How Time and Intensity of Clipping Affect Tall Bluebell[1]

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Highlight

Removing 40, 70, and 100% of the foliage of tall bluebell plants for 4 consecutive years significantly reduced production, height, and stem number. Clipping during flowering and fruiting damaged plants more than treatment before flowering. Grazing systems for tall bluebell ranges should allow for deferment every two or three years to enable plants to maintain vigor and high production.

Tall bluebell (*Mertensia arizonica* var. *leonardii*)[3] is one of the major forbs in aspen and subalpine herbaceous ranges in Utah and surrounding States (Houston, 1954; Ellison, 1954). It produces abundant succulent foliage and is highly palatable to both sheep and cattle (U.S. Forest Service, 1937; Matthews and Conrad, 1968). In spite of its high palatability, tall bluebell sometimes forms almost pure stands in areas that originally had a mixed-forb community. It matures by midsummer and dries rapidly; thus becoming useless as forage. This occurs even earlier in areas dominated by tall bluebell. However, tall bluebell's successional status in the plant community and the effects of different seasons and intensities on this valuable forage species are not clear.

This study was undertaken to obtain background information to use in designing grazing systems for ranges containing tall bluebell. The objectives were to determine: (1) the effect of different levels and times of foliage removal on herbage production, number of stems, and stem height of tall bluebell; and (2) if tall bluebell in essentially pure stands reacts differently to foliage removal than tall bluebell in a mixture with other forbs and grasses.

To meet our objectives, we studied the effect of 4 successive years of foliage removal on the growth and vigor of tall bluebell. We used clipping because it has proven to be a satisfactory, controlled method for studying the effects of known amounts of foliage removal. This was pointed out by Jameson (1963), in a review of clipping studies in which he compared the advantages and disadvantages of the clipping and grazing methods of foliage removal for study purposes.

Study Area and Treatments

The study was conducted on the Mud Creek Sheep allotment, which is about 25 miles southeast of Heber, Utah, on the Uinta National Forest. The two study sites on the allotment are at an elevation of about 8,300 feet, both in openings within aspen forests. One site has a relatively pure stand of tall bluebell; the other has a mixed-forb community. Total production on the bluebell site is approximately 2,200 pounds per acre (air dry) of which tall bluebell makes up about 70%. On the mixed-forb site, production is about 2,800 pounds per acre, 50% of which is tall bluebell and 25% is white polemonium (*Polemonium foliosissimum*). Tall bluebell plants at the bluebell site are considerably larger in diameter and have more stems than those at the mixed-forb site.

Soils at both sites are approximately 5 feet deep with well-developed silt loam A horizons and clay or clay loam B horizons. The vegetation and soils of both sites have been described in detail by Matthews and Conrad (1968).

Treatments of tall bluebell plants consisted of four clipping intensities and an untreated check at each of three phenological stages with four replications at each site. Phenological stage (date) and clipping intensity were assigned at random to each of the 60 plants at each site. The treatments, which were started in 1963 and continued on the same plants through 1966, were: (1) 40% foliage removal (by weight); (2) 70% foliage removal; (3) 100% foliage removal; (4) lodge or simulated trampling; and (5) unclipped check.

The amount of foliage removed was the specified percentage of the production at the time of clipping and not of the total for that year. The 40% treatment removed the top half of the stems, simulating the way sheep utilize this species under "moderate" grazing. The 70% treatment was the same except that all the leaves on the lower half of the stem were also removed. This treatment simulates the way plants are utilized under "heavy" grazing. Stems were clipped at ground level for the 100% treatment. The lodging treatment was an attempt to simulate trampling damage by a band of sheep and consisted of flattening the stems by hand. This merely bent some stems and broke others, thereby imposing a partial clipping treatment.

The approximate date of each clipping was determined by height and phenological development of the unclipped check plants as shown below.

Time of clipping	Phenological stage	Average height of check plants (inch)
Early June	Early growth	7–10
Late June	Early flowering	18–20
Early July	Fruiting-full height	20–28

The first clipping was done 9 to 17 days after snowmelt. Because of slight variations in plant development, actual dates of clipping ranged from June 6–15, June 20–28, and July 7–10 between 1963 and 1965. In 1966, clipping was done about 2 weeks earlier at all three phenological stages because growth started sooner as a result of an early snowmelt. However, plant growth was reduced because frost and low precipitation followed the early snowmelt. Mature check plants attained a height of only 14 inches in 1966.

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[3] Nomenclature of plants follows Holmgren and Reveal (1966).

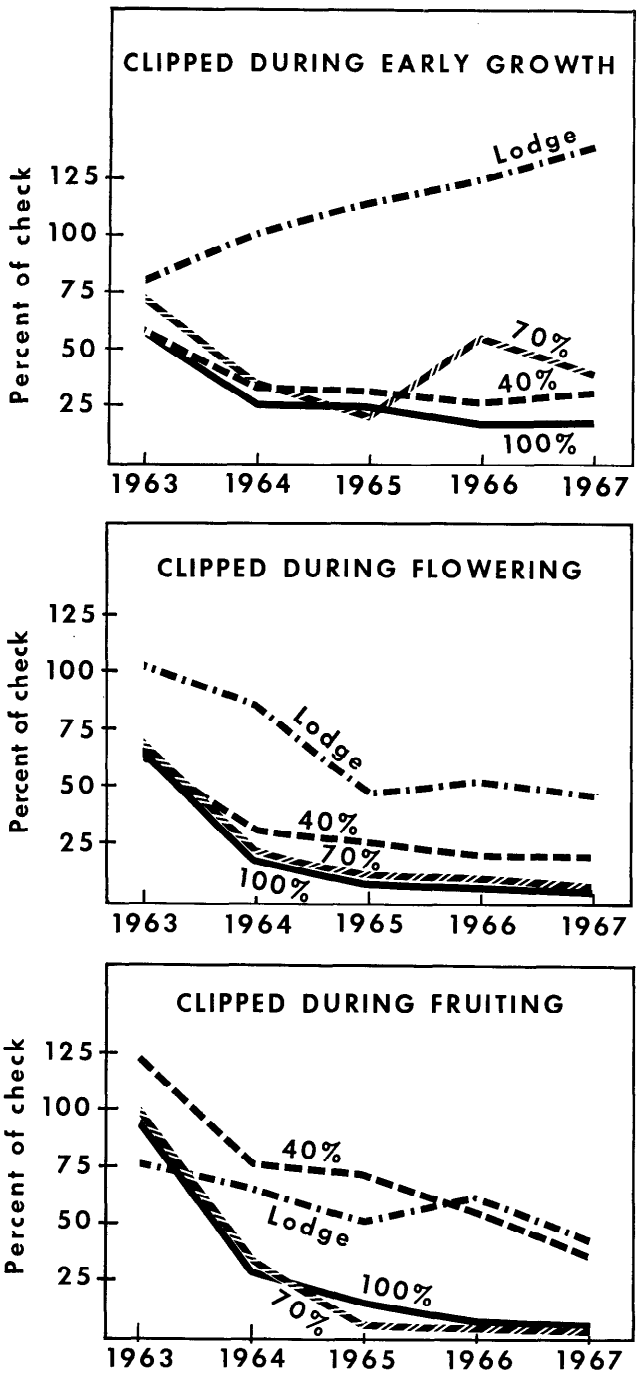

FIG. 1. Average weight of treated tall bluebell plants expressed as a percentage of the average weight of the 12 check plants at the bluebell site.

The total production of all clipped plants was determined each year by adding the air-dry weight of foliage removed, the estimated amount of foliage remaining, and regrowth estimated 2 to 3 weeks after the third clipping date. Total production of the check and "lodge" plants was estimated at the third clipping date.

In 1967, after 4 successive years of clipping, height and stage of development were observed weekly and all plants were allowed to grow to maturity. Production, number of stems, and average stem height were determined for each plant in late July after seed was shed but before the plants dried. To determine production, half of the plants at each site (two replications) were clipped at ground level and dried. Production of the remaining plants was estimated.

Independent analyses of variance were done for production, height, and stem number in 1967 with clipping treatment and phenological stage at time of clipping as fixed effects in a randomized design. Inclusion of clipped and estimated weights in a single analysis might have introduced some bias but the differences between treatments were so great that the bias probably was minimal.

At the bluebell site, the underground plant crowns and major roots of the clipped plants were excavated. Carbohydrate content of the crowns was determined by the acid hydrolysis method.[4]

Results

Herbage Production

At both sites, herbage production was significantly[5] reduced in 1967, as a result of 4 successive years of clipping (Tables 1 and 2). In most instances, foliage removal during the growth stage was less damaging than clipping when plants were flowering and fruiting. For example, at the bluebell site the plants clipped 100% during the growth stage produced only 18% as much herbage in 1967 as the unclipped check plants in 1967, while those clipped at the flowering and fruiting stages produced only 3 and 5% of the check, respectively (Fig. 1).

In 1967, five plants at the bluebell site and one plant at the mixed-forb site were dead. These had been clipped at either 100 or 70% during the flowering and fruiting stages.

Lodging during the growth stage did not significantly reduce herbage production because the stems when flattened were merely bent and in a few days they straightened up and grew normally. Lodging during the flowering and fruiting stages significantly lowered herbage production but the reduction was not as great as clipping during the same stages. This could be explained by the fact that the succulent stems (containing 85–90% water) become brittle as they increase in diameter; thus many of them broke when lodged during the flowering and fruiting stages.

Number and Average Height of Stems

The 100, 70, and 40% clipping treatments significantly reduced stem number and height at all three stages (Tables 1 and 2). However, the effect on stem number and height was not so pronounced as the reduced herbage production by the same

[4] McDonough, Walter T. Carbohydrate reserves in *Mertensia arizonica* as related to growth, temperature, and clipping treatments. Manuscript in preparation.

[5] In this paper the term "significant" refers to the 5% level of probability and "highly significant" refers to the 1% level.

Table 1. Effect on tall bluebell in 1967 after 4 years of clipping treatments.

Time and treatment	Bluebell site: Avg dry wt (g)	Bluebell site: Stems	Bluebell site: Stem height (inch)	Mixed-forb site: Avg dry wt (g)	Mixed-forb site: Stems	Mixed-forb site: Stem height (inch)
Growth stage						
None[1]	186[2]	92	26	106	54	25
Lodge	256[3]	122	28	69	48	22
40%	58	53	21	15	20	15
70%	72	53	22	13	20	14
100%	34	38	15	8	15	13
Flowering stage						
Lodge	84	62	22	28	42	18
40%	36	41	16	8	19	13
70%	8	21	8	12	16	10
100%	6	12	9	1	3	7
Fruiting stage						
Lodge	80	82	18	61	45	24
40%	67	74	18	24	32	18
70%	4	6	6	6	12	14
100%	10	10	7	4	14	10

[1] Check plants were not treated.
[2] Figures for check plants are averages from 12 plants.
[3] Figures for treated plants are averages from four plants.

treatments. For example, on the bluebell site the 100% clipping treatment at the flowering stage reduced herbage production in 1967 to only 3% of the check in 1967 (Fig. 1). But number of stems and stem height were 13 and 35% of check, respectively.

Flowering

Reduction in vigor, which was reflected by a reduction in herbage production, number of stems, and stem height, also delayed development and reduced flower and fruit production in 1967 even though plants were allowed to grow to maturity.

Table 2. Results of multiple range tests comparing the average[1] dry weight, number of stems, and stem height of tall bluebell plants at the two study sites in 1967.

Treatment	Bluebell site: Avg dry wt (g)	Bluebell site: Stems	Bluebell site: Stem height (inch)	Mixed-forb site: Avg dry wt (g)	Mixed-forb site: Stems	Mixed-forb site: Stem height (inch)
None[2]	[3]186[a]	92[c]	26[e]	106	54[h]	25
Lodge	140[a]	89[c]	23[e]	53	45[h]	21
40% clipping	54[b]	56	18	16[g]	24[i]	15[k]
70% clipping	28[b]	27[d]	12[f]	10[g]	16[ij]	13[kl]
100% clipping	17[b]	20[d]	10[f]	4[g]	11[j]	10[l]

[1] Averages of 12 plants with the same treatment at all three dates.
[2] Check plants were not treated.
[3] Within each column, means followed by a common letter are not significantly different at the 5% level as determined by the multiple range test (Duncan, 1955).

Almost all (80 to 100%) of the stems of the check and lodged plants produced flowers and most of these stems produced some fruit. All plants clipped during the growth stage and plants clipped at the 40% level at the flowering and fruiting stages started flowering 1 to 2 weeks later than the check plants in 1967; only 50 to 80% of the stems on these plants produced flowers. Most of the plants clipped at 70 and 100% during the flowering and fruiting stages produced only basal leaves (Fig. 2). The few stems of these plants that did flower did so 2 to 3 weeks later than the check plants.

Relation Between Treatment and Carbohydrate Content

The amount of stored carbohydrates was highly significantly correlated ($r = +.64$, $df = 28$) with amount of herbage production in 1967. Whether this degree of correlation is biologically important is not known and further study is needed. Except for those plants clipped at the 100% level, the

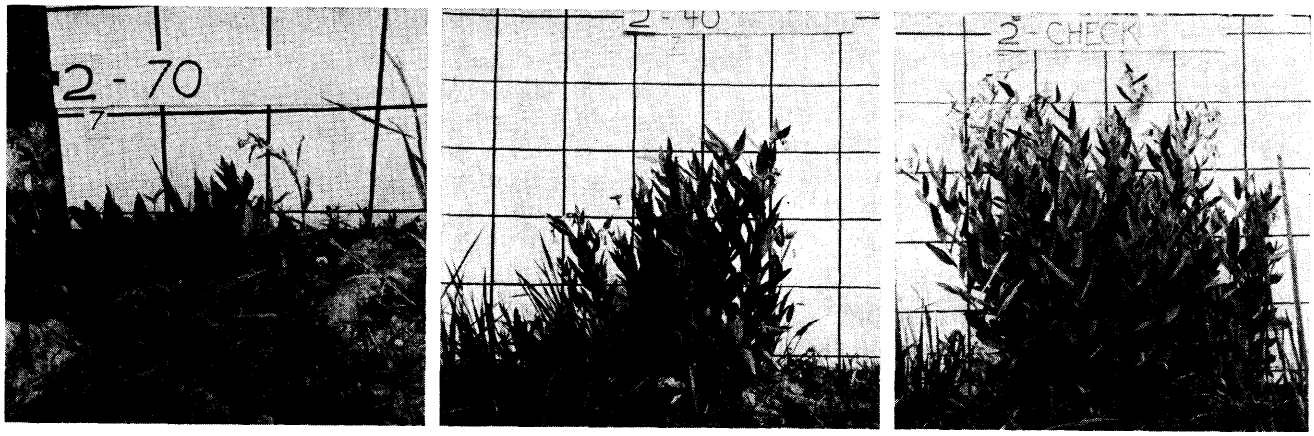

FIG. 2. Growth of representative clipped and unclipped tall bluebell plants at the bluebell site in 1967. Plants with 70 and 40% of their foliage removed in early flowering stage for 4 consecutive years produced only 4 and 43 grams of air-dry herbage, respectively, compared with 126 grams produced by the unclipped check plant. The 70% plant produced only basal leaves and no flowering stems.

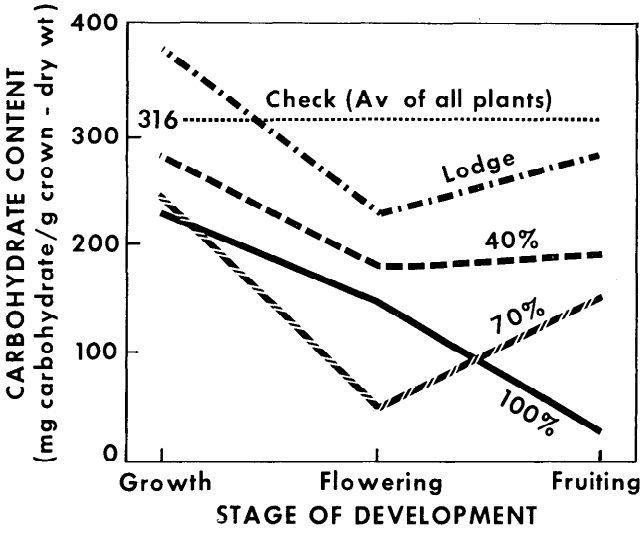

FIG. 3. Carbohydrate content of plant crowns in 1967 of treated and untreated tall bluebell plants.

plants clipped during the growth stage had the lowest levels of stored carbohydrates (Fig. 3).

The amount of stored carbohydrates at the time of foliage removal may influence the relative damage to the plant (Jameson, 1963). A recent study by McDonough[6] on tall bluebell in the study area indicated that carbohydrate in the crown reaches a low when the plant is in the early- to mid-period of vegetative growth before the start of flowering. Carbohydrate levels then build up slowly until the end of fruiting.

Based on McDonough's findings, clipping during early growth the first year was done when carbohydrates were decreasing, clipping during flowering was done when carbohydrates were increasing slightly but were still at a low level, and clipping during fruiting was done when carbohydrate levels had built back to a relatively high point. This would indicate that carbohydrate levels at the time of clipping were not closely correlated with response to clipping because the flowering and fruiting stages were the most damaging to tall bluebell. However, the treatments had the effect of progressively delaying growth and development compared with unclipped check plants as years of treatment increased. Thus the exact time of clipping in relation to the carbohydrate cycle for the clipped plants is not known for the last 2 or 3 years of the study.

Summary and Conclusions

Moderate use (40% clipping) of the bluebell herbage for 4 consecutive years reduced its potential to produce herbage. However, the plants with 40% of their foliage removed maintained a relatively constant level of production during the last 3 years of the study. It appears that 40% foliage removal by grazing every year would reduce the total productivity of a tall bluebell range but probably would not eliminate tall bluebell from the community. Heavy use (70 to 100% clipping) was much more damaging and actually killed some plants. Consistent heavy use over a long period, especially during flowering and fruiting, probably would severely reduce the amount of tall bluebell on the range or eliminate it entirely.

Trampling or lodging of tall bluebell did little damage to the stems in the growth stage but did far more damage during flowering and fruiting stages. Actual trampling damage by sheep on the range also occurs mainly when plants are mature; thus management plans for tall bluebell ranges should be designed to minimize and allow for such damage as well as the amount of herbage actually eaten by sheep.

Since our study has shown that tall bluebell was affected less by clipping in the growth stage than in the flowering and fruiting stages, the implication is that early grazing would not be as damaging to tall bluebell as is commonly supposed by range managers. Grazing begins June 15 each year on the allotment where our study was conducted and on July 1 on most other sheep allotments in the vicinity. Grazing during the early growth stage (early June in most years) would not be as damaging to the plants as grazing in late June or early July each year. However, sheep do not eat a great deal of tall bluebell when they first arrive on the allotment. Instead they eat young, tender grass shoots for a short period and start eating large quantities of tall bluebell when the plants are about half grown (at the beginning of the flowering stage). Therefore, early grazing would not necessarily insure utilization of tall bluebell at the least damaging stage of growth. Other factors that might lead to excessive soil disturbance, such as high soil moisture, would also have to be considered.

Whether or not early grazing is considered, the best management of ranges containing tall bluebell would include a rotation system of grazing insuring use of plants at a different time each year. Deferment from grazing until late summer in some years would be the equivalent of complete rest because tall bluebell stems are dry and often prostrate by late summer. In our study most of the plants clipped 4 successive years showed little recovery of vigor when allowed to grow to maturity the fifth year. Therefore, grazing systems for tall bluebell ranges probably should allow for deferment or rest at more frequent intervals—every 2 or 3 years—to allow plants to maintain vigor and high production.

[6] See footnote 4.

LITERATURE CITED

DUNCAN, D. B. 1955. Multiple range and multiple F tests. Biometrics 11:1–42.

ELLISON, LINCOLN. 1954. Subalpine vegetation of the Wasatch Plateau, Utah. Ecol. Monogr. 19:95–121.

HOLMGREN, ARTHUR H., AND JAMES L. REVEAL. 1966. Checklist of the vascular plants of the Intermountain region. U.S. Forest Serv. Res. Paper INT 32. 160 p.

HOUSTON, WALTER R. 1954. A condition guide for aspen ranges of Utah, Nevada, southern Idaho, and western Wyoming. U.S. Forest Serv., Intermountain Forest and Range Exp. Sta. Res. Paper 32. 17 p.

JAMESON, DONALD A. 1963. Responses of individual plants to harvesting. Bot. Rev. 29:532–594.

MATTHEWS, VERL B., AND PAUL W. CONRAD. 1968. An ecological life history of tall bluebell (*Mertensia arizonica* var. *leonardii*) in Utah. Ecology 49(6):1113–1123, illus.

U.S. FOREST SERVICE. 1937. Range Plant Handbook. U.S. Gov. Print. Off., Wash., D.C., 841 p.