Changes in Crested Wheatgrass Ranges Under Different Grazing Treatments


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Highlight

Crested wheatgrass on three dissimilar sites in Nevada was grazed by cattle on seven schedules over the first 10 years of grazing. Quick utilization was achieved by heavy stocking. Trend in range condition was inferred from re-estimations of crown area, shrub densities, grass yields, seedling establishment and loop transect data. Climatic conditions, site quality, initial density of grass stand, insects and rodents influenced the trend in condition associated with grazing treatments. Season of utilization influenced trend much more than did grazing intensity.

Since 1940 over a million acres of sagebrush have been cleared and seeded to exotic grasses in Nevada. The practice has doubtless been more extensive in at least six less arid states.

Crested wheatgrass, usually a mixture of Agropyron cristatum and A. desertorum, has proved widely adapted to soils, climate and use in the big sagebrush (Artemisia tridentata) type.

Owing to the extensive and increasing areas in crested wheatgrass, and the variable forage needs of the ranchers, response of the grass to particular intensities of use at different developmental stages is a matter of importance. Involved are stand composition, productivity, longevity, soil stability, and return of the undesirable shrubs, especially sagebrush. Frischknecht and Harris (1968) found in Utah that heavy grazing and trampling restricted crown areas and reduced vigor of crested wheatgrass while encouraging return of sagebrush.

Observations in Nevada tend to agree that crested wheatgrass persists under heavy grazing and is most palatable and most often grazed in early spring. Less is known about tendencies of systems of grazing to open these grass stands to reoccupancy by brush.

Changes in Crested Wheatgrass Ranges Under Different Grazing Treatments

The Bureau of Land Management and the Forest Service cooperated with the University and local stockmen who furnished the cattle on their allotments.

Seven grazing treatments were applied to duplicate one-acre paddocks fenced in 1954 on uniform terrain and stands on three widely separated, dissimilar and previously ungrazed seedings. Grazing was scheduled so that the influence of utilization of all plants at a known height and date could be measured.

The grazing treatments were (1) season long, (2) none, (3) heavy in alternate years, (4) heavy early, (5) moderate early, (6) heavy late, and (7) moderate late. A flash grazing technique was used in (3) through (7), i.e., the desired stubble height was reached quickly and uniformly by use of heavy stocking for a short period, four days or less. At two stations half the protected paddock was fenced against rabbits, and small rodents were poisoned annually.

Early grazing was applied when average leaf length was 4 to 6 inches, at dates between mid-April and mid-June. It coincided with turn-out on the seeding. Late grazing, varying from mid-June to mid-September, coincided with conclusion of season long grazing.

Heavy and moderate grazing resulted in average stubble heights of 1 to 1½, and 2½ to 3 inches, respectively, 1955–1964. All fenced paddocks were closed to grazing in 1965 and final data were taken.

Measurements

Vegetation trends were evaluated by several methods:

(1) Plant cover, by species, using the area-list method (Pearce, 1985) on 10 randomly located permanent 9.6 ft² plots in each paddock.

(2) The pregrazing clipping of 6 plots of 9.6 ft² (Frischknecht and Plummer, 1949). Upon maturity of the grass in 1965, plots that had been clipped for nine years at the different dates and levels were compared with each other and with paired adjacent plots previously grazed but not clipped. All were cut at the same height and date.

(3) Two 100-ft loop transects (Parker, 1951) in each paddock. Originally read at the foot marks, the half-foot marks were added in 1956–1958. Final readings were in 1963.

(4) Pre- and postgrazing grass height measurements on the two diagonals of each paddock.

Measurements (1) and (4) were carried out annually, the others irregularly from 1955 through 1964. In 1963 the frequency of halogeton (Halogeton glomeratus), and in 1964 and 1965 the percent frequency of crested wheatgrass and sagebrush was calculated from 200 quadrats per acre unit (Hyder & Sneva, 1964). Vigor of crested wheatgrass under the different treatments was compared, using an adaptation of the method of Weaver and Darland (1947). Eleven uniform cylindrical cores from crowns of crested wheatgrass at Paradise Valley were assembled in October, 1960, and grown in natural light for six weeks.

A high population of jackrabbits was evident at one station in 1959. The possibility that they were grazing differentially was recognized. Accordingly, pellet counts were made on twenty 1-ft² plots in each paddock at one...
Table 1. Ratios of sagebrush (Artr) canopy cover to wheatgrass (Agcr) basal area (cm²) by treatment at beginning and end of grazing study at Pleasant Valley.

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Agcr</td>
<td>Artr</td>
<td>Ratio</td>
<td>Agcr</td>
</tr>
<tr>
<td>Moderate late</td>
<td>77.5</td>
<td>39.1</td>
<td>0.50</td>
<td>248.6</td>
</tr>
<tr>
<td>Not grazed</td>
<td>84.1</td>
<td>83.6</td>
<td>0.99</td>
<td>166.8</td>
</tr>
<tr>
<td>Heavy late</td>
<td>88.6</td>
<td>7.4</td>
<td>0.09</td>
<td>194.6</td>
</tr>
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<td>Heavy early alternate</td>
<td>107.5</td>
<td>23.0</td>
<td>0.21</td>
<td>196.4</td>
</tr>
<tr>
<td>Heavy early</td>
<td>37.1</td>
<td>0.5</td>
<td>0.01</td>
<td>207.4</td>
</tr>
<tr>
<td>Moderate early</td>
<td>72.5</td>
<td>0</td>
<td>0</td>
<td>218.1</td>
</tr>
<tr>
<td>Season long</td>
<td>98.2</td>
<td>2.1</td>
<td>0.02</td>
<td>205.5</td>
</tr>
</tbody>
</table>

As measured in production, crested wheatgrass varied from 205 lb/acre in 1959 to 812 in 1962. Harvests late and at heavy intensities were higher than at the moderate intensities or early (P < .01). Mean yield on the grazed plots in the tenth year was 22% higher than on these clipped for 9 years but the difference was not significant. Least production in the final year was on the heavy early treatment.

Regression equations were calculated for grass production and precipitation. The period October 1 to June 30 produced the highest value, r = +.84 and y = (94.08x) -523.78 where y is production in lb/acre and x is precipitation in inches.

Seedlings of crested wheatgrass, nearly 21,000 in 11 years, varied from none on season long in 1955, 1956, and 1960 to 18/ft² in 1962 on the heavy late. Yearly mean differences were highly significant but treatment differences were non-significant.

Permanent loop transects revealed upward trends under all treatments. Upward trend was strong under moderate early, but weaker under season long grazing. Mean frequencies of crested wheatgrass, as calculated from 1 x 1-ft sample plots in 1964, and from 3 x 3-inch plots in 1965, were significantly higher following late grazing than early grazing. Higher brush frequency was associated with heavy early grazing.

The trampling associated with treatments as measured by the cumulative cattle hours per paddock throughout the study was not reflected by variations in permeability to air by the soil surface.

Crested wheatgrass response.—As measured in basal area, crested wheatgrass under all treatments occurred in 1955 at 20 to 50 cm² per plot, then increased to over 200 cm² in 1961 through 1963, only to decline moderately by 1965. The highest values were achieved under no grazing, 1961, and under moderate late grazing in 1963.

Sagebrush response.—Area-list plots showed that season long grazing was the only treatment that allowed a marked, rapid increase in sagebrush cover (Table 1). The loop-transect method also indicated that season long grazing allowed the greatest increase in sagebrush. From two plants on 10 plots and a mean area of 0.5 cm² it increased to 24 plants in 1957 and a mean canopy cover of 441 cm² per plot in 1962. A general decline in sagebrush canopy in 1965 was anticipated in 1964.
because of a heavy infestation of larvae of the moth *Aroga websteri* (Clark, 1942). However, this decline occurred only under season long and moderate early grazing.

Seedlings of sagebrush were rare after 1957. Of the 539 counted, 94% appeared in the first three years. Seedlings were most encouraged by moderate late, heavy alternate, and heavy grazing but no treatment concluded the 11 years with more than one established plant per plot.

**Rabbitbrush response.**—The trend in crown cover was marked by extreme yearly variation and general decline from the 89% of total brush crown cover present in 1955. The cattle browsed Douglas rabbitbrush heavily at this station. Crown cover was sharply reduced during the 1959 drought, but most of the shrubs survived. The heavy early treatment began with the highest density, 4.8 plants per plot, and decreased to 1.0. Rabbitbrush, regardless of treatment, stabilized finally at 0.7 to 1.0 shrubs per plot. The most stable population existed under no-grazing while the most rapid depopulation was under heavy early grazing.

Of some 500 seedlings counted, nearly all appeared in the first three years. Moderate early grazing was most favorable for seedlings while three treatments, moderate and heavy late, and season long grazing each allowed scarcely any to appear. Densities of rabbitbrush were much more uniform than of sagebrush among years and among treatments. No significant correlation was found between rabbitbrush crown area and basal area of crested wheatgrass.

**Sagebrush-grass ratio.**—Sagebrush canopy cover was more responsive to treatment than was basal area of crested wheatgrass. Inasmuch as sagebrush is the primary undesirable and crested wheatgrass the primary desirable species, the ratio of crown cover of the former to the latter affords an index of condition. Records of 1955 and 1956 are summed in Table 1 as are those for 1964 and 1965, in order to obtain base data for the two species at the beginning and end of the study. The difference between ratio of brush to grass in 1964–65 and the ratio in 1955–56 is suggested as an index of trend. By this criterion moderate late grazing was best and season long worst for trend in composition.

**Residual native species.**—Although abundant before plowing, Sandberg bluegrass was present in plots of only three treatments in 1955. It was present in all treatments, not all plots, in 1962, with no significant between-treatment differences. Bluegrass declined sharply during drought years, even while wheatgrass continued its increase in crown area. It also consistently lagged a year behind in its response to favorable precipitation.

**Relation of jackrabbits to cattle grazing.**—Pellets in early July, 1959 ranged from 6.7 per ft² on season long plots to 18.5 on heavy early alternate years (P < .05). Based on the work of Arnold and Reynolds (1943), with Arizona and Antelope jackrabbits and using 60 rabbits as equivalent to an animal unit, 6.7 pellets per ft² represented roughly 9 animal unit days per acre.

**Other indicators.**—Loop transects afforded several indicators of trend, i.e., differences in numbers of hits on grass, brush, bare ground, litter and pavement plus rock (Table 2). Only bare ground tended to decrease, the other four criteria increasing after 1956. Moderate early grazing, rather than moderate late, by this method appeared to favor crown spread of crested wheatgrass.

### Paradise Valley Study Area

This site is in Humboldt County, three miles southwest of Paradise Valley village at 41°25'N, 117°25'W. Establishment of the stand has been described (Bleak and Miller, 1955) as has the pretreatment vegetation (Cloward and Fulwider, 1955). Eckert et al., 1961 have published a more detailed description of the uniform area selected for this study, including soil physical and chemical properties.

Mean crop-year precipitation during the 11 years was 7.76 inches; median 7.1 inches.

The median date of early grazing was April 17, of late grazing June 20. Grazing schedules were adhered to...
much more closely than at the other stations. Mean leaf length at early grazing for moderate was 4.6 inches, heavy 4.3 inches. Stubbles after grazing were 2.4 and 1.5 inches, respectively. Culm heights before late grazing, moderate were 11.1 inches, heavy 10.6 inches. Stubbles after grazing were 2.8 and 1.7 inches, as 10-year means.

Results

Crested wheatgrass response.—Analysis of 1955 crested wheatgrass data revealed no significant differences in mean basal area among paddocks assigned different treatments. Crested wheatgrass responded to the high precipitation of the 1956 to 1958 period with a general upsurge in crown area, only to decline during the drought of 1959 to 1960. Thereafter there was wide divergence among treatments. The highest basal areas were achieved under complete protection and heavy late grazing, but even these were reduced to near their original cover during the seven dry years, 1959 to 1965.

Mean yields varied from 590 lb/acre in 1957 to 71 lb in 1961. Early grazing had a stronger depressing effect ($P < .01$) on cumulative yield than did heavy grazing. Plots cut at one inch at maturity in 1965 averaged 574 lb/acre, nearly twice as much as the grand mean of the previous eight years. The highest vigor was reflected by a final yield of 812 lb/acre on moderate late. All final yields indicated lower vigor under prolonged early utilization, as illustrated in Fig. 1.

At a final uniform cutting in 1965, 12 previously clipped plots averaged 580 lb/acre compared with 310 lb from grazed plots ($P < .05$). This difference may indicate that temporary protection by cages benefited the grass more than it was injured by uniform clipping before grazing.

Seedling densities varied significantly among years, and were highest in 1958 when 14 per plot were recorded under early grazing at each intensity. Late grazing decimated seedlings while early did not ($P < .01$) but the two intensities did not differentially affect seedling numbers. Only in 1962 and 1964 were no wheatgrass seedlings found in any treatment.

Number, height and weight of shoots emerging from cores of wheatgrass crowns all indicated lowest vigor of plants never grazed, and highest from heavy early and season long (Fig. 2). Root weights were inconsistent. Repetition of the test in the dark resulted in diseased plants and no data.

Brush response.—Trends in sagebrush crown cover were erratic. Late and early heavy grazing reduced cover. The highest average cover, 162 cm$^2$, occurred on plots grazed season long and the most stable brush cover existed under full protection. Regardless of original crown cover or treatment, all converged to similar cover, between 30 and 80 cm$^2$ per plot in 1965.

Ratios of sagebrush canopy area to wheatgrass basal area and their differences are recorded as an index of trend in condition. The maximum decreases in ratio of brush crown areas to wheatgrass were under moderate late and heavy early grazing (Table 3). The widest fluctuations in density were on the season long and late grazed
Bare ground decreased as litter increased, especially under heavy late grazing. The minimum accumulation of litter during the 5 years occurred under no grazing by cattle, season long and heavy early alternate year grazing. No significant difference was found in utilization by rabbits on the basis of pellet densities.

Sweetwater

Study Area

Sweetwater Flat is in Lyon County (38°30'N, 119°121/2'W) at 7100 feet elevation between Bald Mountain and the Sweetwater Range. The soil and natural vegetation have been described elsewhere (Eckert et al., 1961).

Mean crop-year precipitation for the 11 years at Wellington, Nevada and Bridgeport, California was 7.85 inches. October was the driest and February the wettest month. The driest year was 1960 with 3.64 inches and 1963 the wettest with 13.41 inches. December 1955 was the wettest month, 6.84 inches. Soil moisture was usually available in the top foot though not in the top 6 inches at late grazing.

Mean leaf length at early grazing was 5.8 inches, stubble after moderate grazing 2.6 inches, after heavy grazing 1.6 inches. Late moderate grazing began at 11.7 inches mean height and ended with a 3.1 inch stubble. Late heavy grazing grass height was 10.9 inches, grazed to 1.8 inches.

The median date of early grazing was May 22, of late grazing August 6. Grazing was deferred in 1961 and prohibited in 1962 on the season long in an effort to halt downward trend accelerated by drought.

Total time in each paddock ranged from 5.9 cattle days per acre in early moderate to 23.7 cattle days per acre on late heavy alternate year paddocks. This is an indication of the relative amount of trampling inherent in the five flash grazing treatments during seven years for which records are complete.

The initial stand of crested wheatgrass was very dense causing severe intraspecies competition and closing the community to seedling establishment. Further, this site was less suitable for crested wheatgrass than the two foregoing because of adverse soil and climate. Also rodents contributed more to the difficulty of management and controlled experimentation.

Table 4. Differences in loop transects after 5 years under 7 grazing treatments at Paradise Valley.

<table>
<thead>
<tr>
<th>Grazing treatment</th>
<th>Difference in number of hits</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Agcr</td>
</tr>
<tr>
<td>Heavy early alternate</td>
<td>0.62a2</td>
</tr>
<tr>
<td>Moderate early</td>
<td>0.25a</td>
</tr>
<tr>
<td>Heavy late</td>
<td>0.12a</td>
</tr>
<tr>
<td>Heavy early</td>
<td>1.62a</td>
</tr>
<tr>
<td>Moderate late</td>
<td>3.00a</td>
</tr>
<tr>
<td>Not grazed + R3</td>
<td>0.75a</td>
</tr>
<tr>
<td>Not grazed - R3</td>
<td>1.62a</td>
</tr>
<tr>
<td>Season long</td>
<td>1.62a</td>
</tr>
</tbody>
</table>

1Agcr = crested wheatgrass; Artr = sagebrush.
2Means followed by the same letter do not differ significantly at the 5% level of probability.
3-R = closed to rabbits; +R = open to rabbits.
Table 5. Survey of pocket gopher burrows in June, 1961 at Sweetwater.

<table>
<thead>
<tr>
<th>Grazing treatment</th>
<th>Percent hits¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>Season long</td>
<td>16.5a</td>
</tr>
<tr>
<td>Heavy late</td>
<td>17.0a</td>
</tr>
<tr>
<td>Heavy early</td>
<td>17.0a</td>
</tr>
<tr>
<td>Moderate early</td>
<td>18.0ab</td>
</tr>
<tr>
<td>Moderate late</td>
<td>21.0bc</td>
</tr>
<tr>
<td>Heavy late alternate</td>
<td>22.5c</td>
</tr>
<tr>
<td>No grazing</td>
<td>26.5d</td>
</tr>
</tbody>
</table>

¹ Means followed by the same letter are not significantly different at the 5% level of probability.

Pocket gophers were so active in 1961 that a survey of their tunnels was made before grazing by probing 10 times on 10 transects in each paddock. As shown in Table 5, gophers were most active under no grazing and heavy late grazing in alternate years only.

Clearings by harvester ants ranged between 0.2 and 2.2% of ground cover in the 14 paddocks. Crested wheatgrass cover had a strong tendency to vary inversely as the area of ant clearings.

Results

Crested wheatgrass response.—As at the other stations, means of crown cover, yield, and density of seedlings differed significantly among years. All treatments started in 1955 with mean crown areas of 90-100 cm² per plot. Annual changes moved gradually downward together, being especially narrow and close for all treatments during drought periods. Late and season long grazing appeared more favorable during moist years than early or no grazing. Trend under no grazing was intermediate in basal cover.

Mean yields of oven-dry herbage were relatively low, ranging from 5 lb/acre under moderate early in 1961 to 540 under heavy late grazing in 1957. In 1961, the mean of 48 plots was 60 lb/acre compared with 440 lb in 1957. Production on annually clipped plots in 1965 was not significantly more than on annually grazed plots. Yields obtained in 1965 by clipping all plots at maturity indicated that season long grazing had left the grass in higher vigor than had early, none or alternate year grazing. Trend under no grazing was intermediate in basal cover.

Crop-year precipitation accounted for 40 percent of the variation in yield (r = 0.64; P < .10).

Seedlings of crested wheatgrass were absent from the area-list plots of all treatments in 1955 and 1959-62. The highest yearly mean per plot was 18 in 1958. Early grazing permitted more seedlings than late, and moderate more than heavy (P < .05).

Sagebrush response.—Crown cover in all treatments began within the range 60-200 cm² per plot. Season long and annual heavy grazing appeared detrimental to sagebrush. Brush thrived most under alternate year grazing.

Densities of sagebrush followed roughly similar trends independent of treatment. Increases in numbers after 1961 were most rapid under full protection and least under season long grazing.

Rabbitbrush was negligible at this site.

Sagebrush-grass ratio.—The indices in Table 6 reflect a downward trend in condition under all treatments, inasmuch as all ratios of brush to grass are larger in 1964–65 than in 1955–56. Condition was most stable under season long grazing, under flexible controlled management by the District Forest Ranger.

Residual native species.—Skeleton weed (Lygodesmia spinosa) and phlox (Phlox hoodii) were common survivors of plowing at Sweetwater. They responded differentially to the grazings. While basal area of crested wheatgrass decreased under all treatments, that of skeleton weed increased under all treatments. Its frequency in 1965 was higher under season long and no grazing than under other treatments (P < .05).

Phlox declined most under heavy late grazing and gained most in cover under early moderate grazing (n.s.). The frequency of phlox in 2 x 2-ft plots was higher under heavy late grazing in alternate years, 19.5%, than on ungrazed, 4.0%. Early heavy paddocks, 5.0% (Heinze, 1964).

Other indicators.—A comparison of changes in the five indicators of trend may be made with the loop-transect data in Table 7. Hits on crested wheatgrass and bare ground were fewer after 6 years. The decline in bare ground was most under late grazing and least under season long grazing. Decline of wheatgrass was not outstanding under any particular treatment, nor was the increase in sagebrush. Late grazing produced the most litter cover, season long the least. Exposure of pavement and rock was least in the rabbit-proof ungrazed paddock and most under late grazing.

Discussion and Conclusions

Trend in range condition as response to different schedules (seasons and intensities) of grazing is the central objective of this research.

Table 6. Indices of trend in condition based on changing ratios of brush canopy cover to grass basal area at Sweetwater.

<table>
<thead>
<tr>
<th>Grazing treatment</th>
<th>Ratio sagebrush/wheatgrass</th>
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</thead>
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<tr>
<td></td>
<td>1955–56</td>
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<tr>
<td>Season long</td>
<td>11.7</td>
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<tr>
<td>Heavy late</td>
<td>6.6</td>
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<tr>
<td>Moderate late</td>
<td>15.8</td>
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<tr>
<td>Heavy early</td>
<td>18.0</td>
</tr>
<tr>
<td>Not grazed</td>
<td>10.4</td>
</tr>
<tr>
<td>Heavy late alternate</td>
<td>18.0</td>
</tr>
<tr>
<td>Moderate early</td>
<td>17.2</td>
</tr>
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</table>
Table 7. Differences in loop transects after 6 years under 7 grazing treatments at Sweetwater.

<table>
<thead>
<tr>
<th>Grazing treatment</th>
<th>Difference in number of hits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy late alternate</td>
<td>0.6a^2</td>
</tr>
<tr>
<td>Moderate early</td>
<td>3.2a</td>
</tr>
<tr>
<td>Heavy late</td>
<td>0.9a</td>
</tr>
<tr>
<td>Heavy early</td>
<td>9.5a</td>
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<tr>
<td>Moderate late</td>
<td>1.0a</td>
</tr>
<tr>
<td>Not grazed - R^3</td>
<td>4.0a</td>
</tr>
<tr>
<td>Not grazed + R^3</td>
<td>1.8a</td>
</tr>
<tr>
<td>Season long</td>
<td>9.0a</td>
</tr>
</tbody>
</table>

^1 Ager = crested wheatgrass; Artr = sagebrush.
^2 Means followed by the same letter do not differ significantly at the 5% level of probability.
^3 - R = closed to rabbits; + R = open to rabbits.

Since site quality and initial stands differed, parallel responses to all treatments were not obtained. For example, late grazing at Paradise was a month earlier than at Pleasant Valley and seven weeks earlier than at Sweetwater, in accord with differences in elevation.

The indicators of trend which appear useful include changes in cover, density and seedling counts of grass and brush on area-list plots; change in composition as reflected in numbers of hits on more and less desirable species; soil surface protection in terms of litter, bare ground and pavement on Parker loop transects, differences in vigor as reflected by yields on clipped plots and on wheatgrass plugs grown indoors; and perhaps most useful, the changes in ratios of sagebrush canopy to crested wheatgrass basal cover on 9.6 ft^2 plots. Since the frequency method was not used at the beginning of the study, conclusions as to trend based on this method are speculative although highly significant differences among treatments were detected.

Heavy grazing in alternate years produced downward trend at Paradise Valley and Sweetwater but at Pleasant Valley the indicators disagreed. Hence, no reason is seen for recommending alternate year rest after heavy use, nor is it clear that a year's rest will compensate for abusive grazing. Full protection failed to prevent downward trend at Sweetwater or to produce consistent indicators of trend at the other stations. Both continuous protection from stock and rest in alternate years favored concentration of pocket gophers at Sweetwater, a response somewhat parallel to that reported in California (Howard and Childs, 1959).

Trend under heavy early grazing was upward at Paradise Valley, and by most indicators at Paradise Valley, but indefinite at Sweetwater. Indicators were inconsistent at all stations on the early moderately grazed paddocks. Despite an increase in sagebrush on the transects upward trend under heavy late grazing was fairly conclusive at Paradise Valley and Sweetwater. Crested wheatgrass expanded in basal area at Pleasant Valley and Sweetwater but not at Paradise Valley under moderate late grazing. There was no disagreement among indicators over downward trend under season long grazing at Pleasant Valley while at Sweetwater this schedule was the most favorable because of deferred and no grazing under flexible management. Differences among the three sites are highlighted by the difference indices in tables 2, 4, and 8. At Pleasant Valley there are less than 1.0, at Paradise Valley 2.06 is the maximum, while at Sweetwater, the most difficult site, the difference indices of trend soar to 83. Managers of crested wheatgrass should take into account the initial density. A partial stand on a good site can easily be encouraged to thicken, e.g., Pleasant Valley. On the other hand, a dense stand on a mediocre site will decline under most grazing schedules including non-use, e.g., Sweetwater. Only at Sweetwater did sagebrush cover increase to the point where the management agency considered it necessary to spray.

Early but not late grazing was followed by re-growth and seed production in favorable years. An inch or so difference in stubble height either early or late, made scarcely any difference in trend. Time of grazing exerted much more influence. Where any squirreltail was present, it increased under late but not early grazing. Although the effect of insects, rodents and rabbits were uncontrolled variables, they were generally overshadowed by effects of grazing and variable moisture. Variable trampling made no measurable difference in soil surface permeability. In general, grazing at the end of growth improved fair but not excellent stands of crested wheatgrass.

Trends fluctuated with climatic variations, and varied according to grazing schedule, site, and density of original stands. These conditions should
be considered carefully in planning use of crested wheatgrass.

Literature Cited


1 Received April 24, 1969; accepted for publication July 14, 1969.

2 We thank Mr. Joe Ruckman, Department of Agronomy and Range Science; and Specialist, Department of Animal Science, University of California, Davis.

3 P. Lapins and E. R. Watson, personal communication.

Highlight

Paraquat applied to standing annual range forage at anthesis of the grasses resulted in standing hay 57 to 77% higher in protein. Crude fiber was decreased and phosphorus increased. Forage production was generally lower with treatment, because the growing season was shorter. Palatability of dry forage was improved. Lambs on treated forage gained more rapidly. No physiological or pathological changes were found in the lambs. Spraying resulted in less grass and more clover in the year following spraying.

The forage picture on ranges of cismontane California is normally one of feast or famine. During much of the year forage is of low quality although these lands are generally productive, producing dry matter of 1,000 to 6,000 lb/acre. The vegetation is made up almost entirely of annual species of grasses, legumes, and forbs. These plants make most of their growth in a short spring period and then mature and die as days lengthen, temperatures rise, and the moisture supply is abruptly cut off. Total digestible nutrients reach a peak during maximum vegetative growth and decline as the forage matures. Protein and phosphorus decline soon after maturity (Guilbert et al., 1944). Protein is generally more acutely deficient than phosphorus. Wagnon et al. (1942) showed that, without supplements, all classes of cattle lost weight soon after the first of July, regardless of forage abundance. Van Dyne (1965a, b) showed that annual grass protein varied from 2.2 to 3.5% in August, and that fistula samples from cows and sheep declined from 9.5% protein in early summer to 6.9% in late summer.

Nitrogen loss began at flowering in soft chess (Bromus mollis L.) and continued until senescence, whereas losses in subclover (Trifolium subterraneum L.) began after seed setting in Australia. Nitrogen loss was mainly from the herbage, and was probably lost by volatilization to the air.