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Forage Production and Utilization in a Sprayed Aspen Forest in Alberta

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Highlight: *In aspen forest in Alberta, Canada, receiving as little as 3 lb/acre of 2,4-D in a single application achieved an annual herbage production of 874 lb/acre 2 years after treatment compared to only 188 lb/acre in the control. Sprayed forest border areas (small aspen) showed a four-fold increase in herbage production. Grasses, sedges, and forbs increased in herbage production in sprayed forests. Only two forbs were detrimentally affected by the herbicides. In the sprayed forest area, even though there was a considerable amount of obstruction, cattle were able to consume 48% of the total herbage and as much as 58% of the green herbage. However, even with the inclusion of 2,4,5-T in the second herbicide application, there were many woody species in the treatment areas with as high or higher densities than in the control.*

One of the primary concerns of many cattle ranchers in the aspen parkland area of Alberta and Saskatchewan is to increase forage production through the replacement of woody species by usable forage plants. Mechanical means of brush removal are available but often prove costly (Friesen et al., 1965). The use of herbicides is an alternate method of controlling the woody species. Herbicide application to aspen[1] forests of Saskatchewan has shown both increased density and production of desirable forage species (McIver, 1963; Skogland and Coupland, 1966). The purpose of this study was to provide information on the kinds and amount of understory herbage produced as a result of spraying, and how much was grazed by cattle.

The study area was located on the University of Alberta Ranch, 95 miles southeast of Edmonton. The topography was hilly because it was the site of a terminal morraine. It is known locally as knob and kettle topography because of the abundance of 100- to 200-foot-high hills (knobs) with depressions (kettles) between. The vegetation and soil have developed in response to the numerous microclimates. Rough fescue grassland was present on south-facing slopes of hills and uplands while aspen forest occupied the north-facing slopes of hills and well-drained lowlands (Fig. 1). The poorly drained depressions were often occupied by ponds and sedge meadows.

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[1] Scientific names are given in the tables; the botanical nomenclature follows Moss (1959).

Methods

In August, 1966, four 40-acre strips were sprayed with 1, 2, 3 and 4 lb/acre acid equivalent of mixed butyl esters of 2,4-Dichlorophenoxy acetic acid (2,4-D), respectively. A fixed-wing aircraft applied the herbicide in a diesel oil carrier at the rate of 1 gallon total solution/acre. Each strip was 1 mile long by 330 ft wide; the strips were spaced 150 ft apart. Relatively poor mortality of woody plants in the 1 and 2 lb/acre 2,4-D treatments and abundant resuckering in the remaining treatments necessitated further brush control measures. In October, 1967, the 3 lb/acre 2,4-D strip was burned and was identified as the 3+B treatment. In July, 1968, the remaining strips were resprayed at the same rate as in 1966 but with 3 gallons total solution/acre of a diesel oil carrier. In addition to the 2,4-D, the three strips were treated with 8 oz/acre 2,4,5-trichlorophenoxy acetic acid (2,4,5-T) to control the 2,4-D resistant shrubs, wild rose, wild raspberry, and gooseberry. The three strips were identified as the 2, 4 and 8 lb/acre, 2,4-D treatments.

In the spring of 1968, a 136-acre field was constructed to include 59 acres of unaffected grassland and forest and 57 acres of sprayed grassland and forest. The remaining area was bare ground used as a fire guard in a separate study.

Because of a relatively short grazing period in 1968, forage production and utilization were determined by clipping plots before and after grazing (Subcommittee on Range Research Methods, 1962). Only treatments which received 3 and 4 lb/acre of 2,4-D in 1966 were sampled in 1968, because the other two treatments showed little tree damage. A total of 19 transect lines per treatment were randomly located, extending from the upland grassland through the adjacent small aspen zone (DBH<3 inches) and then into the large aspen zone (DBH>3 inches). On each transect line, a 1-foot-square plot was randomly located in each of the vegetation types crossed by the transect lines. From August 12 to 16, all vegetation from the selected plots, except shrubs, was harvested.

On August 23, 1968, 30 head of cows and yearlings and 21 calves were placed in the experimental field. The herd grazed in the study area for 21 days, using 20 animal-unit-months (AUM) of forage. One-foot-square utilization plots adjacent to the production plots were clipped September 16-20, after the cattle had been removed from the field.

In 1969, the study was simplified by limiting it to a comparison of sprayed versus unsprayed areas. The 8, 4, and 0 lb/acre 2,4-D treatments were sampled. Exclosures were built in selected grassland and forest sites before animals were introduced into the field (Fig. 1). Areas with low forage production were avoided because the main interest in 1969 was to determine the utilization of forage present in both treated and control areas. Four rectangular exclosures were constructed on selected locations in the control and in treatments receiving 4 lb/acre and 8 lb/acre of 2,4-D. Each

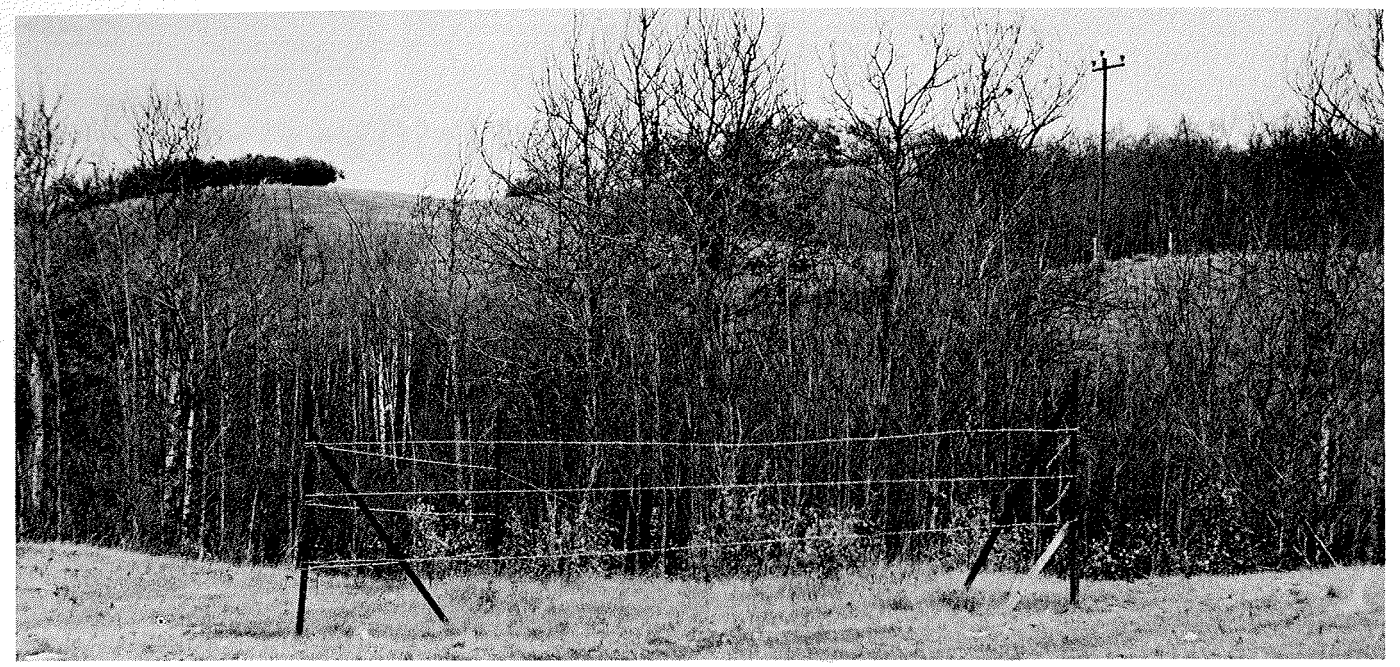

Fig. 1. *An exclosure in sprayed aspen parkland extending from the grassland into aspen forest.*

exclosure extended from the low meadows, through the forest, and 20 ft into the grassland. Each exclosure was 16 ft wide and from 75 to 120 ft long, depending upon the size of the forest area. In order to sample the grasslands on upper slopes, triangular exclosures were located in the appropriate areas. Three 30-ft^2 triangular exclosures were constructed in the upper grassland areas of each treatment.

From June 26 to August 13, 1969, a herd consisting of cows, calves, heifers, and one bull was allowed to graze in the field; this resulted in a total of 47 AUM of grazing.

After the animals were removed, a predetermined number of 1-foot-square plots were clipped inside and outside each rectangular and triangular exclosure. The number of clipped plots chosen in each of the vegetation types was derived from the 1968 data using a sample size formula of Guenther (1965).

The vegetation in a plot was clipped at ground level and frozen for later hand sorting. The number of stems and average height of the shrub species in each 1-foot-square plot was recorded. The amount of browsing on each shrub was estimated following the Subcommittee on Range Research Methods (1962).

The clipped vegetation was hand sorted into grass, sedge, forb and litter categories. The percentage, by weight, of each species in the grass category was estimated. As a check on accuracy, one sample out of every 20 was sorted to species. Forbs were hand sorted to the species level.

Results and Discussion

Herbage Production

The herbicide had little effect on forage production in the grassland, but a dramatic increase appeared in the treated forest types. The 1968 annual herbage production of the grassland treatments ranged from 1071 to 1274 lb/acre compared to 1089 lb/acre in the control (Table 1). Grasses and sedges formed the majority of the annual herbage production, 956 to 1064 lb/acre in the treatments compared to 970 lb/acre in the control. The forb production was nearly equal in the treatments and control.

In the forest types, the annual herbage production increased five to seven-fold upon receiving as little as 3 lb/acre of 2,4-D (Table 1). In the small aspen type, the annual herbage production (green herbage) varied between 1060 and 1312 lb/acre compared to 277 lb/acre in the control. The annual herbage production was also much greater in the sprayed large aspen forest: 356 lb/acre and 766 lb/acre compared to 98 lb/acre in the control. As in the grassland, the grass-sedge component was more productive than the forbs; but the latter were a very important component, forming as much as 46% of the annual herbage production in one treatment.

The forbs were little affected by the August 15, 1966, spraying because of dry soil conditions and lateness in the growing season. It is not understood, however, why the forbs were not more detrimentally affected by the July 2, 1968, herbicide treatment. In both forest types, forb production in the control was similar to the treatment sprayed twice (8 lb/acre 2,4-D) but lower than in the treatment sprayed once (3+B treatment).

The production results of 1969 coincide fairly well with those of 1968 with the exception of a much greater 1969 treatment production in the large aspen type (Table 2). This was largely a result of not locating the exclosures in forest areas which had little or no forage production. As in 1968, the annual herbage production consisted mostly of the grass-sedge component, with the forb component becoming more important in the forest types. In 1969, the higher rate of 2,4-D did not result in a greater amount of forage and did not appear to have a detrimental effect on the overall forb production.

The amount of dead herbage varied considerably among treatments, vegetation types, and years. The relatively low amount of dead herbage in the 3+B treatment of the grassland and small poplar type was due to the October, 1967, burn (Table 1). The greater amount of dead herbage in the 8 lb/acre 2,4-D treatment and control in 1969 probably resulted from the lighter grazing pressure in 1968 compared to 1967.

Production and Utilization by Species

In the grassland areas rough fescue and wheatgrasses constituted the bulk of the forage in the treatments and showed a 70 to 82% level of use (Table 3). In the control, in a more arid grassland, western porcupine grass was also an important forage component, having a production of 175 lb/acre and a 59% level of use. None of the other grasses or the sedge contributed much to the forage production or utilization.

The forb production was low and generally variable. Of the major species in the grassland, only bastard toad-flax, was detrimentally affected by the herbicide.

In the small aspen type, the grass component showed a marked response to herbicide application while the sedges showed little increase (Table 4). As in the grassland, rough fescue and wheatgrasses formed the largest portion of the forage production; but reedgrasses, bluegrasses, and fringed brome were also important forage components. Rough fescue was the most preferred grass. The negative utilization value (-8%) for wheatgrasses in the 4 lb/acre 2,4-D treatment was misleading because wheatgrass had a higher frequency in the grazed area, and it regrows after grazing. Assuming that the cattle did not completely remove a plant species from plots outside the exclosure, the frequency of a particular species inside and outside the exclosure would have had a great effect on the over or underestimation of the use of a forage species (Hilton, 1970).

As a result of the herbicide application, the forb production more than doubled in the small aspen type with most of the increase coming from wild strawberry and the asters.

It is clearly indicated in the small aspen type that wild strawberry, asters, blunt-leaved sandwort, Canada anemone and chickweed benefited from two applications of 2,4-D. Increased forb production in sprayed forests was due to an increased frequency as well as increased production of some species. For other species that had a decreased frequency, the survivors were much larger and more robust than in unsprayed forests. Similar increases in forb production in sprayed forests are reported by Davis (1967). The highly palatable vetchlings were the only major species to be detrimentally affected by herbicide. The majority of the forb species showed relatively high levels of use with the exception of the most productive forb, wild strawberry, which showed a negative use. Wild strawberry was grazed extensively by cattle, but it apparently was stimulated by grazing and the lack of competition for light from the grazed grasses, resulting in much greater regrowth in the grazed areas than in the adjacent ungrazed exclosures.

In the large aspen type, the sedges formed a more important part of the increased herbage production following spraying (Table 5). The sedge production in the treated areas was 261 and 385 lb/acre with an average 45.5% level of use. The dominant grasses (wheatgrass and reedgrass) showed a relatively high level of use ranging between 44 and 86%.

In the large aspen type, the forb production was from 3 to 5 times as much following the herbicide application as before, with the same species as in the small aspen type forming the majority of the forage production. As in the small aspen type, wild strawberry, smooth aster, blunt-leaved sandwort, Canada anemone, and chickweed benefited from the removal of woody competition by herbicides. In the large aspen type,

Table 5. Herbage production (lb/acre) and utilization (%) of selected species in the large aspen type, 1969.

Species	Measurement	2,4-D treatment (lb/acre) 8	4	0
Sedges (*Carex prairea* and others)	Production	261 b[1]	385 a	17 c
	Utilization	45[2]	46	
Wheatgrasses (*Agropyron subsecundum, A. trachycaulum*)	Production	193 a	167 a	5 b
	Utilization	61	44	
Reedgrasses (*Calamagrostis neglecta, C. inexpansa*)	Production	69 b	170 a	0
	Utilization	86	79	
Bluegrass (*Poa palustris, P. pratensis*)	Production	69 a	64 a	1 a
	Utilization	52	50	
Fringed brome (*Bromus ciliatus*)	Production	31 a	58 a	4 a
	Utilization		33	
False melic (*Schizachne purpurescens*)	Production	0	134	0
	Utilization		37	
Other grasses	Production	20	54	0
Wild strawberry (*Fragaria virginiana* var. *glauca*)	Production	96 a	73 a	10 c
	Utilization	14	33	
Chickweed (*Cerastium nutans, C. arvense*)	Production	61	3	1
	Utilization	98		
Northern bedstraw (*Galium boreale*)	Production	35 ab	38 a	5 b
	Utilization	62	54	
Blunt-leaved sandwort (*Arenaria lateriflora*)	Production	38 a	4 ab	2 b
	Utilization	43		
Smooth aster (*Aster laevis* var. *geyeri*)	Production	24	5	1
	Utilization	61		
Canada anemone (*Anemone canadensis*)	Production	19	20	1
	Utilization	78	89	
Vetchling (*Lathyrus ochroleucus, L. venosus*)	Production	2 b	5 b	16 a
Other forbs	Production	95	41	35

[1] Weights followed by the same letter are not significantly different ($P < 0.05$) according to the LSD test.
[2] Utilization percentages are given only for grasses of more than 40 lb/acre and for forbs of more than 20 lb/acre.

Table 1. Herbage production (lb/acre) and utilization (%) in 1968 by category in three vegetation types resulting from three treatments (lb/acre) with 2,4-D.

	2,4-D treatments								
	Grassland			Small aspen			Large aspen		
Measurements	8	3 + B[1]	0	8	3 + B[1]	0	8	3	0
All herbage									
Production	1677	1674	1843	1400	1425	348	390	805	101
Utilization	33	49	42	29	63	22	41	40	44
Dead herbage									
Production	606 a[2]	400 b	754 a	340 a	113 ab	71 b	34 ab	39 a	3 b
Utilization	10	14	26	15	-92	-18	-82	-26	0
Green herbage									
Production	1071	1274	1089	1060	1312	227	356	766	98
Utilization	46	60	53	33	68	35	45	46	45
Green grass and sedge									
Production	956 a	1064	970 a	849 a	767 a	169 b	247 a	410 a	25 b
Utilization	43	60	58	26	72	23	38	49	49
Green forbs									
Production	115 a	210 a	119 a	211 a	545 b	108 a	109 a	356 b	73 a
Utilization	91	64	16	63	63	53	60	43	44

[1] Burned in October, 1967.
[2] Weights within a vegetation type followed by the same letter are not significantly different according to the LSD test ($P < 0.05$).

Herbage Utilization

There was close agreement between the grazing observations (Hilton and Bailey, 1972) and clipped plot data (Table 1) when comparing utilization of sprayed and unsprayed grasslands. In 1968, cattle spent about 44% of the grazing time in the sprayed grasslands and about 40% in the unsprayed grasslands; this is comparable to the average of 53% use of the annual production in the treatments and control (Table 1).

Green grasses and sedges provided most of the forage consumed by the cattle in 1968. The forbs showed a very non-uniform level of use ranging from 91 to 64% in the spray treatments to a low of 16% in the control. The dead herbage showed a low level of use.

In both the grassland and the small aspen type, the herbage of the 3+B treatment was used at a much higher rate than in the other spray treatment or in the control. This may be due to the availability of only green herbage because of the fall burn. In both the small and large aspen types, the amount of forage consumed in the treatments was much greater than in the control; which agrees with the grazing observations showing approximately 13% of the grazing observations occurring in the sprayed forest compared to only 4% in the control.

In 1969, cattle used the sprayed grassland more than the grassland of the control (27% vs 12%) (Hilton and Bailey, 1972). This is consistent with the utilization data in Table 2 which shows an average of 693 lb/acre of annual production consumed (64% use) in the treatments versus 480 lb/acre in the control (51% use). The cattle also showed a much greater preference for the sprayed forest areas over the control forest consuming 539 lb/acre in the sprayed small and large aspen types (50% use) compared to only 95 lb/acre in the control (44% use).

Table 2. Herbage production (lb/acre) and utilization (%) in 1969 by category in three vegetation types resulting from three treatments (lb/acre) with 2,4-D.

	2,4-D treatments								
	Grassland			Small aspen			Large aspen		
Measurements	8	4	0	8	4	0	8	4	0
All herbage									
Production	1980	1954	1794	1887	1660	433	1624	1806	110
Utilization	45	46	17	36	41	47	48	48	-57
Dead herbage									
Production	873 a[1]	894 a	852 a	865 a	540 b	173 a	622 a	592 a	16 b
Utilization	23	22	-21	32	22	24	33	43	
Green herbage									
Production	1107 a	1060 ab	942 b	1022 a	1120 a	260 b	1002 b	1214 a	94 c
Utilization	62	66	51	41	49	63	58	50	25
Green grass and sedge									
Production	964 ab	1008 a	799 b	677 a	762 a	93 b	645 b	1028 a	29 c
Utilization	61	68	51	44	50	39	58	52	
Green forbs									
Production	143 a	52 b	143 a	345 a	358 a	167 a	357 a	186 a	65 b
Utilization	69	37	53	34	48	76	57	39	40

[1] Weights within a vegetation type followed by the same letter are not significantly different ($P < 0.05$) according to the LSD test.

Table 3. Herbage production (lb/acre) and utilization (%) of selected species in the grassland type, 1969.

Species	Measurement	2,4-D Treatment (lb/acre) 8	4	0
Rough fescue (*Festuca scabrella*)	Production	300 ab[1]	500 a	273 b
	Utilization	70[2]	75	50
Wheatgrass (*Agropyron subsecundum, A. trachycaulum*)	Production	402 a	269 a	112 b
	Utilization	82	71	60
Bluegrass (*Poa palustris, P. pratensis*)	Production	57 a	2 b	3 ab
	Utilization	–2		
Western porcupine grass (*Stipa spartea* var. *curtiseta*)	Production	29 a	49 a	175 b
	Utilization		43	59
Other grasses	Production	90	55	158
	Utilization			
Sedge (*Carex obtusata* and others)	Production	89 a	135 a	78 a
	Utilization	30	68	21
Asters (*Aster hesperius, A. pansus*)	Production	49	8	28
	Utilization	77		65
Northern bedstraw (*Galium boreale*)	Production	35 a	11 a	21 a
	Utilization	78		87
Bastard toad-flax (*Comandra pallida*)	Production	7 a	1 a	26 b
	Utilization			82
Other forbs	Production	52	36	68
	Utilization			

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Table 4. Herbage production (lb/acre) and utilization (%) of selected species in the small aspen type, 1969.

Species	Measurement	2,4-D treatment (lb/acre) 8	4	0
Wheatgrass (*Agropyron subsecundum, A. trachycaulum*)	Production	325 a[1]	177 ab	33 b
	Utilization	46[2]	–8	
Rough fescue (*Festuca scabrella*)	Production	35 a	320 b	9 a
	Utilization		93	
Blue grasses (*Poa palustris, P. pratensis*)	Production	149 a	31 b	1 b
	Utilization	67		
Reedgrasses (*Calamagrostis neglecta, C. inexpansa*)	Production	58 a	69 a	0
	Utilization	68	100	
Fringed brome (*Bromus ciliatus*)	Production	22 a	50 a	1 a
	Utilization		57	
Other grasses	Production	2	52	12
	Utilization			
Sedges (*Carex prairea* and others)	Production	87 a	65 a	37 a
	Utilization	–1	–29	1
Wild strawberry (*Frageria virginiana* var. *glauca*)	Production	140 ab	155 a	18 b
	Utilization	–1	–5	
Asters (*Aster hesperius, A. pansus*)	Production	65	61	7
	Utilization	69	98	
Northern bedstraw (*Galium boreale*)	Production	66 a	13 bc	31 ab
	Utilization	80		8
Vetchling (*Lathyrus ochroleucus, L. venosus*)	Production	1 b	8 b	80 a
	Utilization			92
Blunt-leaved sandwort (*Arenaria lateriflora*)	Production	24	38	0
	Utilization	48	99	
Canada anemone (*Anemone canadensis*)	Production	11	28	6
	Utilization		95	
Chickweed (*Cerastium nutans, C. arvense*)	Production	11	24	5
	Utilization		86	
Other forbs	Production	31	34	22

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Reedgrasses (*Calamagrostis neglecta, C. inexpansa*)	Production	69 b	170 a	0
	Utilization	86	79	
Bluegrass (*Poa palustris, P. pratensis*)	Production	69 a	64 a	1 a
	Utilization	52	50	
Fringed brome (*Bromus ciliatus*)	Production	31 a	58 a	4 a
	Utilization		33	
False melic (*Schizachne purpurescens*)	Production	0	134	0
	Utilization		37	
Other grasses	Production	20	54	0
Wild strawberry (*Fragaria virginiana* var. *glauca*)	Production	96 a	73 a	10 c
	Utilization	14	33	
Chickweed (*Cerastium nutans, C. arvense*)	Production	61	3	1
	Utilization	98		
Northern bedstraw (*Galium boreale*)	Production	35 ab	38 a	5 b
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Table 6. Density of woody stems (no./100 ft²), difference in height (%) between ungrazed and grazed areas and utilization level (%) in the 8, 4, and 0 lb/acre 2,4-D.

Species and vegetation type	2,4-D treatment (lb/acre)								
	Density			Difference in height (%)			Utilization level (%)		
	8	4	0	8	4	0	8	4	0
Aspen (*Populus tremuloides*)									
Grassland	7	5	0	P[1]	P	–	25	33	–
Small aspen	30	53	7	50	64	P	8	28	–
Large aspen	9	60	0	71	54	–	43	3	–
Snowberry (*Symphoricarpos occidentalis*)									
Grassland	39	41	38	0	58	23	4	–	–
Small aspen	67	84	230	9	14	15	1	1	2
Large aspen	65	37	109	36	60	0	2	1	2
Wild rose (*Rosa* sp.)									
Grassland	32	67	47	80	75	0	51	33	33
Small aspen	74	54	61	62	88	12	36	30	–
Large aspen	59	102	85	74	60	12	47	30	17
Wild raspberry (*Rubus* sp.)									
Grassland	0	2	0	–	P	–	–	5	–
Small aspen	35	4	39	33	100	71	1	–	–
Large aspen	61	10	50	50	0	41	12	4	5
Gooseberry (*Ribes* sp.)									
Grassland	0	0	0	–	–	–	–	–	–
Small aspen	26	0	0	93	–	–	30	–	–
Large aspen	74	7	9	14	83	86	10	–	–
Total woody stems									
Grassland	77	129	95						
Small aspen	230	199	353						
Large aspen	268	215	275						

[1] P = present only in grazed area.

however, northern bedstraw also had a seven times greater production in sprayed treatments. Only the vetchling produced less in sprayed areas than in the control.

Brush Density and Use by Cattle

In 1969, three growing seasons after initial herbicide treatment, the density of brush species was markedly different in treated areas than in the control (Table 6). The density of aspen was much greater than in the untreated areas. This was because more of the large trees had been killed by the two herbicide treatments but subsequent aspen sucker growth had not all been killed by the second herbicide treatment. The density of 2,4-D susceptible snowberry was unchanged in the grassland but reduced in the two forest types. The 2,4-D resistant shrubs wild rose, wild raspberry, and gooseberry, were not controlled by a single application of 2,4,5-T in 1968.

Cattle browsed some brush species during the 2-month grazing season of 1969. Based upon both the difference-in-height method and the estimated-utilization method, aspen, wild rose, wild raspberry, and gooseberry suckers were preferred browse for cattle. Snowberry, one of the major understory brush species, was usually not preferred. The utilization percentage of the woody species using the ocular-estimate method was generally lower than that obtained from the difference-in-height method; but both methods showed a definite preference by cattle for certain woody species. Aspen generally had a higher density in the grazed areas, probably as a result of the development of lateral sprouts after initial browsing (Maini, 1966).

Three years after initial spraying, the density of woody stems was generally about the same in sprayed areas as in the control. The density of snowberry, however, had been reduced by 2,4-D in the aspen types. Cattle use of some suckers and shrubs helped to control their growth and thereby maintained the valuable understory herbage.

Summary and Conclusions

Herbage production in the aspen types increased sharply after spraying and was readily utilized by cattle. The grasses were the major increasers after spraying in the small aspen type while grasses and sedges increased greatly in the large aspen type. Cattle preferred to graze most grasses over sedge. They also heavily utilized most forbs. Cattle readily browsed some woody species which, when repeated, may aid in their control.

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