Differential Grazing Use of Herbicide-Treated Areas by Cattle

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Abstract

Cows allowed free access to randomly placed plots of Bell rhodesgrass, kleingrass, and weeping lovegrass appeared to prefer to graze plots treated with 2.2 or 4.4 kg/ha (a.i.) of 20% tebuthiuron pellets compared to untreated plots, regardless of grass species. The apparent preference was observed during the summer and fall following herbicide application in the spring but was not detected the growing season 1 year after herbicide application. The cows also appeared to prefer herbicide-treated (2,4-D or picloram sprays at 1 kg/ha, tebuthiuron pellets at 0.5, 1 or 2 kg/ha [a.i.]) little bluestem-brownseed paspalum native stands to untreated plots. Moreover, cows usually grazed on plots treated with 1 or 2 kg/ha of tebuthiuron more than on those plots treated with 2,4-D or picloram sprays. Since all plots were mowed prior to the grazing trials, apparent grazing preferences were not attributable to differences in stage of grass maturity or to control of broadleaves by the herbicides.

Since the advent of phenoxy herbicides in the early 1940's, a wide array of sophisticated herbicides have been developed. Research has emphasized efficacy testing of selective herbicides for woody plant control, mode of herbicide action on the target species, and residual characteristics of herbicides in the environment. However, the responses of nontarget plant species and behavioral responses of animals grazing herbicide-treated ecosystems have received relatively little attention.

Herbicides such as 2,4-D [2,4-dichlorophenoxy) acetic acid] and picloram (4-amino-3,5,6-trichloropicolinic acid) affect a multitude of physiological processes (Ashton and Crafts 1973). Herbicide 2,4-D affects respiration, food reserves, and cell division (Mullison 1979) and may form complexes with proteins or amino acids. Because of the number of physiological processes involved, "the primary mode of action (of 2,4-D) has not been clearly established" (Mullison 1979). Although grasses usually resist phytotoxic effects of such herbicides, seedling growth may be inhibited in the presence of hormone-type herbicides applied at dosages commonly used in field applications (Scifres and Halifax 1972a, 1972b).

Tebuthiuron [*N*-(5-[1,1-dimethylethyl]-1,3,4-thiadiazol-2-yl)-*N,N'*-dimethylurea] was recently registered by the U.S. Environmental Protection Agency for woody plant control on rangeland. The selectivity of tebuthiuron is largely dose related, and damage to grasses may result when the application rate exceeds 2 kg/ha of active ingredient (a.i.) (Scifres 1980). However, aerial applications of pelleted tebuthiuron (20% pellets) at 2 kg/ha (a.i.) have effectively controlled a broad spectrum of woody species on the south Texas Plains (Scifres et al. 1979) and in east-central Texas (Scifres et al. 1981a). By the second growing season after tebuthiuron application at 2.2 kg/ha, the botanical composition of forage stands may be improved significantly for livestock grazing (Scifres and Mutz 1978, Scifres et al. 1981b).

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Although the exact mechanisms have not been clarified, applications of atrazine [2-chloro-4-(ethylamino)-(isopropylamino)-*s*-triazine] may increase nitrogen metabolism in some grasses (Kay 1971) resulting in increased crude protein contents (Baker et al. 1980). Tebuthiuron, like atrazine, is a photosynthetic inhibitor (Mullison 1979); and tebuthiuron applications have increased crude protein contents of several grass species in greenhouse experiments (Biondini and Pettit 1979). These physiological effects on vegetation suggest that the behavior of grazing animals may also be altered in response to changes in plant community structure and chemical composition of forage.

Therefore, this study was designed to evaluate the hypothesis that herbicide application directly alters grazing use of forages by cattle. Characteristics of grazing activity evaluated to test the hypothesis were (1) relative amounts of forage removed from herbicide-treated compared to untreated areas, and (2) the amount of time the cattle spent grazing on the treated areas relative to amount of available forage.

Materials and Methods

Seeded Plots

A grass seeding established in early March 1974 on the Texas A&M University Range Research Area was used for the first experiment. The 0.6-ha, enclosed nursery contained 8 by 31-m plots originally seeded with 3.3 kg/ha pure live seed (PLS) of Bell rhodesgrass *(Chloris gayana)*, "Selection 75" kleingrass *(Panicum coloratum)*, and Ermelo weeping lovegrass *(Eragrostis curvula)*. Plantings of each species were replicated 3 times in a randomized complete block design.

On March 14, 1978, the area containing the nursery was burned with a backfire to remove all standing growth. On April 21, 1978, when the grass regrowth was 15 to 20 cm tall, 20% tebuthiuron pellets at 0, 2.2, or 4.4 kg/ha active ingredient (a.i.) were applied with a hand-operated spreader to randomly assigned 4 by 4-m subplots. A metal rod, 1 m long and with 15 cm of the tip color coded to assure identification from a distance, was driven into the center of each subplot. Subplots were separated by a 1-m strip of untreated vegetation. Cumulative area of subplots in the enclosure was 0.044 ha, approximately 7% of the total area available to the grazing animals. The remainder of the enclosure supported a uniform stand of common bermudagrass *(Cynodon dactylon)*.

Grazing trials during the spring (May 28 to June 2), summer (July 18 to July 22), and fall (October 16 to October 20) of 1978 were conducted with 4, 360-kg cows. Three weeks prior to the summer and fall grazing periods, the nursery was mowed to a 15-cm stubble height to minimize confounding stage of vegetative maturity with effects of herbicide treatment on grazing characteristics. A final grazing trial was conducted during the period July 9-12, 1979, after shredding the study area in mid-March 1979.

Prior to initiation of grazing, standing crop was estimated in 4, 0.25-m^2 areas within 1 m from the center stake in the subplots. One of the 4, 0.25-m^2 areas was then randomly selected for actual harvest. Standing herbage was clipped to a 2.5-cm stubble height, separated into grasses and forbs, oven dried at 60° C for 48 hr, and weighed. Weight estimates were adjusted to actual weights based on a regression equation, and the average values were used as a measure of forage available on each plot. Harvested areas were excluded from sampling during subsequent evaluations. Within 3 days after each grazing trial, the forage estimation procedure was repeated. Differences between pregrazing and postgrazing standing crops were considered valid relative estimates of forage disappearance during each grazing trial.

During each grazing trial, cattle were allowed to graze for 1 to 2 hr (average of all periods was 1.6 hr) each morning beginning at 6 a.m. and again each evening beginning at 7 p.m. except for the fall period when grazing was initiated at 7 a.m. and 6 p.m. Two to 4 observers recorded each cow's activities during each grazing period. A grazing event was initiated when a cow entered a subplot, and the length of each event was timed with a stopwatch. Between grazing periods, the cows were confined to an area immediately adjacent to the study enclosure. The cows were not fed between grazing periods but had access to water and shade.

Native Stands

A second experiment was established in 1979 in a 0.6-ha enclosure immediately adjacent to the 1978 study area. The study area was dominated by little bluestem *(Schizachryium scoparium)* and brownseed paspalum *(Paspalum plicatulum)*. At the time of herbicide application on April 5, 1979, winter annuals (primarily *Bromus* spp.) were abundant. Most abundant forbs were western ironweed *(Vernonia baldwini)* and perennial ragweed *(Ambrosia psilostachya)*.

Herbicides were applied to 10- by 12-m plots separated by 1-m-wide untreated areas and replicated 6 times in a latin square design. Treatments, the isopropyl ester of 2,4-D and the potassium salt of picloram as aqueous sprays applied at 1 kg/ha (a.i.), the 20% pellets of tebuthiuron applied at 0.5, 1 or 2 kg/ha (a.i.), and untreated plots occupied about 76% of the total area available for grazing.

Grazing trials were conducted during the periods, June 25–29, July 30–August 2, and October 30–November 1 in 1979 and during July 8–11 in 1980. The study area was shredded to a 15-cm stubble height in early March of each year.

Three of the cows used were the same as in the 1978 experiment but 3 of the 4 observers had not participated in the previous experiment. Each of the observers watched each of the different cows during 2 grazing periods, once during a morning period and once during an afternoon period, during each trial. A color coded rod was driven in the center of each plot. The observers were not made aware of treatments associated with the coding, and the colors were randomly redesignated to treatments after each grazing period.

The day before each trial commenced, 5, 0.1-m² areas equidistantly spaced on a diagonal across each plot were clipped to a 2.5-cm stubble height. The day after termination of each grazing trial, a second set of sampling areas immediately adjacent to the pre-grazing set were harvested. Standing crop was sorted into grasses and forbs, oven-dried for 48 hr at 60° C, and weighed.

Statistical Analyses and Hypothesis Testing

Analysis of variance was used to evaluate the influence of herbicide treatment on initial standing crops and percentage disappearance at the end of each grazing trial. Analysis of variance was also used to isolate variation among cows, treatments, grazing periods (morning or afternoon) and appropriate interactions within each grazing trial relative to durations of grazing and numbers of visits to each plot. Mean separation was performed by Tukey's *w*-procedure ($P \leq .05$) (Steel and Torrie 1960).

The hypothesis, that herbicide treatment did not affect grazing preference and the cows grazed randomly using all plots equally, was tested by chi-square analyses. Grazing preference for herbicide treated plots was evaluated by the frequency of grazing visits based on an expected value (average number of grazing visits/untreated plot each hour) for each grazing trial.

Chi-square was also used to test the hypothesis that herbicic treatment would not influence amount of time (minutes/hour each grazing trial) spent grazing any given plot. The premise wa that time spent grazing any given plot within the experiment woul be proportional to the amount of grass available. Chi-squa values were calculated as $\chi^2 = \Sigma\frac{(0\text{-}E)}{E}$ where 0 = average time cov were observed grazing a given treatment, and E = average time th cows would be expected to graze that treatments based on gras available. Within each period, E was calculated from $GD_u \cdot SC_t$ SC_u^{-1}
where:
GD_u = mean grazing duration on the untreated plots,
SC_t = mean grass standing crop of the plots treated with herbicid and
SC_u = mean grass standing crop of untreated plots.

A significant χ^2 value was interpreted to mean that cattle graze the herbicide-treated plots longer than would be expected based o available forage.

Results and Discussion

General Considerations

F-ratios from analyses of variance indicated that variatio attributable to differences among cows or between grazing period (morning vs. afternoon), regardless of experiment or year of stud were not significant ($P \leq .05$). Also, the interactions, cow × perio cow × treatment, and cow × period × treatment were not signif cant. Therefore, data were averaged across cows and periods t simplify presentation. In the first experiment, variation attributa ble to grass species and grass species × herbicide treatment intera tions usually accounted for the greatest proportion of the sums c squares. Herbicide treatments were usually the greatest contribu tors to the sum of squares in the second experiment.

The primary non-grass species present in the first experimer was yellow passionflower (*Passiflora lutea* L. var. *glabriflor* Fern.) Yellow passionflower was highly preferred by the cows an had been selectively removed by the end of the second grazin period of the first trial. Forb stands were highly variable an contributed less than 10% to standing crop in the second exper ment. Therefore, only the data collected on grass standing crop a reported.

Table 1. Standing crop (kg/ha) of grasses immediately prior to grazi trials during various periods following tebuthiuron application on Ap 27, 1978, near College Station, Tex.

Tebuthiuron rate (kg/ha)	Grazing period[1] 1978 May 29–June 2	1978 July 18–22	1978 Oct. 16–20	1979 July 9–13
	Bell rhodesgrass			
0	732 e	464 bc	640 cd	1,413 g
2.2	652 de	493 bc	326 ab	973 f
4.4	312 ab	350 ab	190 a	640 cd
	Kleingrass			
0	598 d	678 d	508 cd	1,747 g
2.2	527 cd	368 bc	345 bc	1,426 f
4.4	187 ab	132 a	71 a	1,106 e
	Weeping lovegrass			
0	670 def	675 def	714 ef	1,373 g
2.2	455 bcd	529 cde	493 bcd	733 ef
4.4	214 ab	418 bc	171 a	867 f

[1]Means followed by the same letter and within a species are not significantly differe ($P < .05$) according to Tukey's *w*-procedure.

Seeded Plots

Treatment Influences on Forage Standing Crop

Rainfall during the period from herbicide application to the first grazing trial totaled 7 cm, adequate to dissolve the herbicide. By the first grazing trial, approximately 1 month after tebuthiuron application, mean standing crops were reduced by 4.4 kg/ha of the herbicide, regardless of grass species (Table 1).

Cumulative rainfall from the time of herbicide application to initiation of the second grazing period in July 1978 was 16.5 cm. Neither rate of tebuthiuron had reduced the standing crop of Bell rhodesgrass by the mid-summer grazing trial (Table 1). However, both herbicide rates had reduced the standing crop of kleingrass; and 4.4 kg/ha of tebuthiuron had reduced the standing crop of weeping lovegrass, compared to untreated standing crops. At the time of the grazing trial in July, grasses treated with the higher herbicide rate were noticeably shorter than the untreated plants, stands were obviously thinned, and the plants were uniformly chlorotic. These symptoms were more apparent with kleingrass than with Bell rhodesgrass or weeping lovegrass.

Cumulative rainfall on the study area from time of application of the herbicide in April to initiation of the grazing trial in October was 37 cm. The standing crop of kleingrass had been severely reduced by October where 4.4 kg/ha of tebuthiuron were applied the previous April (Table 1). Average standing crops of grasses were reduced by 48% at the time of the fall grazing trial where 2.2 kg/ha of tebuthiuron were applied.

At the time of the grazing trial on July 9–13, 1979, the study area had received a total of 139 cm of rainfall since herbicide application in 1978. Grass standing crop had not recovered from the applications of tebuthiuron the previous spring (Table 1).

Disappearance of grass standing crop varied with time of grazing, grass species, and herbicide treatment (Table 2). During the first grazing trial after treatment, mean percentage disappearance where 2.2 kg/ha of tebuthiuron were applied was no different than where no herbicide was applied, regardless of grass species. However, percentage disappearance of all species was significantly increased where 4.4 kg/ha of tebuthiuron were applied compared to disappearance of untreated standing crop.

During the grazing trial in July 1978, percentage disappearance was significantly greater from tebuthiuron-treated Bell rhodesgrass plots than from untreated plots (Table 2). However percentage disappearance of kleingrass and weeping lovegrass standing crops was increased only where 4.4 kg/ha of the herbicide had been applied. Percentage disappearance of standing crops in the fall was greater where tebuthiuron had been applied the previous April than from untreated stands, except where 2.2 kg/ha of the herbicide were applied to kleingrass. Moreover, the percentage disappearance of standing crops from plots treated with 4.4 kg/ha was greater than from those treated with 2.2 kg/ha of the herbicide.

During the summer of 1979, after application of the tebuthiuron in the spring of 1978, forage disappearance was increased compared to that from untreated stands where 4.4 kg/ha of tebuthiuron had been applied to Bell rhodesgrass (Table 2). There was also increased percentage disappearance of kleingrass where 2.2 kg/ha were applied.

Table 2. Percentage disappearance of standing crops of grasses immediately following grazing trials during various periods following tebuthiuron application on April 27, 1978, near College Station, Tex.

Tebuthiuron rate (kg/ha)	Grazing period[2] 1978 May 29– July 18–22	Oct. 16–20	July 9–13	1979 July 9–13
	Bell rhodesgrass			
0	45 cde	22 a	30 ab	56 ef
2.2	40 bc	42 cd	49 def	56 ef
4.4	66 fg	60 efg	84 h	72 h
	Kleingrass			
0	33 ab	28 a	41 b	56 cd
2.2	39 b	25 a	32 ab	68 e
4.4	56 cd	62 de	68 e	54 c
	Weeping lovegrass			
0	21 cd	8 ab	14 bc	0 a
2.2	33 de	17 bc	31 de	9 ab
4.4	36 e	42 e	76 f	86 f

[2]Means followed by the same letter within a species are not significantly different ($P \leq .05$) according to Tukey's *w*-procedure.

Table 3. Mean grazing durations (minutes/hour of grazing/cow) at various times after tebuthiuron application on April 27, 1978 near College Station, Texas.

Tebuthiuron rate (kg/ha)		Grazing period[1] 1978 May 29–June 2	July 18–22	Oct. 16–20	1979 July 9–13
		Bell rhodesgrass			
0		3.6 b	1.9 ab	4.8 a	3.9 bc
2.2		3.8 b	2.6 ab	4.6 a	3.0 bc
4.4		1.4 a	1.8 ab	4.7 a	3.1 bc
	χ^2	0.12	0.27	9.43[2]	1.04
		Kleingrass			
0		3.7 b	2.2 ab	6.3 a	3.7 bc
2.2		2.5 ab	3.4 b	4.3 a	4.3 bc
4.4		1.6 ab	2.3 ab	4.3 a	4.0 bc
	χ^2	0.34	12.26[3]	13.27[3]	1.72
		Weeping lovegrass			
0		1.8 ab	1.7 ab	4.1 a	0.1 a
2.2		1.6 ab	2.6 ab	3.5 a	2.0 ab
4.4		1.1 a	1.3 a	3.6 a	4.8 c
	χ^2	-0.60	1.27	7.15	427.68[3]

[1]Means within a column followed by the same letters are not significantly different ($P \leq .05$) according to Tukey's *w*-procedure.
[2]Chi-square significant ($P \leq .05$).
[3]Chi-square significant ($P \leq .01$).

Influence of Treatment on Grazing Patterns

The average time (minutes grazing/hour of trial/cow) spent grazing treatments during the period, May 25–June 2, 1978 (Table 3), appeared to be roughly proportional to availability of forages (Table 1). Thus, chi-square analysis did not indicate deviation of observed grazing durations from those expected (Table 3) even though a greater proportion of the standing forage disappeared where the higher herbicide rate was applied (Table 2). The frequency of grazing visits also tended to decrease as herbicide treatment reduced available forage (Table 4).

During the summer grazing trial of 1978, there were no significant differences among mean grazing durations attributable to herbicide treatment within a grass species (Table 3), and no differences in frequencies of grazing visits (Table 4), regardless of grass species or tebuthiuron rate. This uniform grazing use accounted for increased percentage disappearance where standing crop had been reduced by the herbicide treatment (Table 2). Durations of grazing use of kleingrass on herbicide-treated plots were longer than expected ($P < .01$) based on forage standing crop (Table 3).

During the fall trial, durations of grazing use were again uniform across treatments (Table 3) but there was a tendency for increased frequencies of grazing visits to herbicide-treated plots compared to untreated areas (Table 4). Only with kleingrass was there a tendency for decreased durations of grazing on the plots treated with tebuthiuron (Table 3). Thus, durations of grazing on the herbicide-treated plots were longer than expected if grazing use had been proportional to forage availability. This use accounted for the disproportionate forage disappearance among treatments, regardless of species (Table 2).

Table 4. Frequencies of grazing visits (visits/cow/hour) during grazing trials at various times after application of tebuthiuron on April 27, 1978, to 3 grass species near College Station, Tex.

Tebuthiuron rate (kg/ha)		Grazing period[1] 1978 May 29–June 2	July 18-22	Oct. 16–20	1979 July 9–13
		Bell rhodesgrass			
0		10.0 b	3.5 a	5.0 ab	3.0 ab
2.2		9.3 ab	4.5 a	4.0 ab	4.1 ab
4.4		4.0 a	3.5 a	8.7 ab	5.1 bc
	χ^2	3.65	0.28	2.94	1.87
		Kleingrass			
0		7.3 ab	3.7 a	6.7 ab	4.7 abc
2.2		7.0 ab	4.9 a	8.0 ab	5.2 bc
4.4		5.7 ab	2.7 a	9.3 b	6.9 c
	χ^2	0.36	0.66	1.26	1.08
		Weeping lovegrass			
0		7.7 ab	3.3 a	3.3 a	2.3 a
2.2		4.7 ab	4.7 a	6.0 ab	3.7 ab
4.4		6.0 ab	3.3 a	6.3 ab	4.9 bc
	χ^2	1.38	0.59	4.94	3.79

[1]Means within a column followed by the same letter are not significantly different ($P \leq .05$) according to Tukey's *w*-procedure. No chi-square values were significant ($P \leq .05$).

There were no differences among mean grazing durations attributable to herbicide treatment of Bell rhodesgrass or kleingrass during the grazing trial conducted in July of 1979 (Table 3). However, the frequencies of grazing visits (Table 4) and mean grazing durations (Table 3) were significantly increased where 4.4 kg/ha of tebuthiuron were applied to weeping lovegrass, compared to untreated stands. This increased grazing use apparently accounted for the high percentage of forage which disappeared where the higher rate of the herbicide was applied (Table 2).

Native Stands

Treatment Influences on Forage Availability

As with the artificially seeded grass stands, potential differences in forage standing crops attributable to weed control or to herbicide damage were minimized by the mowings applied prior to the grazing trials. The mowings were judged as being necessary to minimize confounding of the grazing responses with stage of vegetation development induced by herbicide treatment.

By June 25 after herbicide application on April 5, 1979, 43 cm of rainfall has been received on the study area of which 26 cm occurred in May. Standing crops of grass at that time were generally unaffected by treatment (Table 5). However, percentage forage disappearance at the end of the first grazing trial was greater where tebuthiuron was applied at 1 or 2 kg/ha, compared to other treatments.

Although 23 cm of rainfall had been received since the last grazing trial, grass standing crop was uniformly lower during the grazing trial conducted July 20–August 2 than during the June 1979 trial (Table 5). However, mean standing crops on plots treated with the picloram sprays or with the higher rates of tebuthiuron pellets were greater than on untreated plots. Percentage forage disappearance was increased only where 1 or 2 kg/ha of tebuthiuron had been applied compared to that from untreated plots.

At the time of the grazing trial in July 1980, standing crops of grass tended to be greater on plots treated with herbicides than on those not treated, but were significantly increased only where picloram at 1 kg/ha or tebuthiuron at 2 kg/ha had been applied (Table 5). There were not differences in percentage forage disappearance among treatments the year after herbicide applications.

Influence of Treatment on Grazing Patterns

Mean durations of grazing were increased on all plots treated with tebuthiuron, regardless of application rate, during the June 1979 grazing trial (Table 6). Mean frequencies of grazing visits were increased on all herbicide-treated areas except those receiving 2,4-D sprays (Table 7). This increased activity on the herbicide-treated plots was greater than expected ($P \leq .01$) based on differences in herbage standing crops. Patterns of grazing during the July–August 1979 trial were generally similar to those discussed for the grazing trial conducted in late June.

By the fall 1979, there was a trend toward increased durations of grazing on herbicide-treated plots, but there were no significant differences among treatments (Table 6). However, plots treated with 1 or 2 kg/ha of tebuthiuron were visited more frequently than those not treated with herbicide (Table 7). Thus, the trend toward increased grazing activity was adequate to account for increased disappearance of forage from plots treated with 2 kg/ha of tebuthiuron (Table 5). By July, 15 months after herbicide application, there were no differences in grazing activities attributable to herbicide treatment (Tables 6 and 7) accounting for relatively uniform forage disappearance (Table 5).

Conclusions

Applications of tebuthiuron at 2.2 or 4.4 kg/ha reduced standing crops of Bell rhodesgrass, kleingrass, and weeping lovegrass the year of application. Moreover, the higher application rate (4.4 kg/ha) suppressed standing crops of Bell rhodesgrass and kleingrass into the second growing season. However, by midsummer and fall after herbicide applications in the spring, the cows spent more time grazing on plots treated with tebuthiuron than on untreated plots.

Applications of tebuthiuron at 1 or 2 kg/ha did not reduce grass production of native stands dominated by little bluestem and brownseed paspalum. As with the first experiment, cattle spent more time than expected grazing on the tebuthiuron-treated plots. Although cattle usually spent more of their time grazing on plots

Table 5. Grass standing crop (SC) prior to grazing and percentage disappearance (D) of grass grazed at various times after application of several herbicides on April 5, 1979 near College Station, Texas.

Herbicide	Rate (kg/ha)	Formulation	Grazing period[1] 1979 June 24-29 SC (kg/ha)	D (%)	July 20–Aug 2 SC (kg/ha)	D (%)	Oct 30–Nov 1 SC (kg/ha)	D (%)	1980 July 8-11 SC (kg/ha)	D (%)
None	0	—	1,547 ab	45 a	508 a	42 a	754 a	30 a	816 a	35 a
2,4-D	1	Spray	1,989 b	49 a	639 ab	54 ab	1,212 ab	36 ab	1,506 ab	43 a
Picloram	1	Spray	1,323 ab	46 a	858 b	56 ab	1,440 b	37 ab	1,585 b	45 a
Tebuthiuron	0.5	Pellets (20%)	1,428 ab	44 a	721 ab	59 ab	877 ab	31 a	1,429 ab	28 a
Tebuthiuron	1	Pellets (20%)	1,238 ab	68 b	782 b	68 b	1,042 ab	47 ab	1,512 ab	44 a
Tebuthiuron	2	Pellets (20%)	1,135 a	69 b	773 b	72 b	1,344 b	52 b	1,691 b	41 a

[1]Means within a column followed by the same letter are not significantly different ($P \leq .05$) according to Tukey's *w*-procedure.

Table 6. Average grazing duration (minutes/hour of grazing/cow) on herbicide-treated areas during grazing periods at various times following treatment rangeland on April 5, 1979, near College Station, Tex.

			Grazing times (minutes)[1]			
		Rate	1979			1980
Herbicide	Formulation	(kg/ha)	June 25-29	July 30–Aug 2	Oct 30–Nov 1	July 8 -11
None	—	0	5.9 ab	5.6 a	9.1 a-d	7.4 abc
2,4-D	Spray	1	9.8 a-e	10.3 a-f	11.8 b-f	9.8 a-e
Picloram	Spray	1	11.7 b-f	11.4 a-f	11.7 b-g	11.8 b-f
Tebuthiuron	Pellets (20%)	0.5	12.1 c-f	16.0 fg	14.5 d-g	10.8 a-f
Tebuthiuron	Pellets (20%)	1	13.4 c-f	16.2 fg	13.5 def	10.8 a-f
Tebuthiuron	Pellets (20%)	2	19.6 g	15.8 efg	12.8 c-f	12.0 b-f
		χ^2	88.05**	39.10**	4.63	3.26

[1]Means followed by the same letter are not significantly different according to Tukey's *w*- procedure at ($P \leq .05$).
**Significant chi-square value, $P \leq .01$.

Table 7. Frequencies of cow grazing events (visits/cow/hour) at various times after application of herbicides to range on April 6, 1979, near College Station, Tex.

			Frequency by grazing period[1]			
	Rate (kg/ha		1979			1980
Herbicide	[a.i.])	Formulation	June 25–29	July 30–Aug 2	Oct 30–Nov 1	July 8–11
None	0	——	10.8 a	11.7 ab	12.4 abc	15.2 a
2,4-D	1	Spray	15.4 a-d	16.4 a-d	15.9 a-d	15.4 a
Picloram	1	Spray	17.4 bcd	15.7 a-d	17.5 bcd	15.8 a
Tebuthiuron	0.5	Pellets (20%)	17.5 bcd	19.8 d	16.2 a-d	17.5 a
Tebuthiuron	1	Pellets (20%)	17.3 a-d	16.4 a-d	19.1 d	18.4 a
Tebuthiuron	2	Pellets (20%)	21.6 d	19.7 d	18.9 d	17.7 a
		χ^2	24.86**	16.23**	11.06	1.46

[1]Means followed by the same letter are not significantly different according to Tukey's *w*-procedure ($P \leq .05$).
* Significant chi-square value, $P \leq .05$.
**Significant chi-square value, $P \leq .01$.

treated with 2,4-D or picloram than on untreated plots, the time spent on tebuthiuron-treated areas was often greater than that spent grazing plots treated with the other herbicides.

Since the influence of stage of grass plant maturity and impacts of weed control were reduced as much as possible by mowing, results of these experiments indicate a preference by the cattle for areas treated with tebuthiuron. Thus, the hypothesis that herbicide treatment has no effect on the grazing preferences of cows was rejected. However, this preference was generally demonstrated only during the first growing season after application of the herbicides.

The management implications of this study indicate that treatment of portions of a pasture with the herbicide tebuthiuron may cause major shifts in utilization patterns by cattle. Forage on the treated area may be over-utilized in comparison to forage on treated areas. When plans call for treating a portion of a pasture, the manager should probably consider (1) fencing the treated area so it can be grazed independently of the untreated, (2) using stocking rates to prevent over-utilization of the treated area, or (3) deferring grazing during the first growing season.

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