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Abstract: Creosotebush (Larrea tridentata (DC.) Cov.) has increased in the desert rangeland and this extension has caused a decrease in forage production. Tebuthiuron (N-(5-1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl)-N-N¹-dimethyurea) has been shown to control creosotebush and some associated woody plants. This study was conducted to determine vegetation responses following application of different rates of tebuthiuron. Four areas were selected: three in the Chihuahuan desert and one in the Sonoran desert. Tebuthiuron was applied during the spring of 1981 and 1982 at rates of 0.5, 1.0, and 1.5 kg ai/ha. Shrub cover and herbaceous density were measured before and after treatment. Average shrub cover on the four areas decreased, average grass density tended to increase, and average forb density decreased on plots treated.

Creosotebush has no forage value but is invading grassland areas where livestock production is suitable. In the United States it covers about 262,680 km² (10) and in Mexico about 453,250 km² (11). At the present time, creosotebush is increasing its distribution (5), and this shrub and associated woody species reduce forage production of grasses and browse plants. It is well documented that control of woody species increases forage production (7, 9, 13, 14, 16). Tebuthiuron has been used to control many woody species in noncroplands (6, 14). In general, most of the studies not only report control of a specific woody species, but also an increase in herbage yield. Alley (1) using 2.2, 3.4, and 4.5 kg/ha almost completely controlled snakeweed (Gutierrezia sarothrae (Porsch.) Britt and Rusby) after two years; however, grass density decreased from 50 to 85%. Bjerregaard (2) controlled a wide range of woody species at 0.56 to 4.48 kg/ha rates. He found that rates up to 2.24 kg/ha were tolerated by herbaceous plants. Duncan and Scifres (4) report that 2 kg/ha was more effective than 1 kg/ha in controlling yaupon (Ilex vomitoria Ait.). Despite slow herbaceous response, grasses increased and forbs decreased. Johnsen (8) used 2.2 kg/ha to control juniper (Juniperus deppeana Steud. and J. pinchottii Sudw.) and peak forage production was reached after 3 to 5 years. Meyer and Boverly (12) controlled Macartney rose (Rosa bracteata Wendl.) at 4.5 kg/ha. Sosebee et al. (15) report control of mesquite using 2.2, 4.5 and 9.0 kg/ha.

The objective of this study was to determine changes in the cover of shrubs and the density of grasses and forbs in four creosotebush communities following tebuthiuron treatments.

Materials and Methods

Four creosotebush areas were selected for the study. Three of them were located in Mexico: Rancho Los Pozos, Aldama; Rancho La Reforma, Allende; and Rancho El Toro, Villa Ahumada, in the state of Chihuahua; and one in the United States: Santa Rita Experimental Range (SRER), Tucson, AZ.

Los Pozos soils are of alluvial origin with gravel and some rocks in the profile. The topography of the area is mainly flat with undulating slopes which range between 0% and 4% (3). The elevation is 1400 m. The average annual precipitation is about 253 mm. The mean annual temperature is 17.9C. The main shrub species are creosotebush, whitethorn (Acacia constricta Benth.) and tarbush (Flourensia cernua DC.). The predominant grasses are fluffgrass (Tridens pulchellus (H.B.K.) Hitchc.), bushmuhly (Muhlenbergia porteri Scribn.), and spike pappus grass (Enneapogon desvauxii Beauv.).

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La Reforma soils have an alluvial origin with a calcareous layer that occurs near the surface and as deep as 30 cm. The topography is undulating, slopes are from 2% to 16%, and the elevation is 1500 m (3). The average annual precipitation is 400 mm. The mean annual temperature is 17.5C. The most abundant woody species are creosotebush, whitethorn, shrubby senna (Cassia wislizeni Gray), tarbush, and mariola (Parthenium incanum H.B.K.). The most abundant grasses are grama grasses (Bouteloua spp.) and bushmuhly.

El Toro soils are alluvial with gravel and few rocks in the profile. The topography is mainly flat with slopes less than 5%, the elevation is 1380 m and average annual precipitation is about 270 mm (3). The mean annual temperature is 17.7C. The main shrubs are creosotebush, honey mesquite (Prosopis glandulosa (Toor) Cockll.) and tarbush. The main grasses are black grama (Bouteloua eriopoda Torr.) and fluffgrass.

SRER soils originated from alluvial material. The topography is relatively flat with slopes that vary from 1% to 5%. Elevation is 968 m. The average annual precipitation is 290 mm. The mean annual temperature is 17.5C. The dominant woody species are creosotebush, desert zinnia (Zinnia pumila Gray), and velvet mesquite (Prosopis juliflora var. velutina (Woot.) Sarg.). The most abundant grasses are fluffgrass, bushmuhly, and Santa Rita three awn (Aristida glabrata (Vasey) Hitchc.).

In 1981, 0.5 ha plots were established at the four areas and three tebuthiuron treatments were applied: 0.5, 1.0 and 1.5 kg ai/ha plus the control. Treatments were arranged in a complete randomized block design with three replications. The same number and size of plots with the same treatments were repeated in 1982 in all the areas. Since the beginning of the study in 1981, the whole area was fenced to exclude grazing.

Prior to the treatment applications, three permanent transects 30 m long were placed in each plot. Canopy cover was determined measuring the canopy of woody species that were intercepted by the transects. Associated with each transect a belt 30 cm wide was established where herbaceous plants were counted to determinate density. Measurements were made before and after the treatments were applied.

Cover and density were analyzed by using analysis of variance and, where appropriate, mean separation by Duncan's multiple range test.

Results and Discussion

El Toro Site. Table 1 summarizes the cover of creosotebush, mesquite, tarbush and other major woody species at El Toro before treatment and one and two years after. The minor species were whitethorn, condalia (Condalia spp.), snakeweed (Gutierrezia sarothrae (Porsh) Britt and Rusby), and wolfberry (Lycium spp.).

Cover of all shrubs was reduced by all the treatments. The only significant difference was between treatments and untreated control.

Response of herbaceous plants are presented in Table 2. The abundant perennial grasses were black grama, bushmuhly, and fluffgrass. There were no significant differences among rates of herbicide and control either before treatment or after one or two years. However, in plots treated in 1981 there was an increase of grasses between 1981 and 1983. There was a decrease between 1982 and 1983, with the greatest reductions occurring on the plots treated with the higher rates of tebuthiuron.

Table 1. Percent cover of creosotebush, mesquite, tarbush and other shrubs before treatment with 3 rates of tebuthiuron and 1 and 2 years after treatment at Rancho El Toro.^a

Rate (kg/ha)	Creosotebush		Mesquite		Tarbush		Other	
	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>
	-----Treated May, 1981-----							
0.0	27a	31b	9a	8b	Ta	0a	1a	7b
0.5	39a	0a	9a	4a	2a	0a	5a	1a
1.0	37a	Ta	6a	2a	2a	0a	1a	0a
1.5	29a	1a	10a	Ta	6a	0a	2a	0a
	-----Treated May, 1982-----							
0.0	26a	28b	6a	3a	6a	8b	22a	20b
0.5	27a	0a	17b	6a	Ta	0a	12a	2a
1.0	15a	0a	12b	4a	11b	1a	22a	1a
1.5	28a	1a	12b	4a	6a	0a	20a	1a

^aMeans within a column followed by the same letter are not significantly different ($P < 0.05$) according to Duncan's multiple range test.

^bT equals a value less than 1%.

Table 2. Density of herbaceous plants (plants/m²) before treatment with 3 rates of tebuthiuron and 1 and 2 years after treatment at Rancho El Toro.^a

Rate (kg/ha)	Perennial Grasses		Annual Grasses		Perennial Forbs		Annual Forbs	
	-----Treated May, 1981-----							
	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>
0.0	17a	40a	Ta	Ta	2a	1a	145a	2a
0.5	13a	28a	0a	0a	1a	0a	146a	3a
1.0	19a	14a	0a	0a	1a	0	150a	2a
1.5	15a	17a	2a	Ta	1a	0	208a	1a
	-----Treated May, 1982-----							
	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>
0.0	41a	40a	2a	0a	0a	1a	12a	2a
0.5	50a	35a	0a	0a	0a	0a	9a	1a
1.0	48a	30a	Ta	Ta	0a	0a	8a	0a
1.5	46a	26a	1a	0a	0a	0a	4a	1a

^aMeans within a column followed by the same letter are not significantly different (P<0.05) according to Duncan's multiple range test.

^bT equals a value less than 1.0 plant/m².

Annual grasses and perennial forbs were not present in significant amounts. Annual forbs such as spectacle-pod (Dithyrea wislizenii Engelm.) and Aphanostephus ramosissimus (Torr and Gray) were abundant before treatment in 1981, but not in 1983. The decrease could be due to herbicide treatments, but more probably was due to low rainfall in 1983, for the decrease also occurred on untreated plots.

SRER Site. Table 3 shows the percent cover of creosotebush, desert zinnia, and other shrubs which included whitethorn, velvet mesquite, and catclaw.

All treatments applied both in 1981 and 1982 reduced cover of all woody species. There were no significant differences among dosages of tebuthiuron for any species in the 1981 treatments. The 1982 treatments follow the same trend.

Table 4 shows the density of herbaceous plants. The main perennial grasses were fluffgrass, bushmuhly, and Santa Rita three awn. Perennial grasses increased in all plots treated with tebuthiuron in the 1981 and 1982 treatments.

Main perennial forbs were bahia, desert holly (Perezia nana Gray), and goldenweed (Haplopappus gracilis (Nutt.) Gray). Perennial forb response was not significantly different among treatments or between them and the control. However, they were reduced or completely eliminated on the plots treated with tebuthiuron, but the control plots had slight increases after both years of treatment.

Annual grasses were not present on any of the plots at the time of the sampling. Annual forbs present were Chorizanthe rigida (Torr.) Torr. & Gray, spurge (Euphorbia spp.) and Russian thistle (Salsola iberica L.). They were not abundant on the plots treated in 1981 or 1982.

Los Pozos Site. The dominant woody species were creosotebush, whitethorn, and tarbush. Other species present were catclaw, mariola, and whitebrush (Aloysia lycioides Cham.). Table 5 shows cover before and after treatment for applications in 1981 and 1982. All the rates of herbicide reduced shrub cover significantly for all the species in both years of application.

Table 6 presents the data for density of herbaceous plants. The perennial grasses of the area were primarily bushmuhly, fluffgrass and spike pappus grass. At all rates as well as in the control, their densities decreased after the 1981 applications. There were no significant differences between rates. They increased between 1982 and 1983, but without any significant difference between treatments.

Perennial forbs were bahia, croton (Croton corymbulosus Engim.), trailing four-o'clock (Allionia incarnata L.) and sida (Sida procumbense Sw.). On plots treated in 1981 they decreased, but there were no significant differences between treatments. On plots treated in 1982 there were low densities of perennial forbs which increased on the untreated plots by 1983 but not on the plots treated with tebuthiuron.

Annual grasses were not present in significant amounts. Annual forbs present in the area were Aphanostephus ramosissimus Torr. & Gray., spectacle-pod, and Cryptantha pusilla Torr. & Gray. They decreased on plots treated in 1981 and 1982, without significant differences between treatments.

Table 3. Percent cover of creosotebush, desert zinnia, and other shrubs before treatment with 3 rates of tebuthiuron and 1 and 2 years after treatment at SRER.^a

Rate (kg/ha)	Creosotebush		Zinnia		Other	
	------(%) ^b -----					
-----Treated May, 1981-----						
	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>
0.0	61a	65b	3a	6b	10a	5b
0.5	73a	10a	4a	0a	1a	0a
1.0	66a	Ta	5a	0a	8a	0a
1.5	68a	Ta	3a	0a	6a	0a
-----Treated May, 1982-----						
	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>
0.0	70a	63a	3a	7b	2a	6b
0.5	85a	31b	1a	0a	7a	2a
1.0	65a	5b	1a	0a	7a	2a
1.5	71a	2b	1a	0a	10a	0a

^aMeans within a column followed by the same letter are not significantly different ($P < 0.05$) according to Duncan's multiple range test.

^bT equals a value less than 1%.

Table 4. Density of herbaceous plants (plants/m²) before treatment with 3 rates of tebuthiuron and 1 and 2 years after treatment at SRER.^a

Rate	Perennial Grasses		Annual Grasses		Perennial Forbs		Annual Forbs	
	------(Plants/m ²) ^b -----							
-----Treated May 1981-----								
(kg/ha)	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>
0.0	4a	11a	0a	0a	5a	7a	0a	1a
0.5	1a	16a	0a	0a	4a	1a	1a	1a
1.0	2a	58a	0a	0a	11a	1a	1a	0a
1.5	5a	23a	0a	0a	5a	0a	0a	1a
-----Treated May 1982-----								
	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>
0.0	2a	20a	0a	0a	Ta	2a	15a	1a
0.5	0a	21a	0a	0a	Ta	0a	10a	1a
1.0	2a	2a	0a	0a	0a	0a	1a	0a
1.5	2a	12a	0a	0a	0a	0a	6a	0a

^aMeans within a column followed by the same letter are not significantly different ($P < 0.05$) according to Duncan's multiple range test.

^bT equals a value less than 1 plant/m².

Table 5. Percent cover of creosotebush, whitethorn, tarbush and other shrubs before treatment with 3 rates of rebuthiuron and 1 and 2 years after treatment at Rancho Los Pozos.^a

Rate	Creosotebush		Whitethorn		Tarbush		Other	
(kg/ha)	----- (x) ^b -----							
	-----Treated May, 1981-----							
	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>
0.0	51a	33b	1a	1a	3a	16b	3a	3a
0.5	46a	8a	1a	Ta	1a	2a	6a	5a
1.0	49a	7a	2a	0a	2a	1a	8a	1a
1.5	38a	2a	2a	0a	1a	0a	2a	0a
	-----Treated May, 1982-----							
	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>
0.0	34a	28b	15a	18b	Ta	2a	6a	10b
0.5	48a	5a	7a	2a	4a	1a	12a	7a
1.0	39a	6a	15a	7a	3a	Ta	8a	0a
1.5	46a	7a	10a	0a	3a	0a	10a	2a

^aMeans within a column followed by the same letter are not significantly different ($P < 0.05$) according to Duncan's multiple range test.

^bT equals a value less than 1%.

Table 6. Density of herbaceous plants (plants/m²) before treatment with three rates of tebuthiuron and 1 and 2 years after treatment at Rancho Los Pozos.^a

Tebuthiuron (kg/ha)	Perennial Grasses		Annual Grasses		Perennial Forbs		Annual Forbs	
	------(Plants/m ²) ^b -----							
	-----Treated May 1981-----							
	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>
0.0	99a	32a	Ta	0a	80a	33a	80a	33a
0.5	77a	68a	Ta	0a	54a	11a	54a	11a
1.0	114a	38a	Ta	0a	46a	8a	46a	8a
1.5	28a	16a	Ta	0a	37a	3a	37a	3a
	-----Treated May 1982-----							
	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>
0.0	21a	51a	0a	0a	4a	14b	97a	14a
0.5	26a	38a	0a	0a	2a	4a	92a	6a
1.0	23a	32a	0a	0a	2a	2a	100a	2a
1.5	33a	38a	0a	0a	2a	1a	91a	4a

^aMeans within a column followed by the same letter are not significantly different ($P < 0.05$) according to Duncan's multiple range test.

^bT equals a value less than 1 plant/m².

La Reforma Site. The dominant shrubs were creosotebush, whitethorn, shrubby senna, and tarbush. Other shrubby species present were mariola, catclaw, and condalia. Table 7 shows their cover before and after treatments for 1981 and 1982. On the 1981 plots all tebuthiuron rates reduced the cover of creosotebush, tarbush, whitethorn, shrubby senna, and the minor shrubby species. There were no significant differences among dosages. In the plots treated in 1982, there were no significant differences in shrub cover in 1983 for all species, except whitethorn and shrubby senna.

Dominant perennial grasses were bushmuhly, sideoats grama (*Bouteloua curtipendula* (Michx.) Torr.) and blue grama (*B. gracilis* (H.B.K.) Log.). There was not a significant change from 1981 to 1983. Densities of perennial grasses decreased between 1982 and 1983.

Perennial forbs were sida, croton, and *Euphorbia* spp. On plots treated in 1981, perennial forb density decreased between 1981 and 1983. There were no significant differences between treatments. Plots treated in 1982 had some change, but they were not significantly different even though there was an increase on the untreated plots.

Annual grasses were not present in significant amounts at any of the sampling dates.

Main annual forb was *Aphanostephus ramosissimus*. On plots treated in 1981, only those receiving the 1.0 kg/ha rate showed a significant difference in density from other treatments. Plots treated in 1982 show a reduction of annual forbs from 1982 to 1983 with no significant difference between treatments.

Conclusions

Tebuthiuron reduced the cover of most woody species in the creosotebush communities one or two years after application. Perennial grass response varied among the areas since precipitation was also variable. At El Toro and SRER where annual precipitation was average or above average, perennial grasses increased. Los Pozos and La Reforma were the driest areas throughout the study and their grass densities decreased. Perennial forbs decreased regardless of precipitation on all the treated areas. Populations of annual plants were extremely variable and their abundance was due as much to precipitation as to herbicide treatments.

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Table 7. Percent cover of creosotebush, whitethorn, shrubby senna, tarbush and other shrubs before treatment with 3 rates of tebuthiuron and 1 and 2 years after treatment at Rancho La Reforma.^a

Rate (kg/ha)	Creosotebush		Whitethorn		Shrubby Senna		Tarbush		Others	
	(%) ^b									
-----Treated May, 1981-----										
	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>
0.0	10a	10b	24a	22b	17a	18b	9a	18b	21a	22b
0.5	8a	3a	41a	9a	15a	3a	8a	1a	32a	7a
1.0	8a	5a	51a	7a	12a	Ta	10a	1a	42a	6a
1.5	7a	0a	34a	1a	30a	Ta	1a	0a	25a	Ta
-----Treated May, 1982-----										
	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>
0.0	9a	7a	62a	48b	14a	9b	5a	3a	23a	14a
0.5	5a	4a	47a	4a	12a	4a	1a	1a	35a	6a
1.0	5a	1a	30a	3a	9a	1a	5a	0a	47a	11a
1.5	8a	0a	48a	1a	3a	0a	8a	0a	32a	5a

^aMeans within column followed by the same letter are not significantly different ($P < 0.05$) according to Duncan's multiple range test.

^bT equals a value less than 1%.

Table 8. Density of herbaceous plants (plants/m²) before treatment with three rates of tebuthiuron and 1 and 2 years after treatment at Rancho La Reforma.^a

Rate (kg/ha)	Perennial Grasses		Annual Grasses		Perennial Forbs		Annual Forbs	
	------(Plants/m ²) ^b -----							
-----Treated May, 1981-----								
	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>	<u>1981</u>	<u>1983</u>
0.0	0a	1a	0a	0a	70a	24a	120a	20a
0.5	2a	2a	0a	0a	40a	20a	102a	30a
1.0	1a	1a	0a	0a	50a	7a	75a	201b
1.5	0a	0a	0a	0a	86a	6a	140a	25a
-----Treated May, 1982-----								
	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>	<u>1982</u>	<u>1983</u>
0.0	88a	7a	3a	0a	5a	14a	63a	30a
0.5	58a	10a	Ta	0a	8a	8a	46a	19a
1.0	60a	5a	0a	0a	10a	4a	40a	10a
1.5	72a	6a	Ta	0a	5a	1a	45a	4a

^aMeans within a column followed by the same letter are not significantly different ($P < 0.05$) according to Duncan's multiple range test.

^bT equals a value less than 1 plant/m².

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