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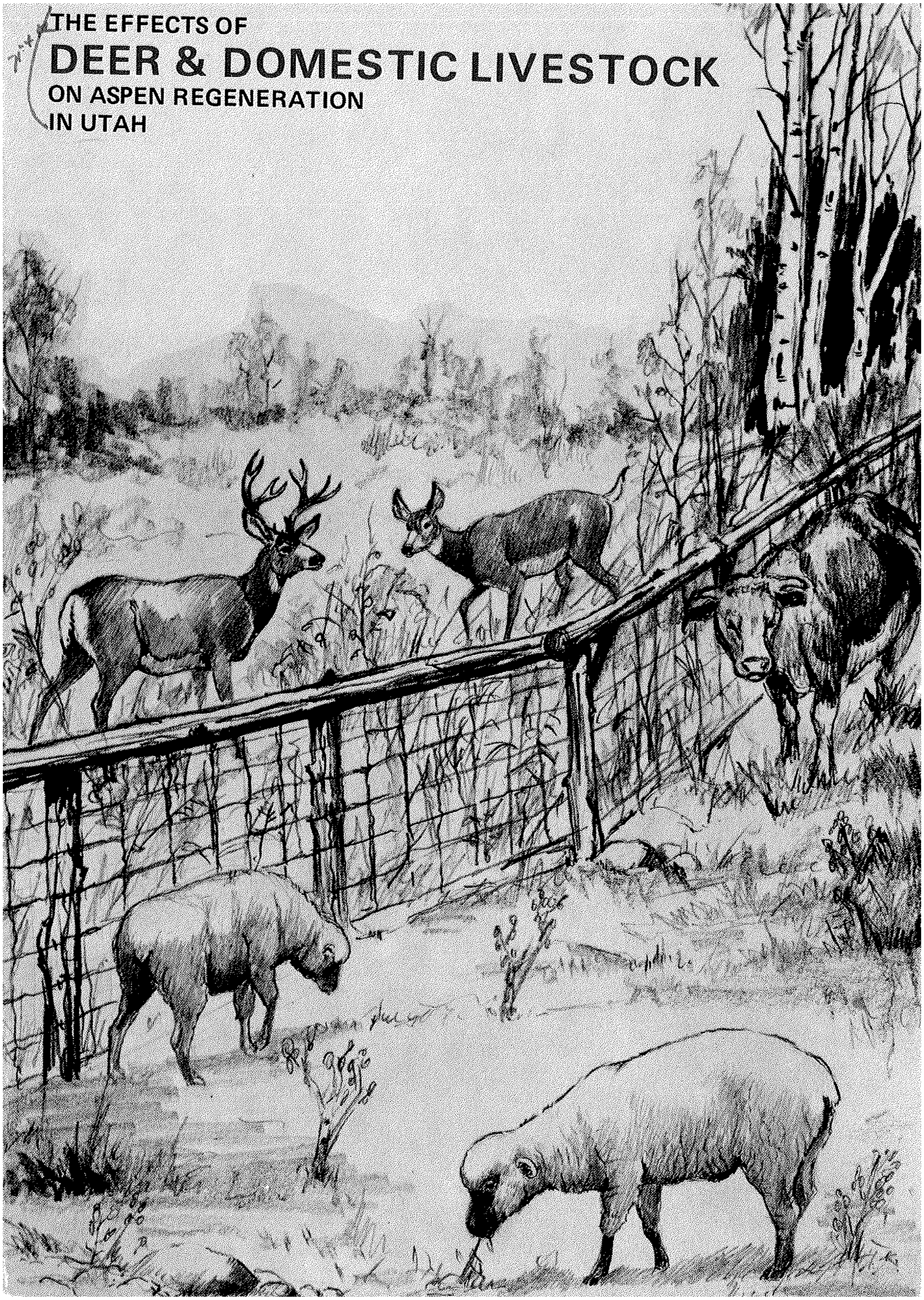

THE EFFECTS OF DEER AND DOMESTIC LIVESTOCK ON ASPEN REGENERATION IN UTAH

by

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SUMMARY

Data were collected on the factors affecting aspen regeneration at four study sites in Utah from 1961 through 1969. The first study was at Betenson Flat on Fishlake National Forest, where aspen had been released by a fire in 1958. Two other study sites, one at Hancock Flat on Fishlake National Forest and one at Webster Flat on Dixie National Forest, were timber sale areas. The fourth was at Twin Creek on Cache National Forest near Logan, Utah, where specific treatments--clear cutting, partial cutting, soil scarification, and girdling of the aspen stand--were imposed. No animal control was exercised at Hancock Flat nor at Twin Creek. A fence at Betenson Flat excluded cattle from part of the study area during the period of study. Fences at Webster Flat enabled us to observe use by deer, sheep and cattle separately; and deer plus sheep and deer plus cattle combined.

The data indicate that populations of deer that were present at the study sites during the study had little effect on the development of aspen reproduction. By contrast, where livestock were present together with deer, utilization of aspen and terminal bud removal were substantially greater than where domestic livestock were absent. At Webster Flat sheep virtually eliminated aspen regeneration from the area open to unregulated use. Where sheep or cattle were grazed within paddocks for short periods excessive use of aspen was not observed even though grazing pressures were heavy. Proper livestock management is essential to regeneration of aspen following removal of the older stands.

The results of attempts to stimulate aspen sprouts by girdling the standing trees or breaking the roots were largely negative. Although the plots with girdled trees yielded significantly more sprouts than appeared in the untreated aspen stands, they produced far fewer than where the stand was cut. Moreover, few of these sprouts survived to the second year following treatment. Disturbing the soil and roots did not significantly increase sprouting.

INTRODUCTION

Aspen *(Populus tremuloides)* is the most widespread deciduous tree in the western United States and is the dominant species on approximately 2,000,000 acres in Utah, Nevada, southern Idaho, and western Wyoming. Its values for grazing, watershed, and timber make the aspen type one of the most valuable vegetation types in the Intermountain area.

Because of the understory vegetation usually present, the aspen type, when in good condition, is valuable summer range for livestock and wildlife; many sites support forbs and grasses that produce 1,000 to 2,000 pounds of air-dry forage per acre. Commonly shrubs are present in the understory vegetation as well. Under moderate grazing the associated forage cover remains a well balanced mixture of grasses, forbs, and shrubs (Costello, 1944). The openings in the stand may provide the major part of the herbaceous forage crop under proper grazing management.

Commonly, however, the openings may produce less forage than is produced within the stands (Ellison and Houston, 1958). Under heavy grazing, forage production is markedly reduced.

In addition, aspen itself is palatable to big game and livestock and provides considerable forage. After clear cutting in the Lake States it may provide 100 to 150 deer days of browsing per acre (Westell, 1954). Moreover, the crude protein content of aspen sprouts is high; samples from a Colorado range averaged 20 percent (Dietz, Udall, and Yeager, 1962). Tew (1970a) reported finding crude protein values as high as 20 percent, although mean values were substantially lower than this.

However, the amount of aspen cutting through the Intermountain area is not great and many aspen stands remain uncut. In such stands little reproduction takes place for, once a mature stand of aspen is established, reproduction is minor until the stand is cut or destroyed as by fire.

Aspen timber provides several commercial products in the West; namely excelsior, posts, poles, lumber, and boxwood. Between 1917 and 1948 the chief product of aspen logs in Utah was excelsior (Curtis, 1948).

There have been two classic studies of aspen in the Intermountain area. Sampson (1919) studied the effects of cattle and sheep browsing upon aspen reproduction, and Baker (1925) studied the silviculture and silvicultural methods for obtaining regeneration of aspen. Both reported substantial damage to aspen from domestic livestock. Neither writer mentioned big game use, but deer were not numerous then and elk had only recently been introduced into Utah (Utah Fish and Game Commission, 1948).

The investigations reported here were undertaken because of the belief, widely held by foresters, that big-game animals were preventing regeneration of aspen throughout Utah. Among the evidences cited for this view were the Grindstone Flat plots on the Beaver district of Fishlake National Forest and sites of recent timber harvest, almost always small, where the aspen reproduction had been suppressed by browsing animals. The Grindstone Flat plots, established in 1934, comprised an area protected from all animal use; one was enclosed by a fence that excluded cattle but permitted deer use, and an open plot was used by both game and livestock. Since 1934 aspen has not reproduced except in the totally protected plot. This fact has been widely cited as proof of suppression of aspen by deer. The release of aspen by a 1,500-acre fire near the site of these plots in 1958 provided opportunity to obtain data from an area sufficiently large to provide an adequate volume of aspen forage. Later other areas were included in the study as sites where aspen was being cut were discovered.

Major objectives of these studies were:

(1) To ascertain the effects of big game and domestic livestock on reproduction of aspen.

(2) To determine the degree to which browsing upon aspen sprouts affected growth and establishment of an aspen stand.

(3) To determine some of the conditions that affected the volume of sprouts produced and ultimate success of reproduction.

PROCEDURES

Description of Study Areas

Betenson Flat. Preliminary studies were started in 1961 on a burned-over area on Beaver Mountain in Fishlake National Forest three years following the fire in 1958. Heights of aspen sprouts at the initial inventory averaged 33 inches.

Two sites were selected for study, one approximately 42 acres in area and the other 14 acres. Except for size, the areas were similar in respect to site and exposure, and, from the evidence at hand, they had supported similar aspen stands prior to the fire. Each site was flanked on one side by a subalpine park (Betenson Flat) and on the other by dense stands of spruce-fir timber. The larger area was fenced in 1961 to exclude cattle but to permit deer use. The other area remained open to use by both deer and cattle. Fig. 1 shows the appearance of this area when data collection was begun.

The soils of the area were formed from Roger Peak breccia of the Pliocene series (Hintze, 1963).

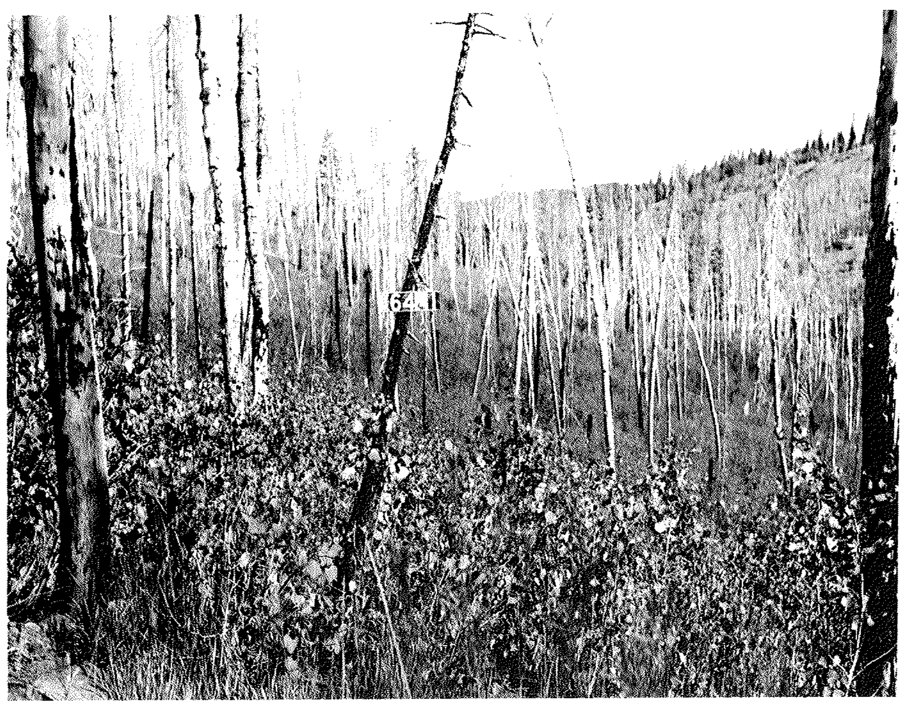

Fig. 1 **Unfenced area at Betenson Flat when data collection began in 1961.**

Hancock Flat. Following the start of the study on Beaver Mountain, we searched for additional study sites where data collection could be begun coincident with timber cutting and the release of reproduction. Such an area was located near Hancock Flat on the Fishlake District of the Fishlake National Forest where an aspen timber sale was completed on 20 acres in 1962; data collection was begun there in the fall. This study area, within a sheep grazing allotment, was surrounded on three sides by aspen and on the fourth by spruce-fir timber. The soil is thin and rocky. The parent rock has been classed as Tertiary basalt (Hintze, 1963).

Webster Flat. Neither of the aforementioned areas provided opportunity for close control of grazing pressures. Accordingly, search continued for an area offering a uniform stand and site that would permit controlled animal use and a replicated design. The area selected was at Webster Flat on Dixie National Forest near Cedar City, Utah. An aspen sale had been in progress in this area over several years and a 32-acre tract was cut in 1965.

This area gently slopes to the southeast and lies at an elevation of 9,200 feet. The soil was developed from a basaltic rock of Quaternary origin which had been extruded upon sedimentary rocks (Hintze, 1963).

The area selected for study was astride a grazing-allotment boundary fence that separated cattle and sheep allotments. This enabled us to observe the effects of these animals under herd management procedures customary in the area. An inventory taken prior to timber cutting showed an aspen stand averaging 13 cords per acre.

Twin Creek. The Twin Creek study area was located on Cache National Forest approximately 25 miles from Logan, Utah, in the Logan Canyon drainage. Elevation at the site is approximately 6,700 feet. The study plots slope to the southeast. Aspen trees in the stand averaged 8 inches in diameter and 58 feet in height in 1965 when treatments were applied. A heavy stand of understory vegetation, mostly forbs, was producing from 1 to 1½ tons per acre green weight. The area was within a cattle allotment, and mule deer and elk also used the area. No provision was made for regulating use by animals, and all three kinds of animals used the study area at will. The soil on the area was formed from Wasatch conglomerate (Williams, 1946).

METHODS

Since conditions differed widely from area to area the objectives set and procedures employed varied accordingly. Some procedures, annual inventories of numbers of sprouts, heights of the sprouts, and incidence of damage to the terminal bud from whatever animals were present were common to all. Forage production data were also taken since it was hypothesized that the use of aspen by browsing animals would be related to the availability of other kinds of forage.

Inventories of sprouts and forage were made within fifty, 9.6-square ft. plots at Betenson and Hancock Flats. At Webster Flat and at Twin Creek, forage production inventories were made in the same sized plots, but 50 mil-acre plots were used for the inventories of aspen sprouts when preliminary analyses of the data indicated that 9.6-square ft. plots were not providing samples with the desired precision. Plots at all sites were located randomly.

Forage production was determined by weight estimates. Inventories of aspen reproduction were made by counting individual sprouts and clumps. These clumps or clusters of sprouts contained from one to several individual sprouts that appeared to have a common point of origin.

Betenson and Hancock Flats. At both these study sites individual sprouts within each plot were marked with a numbered metal tag to make it possible to compile a history of browsing use on individual stems. The sprout selected was one of the tallest and more promising stems of the clump nearest the lower left-hand corner of the plot. An additional sprout was also marked in the event the numbered sprout was destroyed or the tag lost. If a study plot had no aspen sprouts, and this occurred rarely, a sprout in the nearest clump outside the plot was tagged for study.

These numbered sprouts provided a more precise index to rates of growth than the measurements of all the sprouts since the resulting measurements were not affected by the death of unmarked sprouts in the stand. Moreover, they provided opportunity to ascertain at some later date the effect of browsing on the ultimate form of the tree and quality of the wood.

The effects of cattle and deer on aspen reproduction were partially segregated at Betenson Flat by constructing a fence which excluded cattle but not deer from part of the study area. Both animals had access to the comparable but smaller unfenced area.

The Hancock Flat study site was within a sheep allotment. No fence was constructed but the plan was to have sheep graze part of the area in order to compare effects of sheep grazing with those of deer grazing. However, we were unable to consummate this plan; consequently the entire area received only light deer use.

Pellet-group counts provided indexes to deer populations at both areas. Cow-chip counts were also made at Betenson Flat.

Webster Flat. In consequence of our inability to isolate livestock effects at the previous study sites, we planned the layout at Webster Flat so as to achieve precise control of livestock numbers and use. We tried to do the same with deer, but efforts to obtain animals for this purpose aborted.

Approximately 24 acres within the cutover area were encompassed by the 18 study plots each about 1-1/3 acres in area. Nine of these were enclosed within a deer-tight fence that was to have provided three replications each for cattle use, sheep use, and total protection. Three plots adjoining the fenced portion were enclosed by a low jump-over fence that excluded sheep but permitted deer use. Three of the remaining plots were open to both cattle and deer, and the remaining three were open to both sheep and deer. Livestock use in the open plots was subject only to the normal herd-management regulation used on the ranger district. Pellet-group counts provided an index to deer use in the deer-only plots and in the cattle-plus-deer plots.

Grazing within the fenced areas was begun when slender wheatgrass *(Agropyron trachycaulum)* was still in boot stage and Kentucky bluegrass *(Poa pratensis)* was starting to form seed. This was about the third week in July. Sheep used in 1966 were dry ewes; dry ewes and yearlings were used in 1967, and yearlings in 1968. In 1966 a herd of 11 cows, 1 bull, and 9 calves was placed in the paddocks for 2-day periods in mid-August. In 1967 three Holstein cows and in 1968 four Hereford heifers were used. The first paddock was grazed in late July in both years.

In 1967 the length of the grazing period was determined by observing the utilization in the sheep paddock; when dandelion *(Taraxacum officinale)* was 75 percent utilized and bluebell *(Mertensia arizonica)* was 85 percent utilized, grazing was terminated in both the sheep and cattle paddocks. This occurred after 15 days, and subsequent paddocks were then grazed for the same number of days.

In 1968, pre-grazing estimates of herbage production showed availability of only about two-thirds as much forage as in 1967. Accordingly, all paddocks were grazed for 10-day periods.

Twin Creek. During the period of observation at Betenson Flat we noted that browsing damage was most severe where the stand of sprouts was thinnest and where growth was poor; there sprouts usually were browsed repeatedly. Furthermore, our examination of possible study sites had revealed considerable variation in completeness of removal of the timber stand at different sale areas; this could be expected to influence the amount of sprouting. Accordingly, we started the studies at Twin Creek to obtain information about treatment factors that would affect the amount of reproduction. The study at Twin Creek was directed primarily toward isolating factors that influence the volume of aspen reproduction and was only peripherally concerned with the effects of use by livestock and game.

The Twin Creek study was divided into 15 plots, 175 feet on a side, which provided for three replications each for five treatments: clear cut, partial cut, girdled, scarified, and control. In the partial-cut plots approximately one-half the trees judged to be of commercial size were removed. The girdling treatment consisted of girdling all trees, except for the few sprouts present, with a hand axe in order to maintain a microclimate equivalent to that in the uncut stand, but to simulate the physiological effect of timber cutting. In the scarified plots a ripper fashioned from a hand plow was used to disturb the soil surface. In the process, aspen roots up to 2 inches in diameter that were within 3 to 4 inches of the surface were severed or scarred. Thus we simulated the soil and root disturbance caused by timber harvest but left other conditions intact.

Forage production estimates, sprout counts, and sprout-height measurements were taken in 1966 and 1967. Cow chips were counted in all plots.

FINDINGS

Sprouting Response. Under clear cutting, sprouts were produced in abundance at all study sites (Table 1). Inventories made the first year after tree removal showed stands of approximately 30,000 to 50,000 sprouts per acre. These are far in excess of the number that can survive and the number of stems found in mature stands (Baker, 1925). (Table 1).

At Twin Creek, where treatments other than clear cutting were applied, only the partial-cut treatment resulted in anywhere near adequate reproduction, although less than half as many sprouts were produced as under clear cutting (Fig. 2). Plots where trees were girdled produced about 25 percent as many sprouts as did the clear-cut area. Only one scarified plot produced more sprouts than the control plots; the other two plots produced substantially fewer.

Fig. 2 **View of partial-cut plot at Twin Creek showing irregular occurence of sprouts; clear cut in foreground, 1966.**

Analysis of the data collected in 1966 and calculation of Duncan's multiple range test identified only the clear-cut treatment as being significantly different from the others, despite great differences in sprout populations produced by the other treatments. The data revealed that a major source of variance was the

Table 1. Sprouting response and survival of aspen sprouts at three study sites in Utah.

Sites and treatments	Years after cutting or treatment: 1	2		3		4	
	Sprouts per acre	Sprouts per acre	Survival	Sprouts per acre	Survival	Sprouts per acre	Survival
			Pct.		Pct.		Pct.
Hancock Flat	39,703	31,171	79	26,395	67	—	—
Webster Flat							
Cattle	29,736	20,220	68	12,633	42	7,452	25
Sheep	42,471	28,773	68	17,647	42	9,464	22
Protected	38,206	34,387	90	19,907	52	9,636	25
Deer	58,957	26,107	44	18,187	31	11,100	19
Sheep and deer	41,896	14,587	35	2,493	6	280	1 a/
Cattle and deer	38,690	17,300	45	13,020	34	6,210	16
Twin Creek							
Clear cut	52,332	24,040	46	20,809	40	13,200	25
Partial cut	22,053	11,660	53	12,232	55	6,173	28
Girdled	13,038	4,047	31	2,808	22	773	6
Scarified	5,022	1,880	37	3,805 b/	76	2,253	45
Control	3,447	3,466	100	4,140 b/	120	2,400	70

a/ Less than 1 percent

b/ Incomplete counts were made at Twin Creek in 1968 which may explain the increase in sprouts shown.

tremendous difference among clear-cut plots. Accordingly, this clear cutting was excluded because homogeneity did not exist, and the data from the four remaining treatments were analyzed. Both the partial-cut and the girdling treatments differed significantly (.05 level) from the other treatments, but the differences between scarified and control were not significant. By 1967 only the clear-cut and partial-cut treatments were significantly different from all other treatments (Baker, 1969). Failure of the girdling treatment to maintain significance was due to the high mortality suffered between 1966 and 1967.

Survival of Sprouts and Clumps. At Webster Flat there was substantial attrition of sprouts the second year in all treatments; losses varied from 10 percent under protection to 65 percent under combined deer and unregulated sheep use (Table 1). Losses under controlled livestock grazing were intermediate to these – 32 percent.

In the open range at Twin Creek, the mortality among the treatments other than control, where there was a slight increase, ranged from 47 percent to 69 percent. Loss was most severe on the tree-girdled plots, where nearly 70 percent succumbed.

By the third year after cutting, survival on all clear-cut areas was less than 50 percent except under protection at Webster Flat and at Hancock Flat. Sprouts remaining the third year in the plots open both to deer and unregulated sheep use at Webster Flat were only 6 percent of the number inventoried the first year. At Twin Creek, mortality was greatest under the girdling treatment; only 22 percent and 6 percent of the sprouts initially tallied remained at the end of the third and fourth year respectively, following cutting. Best survival through the third year was at Hancock Flat.

By the fourth year after cutting, few treatments either at Webster Flat or Twin Creek had more than 25 percent of the number of sprouts initially tallied. The protected plots were no exception. The fact that percentagewise the scarified and the control areas at Twin Creek showed up well is not significant in view of the small number of sprouts involved both initially and at the final tally. Moreover, a considerable number of the sprouts were new in 1969; this illustrates the propensity of aspen to send up sprouts continually (Baker, 1918).

All treatments at Webster Flat, except under uncontrolled sheep use, and the partial and clear cut areas at Twin Creek had ample sprouts for assuring a stand if the guides for the Lake States are applicable here. There 6,000 to 12,000 sprouts per acre are judged to be adequate to assure a stand (Graham et al., 1963).

At each sprouting point, from one to several sprouts are clustered to form a clump. The number of sprouts in these clumps usually was between 1 and 10, but as many as 18 were recorded. Obviously only one sprout in each cluster can eventually survive to grow into a tree. The distribution and number of clumps is, therefore, a better index to successful regeneration and spacing of the stand than individual sprouts. (Table 2).

Comparison of the clump data (Table 2) with the sprout counts (Table 1) shows that the percentage survival of clumps the second and third years at Webster

Table 2. Number of sprouting clumps of aspen per acre at three locations in Utah.

Area and year of treatment	Year after cutting or treatment						
	1	2		3		4	
	Clumps per acre	Clumps per acre	Survival [a]	Clumps per acre	Survival	Clumps per acre	Survival
			Pct.		Pct.		Pct.
Hancock Flat (1963)	19,329	15,473	80	14,656	76	—	—
Webster Flat (1965)							
Cattle	9,438	7,180	76	4,553	48	4,180	44
Sheep	13,612	10,647	78	6,433	47	5,420	40
Protected	12,524	12,380	99	7,340	59	4,520	36
Deer	21,871	8,787	40	6,913	32	5,500	25
Sheep and deer	14,974	6,140	41	1,227	8	187	1
Cattle and deer	12,796	6,146	48	5,773	45	2,990	23
Twin Creek (1965)							
Clear cut	11,223	—	—	—	—	7,340	65
Partial cut	6,262	—	—	—	—	3,507	56
Girdled	4,507	—	—	—	—	420	9
Scarified	1,482	—	—	—	—	960	65
Control	1,664	—	—	—	—	1,107	67

a/ Computed on first year counts

Flat was little better than that of individual sprouts; survival of clumps averaged about 6 percent higher in individual treatments and areas. Under only one treatment, combined deer and cattle use in 1968, was the difference greater than 10 percent. By the fourth year, the differences were greater and clump survival averaged 10 percent greater than that of individual sprouts. Data for the intermediate years at Twin Creek are not available but in the fourth year the comparison was even more favorable for the clear and partial-cutting treatments, the two which had shown a significant sprouting response. The number of clumps per acre the third year after cutting varied between 1,227 in the combined sheep- and deer-use area at Webster Flat to 14,656 at Hancock Flat. By the fourth season only 187 sprouting clumps per acre were found in the sheep- and deer-use area at Webster Flat and only 420 clumps per acre in the girdled plot at Twin Creek. In all other treatments except scarification, more than 1,000 clumps per acre were tallied.

Reproduction at Webster Flat appeared to be adequate to insure reestablishment of a stand in all treatments except combined sheep and deer use. However, in the cattle- and deer-use area, reproduction was not equally distributed throughout the treatment plots, and part of the area had an inadequate stand. At Twin Creek, only in the clear-cut and partial- cut areas was reproduction adequate.

Causes of Injury. Two kinds of injury are directly attributable to large mammals: removal of the terminal bud and trampling. Tabulation of damage to aspen sprouts at Webster Flat showed small to heavy removal of the terminal bud the first year after clear cutting (Table 3). Sheep were involved in both the lightest and the heaviest use observed – 9 percent in the sheep paddocks and 69 percent on the open range. In subsequent years, removal of terminals in the cattle paddock and in the deer plots was negligible, but deer had taken nearly 26 percent of the terminals the first year. In the uncontrolled range, removal of the terminal bud was moderate to heavy by cattle but severe by sheep, exceeding 70 percent. In 1969, removal of the terminals was almost complete (93 percent) in the open sheep range, but only 19 percent had been taken in the open cattle allotment. Damage by sheep in the uncontrolled area was probably intensified by the progressively fewer number of sprouts available each year and the fact that heavy use had kept the sprouts within easy reach (Table 3).

Damage by trampling was rarely recorded except under controlled cattle grazing, and there it amounted to only 5 percent. At Twin Creek from 1 percent to 9.6 percent of sprouts were injured in individual treatments. Damage was greatest in areas where aspen had been cut and the density of sprouts was greatest.

Only at Webster Flat was effort made to observe and tabulate factors other than browsing by domestic animals that might contribute to sprout mortality (Table 3). The two most important other causes of injury were pocket gophers and disease. Damage from disease was substantial both in 1967 and 1968, but only in 1968 was gopher damage substantial. This was attributed to the unusually heavy snow pack that year, which provided a long period of protective cover for the gophers (Lucas, 1969).

No attempt was made to identify the pathogen responsible for sprout injury.

Table 3. Percentages of aspen sprouts injured at Webster Flat and causes of injury.

Treatment	Browsed terminal			Trampling		Pocket gophers		Disease	
	1966	1967	1968	1967	1968	1967	1968	1967	1968
Cattle	18.3	3.3	3.6	4.6	5.3	3.3	12.8	14.3	10.1
Sheep	8.8	16.7	11.8	0.7	1.4	4.0	12.3	7.7	9.5
Deer	25.5	2.1	3.0	0	0	—	—	—	—
Protected	—	—	—	—	—	2.0	13.6	10.8	8.9
Cattle and deer	43.9	16.9	35.9	—	—	—	—	—	—
Sheep and deer	69.2	72.4	99.8	0.2	1.1	1.4	12.8	3.8	0

Note: In 1968 a heavy snow pack caused some additional damage, affecting 2.1, 2.5, and 7.1 percent of the sprouts in the cattle, sheep, and protected plots, respectively.

However, in 1965 we observed considerable fungal damage to reproduction at Betenson Flat which we believe to be caused by the same organism. This was tentatively attributed to the canker *Dothiora polyspora*, but efforts to culture the organism so that positive identification could be made failed. 1/

Preliminary examination of the Webster Flat area in the fall of 1965 suggested that frost may also injure aspen sprouts. An early and severe frost occurred, and when an inventory was made in early November, 25 percent of the sprouts had blackened and died back partially or completely. It was not definitely determined that frost was the cause, but no other causative agent could be identified. Similar death of the terminal bud was observed at Willow Creek near Salina.

The design of the study at Webster flat and the greatly unequal populations of sprouts among the treatment plots precluded definitive statistical tests for the differences in sprout mortality noted under different grazing treatments. It would appear from the data in Table 1, however, that only in the plots open to unregulated use by both deer and sheep could grazing be judged to be an important factor causing sprout mortality. In these plots the number of sprouts surviving the third year was only 6 percent of the number inventoried in the first year following cutting, and by the fourth year this number had further declined to less than 1 percent. Sprouts in the other treatments declined at rates that varied with the number of sprouts initially present, so that by 1969 percentage survival differed little except on the open sheep range.

Effect of Terminal Bud Damage upon Sprout Mortality. The longest record of sprout numbers and damage to the terminals was obtained at Betenson Flat. The fire occurred in June 1958, and presumably some sprouting may have begun that same year. At the initial inventory in 1961 one sprout in each sample plot was tagged for continuing identification. Each sprout was examined and records were made of loss of the terminal bud in that year and in prior years as evidenced by deformation of the stem caused by continuation of growth from a lateral bud. Thus a nearly complete record was obtained except for sprouts that had been clipped so closely to the ground the first year that the evidence of past use was lost. As many as seven removals were observed on individual sprouts, but almost three-fourths of the sprouts showed only two or fewer removals (Table 4). By 1965, 26 percent of the tagged sprouts had died despite the fact that they were the most promising ones at the outset (Table 4).

Sprout mortality was greater in the area used by cattle and deer (31 percent) than in the area used by deer alone (21 percent). For the years 1961 through 1965, the frequency of terminal removal was three times as great in the area open to cattle (32 percent) as in that available only to deer (11 percent). Although the coincidence of greater use and higher mortality suggests a causal relationship, the

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1/ Letter from Thomas E. Hinds, Rocky Mountain Forest and Range Experiment Station, Fort Collins, Colorado.

Table 4. Mortality among 159 tagged aspen sprouts at Betenson Flat from time of release in 1958 to 1965, related to removal of terminals.

Times browsed	Live sprouts		Dead sprouts		Attained height	
	Number	Percent	Number	Percent	Mean	Maximum
					Inches	
0	24	20	6	15	60	93
1	50	43	7	17	60	75
2	19	16	9	22	37	74
3	6	5	11	27	32	55
4	4	3	6	15	40	91
5	9	8	1	2	32	32
6	2	2	1	2	21	21
7	4	3	0	0	0	0
Totals	118	100	41	100	—	—

data in Table 4 make this less certain; for a third of the dead sprouts had no more than one removal. Moreover, the heights attained by the dead sprouts show them to have been vigorous and rapid growing. In addition, 15 live sprouts had been browsed five or more times.

Growth Rates of Aspen Sprouts. Only the data collected at Hancock Flat provide annual information on growth rates, and these are complicated by a cutting schedule that spanned two summers, 1961 and 1962. Initial inventory at Betenson Flat was not made until 3 years after the burn; at both Twin Creek and Webster Flat incomplete growth data were taken until the fall of 1969 when final tallies were made.

In 1962, when cutting was completed at Hancock Flat, there was already considerable reproduction in consequence of the cutting that had been done in 1961 (Table 5). Most sprouts were less than 2 feet high; only one exceeded 3 feet. In 1965, almost one-fourth of the sprouts were still less than 2 feet tall; but there were only about one-fifth as many sprouts of this size as were found in 1962, the year sprouts were most numerous. By 1965 nearly one-third exceeded 4 feet. However, many sprouts were in the smaller height classes, for many sprouts grow little after the first year, the growth being confined to a few sprouts (Table 5).

Although comparison of growth rates at other sites is not possible from our data, the heights recorded in the final tally show that growth was even more rapid than at Hancock flat. At Webster Flat, for instance, 37 percent, 45 percent, and 46 percent of the sprouts exceeded 60 inches in the deer, cattle, and protected plots, respectively, the fourth year after cutting (Fig. 3).

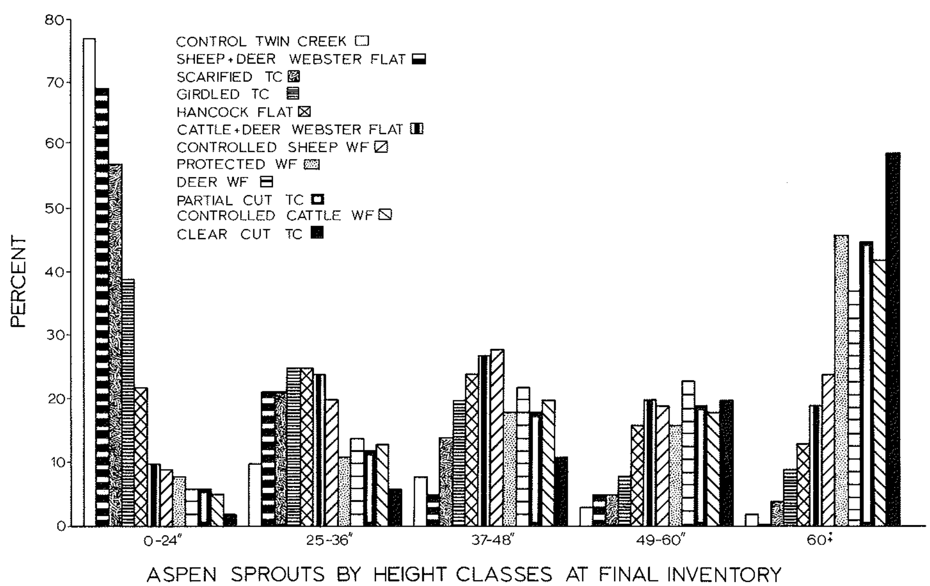

Fig. 3 **Distribution by height classes of aspen sprouts at three study sites, Twin Creek (TC), Webster Flat (WF), and Hancock Flat four years after cutting or treatment.**

Table 5. Number of sprouts per acre and percentages by height classes on Hancock Flat following a clear cut completed in 1962.

Height Class	1962		1963		1964		1965	
Inches	Number	Pct.	Number	Pct.	Number	Pct.	Number	Pct.
1-24	23,414	88	27,543	69	10,164	33	5,899	22
25-36	2,904	11	8,757	22	9,483	30	6,579	25
37-48	363	1	2,586	7	7,441	24	6,216	24
49-60			817	2	4,083	13	4,174	16
60+							3,529	13
Total	26,681		39,703		31,171		26,395	

Relations Between Treatment and Height Growth. Distinct effects of treatment on sprout heights were observed at the end of the period of inventory. (Fig. 2). Three conditions could be identified. In one, most sprouts were shorter than 24 inches – in control, scarified, and girdled treatment plots at Twin Creek and unregulated sheep and deer plots at Webster Flat. The second condition could be identified where more than one-third of the sprouts present in the final inventory exceeded 60 inches – clear cut and partial cut at Twin Creek; and protected, deer, and cattle plots at Webster Flat. In other treatments the greater percentage of the sprouts was in the intermediate height classes. At Hancock Flat substantial numbers of shoots were shorter than 24 inches.

Despite the severe impact of sheep on attained heights in the open-range plots at Webster Flat, there appears to have been only moderate impact on heights of sprouts under controlled sheep use; there almost half the sprouts tallied in 1969 were taller than 4 feet.

Sprout Height and Browsing of Terminal Bud. In late October or early November each year, sprout heights at Betenson Flat and Hancock Flat were measured to the nearest inch and classified as "browsed" or "unbrowsed" depending upon whether the terminal bud had been removed. No continuing record of the same kind was made at Webster Flat or at Twin Creek. The complete data on removal of terminals by sprout heights are available (Table 6) only for the final inventory in 1969.

At all sites studied, damage to aspen terminals virtually ceased after the sprouts attained a length of 60 inches, and browsing of the terminals was of little significance on sprouts longer than 48 inches (Table 6 and Fig. 4). Although a few sprouts longer than this were nipped, they often were either not erect, or the slope of the ground surface resulted in effective reduction in the height of the tip. Light damage to sprouts longer than 36 inches occurred at most study sites, but one-fourth or more of the sprouts in the 37-to-48-inch class were browsed at Twin Creek and in the combined cattle and deer allotment at Webster Flat. Heaviest removal of terminal buds was from sprouts shorter than 24 inches, but under combined cattle and deer use at Betenson Flat more than half the sprouts in the 25-to36-inch class were browsed. Under no other treatment was damage this severe to sprouts of this height.

The data obtained do not permit drawing inferences regarding the height at which aspen become immune to terminal bud removal by a particular species of animal. Cattle, deer, and elk all used the area at Twin Creek but cattle were present in far greater numbers. The data from Betenson Flat provided some evidence of deer and cattle impacts despite the fact deer also used the area open to cattle. Incidence of bud removal was greater for the taller height classes in the area used in common than where deer alone were present (Table 6).

Forage Production. The weight of forage differed greatly among the treatments at Webster Flat and Twin Creek (Table 7). Nearly twice as much forage per acre was produced at Twin Creek as at Webster Flat, and there were equally great differences between treatments. Reasons for these treatment differences are

Table 6. Percentage of terminal buds of aspen browsed by height classes under use by different animals at four locations in Utah, 1969.

	Betenson Flat		Hancock Flat	Twin Creek	Webster Flat	
Height (Inches)	Deer	Cattle-Deer	Deer	Cattle-Deer-Elk	Cattle-Deer	Sheep-Deer
0-24	45	53	30	52	31	25
25-36	24	55	16	36	30	28
37-48	1	30	8	25	22	25
49-60	2	6	0	14	11	17
60+	0	2	0	2	1	5
Total	17	31	18	19	19	27

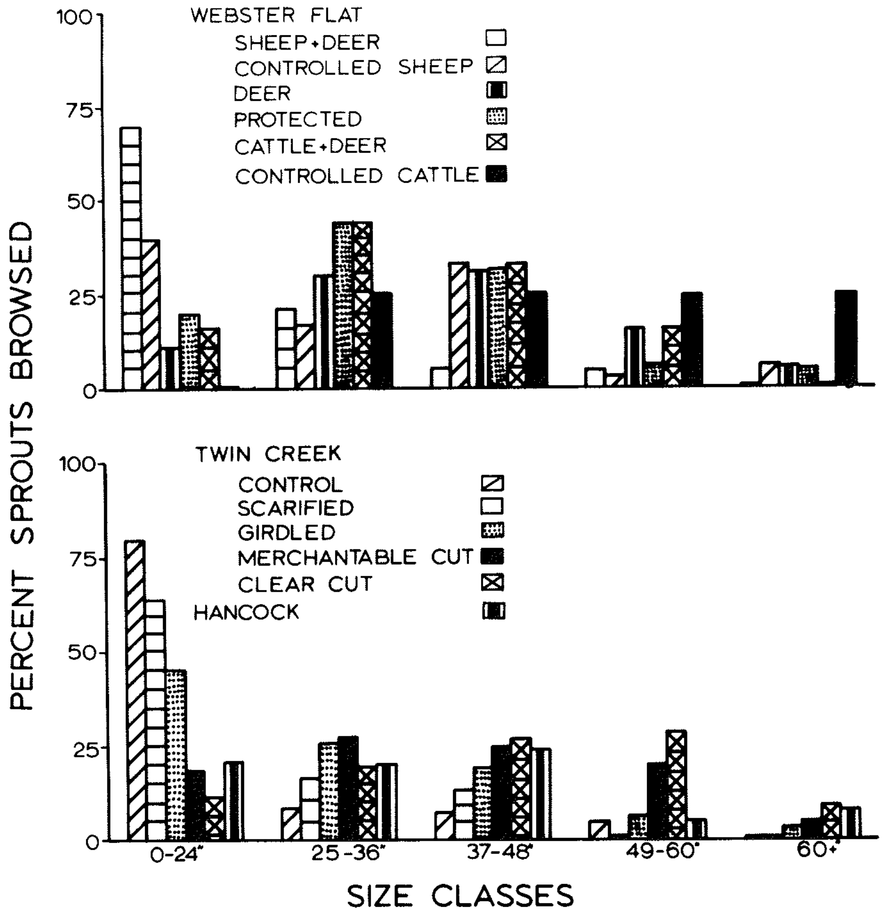

Fig. 4 **Percent of aspen sprouts browsed by height classes at three study sites by treatment.**

not readily apparent. At Webster Flat, soil differences and prior use of the area are the most logical explanations since the higher yields occurred in areas partially or wholly within the cattle allotment which comprised the southwest part of the study area. Soil disturbance by logging, which varied from plot to plot, may also have influenced yields. (Table 7).

At Twin Creek, the higher forage yields were where there had been the greatest assault upon the aspen stand. Production was greatest in the clearcut area, followed in turn by the girdled and the partial-cut treatment plots. Increased penetration of light and reduced competition are possible causes for the greater yields observed where aspen was cut. Since the girdled trees retained a leaf cover until 1968, these reasons seem inadequate to account for the high forage production observed there.

Table 7. Mean annual air dry herbage production at Webster Flat and at Twin Creek, 1966-1968.

Location and treatment	Grass	Forbs	Browse [a]	Total
		Pounds per acre (air-dry)		
Twin Creek				
Clear cut	318	1,261	26	1,605
Girdled	296	1,148	56	1,500
Partial cut	298	755	113	1,166
Control	177	663	19	859
Scarified	169	610	26	805
MEAN	252	887	48	1,187
Webster Flat				
Cattle	426	396	14	836
Protected	394	400	8	802
Cattle-deer	355	406	13	774
Sheep	325	321	2	648
Sheep-deer	277	296	3	526
Deer	231	237	1	469
MEAN	326	343	7	676

a/ Other than aspen.

Browse other than that produced by aspen sprouts was unimportant at either location. Grass and forbs were about equally abundant at Webster Flat, but at Twin Creek forbs comprised just over 75 percent of the total yield. At Twin Creek coneflower *(Rudbeckia occidentalis)* produced the greatest amount of forage under all treatments. Groundsel *(Senecio serra)*, valerian *(Valeriana occidentalis)*, pea vine *(Lathyrus leucanthus)*, sweet anise *(Osmorhiza occidentalis)* and bracken *(Pteridium aquilinum)*, though less uniformly present, contributed heavily to forage yields with now one now another being most in evidence.

The principal grass species at Webster Flat were slender wheatgrass, mountain brome *(Bromus carinatus)* and Kentucky bluegrass; and dandelion, bluebells, and senecio *(Senecio eremophilus)* were major forbs. These were not uniformly present in each treatment plot, but in some mix these provided the bulk of the forage.

Forage Utilization at Webster Flat. Although the study at Webster Flat was intended to provide data on utilization under all combinations of animal use, not all treatments were inventoried each year (Table 8). Complete utilization data for the 3 years of the study are available only for controlled cattle, controlled sheep, and sheep-and-deer treatments. Mean utilization of herbaceous species in these three treatments was progressively heavier each year; in 1968, the third year of the study, utilization exceeded 75 percent. Despite this heavy use and the absence of alternative browse forage, utilization of the aspen sprouts was not great in the controlled cattle and controlled sheep treatments. Aspen use by cattle did not exceed 10 percent in any year or in any paddock and use by sheep did not exceed 20 percent. Only in the open sheep range did aspen sprouts suffer heavy utilization; it averaged 50 percent the first year and 97 percent in the third. The small volume of aspen forage available probably accounts in the part for this increasingly heavy use (Table 8).

Only two years' forage utilization data are available for uncontrolled cattle and deer use, but in those years utilization of herbaceous species was substantially less than under controlled cattle use. Despite this, aspen sprouts the first year were utilized twice as heavily as in the controlled cattle treatment. Although deer were present and might be assumed to have been partially responsible for this greater use, the negligible utilization observed in the plots open only to deer leads us to reject this assumption; nor do the pellet-group counts suggest deer were numerous enough to cause significant use (Table 9).

Widely different volumes of forage were removed in the three years (Table 10). However, the numbers and classes of animals varied so that the data can be compared only on an animal unit basis. In 1967 sheep consumed substantially more herbage than cattle did. In 1968, there was little difference between the consumption by sheep and cattle. Two factors may possibly account for these differences. Unusually high precipitation in 1967 prolonged the growing season, and regrowth may have been considerable. In addition, the Holstein cows used in 1967 seemed not to adapt well to confinement in the paddocks and consequently may not have eaten heartily (Lucas, 1969). The low consumption by sheep recorded in 1966 can be explained only through error in data gathering (Table 10).

Table 8. Utilization by cattle, sheep, and deer by forage classes at Webster Flat, 1966-1968.

	Grasses			Forbs			Browse			Aspen		
Animal use	1966	1967	1968	1966	1967	1968	1966	1967	1968	1966	1967	1968
						Percent						
Cattle	39	37	76	45	48	82	6	5	29	6	1	3
Cattle & deer	11	26	—	10	20	—	3	2	—	15	4	—
Sheep	16	27	70	44	47	80	T	32	91	7	7	15
Sheep & deer	16	42	74	44	56	85	3	61	87	51	14	97
Deer	2	—	—	2	—	—	0	—	—	2	—	—

Table 9. Animal use at four aspen study sites in Utah by years after cutting or from beginning of records, 1962-1968.

Site and use	Years 1	2	3	4	5	Mean
	(Animal days' use per acre)					(Animal Units)
Webster Flat						
Controlled use a/						
Cattle	18	33	29			27
Sheep	73	199	146			26
Open Range						
Cattle	11	6	7			8
Sheep b/	71	114	87			18
Deer	25	4	3			2
Hancock Flat						
Deer	4	15	10			2
Betenson Flat						
Deer	47	29	11	9	9	4
Cattle	5	5	5	10	4	6
Twin Creek						
Cattle	14	15				15

a/ Based on actual use; all other data estimated from fecal counts.

b/ Includes deer since it was not possible to distinguish sheep droppings from deer droppings.

Table 10. Forage removal per acre by cattle and deer in controlled use paddocks at Webster Flat.

Forage class	Cattle 1966	Cattle 1967	Cattle 1968	Sheep 1966	Sheep 1967	Sheep 1968
	Pounds per acre (air dry)					
Grass	141	189	214	28	167	207
Forbs	201	148	182	94	236	166
Browse	T	1	4	0	1	2
Aspen	7	2	14	6	27	62
TOTALS	349	340	414	128	431	437
Consumption per AUD a/	19.9	10.4	20.3	8.3	15.0	21.4

a/ AUD = Animal Unit per day

DISCUSSION AND CONCLUSIONS

These studies provide no evidence that big game animals are primarily responsible for failure to obtain adequate aspen reproduction in Utah. The findings came from four widely separated areas where deer populations were substantial and can be expected to reasonably represent normal populations for the region. We cannot document the impact of deer under animal pressures approaching that commonly experienced with domestic livestock. Consequently, we cannot compare the relative effects of deer and livestock under comparable intensities of use. Nothing in our data suggests that regeneration of aspen is not possible even under heavy use by domestic livestock. Stocking in the controlled sheep and controlled cattle paddocks varied from 0.75 to 2.0 acres per AUM, which can be considered only as heavy use. At the same time, utilization of the herbaceous forage was heavy. Despite this, aspen regeneration was deemed adequate in these two treatments and percentagewise, the survival of sprouts was as good in the fourth year after cutting as under protection (Fig. 5).

Fig. 5 Corner of sheep paddock at Webster Flat used for bedding. Reproduction was suppressed here but otherwise appeared as in the foreground. Protected plot on the left; deer plot in background, 1969.

The reasons for the substantially greater use of aspen in the open range areas than under controlled conditions at Webster Flat are not readily apparent. The intensity of animal use as estimated by fecal counts, always subject to error, was less both for sheep and cattle than known use in the controlled paddocks. Moreover, utilization of the herbaceous species was greater in the controlled livestock paddocks, although utilization data collected immediately after a short grazing period may not be comparable to data collected in the fall after summerlong use where regrowth may have occurred. Although deer were free to use these areas along with livestock, it does not appear that they could be responsible since little use of aspen was observed after the first year in the area used only by deer. Cattle appeared to utilize aspen more heavily as the season advanced (Lucas, 1969). This may partially account for the greater aspen use in the open cattle range, but sheep showed no comparable seasonal grazing patterns. This may suggest that short periods of heavy use are preferable to unrestricted livestock use throughout a longer season.

The observations at Twin Creek further support the view that aspen reproduction can survive heavy grazing. In 1965, numbers of cattle on the treatment plots were unusually high, and use was heavy since cattle were allowed to remain in the area in numbers far greater than normal. Moreover, they showed some preference for the study site (Baker, 1969). In addition, deer and elk both used the area, albeit lightly. Despite these conditions, reproduction was adequate on the treatments in which the initial number of sprouts was large – clear and partial cutting. Conversely, where few sprouts appeared and sprout vigor was poor, damage was severe.

Sheep are potentially a more severe threat to aspen regeneration than are cattle, since they browse aspen more readily than cattle, especially after the first year of sprouting. If sheep are allowed to use a cut-over area repeatedly, they can effectively eliminate aspen, as we observed at Webster Flat under uncontrolled sheep use (Fig. 6). Cattle caused more damage only through trampling, but they can damage aspen seriously through browsing.

The first year following cutting is critical to successful aspen regeneration for that is the year when most of the sprouts emerge. They appear to be most palatable to all browsing mammals then although Sampson (1919) thought otherwise. Thereafter, three factors operate to lessen the impact of use: (1) an apparent decline in palatability, (2) an increased volume of aspen herbage available, which provides some buffering to the dominant leaders, and (3) increase in height of sprouts. To the extent that animals browse the smaller and secondary shoots, the growth and establishment of the dominant ones may be aided.

The results obtained from these studies, together with observations made at other places, seem to confirm the belief that the failure of aspen to reproduce is the result of faulty management of both the timber resource and of livestock. Commonly, the areas cut are so small that the total volume of aspen is not great. Often, the site is comparatively poor and the presence of intermixed unharvested coniferous timber may inhibit maximum sprouting. Under these conditions poor

Fig. 6 **Jump-over fence at Webster Flat showing deer-only use to right, unregulated sheep use to the left, 1968.**

vigor and slow growth further increase the susceptibility of sprouts to damage. If, in addition, livestock are permitted to congregate in the cutover areas, the potential for damage is great.

Whether removal of the terminal shoot during these early years affects the quality of the wood product has not yet been determined. To all appearances, browsing the terminals of vigorous shoots causes little permanent damage after the first year. Snow is a much more serious cause of sprout deformation than moderate animal use. Moreover, snow can damage aspen sprouts after they have grown out of reach of animals.

The treatments applied at Twin Creek gave unexpected results. Sprouting response was substantial the first year in the stem-girdled plots, but it was not so great as where the trees had been removed. This response differs from the results reported by Farmer (1962), who found no sprouting response following removal of the stem phloem in aspen seedlings. Moreover, presence of the overhead canopy, which persisted into the third year, maintained a microclimate (light, air, and soil temperature) similar to that found in uncut stands. If soil temperatures trigger sprouting, as Maini and Horton (1966) believe, we would not have experienced the response we did, for soil temperatures in the girdled plots did not differ appreciably from those in the controls (Baker, 1969).

We had reason to anticipate, from Farmer's results (1962), that severing the roots would stimulate sprouting. This did not occur. Our results leave unanswered the question of what triggers sprouting response, but they confirm observations made at the other study sites; namely, that a thick heavy stand of sprouts such as results from complete removal of standing timber can be expected to survive reasonably heavy grazing. We attribute the poor success and ultimate almost complete elimination of the sprouts in the girdled stand to a lack of sprout vigor under the canopy and reduced light there. By the time the leaves had disappeared from the overstory trees (1968), the sprouting stimulus had gone or the roots were devoid of food reserves necessary for sprout production. Tew (1970) observed early cessation of sprout growth from aspen root sections removed to the greenhouse.

The following practices are suggested as a means of ensuring regeneration of aspen stand in Utah:

(1) Cut a sufficiently large acreage to provide an excess of aspen forage. Size of the cut should be larger where other forage is scarce than where it is abundant.

(2) Completely remove the timber stand so as to provide maximum stimulus to sprouting.

(3) Graze the area cautiously or protect it the first year following timber harvest. On poorer sites, particularly on sheep ranges, some protection may be required the second year.

LITERATURE CITED

Baker, C. O. 1969. The effects of some silvicultural and soil treatments on aspen *(Populus tremuloides Michx.)* reproduction in northern Utah. Unpubl. M.S. thesis. Utah State University, Logan, Utah, 54pp.

Baker, F. S. 1918. Aspen reproduction in relation to management. J. Forestry 16(4): 389-398.

_______________ 1925. Aspen in the Central Rocky Mountain region. U.S.D.A. Department Bull. 1291. 43 pp.

Costello, D. F. 1944. Important species of the major forage types in Colorado and Wyoming. Ecol. Monog. 14(1): 107-134.

Curtis, J. D. 1948. Aspen: the utility timber crop of Utah. Timberman 49: 56-57.

Dietz, D. R., R. H. Udall, and L. E. Yeager. 1962. Chemical composition and digestibility by mule deer of selected forage species, Cache Poudre Range, Colorado. Colo. Game and Fish Publ. No. 14. 89 pp.

Ellison, L., and W. R. Houston. 1958. Production of herbaceous vegetation in openings and under canopies of western aspen. Ecology 39(2): 337-345.

Farmer, R. E. 1962. Aspen root sucker formation and apical dominance. Forest Sci. 8(4): 403-410.

Graham, S. A., R. P. Harrison, Jr., and C. E. Westell, Jr. 1963. Aspens, Phoenix trees of the Great Lakes region. Univ. of Michigan Press, Ann Arbor. 272 pp.

Hintze, L. H. 1963. Geologic map of southwestern Utah. Department of Geology, Brigham Young University, Provo.

Lucas, P. A. 1969. The effect of cattle, sheep, and other factors on aspen *(Populus tremuloides)* reproduction after clear-cut logging in southern Utah. Unpubl. M.S. thesis. Utah State University, Logan, Utah. 69 pp.

Maini, J. S., and K. W. Horton. 1966. Vegetative propagation of Populus spp.; I. Influence of temperature on formation and initial growth of aspen suckers. Can. J. Bot. 44(9): 1183-1189.

Sampson, A. W. 1919. Effect of grazing upon aspen reproduction. U.S.D.A. Bull. 741. 29 pp.

Tew, R. K. 1970a. Seasonal variation in the nutrient content of aspen foliage. J. Wildlife Mgmt. 34(2): 475-478.

Tew, R. K. 1970b. Root carbohydrate reserves in vegetative reproduction of aspen. Forest Sci. 16(3): 318-320.

Utah Fish and Game Commission. 1948. History of big game in Utah. Twenty-eighth Biennial Report, 1947-1948.

Westell, C. E., Jr. 1954. Available browse following aspen logging in lower Michigan. J. Wildl. Mgmt. 18(2): 266-271.

Williams, J. S. 1946. Geologic map of the Logan quadrangle. Bull. Geol. Soc. of Am. Vol. 59, Plat 1.