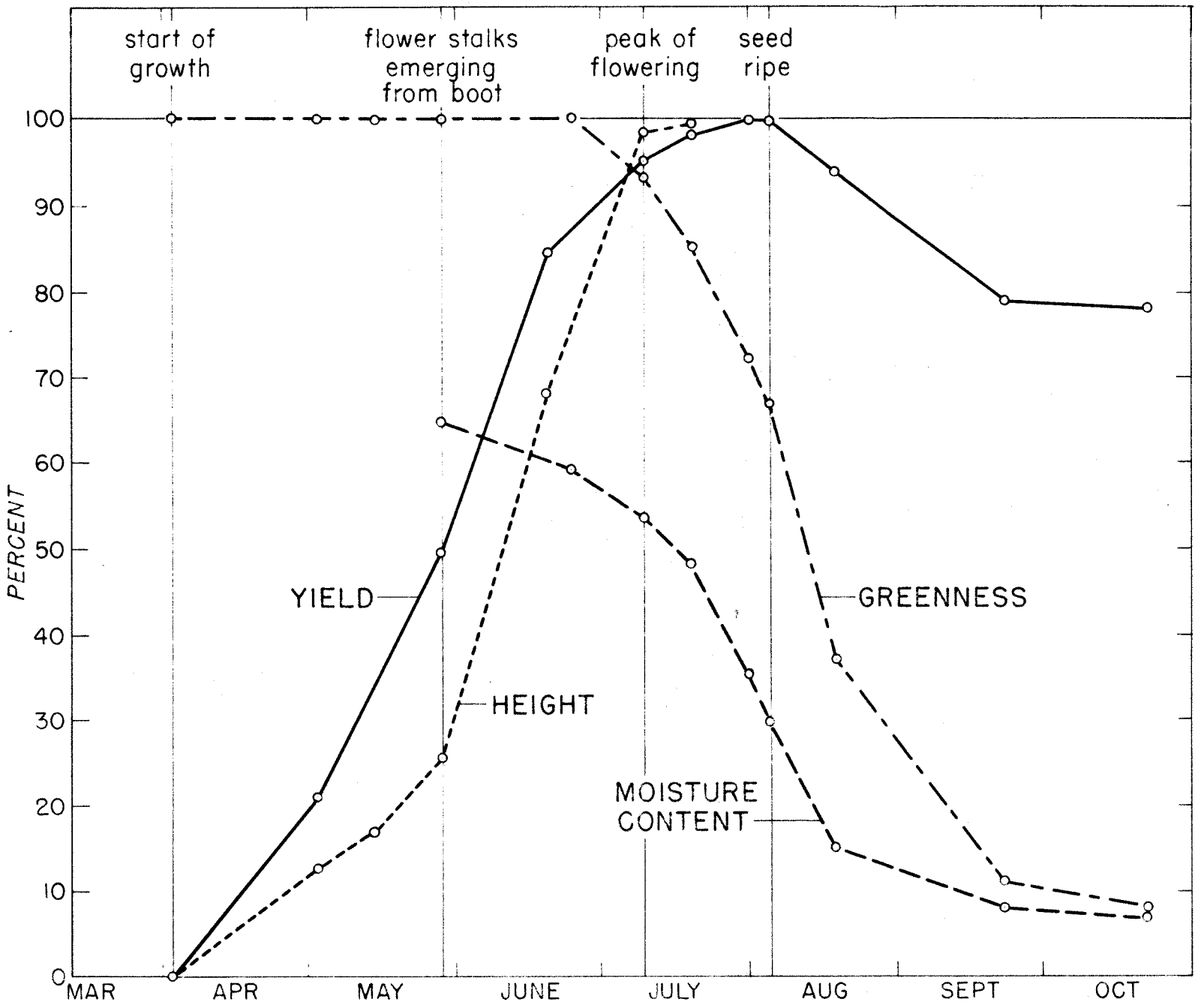


Figure 11.--Average seasonal growth and development of Idaho fescue.

Species Differences

The various plant species grew and developed at different rates during the season. Different species flowered at different times between May and September and ripened seed between June and October (table 4). For example, Ross sedge developed early. It flowered about May 15 and ripened seed about June 24. Big sagebrush, on the other hand, developed much later. It flowered about September 8 and ripened seed about October 6.

Cheatgrass and Sandberg bluegrass dried in July whereas Ross sedge, Idaho fescue, and woolly mulesears dried about a month later. The first two species dried completely, but the latter three retained some greenness even at the end of the summer. Bitterbrush dried during September and October. Big sagebrush remained green throughout the year.

Yearly Differences

The growth and development of individual species and of the vegetation as a whole also varied considerably from year to year. In Idaho fescue from 1936 to 1951, for example, the start of growth varied as much as 33 days in successive years; the flower-stalks-emerging stage, 25 days; date of flowering, 25 days; and the date of seed ripening, 19 days (fig. 12).

Figure 12.--Yearly variations in four main plant growth stages, Idaho fescue, 1936 to 1951.

Table 4.--Average date of flowering and seed ripening of some plant species in the pine timber type, Burgess Spring Experimental Range, 1936-54

Species	Flowering			Seed ripening		
	Month	Day	Basis, years	Month	Day	Basis, years
			No.			No.
Ross sedge	May	15	5	June	24	7
Slender Phlox	June	1	3	July	2	2
Littleflower collinsia	June	2	2	July	2	2
Lambstongue groundsel	June	6	4	July	10	4
Bitterbrush	June	10	12	Aug.	5	5
Woolly mulesears	June	18	13	Aug.	1	6
Cheatgrass	June	19	10	July	24	8
Lemmon needlegrass	June	19	9	July	23	8
Sandberg bluegrass	June	21	10	July	24	7
Longspur lupine	June	25	14	July	29	6
Mountain brome	July	3	5	Aug.	7	5
Bottlebrush squirreltail	July	4	12	Aug.	6	6
Idaho fescue	July	9	13	Aug.	5	11
Flatpod groundsmoke	July	11	3	Aug.	27	2
Bloomer rabbitbrush	S pt.	5	12	Oct.	5	6
Big sagebrush	Sept.	8	8	Oct.	6	4

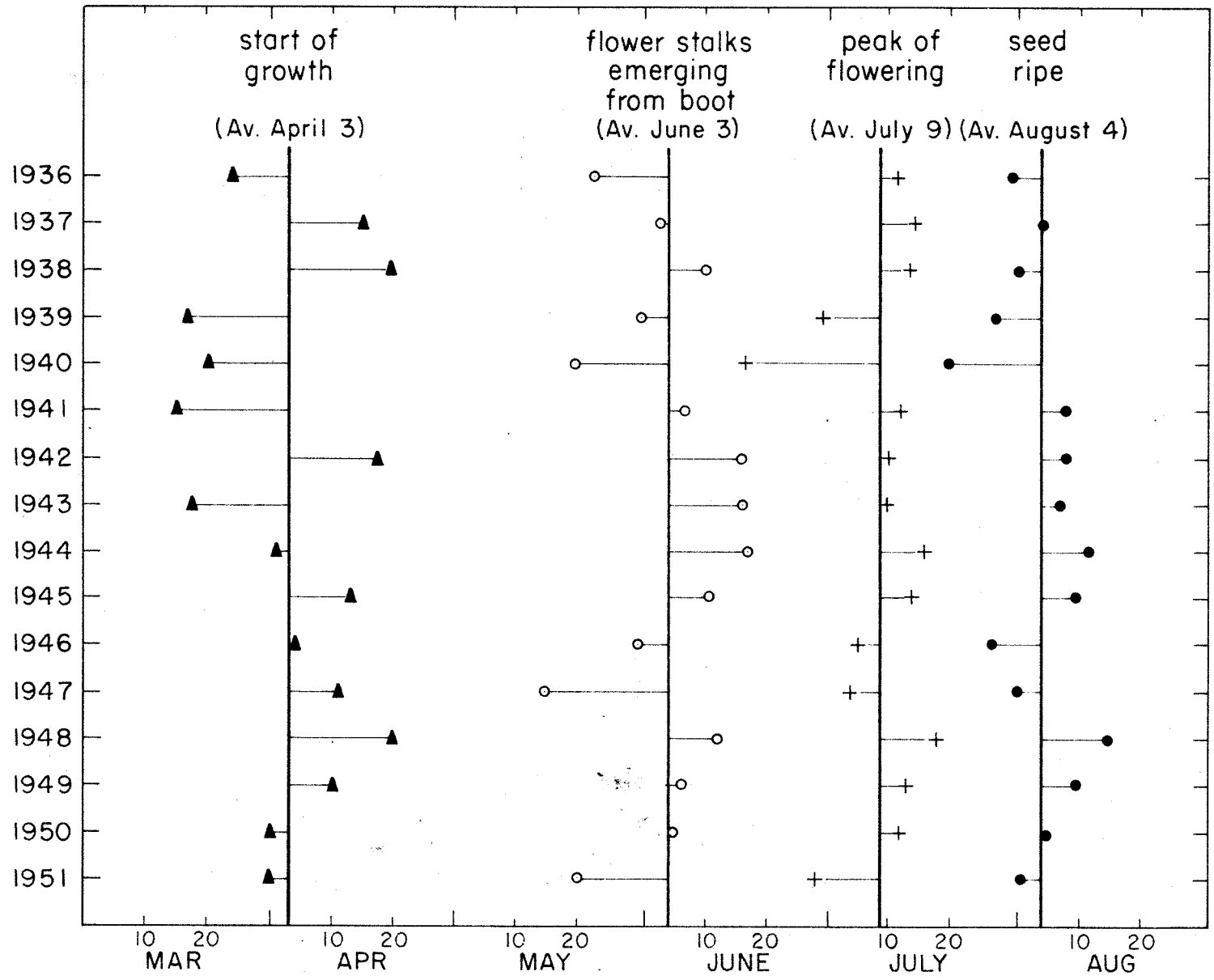


Figure 12.--Yearly variations in four main plant growth stages, Idaho fescue, 1936 to 1951.

Herbage production in 1938, the best growth year, was estimated to be about 3 times greater than in 1939, the poorest year (table 5). In 1938, forage production was 43 percent above average and in 1939, 51 percent below average.

Flower-stalk production varied considerably more than herbage yield from year to year. In Idaho fescue, for example, an average of only 0.7 of a flower stalk was produced per plant in 1949, on a measured series of 10 plants. In 1951, 106 flower stalks were produced per plant in the same series.

Growing conditions that produced a heavy yield of flower stalks in one species did not necessarily produce a heavy yield in other species. For example, in some years when Idaho fescue produced a heavy crop of flower stalks, longspur lupine produced only a light or moderate crop (table 5).

Some species produced seed more regularly from year to year than others. Western needlegrass and cheatgrass produced seed most consistently, followed in approximate order by bottlebrush squirreltail, mountain brome, Idaho fescue, Lemmon needlegrass, Sandberg bluegrass, longspur lupine, Ross sedge, bitterbrush, and woolly mulesears. Drying of the soil early in the season, or freezing at flowering time, reduced or prevented seed production in some species in some years.

Table 5.--Herbage yield of principal forage species in timber type, and flower-stalk production of Idaho fescue and longspur lupine, Burgess Spring Experimental Range, 1936-51

Year	Growing conditions	Average herbage yield	Flower stalk production	
			Idaho fescue	Longspur lupine
		Percent		
1936	Very good	104	Heavy	Heavy
1937	Fair	88	Average	Heavy
1938	Excellent	143	Heavy	Heavy
1939	Very poor	49	Very light	None
1940	Good	121	Heavy	Average
1941	Excellent	143	Heavy	Light
1942	Very good	121	Heavy	Heavy
1943	Fair	66	Light	Light
1944	Good	99	Average	Light
1945	Good	104	Average	Heavy
1946	Poor	55	Light	Light
1947	Good	88	Light	Light
1948	Excellent	137	Heavy	Average
1949	Poor	60	Very light	None
1950	Fair	88	Light	Light
1951	Excellent	132	Heavy	Light

GROWTH IN GRASSLAND TYPE

The vegetation in the grassland type developed in about the same way as the vegetation in the timber type; however, it grew more slowly after growth started, probably because the site was colder. Some species, like shorthair sedge, longstalk clover, and some of the sedges and rushes, developed rather early in the season, as indicated by the date of flowering (table 6). Therefore, an appreciable volume of high-value forage became available for grazing earlier in the season in the grassland type than in the timber type.

Herbage production in the grassland type was estimated to be 5 or 6 times greater in good growth years than in poor ones. This variation is about twice as great as that in the timber type.

EFFECT OF CLIPPING ON GROWTH

The growth, vigor, and reproduction of grazed plants is determined by many factors. Important ones are closeness and frequency of cropping, plant growth stage at time of cropping, and inherent differences between species in ability to withstand cropping. An understanding of the effects of these factors on the plant is necessary for proper management of grazing. Clipping studies were conducted with four different species to provide information on some of these factors.

Table 6.--Average date of flowering of some abundant plant species, grassland, Burgess Spring Experimental Ranges 1944-52

Species	Month	Day	Basis, years
			No.
Shorthair sedge	May	9	5
Plantainleaf buttercup	May	15	7
Biscuitroot	May	30	7
Longstalk clover	June	6	8
Nebraska sedge	June	9	5
American bistort	June	12	7
Sandberg bluegrass	June	17	4
Wire-rush	June	19	5
Water groundsel	June	21	8
Hairy California danthonia	June	24	2
Meadow barley	June	30	2
Northwest cinquefoil	July	1	8
Low pussytoes	July	6	4
Nevada bluegrass	July	11	9
Mat muhly	July	12	5
Aster	July	18	2
Tufted hairgrass	July	20	4
Oregon checkermallow	July	24	8
Black sagebrush	August	1	6
Silver sagebrush	September	9	5

Clipping to a 1.5-inch stubble during the vegetative growing season reduced both herbage yield and flower stalk production during the season of clipping and in subsequent years in the case of Idaho fescue, bottlebrush squirreltail, woolly mulesears and longspur lupine. Ten plants of each species were clipped at different growth stages between the time the plants were 3 inches tall and the time they reached the seed-in-milk stage. The plants were clipped only once a season except when regrowth was produced. Then the plants were clipped a second time when the regrowth was full grown.

Effect During Season of Clipping

Herbage Yield

Average herbage yields from Idaho fescue for 4 years illustrate the general responses obtained from clipping (table 7). The plants produced regrowth after being clipped at early growth stages. No regrowth was produced after the plants reached the seed-in-milk stage. The yield of regrowth declined steadily with lateness of clipping, apparently in response to the downward trend of soil moisture. Most regrowth was produced after clipping at the earlier growth stages. The total seasonal yield of initial growth and regrowth was practically always less than the yield from unclipped, full-grown plants. All four species reacted in the same general way (table 8).

Table 7.--Yield of initial growth and regrowth of Idaho fescue clipped once to a 1.5-inch stubble at various growth stages, Burgess Spring Experimental Range 1946, 1947, 1948, and 1951

Average date and growth stage at time of clipping	Average yield: Initial growth	Regrowth	Initial growth and regrowth combined	Comparison with full grown plants
				Percent
May 1--Leaves about 3 inches tall	0.78	0.70	1.48	60
May 13--Low boot stage	1.09	0.29	1.38	56
May 27--Flower stalks surpassing basal leaves	1.42	0.20	1.62	66
June 17--Flower stalks two-thirds grown	2.16	0.05	2.21	90
July 6--Peak of flowering	2.39	0.01	2.40	98
July 9--Flower stalks full grown	2.41	0.01	2.42	99
July 18--Seed-in-milk	2.45	0	2.45	100

Table 8.--Total yield of initial growth and regrowth per unit of basal area in 4 forage species clipped to a 1.5-inch stubble at various growth stages, Burgess Spring Experimental Range, 1946

Average growth stages at time of clipping and date	Idaho fescue	Bottlebrush squirreltail	Longspur lupine	Woolly mulesears
	Grams per sq. in.	Grams per sq. in.	Grams per fascicle 1/	Grams per fascicle 1/
May 1--Leaves about 3 inches tall	0.59	--	--	--
May 15--Flower stalks just evident (in grasses in low boot)	0.81	1.22	0.45	5.09
May 26--Flower stalks one-third grown (in grasses just surpassing basal leaves)	1.02	1.79	0.43	6.92
June 16--Flower stalks two-thirds grown	2.28	2.42	0.70	18.09
July 3--Peak of flowering	2.41	2.72	0.82	13.00
July 6--Flower stalks full grown	2.44	3.02	0.77	15.93
July 17--Seed in milk	2/2.46	2/2.98	2/0.84	2/16.00

1/ A fascicle is a group of leaves or leaves and flower stalks which originate from a bud.

2/ Extrapolated.

Repeated clipping of Idaho fescue at monthly intervals starting at four different growth stages produced essentially the same results as clipping at the starting stages and when regrowth was full grown (table 9). Three increments of regrowth averaging 3 inches tall were obtained during the season from repeated clipping started when the plants were 3 inches tall. Clipping that started when the flower stalks were in low boot produced two increments of regrowth; when the flowers were two-thirds gown, only one; and when the plants were full grown, none. These repeat clippings indicate more nearly what happens under grazing.

Flower Stalk Production

Measurements of Idaho fescue showed that clipping during the active growing season materially reduced flower stalk production and hence seed production during the season (table 10). Some flower stalks were produced in the earliest clippings, but they were stunted and produced few viable seeds. Under repeated monthly clipping, a few aborted stalks were produced after the earliest clippings, but these were removed in the repeat clipping.

Table 9.--Herbage yields from Idaho fescue plants clipped repeatedly at monthly intervals and clipped once or twice, Burgess Spring Experimental Ranges, 1951

Growth stage at time of clipping	Clipped at monthly intervals		Clipped once or twice 1/	
	Grams per sq. in.	Percent	Grams per sq. in.	Percent
Leaves 3 inches tall	2.76	87	2.45	77
Flower stalks low in boot	2.22	70	2.40	75
Flower stalks two-thirds grown	3.04	95	3.10	97
Plants full grown	3.19	100	3.20	100

1/ Where regrowth was produced, the plants were clipped twice.

Table 10.--Average number and height of flower stalks in regrowth of Idaho fescue clipped to a 1.5-inch stubble at different growth stages, Burgess Spring Experimental Range, 1946, 1947, 1948, and 1951

Growth stage at time of initial clipping 1/	Number		Height	
	Per sq. in. of basal area	Percent of checked plants	Inches	Percent of checked plants
Leaves 3 inches tall	2.62	20.0	14.50	61.4
Flower stalks low in boot	0.79	6.0	10.82	45.8
Flower stalks emerging from boot	0.30	2.3	6.82	28.9
Flower stalks two-thirds grown	0.04	0.3	0.65	2.8
Peak of flowering	T	T	T	T
Plants full grown	0	0	0	0
Check plants	13.09	100	23.62	100

1/ When regrowth was produced the plants were clipped again when full grown to remove the regrowth.

Effect of Clipping in Subsequent Years

Basal Area

The first year after clipping, basal area of Idaho fescue was reduced an average of 58 percent; of longspur lupine, 59 percent; of bottlebrush squirreltail, 21 percent, and of woolly mulesears, 8 percent (table 11). Even after the plants were matured and dried, clipping of Idaho fescue reduced basal area appreciably (table 12). Clipping appeared to be most harmful when the flower stalks were about two-thirds grown.

Clipping at the seed-in-milk stage continuously for 4 years reduced the basal area of Idaho fescue to 20 percent of the area at the start of clipping, of lupine to 9 percent, of squirreltail to 38 percent, and of mulesears to 84 percent (table 13). Two out of 10 plants of Idaho fescue and 6 out of 10 plants of lupine were killed, but none of the squirreltail and woolly mulesears plants was killed.

Basal area of these species increased very little after 3 years of rest from clipping (table 14). We believe that adjoining unclipped plants encroached on the growing space lost by the clipped plants as they decreased in size.

Table 11.--Basal area or number fascicles when clipped and 1 year later of 4 forage species clipped at 4 different growth stages, Burgess Spring Experimental Range, 1946

Average date and growth stage at time of clipping	Idaho fescue		Longspur lupine		Bottlebrush squirreltail		Woolly wulesears	
	When clipped	After 1 year	When clipped	After 1 year	When clipped	After 1 year	When clipped	After 1 year
	Sq. in.	Sq. in.	No. fascicles	No. fascicles	Sq. in.	Sq. in.	No. fascicles	No. fascicles
May 16--Flower stalk evident (low boot in grasses)	4.20	1.43	8.8	3.2	2.25	1.44	6.9	5.3
May 26--Flower stalks one-third grown	3.56	2.12	12.0	6.4	2.23	1.64	7.8	7.0
June 13--Flower stalks two-thirds grown	3.44	1.82	19.4	7.7	2.15	1.75	3.8	4.5
July 2--Plants flowering	4.16	2.16	16.2	5.6	2.01	2.00	6.5	6.3
Average	4.17	1.76	14.1	5.7	2.16	1.71	6.3	5.8
Percent reduction	--	58	--	59	--	21	--	8

Table 12.--Average basal area of Idaho fescue plants when clipped and 1 year later, Burgess Spring Experimental Range, 1948 and 1951

Average date and growth stage of clipping	When clipped	1 year after clipping	Reduction
	Sq. in.	Sq. in.	Percent
April 25--Leaves about 3 inches tall	4.95	1.62	67
May 13--Stems low in boot	5.41	1.13	79
May 27--Stems emerging from boot	5.00	.70	86
June 17--Stems two-thirds grown	4.54	.71	84
July 6--Peak of flowering	4.31	.52	87
July 21--Seed-in-milk	4.54	1.01	78
Aug. 8--Seed ripe	4.88	1.61	67
Aug. 19--Plant 80 percent dry	4.51	1.55	66
Sept. 1--Plant 90 percent dry	4.70	1.98	58
Sept. 29--Plant 95 percent dry	3.79	1.86	51
Average	4.66	1.27	72

Table 13.--Basal area of 4 forage species clipped in each of 4 years at the seed-in-milk stage[1/] Burgess Spring Experimental Range

Year	Idaho fescue		Bottlebrush squirreltail		Longspur lupine		Woolly wulesears	
	Sq. in.	Percent	Sq. in.	Percent	Fascicles No.	Percent	Fascicles No.	Percent
1946	4.16	100	1.88	100	15.4	100	8.2	100
1947	2.16	52	2.22	118	5.0	32	7.7	94
1948	1.67	40	2.25	120	6.5	42	8.8	107
1949	1.39	33	0.69	37	2.4	16	7.9	96
1950	0.83	20	0.71	38	1.4	9	6.9	84

1/ Clipping was started in 1946 in all 4 species. The effect of a particular clipping is reflected in growth the year after clipping. Thus the effect of clipping in 1946 is reflected in the figures for 1947; clipping in the fourth year 1949, is reflected in 1950.

Table 14.--Basal area or number fascicles of 4 species after 4 years of clipping at the seed-in-milk stage and 3 years of rest, Burgess Spring Experimental Range

Treatment schedule	Idaho fescue	Bottlebrush squirreltail	Longspur lupine	Woolly mulesears
	Sq. in.	Sq. in.	No. fascicles	No. fascicles
Start of clipping	4.16	1.88	15.4	8.2
End of clipping	0.83	0.71	1.4	6.9
One year of rest	0.70	1.42	2.1	6.7
Two years of rest	0.71	0.92	2.0	6.7
Three years of rest	1.02	0.61	2.4	6.9

Flower Stalk Production

Clipping Idaho fescue for 1 year at various growth stages up to flowering time reduced flower stalk production by 94 to 100 percent the following year (table 15). Clipping even late in the year reduced flower stalk production appreciably. Average results from clipping in 1948 and 1951 showed a 92 percent reduction at the seed-ripe stage and a gradual downward trend to 82 percent reduction when the plants were 95 percent dry, near the end of September.

Normal flower stalk production was restored by about 2 years of rest from clipping, and more than half of normal production by 1 year of rest (table 16). This means that appreciable seed production of Idaho fescue cannot be expected before the second growing season after close clipping.

The four species responded differently to clipping. Idaho fescue and longspur lupine were harmed most, squirreltail somewhat less, and woolly mulesears the least. The ability of woolly mulesears to withstand defoliation appears to lie in its capacity to store a large amount of food reserves in its large tap root.

Clipping studies by Blaisdell and Pechanec (3) with bluebunch wheatgrass and arrowleaf balsamroot at eight different plant growth stages during the growing season, gave results very similar to those reported here.

Table 15.--Flower stalk production of Idaho fescue 1 year after clipping at 5 different growth stages, average 1946, 1947, 1948, and 1951

Average date and growth stages at time of initial clipping 1/	Per square inch of basal area	Reduction 2/
	Number	Percent
April 25 Leaves about 3 inches tall	0.35	94
May 13 Low boot stage	0	100
May 27 Stems emerging	0.33	94
June 17 Stems two-thirds grown	0.20	96
July 6 Peak of flowering	0.28	95
Average	0.28	96
Check plants	5.67	0

1/ Plants producing regrowth were clipped twice.

2/ Compared with check plants.

Table 16.--Flower stalk production in Idaho fescue when rested from clipping

Years of rest after clipping	Flower stalk production: Previously clipped plants	Flower stalk production: Check plants	As percent of check plants
	Number per sq. in.	Number per sq. in.	Percent
1	0	1.12	0
2	13.27	23.57	56
3	1.07	0.61	175
4	2.86	3.91	73

Chemical studies by Granfield (10), McCarty (18), McCarty and Price (19), Sampson and McCarty (25), Weinmann (28), and others on carbohydrate storage in perennial plants, provide an explanation of some of these clipping results. Some of the food manufactured by perennial plants like those studied here is stored in the roots or stems for future use. The bulk of the stored food usually consists of carbohydrates (starches and sugars). A large part of these reserves is used during fall and winter when the plant is dormant and during spring for initial growth. In mountain brome, 75 percent of the carbohydrate reserves may be used by the time 10 percent of the new season's growth is produced (18). When the plant is growing most rapidly, the food manufactured currently may not be sufficient for growth, and additional food reserves may be utilized. Therefore, stored food reserves are usually at a minimum sometime during the period of rapid growth. Food materials are stored mainly after the growth rate slackens. Stored food reaches a high about the time the plant ripens seed.

Close removal of herbage almost any time during the growing season, therefore, is harmful to the plant. Repeated close defoliation over a period of years will starve the plant and kill it (2, 4, 27).

ESTABLISHMENT OF REPRODUCTION

Because improvement of bunchgrass type ranges depends on regular establishment of seedlings, grazing must be managed so as to provide favorable conditions. Unfortunately, many areas are unfavorable for establishment of the better forage species. The soil between existing plants is eroded, hard, and devoid of litter and humus. Many seeds that lodge in these interspaces are picked up by rodents, insects, and birds. Most of the seedlings that do germinate die because of unfavorable soil moisture.

Under these conditions seedlings that get started are anchored by only a few hair-like roots in the first year--and often even in the second and third years when moisture and temperature are unfavorable. They are easily pulled up and trampled out by livestock.

Artificial reseeding experience and observations on areas trampled heavily by livestock have revealed that depth of seeding is a critical factor in establishment. Seeds buried deep in the soil--within the limit of seedling emergence--even on eroded areas, develop into larger, more vigorous seedlings than those germinating on the soil surface. Furthermore many more germinate and survive.

Livestock trampling has proved effective in getting seeds buried in both light and heavy soils. In light soils trampling was effective even when the soils were dry (fig. 13). However, in heavy soils trampling was more effective when the soil was wet and soft. Under these conditions, trampling produced deep hoofprints that collected extra moisture, litter, and seeds and favored establishment of seedlings (fig. 14).

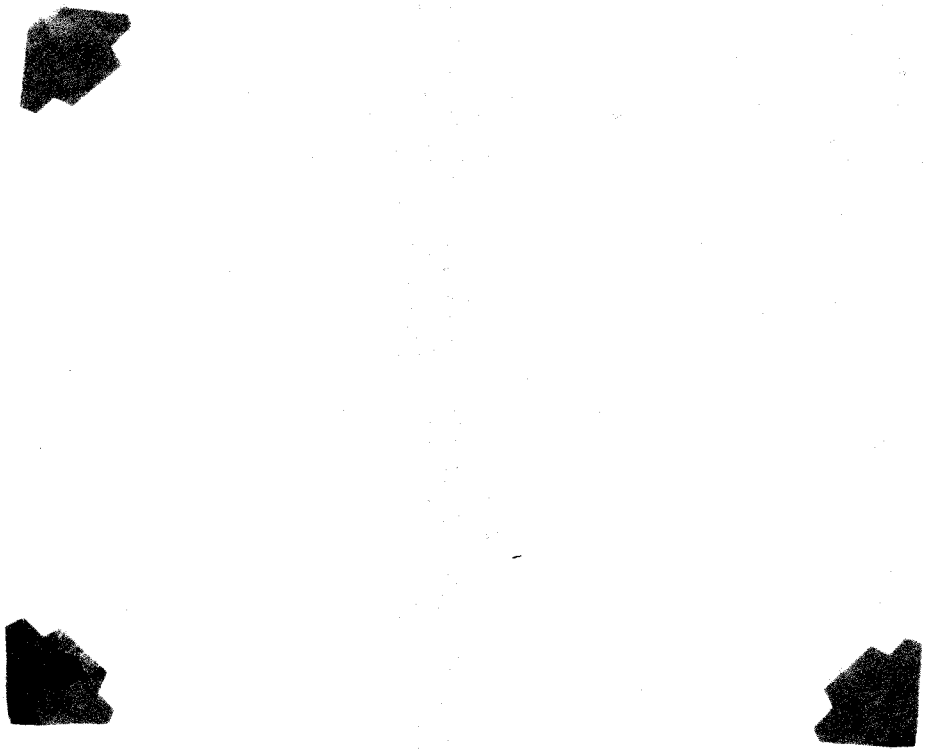
ALE-920

Figure 13.--Seedlings of western needlegrass growing in an area in the timber pasture heavily trampled by livestock after seed fell.

ALE-1302

Figure 14.--Seedlings of bottlebrush squirreltail and Nevada bluegrass germinating in a cow track on a heavy clay loam soil. The track was made while the soil was wet and soft. Accumulation of seed, litter, and extra moisture on the spot favored seedling germination.

Trampling by livestock is the only practical way of getting seeds worked into the soil over most of the range. Mechanical reseeding equipment can be used on a relatively small portion of most ranges because of rough topography, rockiness, vegetation, and other obstructions. Livestock trampling is, therefore, an important management tool.



ALE-920

Figure 13.--Seedlings of western needlegrass growing in an area in the timber pasture heavily trampled by livestock after seed fall.

ALR-1302

Figure 14.--Seedlings of bottlebrush squirreltail and Nevada bluegrass germinating in a cow track on a heavy clay loam soil. The track was made while the soil was wet and soft. Accumulation of seed, litter, and extra moisture on the spot favored seedling germination.

HOW THE VEGETATION WAS GRAZED

In both the timber and grassland types, cattle grazed the vegetation selectively. They grazed certain species and plants on certain areas more consistently and more closely than on others, resulting in very uneven utilization of the vegetation. The pattern of use was complex, but similar from season to season because it was determined mainly by the grazing habits of the cattle. The utilization pattern also was influenced by many other factors—the composition of the vegetation, the abundance, growth stage, growth form, and palatability of the species the topography, the location of fences, watering places, and salt grounds, the stocking rate, and the season of grazing. Nevertheless, because of selective use by the animals, part of the cover tended to be grazed closely each season even under light or moderate stocking of the pastures as a whole.

Utilization in Timber Type

Species

Practically all of the plant species in the timber type were grazed to some extent at one time or another during any given season. Of the 20 more abundant species, 6 were grazed closely and more consistently throughout the season, whether stocking was light, moderate, or heavy (table 17). These 6 were Idaho fescue, bottlebrush squirreltail, mountain brome, woolly mulesears, longspur lupine, and bitterbrush. Twenty-nine percent of the total forage eaten during the season consisted of Idaho fescue (table 18). This species ranked first, second, or third in daily herbage volume intake throughout the season. It was considered the key species in the type from the standpoint of forage and soil cover.

Bottlebrush squirreltail ranked second to Idaho fescue in volume intake and consistence of use. Together they made up 42 percent of the diet of the cattle during the season. Twelve species supplied 95 percent of the herbage intake. Grasses supplied 61 percent, forbs 27 percent, and shrubs 12 percent.

Squawcarpet ceanothus, big sagebrush, greenleaf manzanita, and some forbs were grazed very lightly and could hardly be considered forage species. Littleflower collinsia and slender phlox, both annuals, were not grazed at all.

Table 17.--Daily and seasonal use of specified plants,

Burgess Spring Experimental Range, 1936-38

Species, proportion of cover, and degree of stocking	Proportion of species in daily diet during 2-week period 1/							Utilization at end of grazing season
	June 15 to July 6	July 7 to July 21	July 22 to Aug. 5	Aug. 6 to Aug. 20	Aug. 21 to Sept. 4	Sept. 5 to Sept. 19	Sept. 20 to Sept. 30	
	Percent	Percent	Percent	Percent	Percent	Percent	Percent	Percent
Grasses and sedges:								
Idaho fescue, 19.2 percent								
Light stocking, 1936	5	21	7	8	22	50	59	5
Moderate stocking, 1937	15	10	9	10	39	61	78	11
Heavy stocking, 1938	(2/)	39	27	23	26	38	(2/)	30
Bottlebrush squirreltail, 3 percent								
Light stocking, 1936	11	4	4	3	8	13	15	9
Moderate stocking, 1937	46	11	6	7	13	12	2	16
Heavy stocking, 1938	(2/)	6	9	18	16	12	(2/)	31
Needlegrass, 2.7 percent								
Light stocking, 1936	2	2	1	T	T	1	T	7
Moderate stocking, 1937	1	3	3	4	4	3	2	13
Heavy stocking, 1938	(2/)	3	3	2	2	0	(2/)	18
Sandberg bluegrass, 1.1 percent								
Light stocking, 1936	1	1	T	T	4	1	0	6
Moderate stocking, 1937	T	1	1	0	1	T	T	26
Heavy stocking, 1938	(2/)	1	1	0	0	0	(2/)	34
Ross sedge, 1 percent								
Light stocking, 1936	18	9	2	3	2	1	3	1
Moderate stocking, 1937	2	3	1	T	1	T	4	18
Heavy stocking, 1938	(2/)	10	6	6	7	4	(2/)	38
Cheatgrass, 0.7 percent								
Light stocking, 1936	0	0	11	21	4	0	0	70
Moderate stocking, 1937	0	2	T	4	5	1	0	65
Heavy stocking, 1938	(2/)	0	0	T	0	4	(2/)	60
Mountain brome, 0.2 percent								
Light stocking, 1936	12	7	2	3	5	6	6	9
Moderate stocking, 1937	6	11	1	17	5	2	0	45
Heavy stocking, 1938	(2/)	T	T	13	13	5	(2/)	45
Others 3/, 0.1 percent	—	—	—	—	—	—	—	—
Total 28.0 percent	—	—	—	—	—	—	—	—
Other herbs:								
Woolly mulesears, 17.6 percent								
Light stocking, 1936	0	1	T	1	6	6	9	1
Moderate stocking, 1937	4	T	T	4	11	4	3	1
Heavy stocking, 1938	(2/)	12	8	7	14	17	(2/)	5
Longspur lupine, 5.2 percent								
Light stocking, 1936	0	1	41	36	25	4	T	18
Moderate stocking, 1937	0	4	42	41	17	8	T	36
Heavy stocking, 1938	(2/)	6	24	17	11	4	(2/)	50
Arrowleaf balsamroot 0.7 percent								
Light stocking, 1936	3	7	1	0	1	1	0	7
Moderate stocking, 1937	1	2	3	1	T	1	T	16
Heavy stocking, 1938	(2/)	3	4	2	T	2	(2/)	12
Penstemon, 0.3 percent								
Fireplug groundsmoke								
Light stocking, 1936	T	1	T	2	2	T	T	2
Moderate stocking, 1937	1	5	2	2	T	1	T	10
Heavy stocking, 1938	(2/)	2	2	3	2	1	(2/)	5
Little flower collinsia								
Light stocking, 1936	0	0	0	0	0	0	0	0
Moderate stocking, 1937	0	0	0	0	0	0	0	0
Heavy stocking, 1938	(2/)	0	0	0	0	0	(2/)	0
Slender phlox								
Light stocking, 1936	0	0	0	0	0	0	0	0
Moderate stocking, 1937	0	0	0	0	0	0	0	0
Heavy stocking, 1938	(2/)	0	0	0	0	0	(2/)	0
Tapertip hawksbeard								
Light stocking, 1936	21	0	0	0	0	0	0	2
Moderate stocking, 1937	3	1	T	T	0	0	0	5
Heavy stocking, 1938	(2/)	1	T	T	0	0	(2/)	5
Barestem eriogum								
Light stocking, 1936	4	0	1	1	T	T	0	(3/)
Moderate stocking, 1937	0	T	T	1	T	T	T	(3/)
Heavy stocking, 1938	(2/)	1	T	T	T	0	(2/)	(3/)
Others								
Light stocking, 1936	23	25	7	6	8	5	2	8
Moderate stocking, 1937	19	12	12	5	2	2	1	(3/)
Heavy stocking, 1938	(2/)	2	8	3	2	2	(2/)	(3/)
Total 29.4 percent	—	—	—	—	—	—	—	—
Shrubs:								
Spiraealeaf cercocarpus, 34.6 percent								
Light stocking, 1936	0	0	0	0	0	0	2	T
Moderate stocking, 1937	0	2	2	2	1	T	T	T
Heavy stocking, 1938	(2/)	1	T	3	3	11	(2/)	T
Big sagebrush, 3.9 percent								
Light stocking, 1936	0	0	0	0	T	1	0	T
Moderate stocking, 1937	0	0	0	0	0	T	0	T
Heavy stocking, 1938	(2/)	0	0	0	0	T	(2/)	(3/)
Antelope bitterbrush, 1.5 percent								
Light stocking, 1936	0	21	15	15	8	6	T	90
Moderate stocking, 1937	2	32	18	2	1	2	4	89
Heavy stocking, 1938	(2/)	13	8	1	T	0	(2/)	87
Greenleaf manzanita, 0.9 percent								
Light stocking, 1936	0	0	8	1	2	0	3	2
Moderate stocking, 1937	0	1	T	T	0	0	0	1
Heavy stocking, 1938	(2/)	T	T	T	T	T	(2/)	1
Bloomer rabbitbrush, 0.7 percent								
Light stocking, 1936	0	0	0	T	3	5	1	5
Moderate stocking, 1937	0	0	0	0	T	1	6	3
Heavy stocking, 1938	(2/)	0	0	0	4	0	(2/)	2
Others 3/, 1.0 percent	—	—	—	—	—	—	—	—
Total 42.6 percent	—	—	—	—	—	—	—	—
All species, 100 percent								
Light stocking, 1936	—	—	—	—	—	—	—	12
Moderate stocking, 1937	—	—	—	—	—	—	—	15
Heavy stocking, 1938	—	—	—	—	—	—	—	26

1/ These records were obtained by direct observations on grazing cattle during daylight hours. The animals were followed on foot and records were made of the number of bites taken of the various plant species. Observations were made for 4 to 6 days every 2 weeks throughout the grazing season.

2/ No grazing in pasture.

3/ Insignificant. Not estimated.

Table 18.--Average yield and utilization of forage species in timber pasture, Burgess Spring Experimental Range, 1936-38 and 1944-48

Species	Yield[1]		Utilization		Proportion of diet
	Pounds	Percent	Pounds	Percent	Percent
Grasses and sedges:					
Idaho fescue	77.6	24	23.1	30	29
Bottlebrush squirreltail	34.0	11	10.0	29	13
Needlegrasses	12.1	4	3.7	31	5
Sandberg bluegrass	6.5	2	2.3	35	3
Ross sedge	9.5	3	2.6	27	3
Mountain brome	5.4	2	3.0	56	4
Cheatgrass	5.0	1	3.4	68	4
Others	T	T	0	0	0
Total	150.1	47	48.1	--	61
Average	--	--	--	32	--
Forbs:					
Woolly mulesears	103.6	32	9.3	9	12
Longspur lupine	24.0	8	8.1	34	10
Arrowleaf balsamroot	3.7	1	.7	19	1
Others	22.9	7	3.4	15	4
Total	154.2	48	21.5	--	27
Average	--	--	--	14	--
Shrubs:					
Bitterbrush	10.0	3	8.9	89	11
Bloomer rabbitbrush	2.6	1	.2	8	T
Others	2.1	1	.3	14	1
Total	14.7	5	9.4	--	12
Average	--	--	--	64	--
Total all species	319.0	100	79.0	--	100
Average all species	--	--	--	25	--

1/ Based on herbage above a stubble height of 1 1/2 inches for grasses and forbs and on twig growth of current season for shrubs.

The species yields were determined from clippings in 1936, 1947, and 1948 and from estimates in the other years.

The degree of use of a species was affected not only by palatability, but also by abundance and distribution of the species. For example; cheatgrass, considered much less palatable than Idaho fescue, was utilized more heavily than Idaho fescue by the end of the season, mainly because cheatgrass occurred in small amounts in the pasture and grew around a stock watering place where it was readily available to the cattle. Bitterbrush, mountain brome, and lupine were grazed more heavily than Idaho fescue because they occurred in relatively small amounts in the pasture. Bitterbrush was utilized practically completely by mid-season.

Most species were grazed more heavily at one time of the season than another because of changes in palatability as the plants developed. Longspur lupine was not grazed at all until about flowering time. Thereafter, the entire plant was grazed heavily until it dried. Bloomer rabbitbrush, too, was not grazed until flowering time, and then only flower stalks were taken. Woolly mulesears was grazed very lightly before flowering, moderately at flowering time, and rather heavily after the plants started to dry.

Species also differed as to correlation between degree of use and stocking rate. Use of Idaho fescue--the most abundant palatable species--was most closely correlated. Less abundant palatable species like bitterbrush, and moderately palatable ones like cheatgrass, were grazed as closely under light or moderate stocking as under heavy.

Areas

Some areas in the pasture were consistently grazed closely, some moderately, and some lightly or not at all. Some were cropped down in a short time; others were grazed down more gradually throughout the entire season (fig. 15). The timber opening shown in figure 15 was located away from the influence of fences, water, and salt. It was grazed completely after only 6 weeks of grazing although utilization of the entire timber pasture was very light. Concentration areas like this deteriorate rapidly under improper grazing management. They are the key areas on the range.

ALH-845, 876

Figure 15.--A, an ungrazed stand of western needlegrass on a favored grazing site in the timber pasture. B, 6 weeks later, illustrating very close utilization of particular areas; the ungrazed grass under the trees in the background is Idaho fescue.

Ravine bottoms were grazed first during the season. Next were openings in the timber stand on gentle slopes, areas around water, areas along fences and ridge tops, salt grounds, accessible openings in timber on steeper slopes, and finally areas under large trees and in tree thickets.

Vegetation was grazed more closely in timber openings than under crowns of the trees even though the density and composition of the vegetation on these sites did not differ greatly. When use of Idaho fescue in the timber openings averaged 45 percent, use was only 12 percent under the large trees and less than 5 percent in the tree thickets.

ALH-845

ALH-876

Figure 15.--A, an ungrazed stand of western needlegrass on a favored grazing site in the timber pasture. B, 6 weeks later, illustrating very close utilization of particular areas; the ungrazed grass under the trees in the background is Idaho fescue.

The area of light use under large trees coincided with the area on which pine needles fell. A similar utilization pattern is reported for the pine type in northern Arizona (9). At Burgess Spring plants laden with pine needles tended to be avoided by the cattle. Heaviest accumulations of needles were in the basal leaves of grasses, especially Idaho fescue. Broadleaved species, like woolly mulesears, which held fewer needles, were grazed more closely. Heavy stocking in the pasture failed to force heavy use under the trees.

Measurements in 1949 showed that grazing was selective even for a single species on a given site. In that year, the average use of Idaho fescue in timber openings was 43 percent. The average stubble height at the end of grazing was 4 inches. Forty percent of the plants represented in this average were grazed to a 1-inch stubble; 29 percent to a 2-inch stubble; 13 percent to a 3-inch stubble; 3 percent to a 4-inch or larger stubble. Thus, although the average use of the species was only 43 percent, more than 40 percent of the plants were grazed to a height of 1.5 inches or less.

On rangeland adjoining the experimental area, striking differences in use also were observed between types of vegetation and between broad areas like valley bottoms and mountain sides. For example, cattle grazed principally in the bottomland, grassland, and sagebrush types from June until about mid-August, or until most of the forage on these sites was grazed off. Only after that time did the cattle graze appreciably in the upland timbered and brushy areas. This pattern of use was consistent from year to year.

In cattle grazing studies on ponderosa pine bunchgrass ranges in Colorado, Johnson (17) found that "Under all grazing intensities, irregular patterns of use developed. Even in the lightly grazed pastures, areas of moderate and heavy grazing occurred."

Woolfolk (29), working with sheep under pasture conditions in the Great Plains Region, reported that "The important forage plants were grazed to a low stubble height in all pastures, even though more range acreage and forage were available for each sheep under conservative and light stocking than under heavy stocking. Variations in utilization between pastures stocked at different intensities resulted more often from differences in the percentage of the total number of plants that were grazed."

Utilization of Grassland Type

The pattern of use in the grassland type differed somewhat from that in the timber type because of differences in species and sites. The closed basin site in the pastures was utilized consistently more closely than any other, followed in order by the wet meadow, drained basin, and terrace sites. The principal species grazed were rushes, sedges, Nevada bluegrass, Sandberg bluegrass, aster, mat muhly, hairy California danthonia, squirreltail, and black sagebrush (table 19). Bunch-type grasses and forbs and shrubs furnished about half the total forage intake. About 30 percent of the herbage eaten consisted of inferior grazing species, like wire rush and sagebrush.

Table 19.--Average composition and utilization of vegetation on the principal sites in the grassland pastures, Burgess Spring Experimental Range, 1943 to 1951

Species	Composition	Use	Proportion of diet
	Percent	Percent	Percent
Grass and grass-like:			
Tufted bunch grasses:			
Nevada bluegrass	6	70	10
Sandberg bluegrass	4	79	8
Shorthair sedge	3	15	1
Hairy California danthonia	3	59	5
Idaho fescue	2	73	3
Bottlebrush squirreltail	2	70	3
Tufted hairgrass	T	30	T
Prairie Junegrass	T	50	T
Needlegrasses	T	70	T
Total	20		30
Rhizome formers:			
Baltic rush	22	35	18
Nebraska sedge	3	50	4
Spikesedges	3	60	5
Mat muhly	3	71	5
Rush spp.	2	37	2
Sedge spp.	1	30	1
Thin bentgrass	T	20	T
Total	34		36
Total grass and grass-like	54		66
Forbs:			
Tufted:			
Bisquitroot	8	5	1
Plantainleaf buttercup	7	T	T
Eryngo	1	90	2
Water groundsel	1	60	1
American bistort	T	5	T
Northwest cinquefoil	T	70	1
Oregon checkermallow	T	70	T
Total	17		5
Rhizome formers:			
Aster	4	60	6
Pussytoes	3	28	2
Longstalk clover	1	70	2
Total	8		10
Total forbs	25		15
Shrubs:			
Black sagebrush	7	15	3
Silver sagebrush	3	20	1
Big sagebrush	2	5	T
Total	12		4
Other species	9		16
All species	100		100

EFFECT OF CATTLE GRAZING AND LOGGING ON HERBAGE PRODUCTION IN TIMBER TYPE

Cattle Grazing

Eight years of season-long grazing by cattle during the 11-year period from 1936-1946 reduced the yield of the key species, Idaho fescue, in open areas in the timber type by 29 percent, or 21 pounds per acre (table 20). This loss was produced by an average utilization of vegetation amounting to only 31 percent (table 21). The loss from 6 important forage species totalled about 26 pounds of herbage per acre.

During this period the vegetation increased on both grazed and ungrazed areas as it became reestablished on the bare soil created by logging. However, the vegetation became reestablished more rapidly and more densely on the ungrazed areas. Idaho fescue, for example, produced 25 percent more large plants and 28 percent more small plants on protected areas than on grazed areas. The main species reacted differently. Grazing reduced the number of both large and small Idaho fescue plants. Among other species--bottlebrush squirreltail, the needlegrasses, and longspur lupine--the number of large plants was reduced but the number of small plants was increased. Either these species have stronger seeding habits than Idaho fescue, or their seedlings withstand livestock grazing and trampling better. Ross sedge increased under grazing use, probably because it is better able to withstand grazing than the other species. Woolly mulesears, as expected, decreased only slightly.

Table 20.—Changes in herbage production of 6 abundant forage species on grazed and ungrazed quadrats in open areas, timber type, Burgess Spring Experimental Range, 1936-46[1/]

Species and plant units	Protected quadrats (67)			Grazed quadrats (291)			Difference between grazed and ungrazed quadrats, 1946
	Plant units: 1936	Plant units: 1946	Change 1936 to 1946	Plant units: 1936	Plant units: 1946	Change 1936 to 1946	
	Number	Number	Percent	Number	Number	Percent	Percent
Idaho fescue							Lbs. per acre
Large plants	74	128	+ 73	451	584	+ 29	- 25
Small plants	37	32	- 14	198	121	- 39	- 28
Total							- 21.4
Bottlebrush squirreltail							
Large plants	55	118	+115	185	352	+ 90	- 13
Small plants	133	148	+ 11	384	484	+ 26	+ 14
Total							- 3.0
Needlegrass							
Large plants	20	73	+265	127	332	+161	- 29
Small plants	68	99	+ 46	308	561	+ 82	+ 25
Total							- 1.4
Longspur lupine							
Large plants	26	32	+ 23	93	88	- 5	- 23
Small plants	35	8	- 77	142	134	- 6	+308
Total							+ 2.0
Woolly mulesears Fascicles	141	154	+ 9	470	490	+ 4	- 5 - 5.4
Ross sedge Clusters	151	147	- 3	743	908	+ 22	+ 26 + 3.3
Total							- 25.9

1/ Herbage production for each species was determined from counts and clipped weights of four appropriate plant units, counted on one-fourth milacre quadrats. Units consisted of large and small plants, fascicles, and clusters. A large plant is one having a basal area of 1 square inch or larger; and a small plant, one having a basal area of less than 1 square inch. A fascicle is a group of leaves or leaves and flower stems originating from a single bud. Several closely grouped fascicles is a cluster. Seedlings in the first year of growth were not counted. Weights of these four plant units were determined from clippings of ungrazed plants.

Table 21.--Estimated herbage utilization in openings in timber type, Burgess Spring Experimental Range, 1936-46

Year	Herbage utilization	
	Percent 1/	General appearance
1936	18	Light
1937	22	Moderate
1938	39	Close
1939	7	Very light
1940	0	No use
1941	0	No use
1942	0	No use
1943	19	Light
1944	22	Moderate
1945	56	Very close
1946	63	Very close
Average 2/	31	Moderate

1/ Ocular estimate of volume utilized.

2/ Excluding 1940, 1941 and 1942.

Plants on grazed areas were less vigorous than on protected areas. In 1948, for example, the herbage yield from Idaho fescue plants on grazed areas was about 30 percent less, and flower-stalk production was 28 percent less than from plants on ungrazed areas.

Continuous selective grazing year after year even under comparatively moderate use, therefore, resulted in a reduction of desirable forage plants and prevented adequate establishment of reproduction on certain areas.

Logging

Logging increased the grazing capacity of the pine type 91 percent 1 year after cutting, and 262 percent 11 years after cutting, as measured on 6 1.5-acre plots located on range grazed by cattle adjoining the Burgess Spring timber pasture.

The areas on which the plots were located were logged with tractors in the fall of 1936. Fifty-nine percent of the merchantable trees, 16 inches and larger in diameter at breast height, were cut. The vegetation and logging debris on the plots were measured in 1935, the year before logging; in 1938, theyear after logging; and again in 1946, 11 years after logging.

Forty-two percent of the area of the plots was skidded over or covered with debris. This reduced the density of all ground vegetation 38 percent and of forage species 11 percent. In spite of this reduction, grazing capacity was increased immediately after logging because much of the vegetation under trees that was grazed only lightly, or not at all, before logging, became available for grazing after the trees were cut. Available grazing area increased from 6 percent in 1935 to 40 percent in 1937, or nearly sevenfold.

The density of the ground vegetation increased rapidly during the first 2 or 3 years after logging because of enlargement of existing plants. Thereafter the density increased mainly because of establishment of new plants. Eleven years after logging only 40 percent of the bare soil areas created by logging were reclothed with vegetation. Later observations indicated that grazing capacity on the plots increased for about 15 years after logging and then started to decline as tree growth began to crowd out the forage species.

How much logging will increase grazing capacity, or how long high grazing values will last on an area depends on the structure of the tree stand, the degree of cutting, the amount of ground disturbance, the amount of tree reproduction on the ground after logging, the character of the understory vegetation, and similar factors.

From the work at Burgess Spring we can conclude that some increase in grazing capacity can be expected after logging most anywhere in the pine type in northeastern California, under present silvicultural practices. High grazing values can be expected to last almost indefinitely on low timber-producing sites or in the transition zone between the timber type and other types where dense stand development is precluded by soil, rockiness, and drainage. Under good silviculture, the better timber sites can be expected to produce relatively little herbage for livestock because trees will occupy most of the ground space. Here, grazing values will at best be temperary.

CATTLE PERFORMANCE IN TIMBER AND GRASSLAND TYPES

SEASONAL WEIGHT TRENDS

In both the timber and grassland types, cattle changed weight continuously during the season in relation to the development of the vegetation. An understanding of this trend provides a basis for determining when the vegetation can be grazed to best advantage for maximum livestock production.

The best weight data for the timber and grassland types were obtained from 1944 to 1948, when yearling heifers of essentially the same kind were used each season. These young cattle had a high capacity to gain weight and respond sensitively to changes in the nutritive value of the vegetation.

During this period (fig. 16), the cattle grazed in the timber type gained weight at a rate of 1.14 pounds per head per day the first 2 weeks after they were placed in the pasture. At that time (May 22) the vegetation was about 4 inches tall. Judging from the weight trend, the cattle would have gained weight at an even earlier plant growth stage. The rate of gain increased to 1.93 pounds per day when the flower stalks on the plants were about half developed. A maximum rate of 2.29 pounds per day was reached just before flowering time in early July. Thereafter, the rate of gain decreased gradually until early October, when the cattle started to lose weight. The rate of weight loss after peak weight was about the same as the rate of gain up to peak weight for a comparable period of time.

MAXIMUM GAINS

From 1944 to 1948, yearling Hereford heifers grazed season long in the timber type gained an average of 217 pounds per head. Similar heifers in grassland during the same period gained 227 pounds per head, or 10 pounds more (table 22). Part of this difference in gain may be due to a difference in the nutritive value of the vegetation in the two types and part to differences in energy expended in grazing. The cattle in the timber type grazed over a larger, steeper area than those in the grassland.

In some years the difference in gains was negligible and in others appreciable. In 1944 the gains were the same. In 1948 the cattle in the grassland gained 23 pounds more per head than the cattle in the timber.

Daily weight gains in the grassland type averaged 1.74 pounds per head during a 131-day period, from May 23 to October 1. In the timber type gains averaged 1.61 pounds in 136 days, from May 23 to October 6. Thus the cattle in the timber type gained 0.13 pounds less per day than the cattle in the grassland type but gained for a 5-day longer period. The daily gains in both types were very similar from year to year. The weight-producing quality of the vegetation in the two types, therefore, was about the same. Both types have high grazing value for cattle and from the standpoint of livestock weight gains can be utilized during the same period of the year.

Table 22.--Weight gains of yearling Hereford heifers grazed in timber and grassland types, Burgess Spring Experimental Range, 1944-48

TIMBER TYPE

Year	Period	Season	Days	Weight: Beginning of season	Weight: Maximum during season	Gain: Seasonal	Gain: Daily
				Lbs.	Lbs.	Lbs.	Lbs.
1944	June 2-Oct. 20		140	443	656	213	1.53
1945	May 23-Oct. 7		137	450	670	220	1.62
1946	May 12-Sept. 21		132	390	609	219	1.66
1947	May 7-Oct. 1		147	380	608	228	1.55
1948	June 9-Oct. 10		123	444	651	207	1.68
Average	May 23-Oct. 6		136	421	639	217	1.61

GRASSLAND TYPE

1944	June 2-Oct. 6		126	443	656	213	1.70
1945	May 23-Oct. 2		132	446	670	224	1.70
1946	May 12-Sept. 25		136	385	616	231	1.70
1947	May 7-Sept. 21		138	380	619	239	1.73
1948	June 9-Oct. 10		123	448	678	230	1.87
Average	May 23-Oct. 1		131	420	648	227	1.74

EFFECT OF MOVING CATTLE BETWEEN TYPES

Cattle that were moved from the timber type to the grassland type and back during the season gained 18 pounds less weight than cattle grazed season long in the timber and 28 pounds less than cattle grazed season long in the grassland.

The shifts between pastures were timed so the cattle would be moved either to ungrazed vegetation or to grazed pastures in which cattle were gaining weight more rapidly than those to be moved. Those that were moved were first grazed in the timber pasture, together with other cattle that remained in the pasture throughout the season. The move to ungrazed grassland was made in mid-June, and in late August the cattle were moved back into the timber pasture. Unnecessary handling was avoided. The animals were simply turned into appropriate pastures after weighing.

In 1948 a group of cattle were permitted free access to both timber and grassland pastures during the season. These gained 16 pounds less weight than cattle grazed season long in the grassland type, but 7 pounds more than cattle grazed season long in the timber type.

These results indicated that shifting cattle between different vegetation types during the grazing season may be undesirable and should be avoided or held to a minimum.

SIGNIFICANCE OF RESULTS IN RANGE MANAGEMENT

Results of the Burgess Spring experimental work provide a basis for improving and making efficient use of mountain bunchgrass ranges. Ranges can be improved through cultural measures like artificial reseeding, weed control, drainage improvement, and water spreading. But maintenance of the range depends on proper management of grazing. Proper management of grazing, therefore, is all important in range management.

It should be appreciated that livestock grazing is managed through the manipulation of only four factors: Stocking rate, season of use, livestock distribution, and frequency of use. A range improves or deteriorates and livestock are produced efficiently or inefficiently depending on how these factors are manipulated. All other factors that affect grazing management are beyond the control of the range operator.

There is no set formula for regulating these four factors, for every range presents a different problem. Management rests mainly on a background knowledge of range and livestock behavior, supplemented by experience and good judgment. It consists of making appropriate and timely adjustments in the grazing factors in response to reactions of the range and livestock. Management of grazing, therefore, cannot be based on general guidâs. It must be based on specific facts on range and livestock behavior like those developed in this study. Such facts are the A, B, C's of the language of proper range management.

RANGE IMPROVEMENT AND MAINTENANCE

The most significant facts bearing on improvement and maintenance of the range are:

1. The range is unevenly utilized because of the selective grazing habits of livestock and the diverse character of the range.
2. The pattern of grazing is essentially the same from year to year because of the inherent grazing habits of livestock.
3. Under season-long grazing year after year, part of the vegetation is closely utilized and is gradually killed out even under moderate stocking.

Range improvement, therefore, centers around the maintenance of the relatively small part of the total vegetation that is closely cropped each year. The question is: How can grazing be regulated to prevent close use of these plants?

Clearly no livestock distribution measure can prevent selective grazing. Even on the smallest area, livestock tend to graze the palatable species and leave the unpalatable ones. As the better species are killed out and these spots become covered with less desirable forage species or become bare, livestock are forced to graze on less desirable forage species or to move on to less accessible areas. This leads to an ever-enlarging areas of deterioration. Range breakdown is spotty, not only because of selective grazing, but also because some sites deteriorate more rapidly than others under the same grazing pressure because of difference in vegetation, soil, and related factors. Evidence that ranges deteriorate in this general manner is stamped on practically every mountain range in northeastern California.

Nor can regulation of stocking rate prevent close cropping of vegetation on the preferred areas. The general effect of reducing stocking is to reduce the total area grazed and the number of plants that are closely cropped. But close use--as close as under heavy stocking--still prevails on the preferred, readily accessible areas within the usable range area. As stocking is reduced, more and more of the vegetation is left ungrazed on outlying areas and less and less efficient use is made of the range. There is no practical point on the stocking scale where close grazing of part of the vegetation does not occur.

Varying the grazing season provides little opportunity for preventing injury to the vegetation. In the first place, close cropping is damaging to the vegetation practically throughout the grazing season, even when the vegetation is mature. It is particularly harmful up to about the time of seed ripening and most harmful when the plants are growing most rapidly. Foregoing use of the vegetation during the growing period is impractical because the vegetation has highest grazing value at that time.

Adjustment of stocking rate at the more critical plant growth stages, is not practical either because time is too short, and also because moving livestock reduces their weight gains.

- Periodic Resting Essential

Frequency of use, then, is the most important factor in maintenance and improvement of the range. The grazing and clipping experiments both showed that continuous close defoliation is harmful to the plants. They indicate the need for resting the plants from grazing to restore plant vigor, and establish new reproduction. This is the fundamental answer to range improvement and maintenance.

The amount and timing of rest should be determined by the growth requirements of the key species on the range--the one species that is most desired for forage and soil cover. Grazing and resting should be timed to allow the plants to recover vigor, produce seed, and establish reproduction. In this experiment Idaho fescue was found to need one full season of rest to restore normal plant vigor and produce abundant seed. It required a minimum of one season of rest to insure seedling establishment.

The duration and timing of grazing and resting in a rest-rotation grazing system based on Idaho fescue would be as follows:

Year:	Grazing treatment
1st	Graze closely entire season for maximum forage use.
2nd	Rest entire season to restore vigor of grazed plants.
3rd	Rest during first half of season to protect developing seed crop from being grazed. Graze closely during second half of season for maximum forage use and to get seed trampled in the soil.
4th	Rest entire season to insure establishment of seedlings.

This sequence of use and rest provides for establishment of reproduction in a grazing unit once every 4 years, weather and site conditions permitting. The rest periods, it will be seen, encompass entire grazing seasons. For this reason they satisfy the growth requirements of most of the other plant species associated with the key species on any given site. The entire ungrazed herbage growth of two seasons out of four is returned to the soil to maintain soil fertility and prevent erosion. During these seasons litter is deposited on all areas on the range--even those that are usually closely grazed.

Thus, although selective, uneven grazing cannot be prevented so long as the range is grazed, the harmful effects of such use can be overcome by resting the range from grazing at suitable intervals. To operate a grazing system involving resting requires subdivision of the range into units and resting and grazing these units in rotation.

Number of Range Units

The number of units needed in a rest-rotation grazing system is determined by the number of grazing treatments used. In a plan requiring four grazing treatments, for example, the range should be divided into four units. The units should be nearly equal in grazing capacity. The minimum number of units that could be used is two. There is no definite maximum number. Five-, six-, and even seven-unit rotations are feasible. The greater the number of units, the better opportunity there is for providing the needed rest and intensity of grazing at the right time.

Timing of Resting

In a four-unit system the units would be grazed over a 4-year cycle (table 23). In this sequence, provision is made for establishment of reproduction in a different unit each year, weather permitting. In the occasional year when a bumper seed crop is produced, some unit is always in a position to benefit.

After the range is revegetated with as dense a cover as the soil is capable of supporting in its current condition, one or all of the range units that are normally rested season long can be opened to some grazing from time to time, so more efficient use can be made of the vegetation on the entire range. The amount of grazing that can be tolerated has to be determined by local conditions.

Provisions for Low Production Years

In years of low herbage production part or all of the vegetation in the rested units can be grazed if necessary. By this means livestock can be carried through seasons of below-average herbage production. In a four-unit system, grazing can be continued with the usual livestock numbers in years when herbage production is as low as half of average.

Table 23.--Schedule of grazing treatments in a four-unit rest-rotation grazing system

Year	Range unit			
	1	2	3	4
1st	1/2 graze 1/2 rest	Rest	1/2 rest 1/2 graze	Rest
2nd	Rest	1/2 rest 1/2 graze	Rest	1/2 graze 1/2 rest
3rd	1/2 rest 1/2 graze	Rest	1/2 graze 1/2 rest	Rest
4th	Rest	1/2 graze 1/2 rest	Rest	1/2 rest 1/2 graze

In years when only part of the reserve vegetation is needed the unit being rested season-long to restore plant vigor should be used first. If all of the reserve is needed, then the unit in which new seedlings are becoming established can be used next. In this way new reproduction is protected from grazing for as long a time as possible.

Role of Stocking

During grazing periods, stocking should be maintained at a high level to promote maximum allowable use of the range and aid in the establishment of reproduction of the better forage species. A high stocking rate results in close use of some of the inferior grazing species and therefore gives the more desirable forage species a better chance to persist on the range. It promotes heavy livestock trampling, which encourages establishment of reproduction of the better forage species. It spreads grazing over a wider area and promotes fuller range use.

No figure can be prescribed specifying the upper limit of stocking or grazing use that can be tolerated by the range without deterioration. Requirements of ranges differ from place to place. To determine whether stocking in a particular case is excessive or not, the range should be observed for evidence of accelerated soil erosion related to current grazing. Too-close cropping of the vegetation exposes the soil to erosion by wind and water. If accelerated erosion is evident, stocking should be reduced.

Stocking should be based on the yield of herbage from all forage species on the usable portions of the range and not on the key species alone. If the grazing manager has no previous knowledge of how grazing will affect a particular area, he should try to set the stocking rate at a level that will result in not more than about two-thirds use of the available herbage in the most heavily grazed range unit.

How to Judge Effectiveness of Grazing System

Establishment of new seedlings is the most important single criterion that can be used to judge whether or not rest-rotation grazing system is improving and maintaining the range. Numerous 1-, 2-, and 3-year-old seedlings in the spaces between the older plants show that the range is improving and that adequate and properly timed rest is being provided (fig. 17). Conversely, the absence of seedlings shows that the range is static or deteriorating and that insufficient or improperly timed rest is being provided. The range manager can feel satisfied that so long as reproduction of the main forage species, particularly the key species, is becoming established, the range is improving and grazing capacity is increasing--or holding up to maximum if the range is in excellent condition. The place to look for new seedlings is on areas that are usually moderately to closely grazed.

ALH-1801

Figure 17.--The presence of small, young plants of desirable forage species on the range indicates that the range is improving. Here seedlings of Idaho fescue are evident among older and larger plants.

ALR-1801

Figure 17.--The presence of small, young plants of desirable forage species on the range indicates that the range is improving. Here seedlings of Idaho fescue are evident among older and larger plants.

The rate of range improvement will vary from site to site depending on the character of the soil and vegetation and the condition of the range. Where much top soil has been lost, or where weed species dominate the site, improvement will be slow. Species best adapted to prevailing site conditions will regenerate most rapidly. With improvement of the site, one species will be replaced by another, other factors of plant succession being favorable.

Management of Vegetation Stands Produced Culturally

Stands of vegetation obtained through artificial reseeding or other cultural measures can be used and maintained together with the native vegetation under a rest-rotation system without special management facilities. Artificial reseeding is best carried out in the unit that is deferred from grazing until the native species ripen seed. In this way the seed of introduced and native species are "planted" in the same season and the seedlings managed in the same way thereafter. Chemical weed control, water spreading, and drainage improvement can be undertaken in any unit any year such work is feasible.

What this all boils down to is the following principle: Properly timed periodic resting of the range from grazing is the main requirement for the improvement and maintenance of perennial bunchgrass type ranges.

EFFICIENT LIVESTOCK PRODUCTION

The efficiency of livestock production is determined primarily by distribution of the livestock over the range, the season of grazing, and stocking rate.

Livestock Distribution

The problems of livestock distribution on mountain ranges are usually rather obvious. Their solution depends largely on the good judgment of the range operator and his ability to finance the needed distribution measures. In northeastern California, fencing, water development, salting, and riding are the principal distribution measures employed on cattle ranges.

Additional fences are needed on many cattle ranges to effectively carry out a rest-rotation grazing system. Where the cost of fencing is prohibitive and where water is supplied by tanks, springs, and wells, attention should be given to the possibility of getting improved livestock control through controlling water and salting. Some watering places can be closed and others opened to get the needed distribution and timing of grazing. Where the aim is to get cattle to stay in a given locality, salt should be placed near water. Where the aim is to get wider distribution over the range, salt should be placed away from water, but always within easy grazing range of the animals.

Some cattlemen do not like to place salt away from water because they feel that livestock have to drink soon after salting and will therefore "walk off" weight. In a 3-year study in the Burgess Spring timber pasture, it was found that cattle usually did not go to water soon after salting (1). In this case, salt was placed about three-quarters of a mile from water--a distance that could be easily walked by the cattle in 20 minutes. Yet the average elapsed time between salting and watering was 7 1/2 hours. Salt grounds should be located on the basis of the range utilization pattern and moved from time to time as needed. On sheep ranges, proper attention to herding, water development, and salting should usually give desirable results without fencing.

Season of Grazing and Stocking Rate

Season of grazing and stocking rate must be considered together, for a given range can be used during a short period of time by a large number of animals or during a long period of time by a small number. In planning grazing management, the range manager should determine the season of grazing first and stock the range accordingly.

The amount of herbage and livestock production that could be expected from various 1-, 2-, 3-, 4-, and 5-month-long grazing seasons and correlated stocking rates were calculated from data collected in the timber pasture (table 24). If the beginning and ending dates of these seasons are interpreted in terms of plant growth stages, the figures can serve as a general guide for selecting grazing seasons for northeastern California and other bunchgrass ranges. In these calculations, consideration was given to the possible effect of grazing during the growing season on seasonal herbage yield and to differences in rate of gain of the livestock at different times in the season.

These figures have comparative value primarily. They show that high livestock production per acre and low seasonal gains per animal are obtained with the shorter seasons and low livestock production per acre and high seasonal gains per animal with the longer ones. Under the optimum 2-month season, for example, cattle gains average 130 pounds; under the optimum 4-month season, 212 pounds. On the other hand, livestock production per acre is 12.0 pounds for the 2-month season and only 9.6 pounds for the 4-month.

Table 24.--Calculated forage and livestock production for various grazing seasons and stocking rates.[1/]

Pine timber type, Burgess Spring Experimental Range

Date and vegetative growth stage at beginning of season[2/]	End date	Stocking per section	Weight gain per animal unit	Livestock production per acre	Forage production per acre
		Animal units	Pounds	Pounds	Pounds
1-MONTH SEASONS					
May 12--Flower stalks low in boot	June 10	95	48	7.1	187
May 22--Flower stalks in mid-boot	June 20	104	58	9.4	204
June 1--Flower stalks emerging from boot	June 30	111	64	11.1	218
June 11--Flower stalks one-third grown	July 10	115	68	12.2	227
June 21--Flower stalks two-thirds grown	July 20	117	71	13.0	234
July 1--Near flowering	July 30	119	69	12.8	235
July 11--Just past peak flowering	Aug. 9	120	62	11.6	234
July 21--Seed in milk	Aug. 19	118	54	10.0	231
July 31--Seed in dough	Aug. 29	117	46	8.4	228
Aug. 10--Seed ripe	Sept. 8	116	31	5.6	226
2-MONTH SEASONS					
May 12--Flower stalks low in boot	July 10	52	116	9.4	205
May 22--Flower stalks in mid-boot	July 20	55	127	10.9	216
June 1--Flower stalks emerging from boot	July 30	58	131	11.9	227
June 11--Flower stalks one-third grown	Aug. 9	59	130	12.0	231
June 21--Flower stalks two-thirds grown	Aug. 19	59	124	11.4	231
July 1--Near flowering	Aug. 29	59	114	10.5	231
July 11--Just past peak flowering	Sept. 8	59	100	9.2	231
July 21--Seed in milk	Sept. 18	58	84	7.6	229
3-MONTH SEASONS					
May 12--Flower stalks low in boot	Aug. 9	36	178	10.0	215
May 22--Flower stalks in mid-boot	Aug. 19	38	182	10.8	225
June 1--Flower stalks emerging from boot	Aug. 29	39	177	10.8	228
June 11--Flower stalks one-third grown	Sept. 8	39	168	10.2	230
June 21--Flower stalks two-thirds grown	Sept. 18	39	155	9.4	231
July 1--Near flowering	Sept. 28	39	134	8.2	230
4-MONTH SEASONS					
May 12--Flower stalks low in boot	Sept. 8	27	216	9.1	220
May 22--Flower stalks in mid-boot	Sept. 18	29	212	9.6	226
June 1--Flower stalks emerging from boot	Sept. 28	29	198	9.0	228
June 11--Flower stalks one-third grown	Oct. 8	29	178	8.1	229
June 21--Flower stalks two-thirds grown	Oct. 18	29	152	6.9	227
5-MONTH SEASONS					
April 22--Leaves 2 inches	Sept. 18	21	232	7.6	205
May 2--Leaves 3 inches	Sept. 28	22	234	8.0	215
May 12--Flower stalks low in boot	Oct. 8	22	227	7.8	221
May 22--Flower stalks in mid-boot	Oct. 18	22	210	7.2	221

[1/] Assumed 33 percent forage use measured on October 18 for all seasons. The optimum season in each season class is underlined.

[2/] In terms of Idaho fescue.

The season that gives the best results in a particular case is determined not only by the livestock-production potentialities of the season, but also by other considerations like: The time the particular range is needed in the ranching operation, the condition and weight gains desired in the livestock, and the livestock production desired per acre. For example, the longest practical grazing season in the Burgess Spring locality is about 5 months, starting May 2 when the vegetation is 3 inches tall and ending September 28 about the time cattle start losing weight. This season would produce 234 pounds gain per animal and 8.0 pounds livestock production per acre. Starting the season this early, however, could lead to excessive soil compaction and erosion.

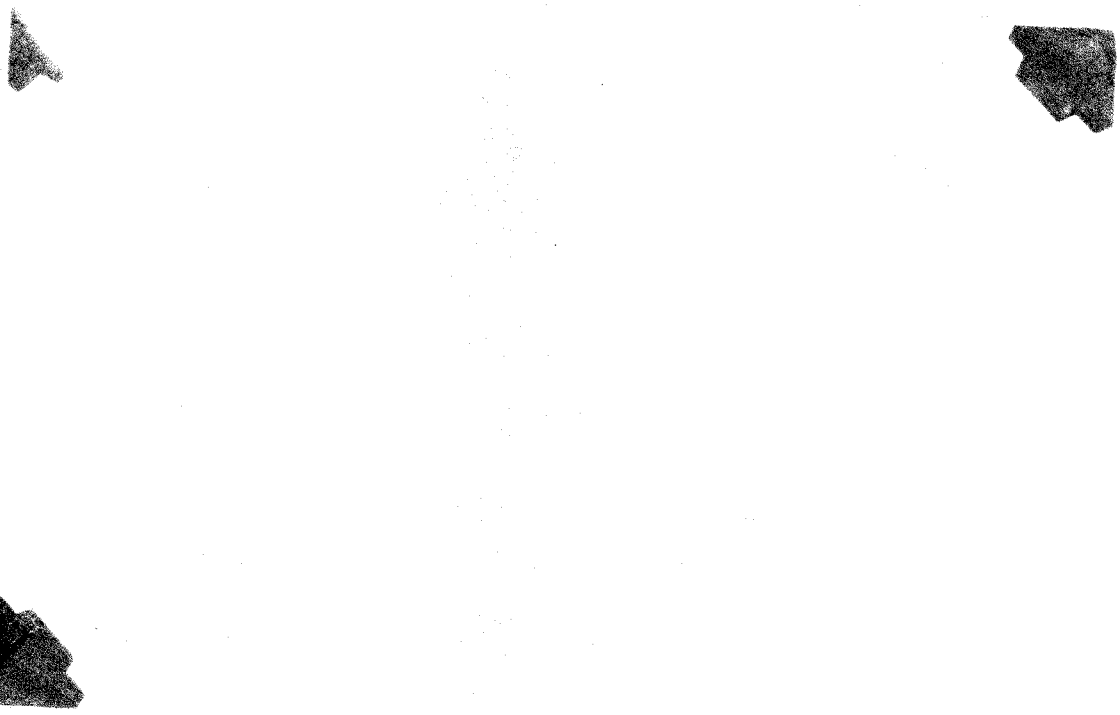
A 4-month grazing season starting on May 22 when the flower stalks of Idaho fescue are in mid-boot (fig. 18), would produce only 212 pounds gain per animal but 9.6 pounds of livestock per acre. Although the seasonal weight gain of the individual animal is 9 percent less than in the 5-month season, livestock production per acre is 17 percent greater. Soil is usually firm by the start of this shorter season and there is little likelihood of erosion or excessive soil compaction by trampling. If the condition of the animals can be considered acceptable, then the 4-month season seems better than the 5-month season for the Burgess Spring locality.

ALR-723

Figure 18.--Stage of development of the vegetation in the pine timber type at the beginning of the optimum 4-month grazing season. Flower stalks in the grasses are in the mid-boot stage. Species evident in the photo are Idaho fescue (dark tufts right center), bottlebrush squirreltail (gray tuft lower center), longspur lupine, and woolly mulesears.

Once the grazing system, season of grazing, and livestock distribution have been determined for a particular range, they remain more or less fixed for long periods of time. Management of grazing then becomes largely a matter of adjusting stocking. An initial estimate of stocking can be obtained from a range survey--or if the range is being grazed, from knowledge of the number of animals grazed and observations on forage utilization at the end of the grazing season. Stocking is adjusted upward or downward depending on the responses obtained in the range and livestock. If accelerated soil erosion is being induced, establishment of reproduction of forage species is being hindered, or livestock are not making satisfactory weight gains, the range is overstocked. If soil erosion is not evident, reproduction of forage species is becoming established, and livestock are making satisfactory gains, the range is properly stocked or understocked.

Direct observations on soil and vegetation will provide clues as to whether the range is being damaged or not. However, satisfactory standards of livestock performance on the particular range can be obtained only by keeping a record of the number, weights, and condition of the animals grazed on the range.



ALH-723

Figure 18.--Stage of development of the vegetation in the pine timber type at the beginning of the optimum 4-month grazing season. Flower stalks in the grasses are in the mid-boot stage. Species evident in the photo are Idaho fescue (dark tufts right center), bottlebrush squirreltail (gray tuft lower center), longspur lupine and woolly mulesears.

PILOT TEST OF A 5-UNIT REST-ROTATION GRAZING SYSTEM

A practical test of the effectiveness of a rest-rotation grazing system based on Idaho fescue, was started on the Harvey Valley cattle allotment on the Lassen National Forest in 1952. The allotment covers 32,352 acres of which 20,645 acres are usable by livestock. It furnishes grazing for 500 animal units during a season from June 1 to September 30.

In the Harvey Valley grazing plan, five treatments are used to provide sufficient rest in the grazing cycle during the period of seedling establishment. The grazing treatments are as follows:

Year:	Grazing treatment
1st	Close grazing.
2nd	Rest all season.
3rd	Rest until midseason. Close grazing remainder of season.
4th	Rest all season.
5th	Moderate grazing till midseason, rest remainder of season.

Grazing schedules for the five units have been worked out for the period 1952-1960 (table 25). Although increases in stocking rate are anticipated during this period, a stocking rate of 500 head was used for all years to simplify illustration of the grazing schedule. Thirty-three percent use is made of all the available forage on the allotment each year. This degree of use is obtained by making 66 percent use in the closely grazed units and 33 percent in the moderately grazed unit.

Table 25.--Grazing schedule for Harvey Valley allotment, 1952-60

Year	Stocking in range unit number-- 1	2	3	4	5
		Animal units			
1952	Rest	Rest[1/] 400	Rest	Rest 200	100 300
1953	Rest 400	Rest	Rest 200	300 100	Rest
1954	Rest	200 Rest	300 100	Rest	Rest 400
1955	200 Rest	300 100	Rest	Rest 400	Rest
1956	300 100	Rest	Rest 400	Rest	200 Rest
1957	Rest	Rest 400	Rest	200 Rest	300 100
1958	Rest 400	Rest	200 Rest	300 100	Rest
1959	Rest	200 Rest	300 100	Rest	Rest 400
1960	200 Rest	300 100	Rest	Rest 400	Rest

1/ Treatments above the dotted line were not applied in the years indicated because fences were not completed. Top figure or comment indicates stocking or treatment during first 2 months of the season, and bottom figure or comment indicates stocking or treatment during last 2 months of the season.

The way that the desired grazing intensity in each unit is obtained in a given season can be illustrated by the schedule for 1956 (table 25). At the beginning of the grazing season, 60 percent of the animals to be grazed on the allotment are placed in Unit 1 and the remaining 40 percent are placed in Unit 3. In mid-season, two-thirds of the animals in Unit 1, or 200 head, and all of those in Unit 3, also 200 head, are moved to Unit 5. In this way, Units 1 and 5 are grazed closely, Unit 3 moderately, and Units 2 and 4 are rested. Livestock are moved from one unit to another only once during the season.

Through application of this grazing plan, suitable cultural measures (5), and logging, the grazing capacity of the allotment is expected to be doubled in about 20 years. About 43 percent of the total increase is expected on areas where grazing alone will be managed, an additional 42 percent on areas where a combination of cultural treatments and grazing management will be applied, and another 15 percent on logged areas where grazing management will be in effect.

As of 1955 some areas on the allotment have been reseeded artificially (fig. 19). Others have been sprayed with 2,4-D to control sagebrush and other weed species (fig. 20). Results to date indicate that forage stands produced by cultural methods can be established and maintained under the grazing plan.

ALH-1074A

Figure 19.--A heavy stand of smooth brome seeded in 1951 on a drained basin site in Unit 1 on the Harvey Valley Experimental Allotment. The stand is in its second year of growth and is being grazed for the first time at mid-season.

ALH-1079

Figure 20.--Close up of big sagebrush area, 1 year after spraying with 2,4-D by airplane. The native grasses, primarily western needlegrass and Idaho fescue, made heavy growth after release from competition with sagebrush.

Drainage improvement is planned on a limited acreage. About half the timbered areas on the allotment have been cutover as of 1955. The remainder is expected to be cut within about 10 years.

The first overall appraisal of changes in grazing capacity of the allotment will be made in 1960, when all of the five units will have had one complete cycle of treatments and an opportunity to produce the first crop of seedlings. As of 1955 two of the five range units have reached the seedling-production stage. Both have produced seedlings of native forage species (fig. 21), providing the first indication on a large scale that the system will increase grazing capacity.

ALH-1302A

Figure 21.--First year seedlings of bottlebrush squirreltail becoming established among scattered large parent plants as a result of the five-unit grazing system.

ALH-1074A

Figure 19.--A heavy stand of smooth brome seeded in 1951 on a drained basin site in Unit 1 on the Harvey Valley Experimental Allotment. The stand is in its second year of growth and is being grazed for the first time at mid-season.

ALH-1079

Figure 20 --Close up of big sagebrush area, 1 year after spraying with 2,4-D by airplane The native grasses primarily western needlegrass and Idaho fescue, made heavy growth after release from competition with sagebrush.

ALH-1302A

Figure 21 --First year seedlings of bottlebrush squirreltail becoming established among scattered large parent plants as a result of the five-unit grazing system.

SUMMARY

Like many mountain livestock ranges throughout the West, northeastern California mountain ranges are heavily deteriorated. They are estimated to be producing only about half of potential capacity of forage and livestock at present. The vegetation has been thinned and reduced in grazing value, and much productive topsoil has been eroded away. The relatively poor condition of the vegetation and soils of these ranges is resulting not only in decreased production of beef cattle and sheep, but also in poorer watershed conditions and lower wildlife and recreational values. Improvement of these ranges would have far reaching influence on the economy of the State.

Northeastern California mountain ranges are covered primarily with bunchgrass type forage. Many factors have contributed to the deterioration of these ranges over a long period of time starting about 1860. The most important factor has been faulty management of livestock grazing.

In 1936 the California Forest and Range Experiment Station undertook studies at the Burgess Spring Experimental Range in Lassen County, to develop grazing management methods that would restore and maintain the productive capacity of these ranges. These studies were carried on through 1951. They indicated that ranges are deteriorated mainly by three factors: (1) Selective grazing of particular plants and areas by livestock, (2) repetition of this pattern each year, and (3) continuous season-long grazing year after year. This combination of factors results in continuous close cropping and gradual destruction of the better forage plants on the more accessible areas on the range. As the more frequently grazed plants are killed out, grazing is forced onto less desirable species and less accessible areas. This leads to ever enlarging areas of deterioration. By regulating stocking, season of grazing, and livestock distribution, the rate of deterioration can be increased or decreased but cannot be stopped altogether.

It was concluded that range deterioration can be prevented only by resting the range from grazing at suitable intervals. Timing and duration of rest periods must be based on the growth requirements of the key forage species on the range--the one species that is most desired for forage and soil cover. The main purpose of the rest periods is to allow the plants to recover vigor, produce seed, and establish reproduction.

The present studies have provided a basis for formulating systems of rest-rotation grazing management that promise to improve and maintain mountain bunchgrass ranges. The principles on which these grazing systems rest are outlined in this publication. A large scale test of the effectiveness of one grazing plan is being made on the 32,000-acre Harvey Valley cattle allotment on the Lassen National Forest. This test is in the fourth year and is yielding very encouraging results.

COMMON AND BOTANICAL NAMES OF SPECIES MENTIONED

TREES

Alder	Alnus spp.
Aspen	Populus spp.
California red fir	Abies magnifica
Jeffrey pine	Pinus jeffreyi
Oak	Quercus spp.
Ponderosa pine	Pinus ponderosa
Sierra juniper	Juniperus occidentalis
White fir	Abies concolor
Incense-cedar	Libocedras decurrens

GRASSES

Bluebunch wheatgrass	Agropyron spicatum
Bottlebrush squirreltail	Sitanion hystrix
Cheatgrass	Bromus tectorum
Elmer needlegrass	Stipa elmeri
Hairy California danthonia	Danthonia californica var. americana
Idaho fescue	Festuca idahoensis
Kentucky bluegrass	Poa pratensis
Mat muhly	Muhlenbergia squarrosa
Lemmon needlegrass	Stipa lemmoni
Meadow barley	Hordeum nodosum
Mountain brome	Bromus carinatus
Nevada bluegrass	Poa nevadensis
Prairie junegrass	Koeleria cristata
Sandberg bluegrass	Poa sandbergii
Smooth brome	Bromus inermis
Thin bentgrass	Agrostis diegoensis
Tufted hairgrass	Deschampsia caespitosa
Western needlegrass	Stipa occidentalis

SEDGES AND RUSHES

Chamisso sedge	Carex pachystachya
Common spikesedge	Eleocharis palustris
Nebraska sedge	Carex nebraskensis
Ross sedge	Carex rossii
Shorthair sedge	Carex exserta
Silver sedge	Carex paucicostata
Wire rush (Baltic rush)	Juncus balticus

FORBS

American bistort	Polygonum bistortoides
Arrowleaf balsamroot	Balsamorhiza sagittata
Aster	Aster shastensis
Biscuitroot	Lomatium spp.
Eryngo	Eryngium alismaefolium
Cluster tarweed (meadow)	Madia glomerata
Common arrowhead	Sagittaria latifolia
Common camas	Camassia quamash
Flatpod groundsmoke	Gayophytum humile
Hoaryleaf arnica	Arnica foliosa var incana
Lambstongue groundsel	Senecio integerrimus
Littleflower collinsia	Collinsia parviflora
Longspur lupine	Lupinus laxiflorus calcaratus
Longstalk clover	Trifolium longipes
Low pussytoes	Antennaria dimorpha
Northwest cinquefoil	Potentilla gracilis
Oregon checkermallow	Sidalcea oregana
Plantainleaf buttercup	Ranunculus alismaefolius
Pussytoes	Antennaria argentea
Slender phlox	Phlox gracilis
Water groundsel	Senecio hydrophilus
Western buttercup	Ranunculus occidentalis
Woolly mulesears	Wyethia mollis

SHRUBS

Bitterbrush	Purshia tridentata
Big sagebrush	Artemisia tridentata
Black sagebrush	Artemisia arbuscula
Bloomer rabbitbrush	Chrysothamnus bloomeri
Greenleaf manzanita	Arctostaphylos patula
Silver sagebrush	Artemisia cana
Squawcarpet ceanothus	Ceanothus prostratus

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