Effect of Clipping on Herbage and Flower Stalk Production of Three Summer Range Forbs

ODELL JULANDER[1]

Principal Plant Ecologist,
Intermountain Forest and Range Experiment Station,
Forest Service, U.S.D.A., Ogden, Utah;
headquartered at Provo, Utah.

Highlight

Unclipped forbs produced more herbage and flower stalks over a 10-year period than plants clipped 50, 75, and 90%. Herbage production by the plants clipped 75 and 90% decreased rapidly over the years and few mature seeds were produced after 3 or 4 years of treatment. Ligusticum and valerian can apparently stand about 50% use each year, but geranium should be grazed somewhat less.

Forbs supply the primary forage for deer and sheep on mountainous ranges from early spring to late summer. Forbs also supply much of the choice spring and summer forage for elk and cattle on many ranges. Therefore, some standard of optimum utilization of palatable forbs is necessary as a guide to regulation of grazing. Obviously, to preserve the grazing lands, range managers must determine how many animals should be grazed on a given range. Yet, information is lacking about the amount of grazing that forbs can withstand and still produce a sustained yield of forage. One way to study this problem is to approximate various grazing intensities by clipping of plants and to observe the effects over a long period of time.

Most previous studies employing the clipping method have dealt with grasses and shrubs; but results of these studies apply to forbs because the physiological processes of all three groups of plants are much the same. Studies of the effects of different intensities of clipping on grasses show that grazing during the growing season usually reduces plant growth. The more frequent and severe the defoliation, the more depressed the herbage production and root growth (Parker and Sampson, 1931; Robertson, 1933; Weaver and Hougen, 1939; Carter and Law, 1948; Branson, 1956; and Cook et al., 1958). Heavy clipping of forage plants likewise reduces seed production (Julander, 1937; Hanson and Stoddart, 1940; Blaisdell and Pechanec, 1949; Driscoll, 1957). The time of clipping strongly affects results. McCarty and Price (1942) found that, in the mountains of Utah, Richardson geranium (*Geranium richardsoni* Fisch. and Trautv.) plants clipped 1 inch above the ground at the close of the grazing season maintained a greater percent of yield and higher carbohydrate reserves the following year than those clipped during the main part of the growing season. Blaisdell and Pechanec (1949), working on the Snake River Plains of Idaho, found that complete removal of arrowleaf balsamroot (*Balsamorhiza sagittata* (Pursh) Nutt.) herbage reduced the following year's herbage and flower stalk production. Flower stalk production was more severely affected than herbage. Clipping in May and early June—the period of full bloom for balsamroot—was most harmful. Injury was progressively less severe for clippings later in the season.

The present study was designed to provide guides to the proper utilization of three important forbs by determining the effect of different degrees of clipping on herbage and flower stalk production over a 10-year period. The plants chosen are important as summer forage for deer and livestock; they are Richardson geranium, Porter ligusticum (*Ligusticum porteri* Coult. & Rose), and edible valerian (*Valeriana edulis* Nutt. ex T. & G.). All are long-lived perennials. The study area is on the west flank of the Wasatch Plateau east of Ephraim, Utah. Here the geranium plants grow in the lower aspen zone at an elevation of 8,450 ft, and the other species grow in the subalpine zone at about 9,900 ft. Precipitation averages about 23 inches annually in the lower aspen zone and about 33 inches in the subalpine zone.

Methods

Twenty-four vigorous plants of each species were chosen for the study, including 12 in each of two adjacent blocks. The plants varied in size and were randomly assigned treatment within each block; some were control plants (unclipped) and others were clipped 50, 75, or 90% by weight. Treatments were repeated once each year over a 10-year period, from 1951 through 1960. All plants were protected from grazing during the study period.

Plants were clipped in late flowering, at or near maximum vegetative growth stage. This stage was usually reached near the middle of July for geranium and during the first 10 days of August for ligusticum and valerian. During the first 4 years, regrowth was measured, but later regrowth was found to be negligible. Regrowth was therefore ignored in calculations.

In clipping, appropriate percentages of both leaves and flower stalks were removed; clipping simulated natural grazing as closely as possible. Green weights of the clipped portions were converted to air-dry weights, and the conversion factors were determined annually for each species. Total production of the clipped plants was calculated according to the percentage of the plant represented by the clipped portions. The production of the unclipped control plants was estimated by counting the leaves and

[1] Justin G. Smith of the Pacific Northwest Forest and Range Experiment Station did the first few years of clipping on this study. His help is appreciated.

Table 1. Average annual herbage production over a 10-year period, in grams per plant.

Treatment	Ligusticum	Valerian	Geranium
Unclipped	51.60	28.17	43.27
Clipped:			
50%	33.25	20.98	20.35
75%	25.88	9.75	13.75
90%	13.90	8.72	9.75

flower stalks of these plants and relating the result to average weights of similar ungrazed neighboring plants that were cut at ground level and weighed.

All plants were checked in the autumn of 1965 to determine mortality during the 5-year period following treatment, and to estimate relative vigor of plants from the amount of current growth produced. During this 5-year period, geranium plants had received extremely light annual use by deer, and the ligusticum and valerian had been utilized lightly by sheep each autumn.

The study was analyzed as a randomized block design having four treatments in each of two blocks. Three plants were represented in each treatment-block combination—a total of 24 plants. The analyses of variance for the data, including the observations over the 10-year span, were conducted as a split-plot design since the same plants were observed each year.

Because the variation in the experiment was approximately proportional to production in a given year, and the average increase or decrease associated with the treatments was expected to be approximately proportional to the previous production, a log transformation of the data was used for both vegetation and flower stalks. This transformation provided for homogeneity of variance and provided also that the main relationship of herbage production and flower stalk production with time (years) would be linear. It was expected that changes in environmental conditions from year to year would cause some fluctuations from this linear trend. To investigate this, we analyzed trends in forage production with time by the use of orthogonal polynomials in the analysis of variance. An upper bound for the unclipped plants, based on production in 1957, was used for fitting the linear trend; 1957 was the year of maximum production during the study period.

Results

The results of the study are expressed in terms of weight of herbage produced and number of flower stalks produced. Both average annual yields and trends over the 10-year period were examined, and data were compared for unclipped and clipped plants of the three species.

Herbage Production

Unclipped plants produced a substantially greater average annual yield of herbage than plants clipped 50%, and two or more times greater than plants clipped 75 and 90% ($p \leq .01$) (Table 1).

The trend in production of unclipped plants of all species was definitely upward over the 10-year period (Fig. 1). Size increase of younger plants, release from past grazing, and favorable growing conditions during certain years may all have contributed to this upward trend. Precipitation was generally low during this period; but 1957 was unusually wet.

The three species responded differently to growing conditions. Plants of ligusticum and valerian

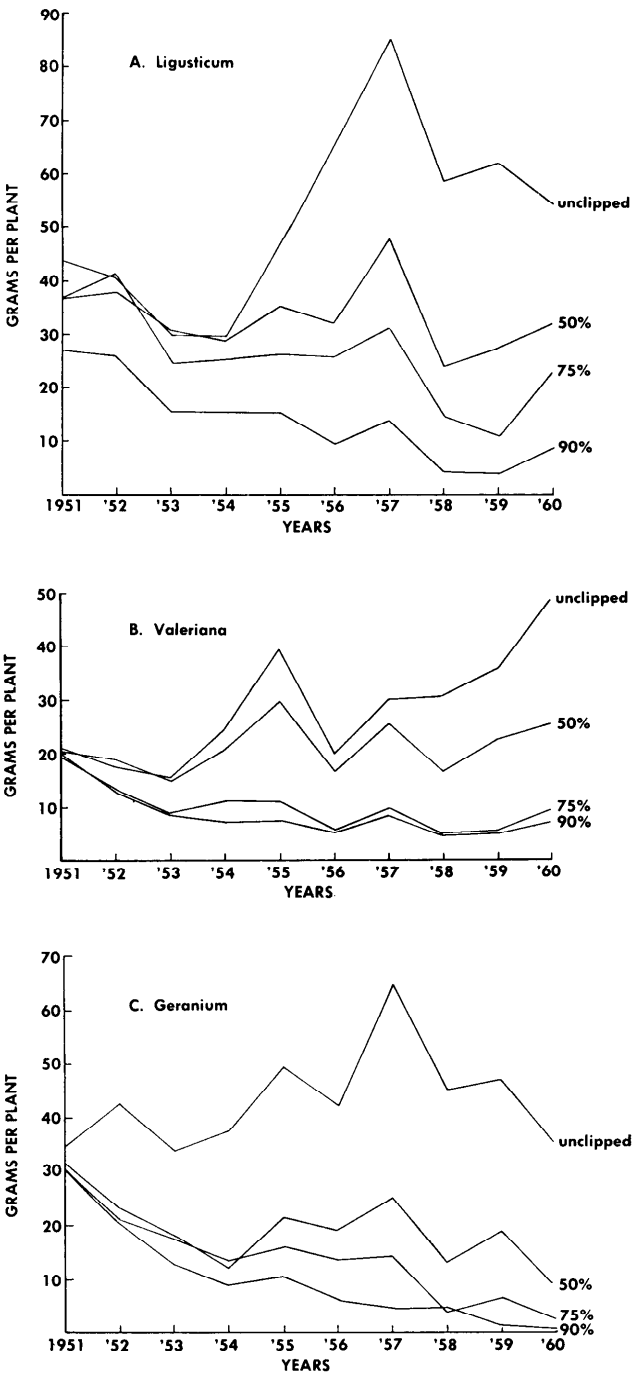

FIG. 1. Average annual herbage production: actual values for unclipped plants and plants clipped 50%, 75%, and 90%, in g/plant.

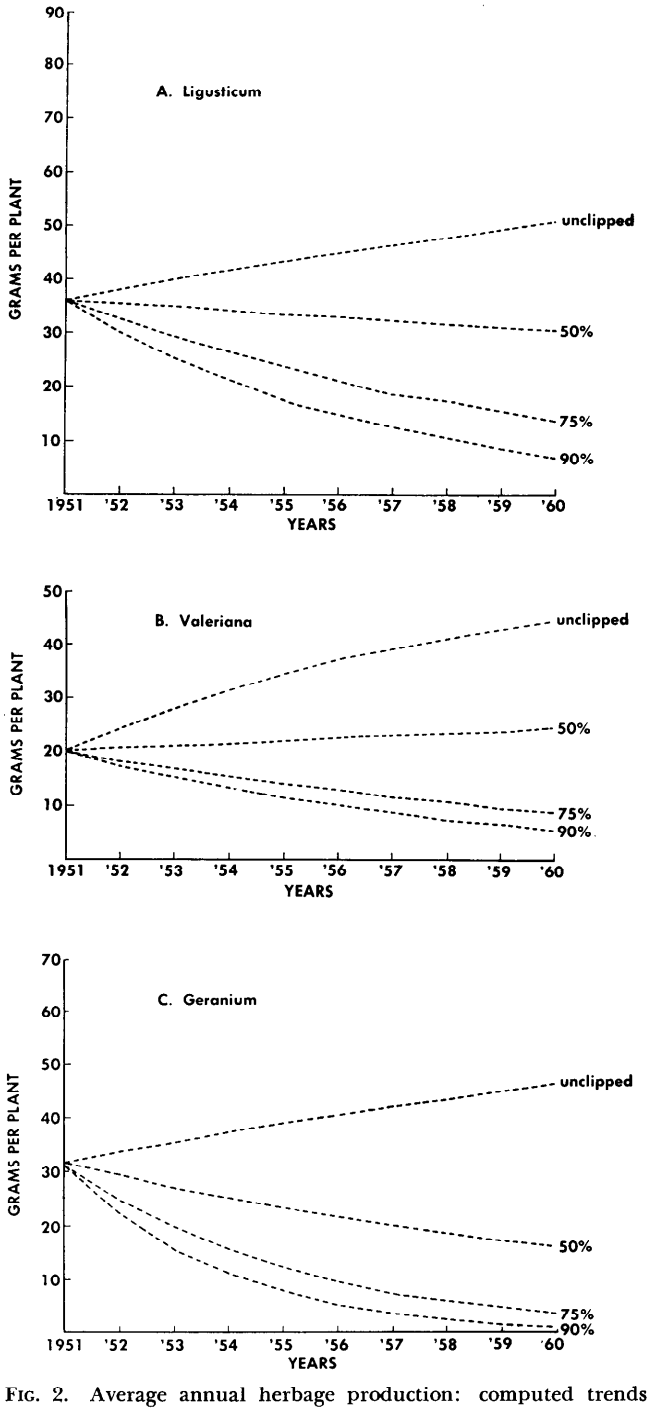

FIG. 2. Average annual herbage production: computed trends for unclipped and clipped plants as in Fig. 1.

were immediately adjacent; so growth factors were comparable. However, unclipped ligusticum (like geranium) reached maximum herbage and flower stalk production for the 10-year period in the high rainfall year of 1957. On the other hand, 1957 production of valerian herbage and flower stalks was about normal, and peak production of herbage was made in 1955 and 1960, whereas peak flower stalk production occurred in 1959 and 1960. Good growth years are not always good seed years for all species.

The trends in herbage production for the clipped plants varied according to species and severity of clipping (Fig. 1). In contrast to the trend towards increased production of unclipped plants of all species, the trend was to decreased production for the clipped plants. Fig. 1 shows an overall trend associated with the clipping treatments and also yearly variations which appear to be primarily associated with changes in environmental conditions. The orthogonal polynomial analysis demonstrated that most of the variation with time was associated with the linear trend, and the part that remained was associated mainly with curvilinear components. For this reason, the linear trend was taken to represent the effect of clipping, and the results were used to obtain curves (Fig. 2) which would estimate the effect of clipping on the average. For presentation, the computed trends were adjusted to a common initial production.

The trends for individual species show differences of varying significance. Ligusticum plants clipped 50% almost held their own in production during the 10-year period. For plants clipped 75%, the trend was definitely downward, and for plants clipped 90% the downward trend was considerably steeper. These trends differ significantly (Fig. 2A).

Valerian plants clipped 50% showed a slight upward trend in production of herbage [50% vs. 75% and 90% ($p \leq .01$)]. Plants clipped 75 and 90% showed rather drastic downward trends, but the differences between the two rates of clipping were not significant (Fig. 2B).

Geranium plants clipped 50% showed a definite downward trend and produced less forage than the unclipped plants, but significantly more than those clipped more heavily ($p \leq .01$). Although plants clipped both 75 and 90% showed drastic downward trends, the plants clipped 90% had only a slightly steeper downward trend than those clipped 75% (Fig. 2C).

Differences in the ability of perennial forbs to withstand grazing is evident from these results. Geranium was more severely affected by clipping than the others and did not tolerate even the 50% clipping treatment. Valerian withstood the 50% clipping better than ligusticum, but ligusticum tolerated the 75% clipping better than valerian, as indicated by the ligusticum's higher production and greater response to good growing conditions at the end of the study period.

Since fluctuations in growing conditions are not predictable, we did not attempt to calculate a trend to account for growing conditions from year to year. However, the magnitudes of the fluctuations are useful in indicating the differences in production that might be expected. Effects of

Table 2. Herbage production of clipped plants as a percentage of the unclipped plants, based on computed trend values, 1951–1960.

Treatment	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
Ligusticum										
Clipped:										
50%	100	93.3	87.4	82.1	77.4	73.2	69.4	66.0	63.2	59.9
75%	100	85.7	73.7	63.6	55.0	47.7	41.5	36.1	31.5	27.5
90%	100	79.7	63.7	51.1	41.0	33.0	26.5	21.3	17.1	13.7
Valerian										
50%	100	84.7	75.2	69.0	64.6	61.5	59.2	57.5	56.3	55.4
75%	100	75.5	59.8	48.9	40.9	34.7	29.9	25.9	22.6	19.9
90%	100	72.1	54.6	42.6	34.0	27.5	22.5	19.2	15.4	12.8
Geranium										
50%	100	88.1	76.7	67.7	60.1	53.5	47.8	42.8	38.4	34.5
75%	100	74.7	56.1	42.2	31.8	23.9	18.0	13.4	10.0	7.3
90%	100	66.2	43.9	29.0	19.0	12.3	7.8	4.7	2.6	1.2

clipping were expressed in annual fluctuations, as shown by the greater response of unclipped plants compared to that of heavily clipped plants in good growing years (Fig. 1). Plants clipped 90% showed little growth response to favorable growing conditions (for example, in 1957). Heavily clipped ligusticum plants appeared more vigorous and showed greater response in good growth years than the other two species. Hence, ligusticum might have greater potential for recovery than valerian or geranium.

The computed trends of herbage production indicate what might be expected over a 10-year period similar to the period of study. These calculations are not precise because natural maximum limits of production were not known. However, over the 10-year period these estimates are the best available. All clipping treatments depressed the forage yield as compared to yield from the unclipped plants. Differences increased with intensity of clipping and with number of consecutive years of treatment (Table 2). After 10 years, overgrazed plants could be expected to produce about 20 to 45% as much forage as those moderately grazed. (Percentages are even lower for geranium.) A somewhat longer period of overgrazing could be expected to reduce production on heavily grazed plants to zero. The curves for plants clipped 75 and 90% may well present a diagrammatic picture of the fate of many palatable forage plants under continuous overgrazing in past years.

Such long-range predictions are possible only on the basis of observations over a long period. The exact year that differences in production due to clipping became significant may not be as important as the overall trends. In the present study, growth fluctuated greatly from year to year, and differences might have been significant one year and not the next. Most of the differences were not clearcut until after about 3 or 4 years of clipping. Preliminary analyses after 4 years of treatment showed significant differences due to clipping for geranium and valerian but not for ligusticum. Differences between unclipped plants and those clipped 50% were nonsignificant for all three species. These facts show the necessity for long-term studies to determine effects of clipping or grazing on forage plants.

Flower Stalk Production

Flower stalk production over the 10-year period for unclipped plants of all three species followed no definite trends (Table 3). A slight upward

Table 3. Flower stalk production: average number per plant by species, year, and treatment.

Treatment	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960	10-year mean
Ligusticum											
Unclipped	5.50	3.50	3.50	1.33	4.50	2.17	6.67	4.17	4.00	5.83	4.11
Clipped:											
50%	4.00	2.83	2.67	3.00	2.17	1.67	5.17	2.17	3.00	4.17	3.08
75%	3.33	2.17	2.17	1.33	3.33	1.50	2.17	0.83	1.00	2.50	2.03
90%	3.50	1.17	2.00	1.33	1.50	1.00	2.17	0.50	0.17	0.67	1.40
Valerian											
Unclipped	1.83	0.50	1.00	2.00	1.83	1.67	1.67	1.50	2.67	3.00	1.72
Clipped:											
50%	1.83	0.83	0.33	0.50	2.17	1.17	0.67	0.67	0.83	0.50	0.95
75%	2.00	0.67	0.17	0.50	1.00	0.83	0.00	1.17	0.33	0.17	0.68
90%	1.50	1.17	0.50	0.50	0.33	0.67	0.17	0.33	0.33	0.33	0.58
Geranium											
Unclipped	10.17	7.33	3.67	7.50	7.33	5.83	11.50	4.67	5.17	5.17	6.83
Clipped:											
50%	8.33	5.83	2.50	5.50	4.67	3.17	7.00	2.17	1.67	2.50	4.33
75%	8.33	4.17	3.00	2.50	4.83	1.00	1.83	1.00	0.50	0.50	2.77
90%	7.17	4.50	2.33	1.83	3.16	0.67	0.83	0.00	0.00	0.00	2.05

trend for ligusticum plants clipped 50% was observed, and a similar slight downward trend for the other two species. Clipped plants of all three species produced less than unclipped plants (for ligusticum and valerian, $p \leq .01$ and for geranium, $p \leq .05$). Production decreased with increase in clipping intensity and length of treatment (Table 3). Production differences between plant groups clipped 50% and those clipped 75 and 90% were significant for ligusticum only ($p \leq .05$). Differences between the plant groups clipped 75 and 90% were not significant.

Average annual fluctuations were not as great as those in herbage production. However, larger plants consistently produced more flower stalks than did smaller plants, and some thrifty plants produced abundant flower stalks one year and none the next year.

The reaction of valerian to varying growth conditions over the years was different from that of the other two species. Some selective growth factor or factors were apparently operating. For example, unclipped valerian produced fewer than average flower stalks in 1957, when the other species produced their maximum numbers.

In spite of these fluctuations it appears that the overall downward trends in flower stalk production, as in forage production, are due to clipping.

Vigor and Mortality

In all three species, all unclipped plants and those clipped 50% survived, matured seed, and appeared thrifty throughout the 10-year study period. This ability to produce mature seed is essential to the survival of the species over long periods of grazing use.

Most plants clipped 75%, particularly geranium, were low in vigor after 4 years of treatment. Flower stalks developed late and often failed to produce mature seed. One of the six geranium plants died after 7 years of treatment; the others were reduced in size.

All plants clipped 90% were much reduced in size and low in vigor. Only a few flower stalks were produced after 4 years of clipping and these were weak and spindly—flowers were late, and no mature seed was produced. Three geranium (one-half of the total) and one valerian died, most of them following the seventh-year clipping. All six of the ligusticum plants were alive but weak. Near the end of the 10-year study period, these ligusticum plants still responded better to good growing conditions than the other two species, indicating greater recuperative ability.

In 1965, 5 years after the last treatment, all unclipped plants of all three species were alive and vigorous. Ligusticum plants that had been clipped 50 and 75% were thrifty and productive. Of those clipped 90%, all were alive, two were very vigorous, and only one was still weak, with low herbage production.

Valerian plants that had been clipped 50% were all thrifty and were recovering well by 1965. Those clipped 75% were all alive; one was making excellent recovery, one showed but little recovery, and four were making moderate recovery. Of the valerian plants that had been clipped 90%, one had died since 1960, two were making little recovery, and two were making moderate recovery.

Geranium plants that had been clipped 50% were all alive in 1965. All were thrifty and recovering except one which was producing about the same as in 1960. Of the plants clipped 75%, two additional plants had died since 1960, and the remaining three were making fair recovery. Production of the live plants was still very low compared to that of unclipped plants. Geranium plants that had been clipped 90% were all dead in 1965. Three had died since 1960.

These observations on survival and vigor substantiate the findings during the 10-year study: Ligusticum has the greatest and geranium the least ability of the three species to withstand clipping and to recover after heavy clipping.

Discussion

The results of this study offer several guides for range management. The status of the three species studied as increasers or decreasers of a grazed range is largely determined by the differences in ability of each to withstand heavy grazing and to reproduce and recuperate after heavy use.

The study showed that valerian and ligusticum can withstand a maximum of about 50% utilization and still maintain themselves indefinitely and produce seed for regeneration. Geranium, however, did not tolerate 50% utilization as well as the others. All three species were shown to be fairly resistant over short periods of time. There was no significant difference in herbage or flower stalk production of ligusticum or valerian, regardless of intensity of clip, until 3 or 4 years after clipping was started, and no mortality occurred until the seventh year. Geranium plants were particularly low in vigor, however, by the fourth year.

In ability to recover from clipping, ligusticum and valerian also showed an advantage over geranium. Most of the ligusticum and valerian plants clipped 75% had made good recovery by 1965—5 years after clipping ended—whereas half the geranium plants that had been clipped 75% were dead, and the remaining three were making only fair recovery.

These conclusions suggest that ligusticum and valerian are well adapted to rather heavy grazing and also to grazing systems which require very

heavy use during one or more years, followed by rest or lighter use in succeeding years. Geranium, being more sensitive to heavy use and less responsive in recovering from it, should be utilized somewhat more lightly than the other two species if it is to be grazed every year without deterioration.

The present study does not include the effect of trampling, season of use, nor continuous removal of herbage throughout the summer, as by deer grazing. The clipping treatments more nearly resemble "once-over" sheep grazing that occurs on the area studied at about the same season when clippings were made. Natural competition of other plants prevailed during the study. Limited past studies on other forbs (Blaisdell and Pechanec, 1949) indicate that earlier clipping might have been more detrimental to plants than is reported here. Other studies (McCarty and Price, 1942) indicate that season-long grazing (as in use by deer), which removes herbage gradually throughout the summer, might be less harmful to plants than a single clip during flowering and fruiting stage.

Summary

Unclipped plants of ligusticum, valerian, and geranium produced more herbage and flower stalks than did plants clipped 50, 75, and 90% over a 10-year period. The differences increased with intensity of clipping and with number of years clipped.

Plants clipped 50% for 10 years survived, appeared thrifty, and produced mature seed. Ligusticum and valerian can apparently withstand about 50% annual utilization indefinitely. Forage production of geranium gradually decreased under the 50% clip, and this species should apparently be utilized somewhat more lightly or should be managed under some suitable rest-rotation system.

Plants of all three species that were clipped 75% decreased in herbage and flower stalk production over the 10-year period. Plants were reduced in size and vigor and mature seeds were seldom produced after the first 3 or 4 years of treatment.

Plants clipped 90% were drastically reduced in size and vigor and no mature seed was produced after the first 3 or 4 years of treatment.

Growth response to favorable conditions decreased for all three species with intensity of clipping and with number of years clipped.

No mortality occurred under heavier clipping until after the seventh year, indicating that all three species were long-lived and resistant to heavy grazing for several years. Ligusticum showed the greatest and geranium the least ability of the three to withstand heavy clipping and to recover following a period of heavy clipping.

LITERATURE CITED

BLAISDELL, JAMES P., AND JOSEPH F. PECHANEC. 1949. Effects of herbage removal at various dates on vigor of bluebunch wheatgrass and arrowleaf balsamroot. Ecology 30:298–305.

BRANSON, FARREL A. 1956. Quantitative effects of clipping treatments on five range grasses. J. Range Manage. 9:86–88.

CARTER, J. F., AND A. G. LAW. 1948. The effect of clipping on the vegetative development of some perennial grasses. J. Amer. Soc. Agron. 40:1084–1091.

COOK, C. W., L. A. STODDART, AND F. E. KINSINGER. 1958. Responses of crested wheatgrass to various clipping treatments. Ecol. Monogr. 28:237–272.

DRISCOLL, RICHARD S. 1957. Effects of intensity and date of herbage removal on herbage production of elk sedge. J. Range Manage. 10:212.

HANSON, W. R., AND L. A. STODDART. 1940. Effects of grazing upon bunch wheatgrass. J. Amer. Soc. Agron. 32:278–389.

JULANDER, ODELL. 1937. Utilization of browse by wildlife. North Amer. Wildlife Conf. Trans. 2:276–287.

MCCARTY, EDWARD C., AND RAYMOND PRICE. 1942. Growth and carbohydrate content of important forage plants in central Utah as affected by clipping and grazing. U.S. Dep. Agr. Tech. Bull. 818. 51 p.

PARKER, K. W., AND A. W. SAMPSON. 1931. Growth and yield of certain Gramineae as influenced by reduction in photosynthetic tissue. Hilgardia 5:361–381.

ROBERTSON, JOSEPH H. 1933. Effect of frequent clipping on the development of certain grass seedlings. Plant Physiol. 8:425–447.

WEAVER, J. E., AND V. H. HOUGEN. 1939. Effect of frequent clipping on plant production in prairie and pasture. Amer. Midland Natur. 21:396–414.