# Field-Scale Tebuthiuron Application on Brush-Infested Rangeland[1]

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**Abstract.** The objective of this study was to determine the effectiveness of tebuthiuron {*N*-[5-(1,1-dimethylethyl)-1,3,4-thiadiazol-2-yl]-*N*,*N*'-dimethylurea} to treat brush-infested arid rangeland under field-scale conditions. A 130-ha tract in southern New Mexico dominated by creosotebush [*Larrea tridentata* (Sesse & Moc. ex DC.) Coville #[3] LARTR] was treated with pelleted tebuthiuron at 0.4 kg ai/ha. After the fourth season following treatment, control of creosotebush, honey mesquite (*Prosopis glandulosa* Torr. # PRCJG), and tarbush (*Flourensia cernua* DC. # FLOCE) was 87, 48, and 100%, respectively. Total shrub density was reduced from 4440 plants/ha to 570 plants/ha. Grass basal area increased from 1.1 to 3.4%. The treatment did not affect forbs greatly. Total herbaceous above-ground biomass production in the fourth season after treatment was 860 kg/ha compared to 140 kg/ha on an adjacent untreated area. Perennial grass production was nearly 11-fold greater on the treated area than on the untreated area.

**Additional index words:** *Flourensia cernua, Larrea tridentata, Prosopis glandulosa*, grass cover, arid rangeland, FLOCE, LARTR, PRCJG.

## INTRODUCTION

Since 1900, shrubs have become dominant on many former grasslands in the Southwest (19). Creosotebush, mesquite, and tarbush have increased on arid rangelands (2), occurring on an estimated 37.7, 18.8, and 5.4 million ha, respectively (12). Early recognition of the adverse effects of brush upon forage production has led to efforts to find effective control techniques (5, 16).

Tebuthiuron effectively controls various woody plants (8, 9, 13). Jacoby et al. (7) reported that tebuthiuron at 0.5, 0.7, and 1.0 kg/ha on gravelly loams in eastern Trans-Pecos in Texas killed 86, 91, and 99%, respectively, of creosotebush. Grass production 44 months after application at 0.5 kg/ha was 657 kg/ha on treated plots and was 259 kg/ha on untreated rangeland. Forb production 33 months after application on the treated area was 38% less than on the untreated area. At 44 months after application, forb production was 401 and 138 kg/ha on treated and untreated areas, respectively.

Tebuthiuron at 0.4, 0.8, and 1.6 kg/ha on silty clay loams in western Edwards Plateau in Texas killed 68, 95, and 98%, respectively, of tarbush (15). Compared to untreated rangeland, grass production was increased 81 and 158% during the second growing season and 61 and 90% during the third growing season after tebuthiuron at 0.8 and 1.6 kg/ha, respectively, was applied. Forb production on treated areas was 43% of that on untreated areas the second season after application, but in the third season forb production was 126 and 182% greater than on the untreated area on the 0.8 and 1.6 kg/ha treated areas, respectively.

Tebuthiuron at 0.56, 1.12, and 2.24 kg/ha on a sandy loam in southern Arizona killed 77, 97, and 99% of creosotebush and 78, 100, and 100% of velvet mesquite (*P. velutina* Woot. # PRCJV) plants, respectively (10). After 21 months, tebuthiuron at 0.84 kg/ha on loamy-skeletal soils in Arizona apparently killed 100% of tarbush, fourwing saltbush [*Atriplex canescens* (Pursh.) Nuttall # ATXCA], and littleleaf sumac (*Rhus microphylla* Engelm. # RHUMC). Kills for creosotebush, whitethorn (*Acacia constricta* Gray # ACACS), and graythorn (*Condalia spathulata* Gray) were 61, 92, and 0% respectively (4). Tebuthiuron at 0.20 to 3.28 kg/ha was applied aerially to 5-ha plots on a loamy range site on the Jornada Experimental Range for 4 yr, 1977–80 (6). Creosotebush kill ranged from 37 to 99%, and tarbush kills ranged from 76 to 100%.

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[3] Letters following this symbol are a WSSA-approved computer code from Composite List of Weeds, Weed Sci. 32, Suppl. 2. Available from WSSA, 309 West Clark Street, Champaign, IL 61820.

Because acceptable creosotebush kills (75%) had been obtained from tebuthiuron rates between 0.3 and 0.6 kg/ha, a field-scale application at 0.4 kg/ha was made on an area dominated by creosotebush to determine both if effective levels of shrub kill and if an increase in herbaceous production could be obtained at a relatively low herbicide application rate.

## MATERIALS AND METHODS

This study was conducted on the Jornada Experimental Range, 37 km north of Las Cruces, NM. Annual rainfall at the Jornada Headquarters averages 230 mm. The area treated was on a bajada slope at an elevation of 1415 m with soils classified as the Tencee-Nickel Association (11). Tencee soils are loamy-skeletal, carbonatic, thermic, shallow, Typic Paleorthids, and Nickel soils are loamy-skeletal, mixed thermic, Typic Calciorthids. Creosotebush dominated the area, but mesquite, tarbush, and other shrubs were present.

On June 9, 1981, tebuthiuron at 0.4 kg/ha (20% ai pellets) was applied to a 130-ha, rectangular area (804 by 1609 m) with a Piper Pawnee "C" airplane[4] equipped with a Transland spreader and a slotted metering plate[5] in the herbicide hopper. Rain totaling 41 mm fell six times between herbicide application and completion of the first vegetation sampling on July 14, 1981. When the treated area was sampled to determine brush cover and density, ground cover, and number of forbs, the effect of tebuthiuron was not visible.

The long axis of the rectangular plot was parallel to the 5 to 6% bajada slope. A base line, perpendicular to the slope, was established in each quadrant of the plot. Starting points for four permanent transects were selected randomly along each base line with the restriction that transects would be at least 10 m apart and 30 m from the plot borders. Transects were parallel with the slope and perpendicular to application flight lines. Each transect was 152.4 m long, and a metal stake was placed every 30.5 m.

A metal tape under spring tension was stretched between the metal stakes. Using a plumb bob, line point plots were read every 0.3 m along the tape. At each point, shrub canopy cover and ground cover classes, i.e., basal area of grasses and shrubs, litter, debris, rock, pavement (soil surface covered with pebbles), and bare ground, were recorded. Shrubs were counted in a belt transect extending 0.76 m on each side of the tape. Forbs were counted in a belt transect extending 0.15 m on each side of the tape. The transects were resampled during August and September in 1982, 1983, 1984, and 1985.

Shrub mortality was determined from the difference between beginning and subsequent numbers of living plants. In 1982, a similar set of transects was established on an adjacent, equal-sized untreated area with shrub cover similar to the treated area and was sampled each year thereafter. In October 1985, two locations were randomly chosen for each 30.5-m segment of transect, and all herbaceous plants were harvested from a 0.5 $m^2$ circular plot at each location (160 plots each for treated and untreated). Harvested plants were separated by species, live and recent dead were separated from standing dead, and oven dry weights (60 C) were determined for live and for recent dead material.

The abundance of heliotrope (*Heliotropium greggii* Torr.) on the untreated area in 1983 and 1984 necessitated a modification of sampling methods. Instead of counting this species in the full 0.3-m wide belt transect, only a 0.3- by 0.3-m plot randomly chosen in each 0.76-m length of line was counted. This technique was used for all forb species on both the treated and nontreated areas in 1985. Rainfall records for 1981 were obtained from a recording rain gauge located 0.8 km from the treated-area. Records for 1982–85 were obtained from a rain gauge located adjacent to the treated area.

Data from each transect were considered as an experimental unit, and means and standard deviations were calculated. The lack of treatment replication precluded use of ANOVA procedures. Simple linear regression was used to determine the relationship between initial densities of creosotebush in each 30.5-m transect segment and ultimate mortality following arc sine $\sqrt{\text{percentage}}$ transformation of mortality data. Regression was used to examine

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[4] Piper Aircraft Corp. P.O.B. 6310, Lakeland, FL 33807.

[5] Transland, Inc., 24511 Frampton Ave., Harbor City, CA 90710.

*Table 1.* Crop year precipitation (Oct. 1 – Sept. 30) for 1981 to 1985. Long-term average precipitation is 230 mm.

| Year | October | November | December | January | February | March | April | May | June | July | August | September | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (mm) | | | | | | | | | | | | |
| 1981 | 8 | 0 | 1 | 13 | 2 | 13 | 45 | 1 | 48 | 36 | 85 | 30 | 282 |
| 1982 | 16 | 14 | 2 | 19 | 3 | 1 | 0 | 12 | 14 | 11 | 24 | 84 | 200 |
| 1983 | 1 | 17 | 39 | 18 | 10 | 5 | 11 | 1 | 4 | 75 | 16 | 59 | 256 |
| 1984 | 50 | 37 | 5 | 10 | 0 | 4 | 1 | 24 | 39 | 29 | 110 | 8 | 317 |
| 1985 | 81 | 18 | 67 | 30 | 8 | 11 | 16 | 1 | 9 | 51 | 32 | 97 | 421 |

relationships between forb densities and brush canopy cover on 1.52-m transect segments.

## RESULTS AND DISCUSSION

The tebuthiuron was applied in 1981 followed by below-average precipitation in 1982 but precipitation in subsequent years was above average (Table 1). Tebuthiuron was applied when there were 4440 shrubs per hectare (Table 2). Creosotebush made up 71% of the total, tarbush 15%, and mesquite 6%. Other species made up the remaining 8%, including Berlandier wolfberry (*Lycium berlandieri* Dunal # LYUBE), fourwing saltbush, broom snakeweed [*Gutierrezia sarothrae* (Pursh) Britt. & Rusby # GUESA], and mariola (*Parthenium incanum* (H.B.K.).

After 1 yr, all wolfberry and broom snakeweed plants were dead as were 77% of the tarbush plants (Table 2), while creosotebush and mesquite mortality was only 12 and 4%, respectively. Mortality of creosotebush and mesquite was greatest in the second year after treatment and declined thereafter (Table 2). Less than half of the mesquite plants had died four seasons after treatment. This confirmed previous studies which indicated that relatively high application rates of tebuthiuron are necessary to control mesquite (6).

Total shrub density was reduced from 4440 plants/ha in 1981 to 570 plants/ha in 1985, a total shrub kill of 87%. More creosotebush plants probably will die because 34% of plants alive in 1985 were estimated to have >80% top kill and 19% to have <20% top kill. Continued growth of bush muhly (*Muhlenbergia porteri* Scribn.) clumps, which can shade out creosotebush plants (17), may cause additional creosotebush mortality. No relation between original creosotebush density and mortality ($R^2$ <0.01) occurred, similar to results Ueckert et al. (15) reported for tarbush treated with tebuthiuron. No shrub mortality occurred on the untreated transects during the study period.

In 1981, canopy cover of creosotebush, tarbush, and mesquite was 16.7, 1.9, and 2.4%, respectively (data not presented). Total shrub canopy cover declined from 20.8% in 1981 to 2.8% in 1985 (Table 3). Practically all mesquite plants were defoliated completely the first season after treatment, but the surviving plants produced leaves in subsequent seasons; and in 1985, mesquite contributed 90% of shrub canopy cover. The amount of bare ground remained fairly constant after treatment. Pavement covered about 34% of the bare area, providing some protection from erosion. Litter declined after treatment until 1985, reflecting the dissipation of litter accumulated under shrub canopies.

Perennial grass basal area was reduced in the first and second seasons after treatment. Britton and Sneva (1) and Scifres et al. (14) reported phytotoxicity of tebuthiuron to native grasses during the first growing season after application. Tebu-

*Table 2.* Number of shrubs per hectare (mean ± SD) at time of treatment (1981) and cumulative kill in post-treatment years (1982-85).

| Species | Density 1981 | Control 1982 | 1983 | 1984 | 1985 |
|---|---|---|---|---|---|
| | (plants/ha) | (%) | | | |
| Creosotebush | 3150 ± 770 | 12 | 61 | 83 | 87 |
| Tarbush | 690 ± 600 | 77 | 98 | 99 | 100 |
| Mesquite | 250 ± 190 | 4 | 36 | 45 | 48 |
| Other[a] | 350 ± 860 | 78 | 95 | 96 | 96 |

[a] Includes Berlandier wolfberry, fourwing saltbush, broom snakeweed, and mariola.

*Table 3.* Percentage ground cover classes and shrub canopy cover (mean ± SD) in year of tebuthiuron application (1981) and in post-treatment years (1982-85) for treated area and in 1985 for untreated area.

| | Treated | | | | | Untreated |
|---|---|---|---|---|---|---|
| Class | 1981 | 1982 | 1983 | 1984 | 1985 | 1985 |
| | (% cover) | | | | | |
| Bare (including pavement and rock) | 92.6 ± 2.7 | 95.8 ± 2.0 | 96.7 ± 1.9 | 96.0 ± 2.4 | 92.0 ± 3.6 | 96.0 ± 1.6 |
| Litter | 5.2 ± 1.9 | 2.8 ± 1.5 | 1.9 ± 0.9 | 1.0 ± 0.8 | 4.1 ± 2.0 | 2.5 ± 1.1 |
| Debris | 0.4 ± 0.3 | 0.4 ± 0.3 | 0.5 ± 0.2 | 0.6 ± 0.3 | 0.5 ± 0.2 | 0.2 ± 0.2 |
| Shrub basal area | 0.7 ± 0.4 | 0.4 ± 0.3 | 0.2 ± 0.2 | 0.1 ± 0.1 | <0.1 | 0.7 ± 0.3 |
| Perennial grass basal area | 1.1 ± 1.3 | 0.6 ± 0.8 | 0.7 ± 1.2 | 2.3 ± 1.8 | 3.4 ± 1.9 | 0.6 ± 0.8 |
| Shrub canopy cover | 20.8 ± 4.3 | 6.8 ± 1.9 | 2.9 ± 1.5 | 2.3 ± 1.8 | 2.8 ± 2.2 | 18.4 ± 3.7 |

thiuron possibly contributed to the decline in grass basal area. However, many grasses have tolerated tebuthiuron rates higher than that used here (3, 18). The low precipitation in 1982 probably contributed to the reduced grass basal area. The increase of grass basal area on the treated area in 1984 and 1985 is attributed to the reduced shrub competition and to the above-average rainfall (Table 1). Grass basal area on the untreated area was 0.6% in 1985.

Perennial forb densities were lower on the treated area than on the untreated area (Table 4). Shrub canopy cover (18.4%) and shrub density (3870 plants/ha) were lower on the untreated area than on the treated area. With fewer shrubs, the untreated area would probably have more perennial forbs than the treated area and this should be considered when comparing forb densities. Heliotrope, desert holly (*Perezia nana* Gray), and hairyseed bahia (*Bahia absinthifolia* Benth.) are rhizomatous or subrhizomatous (desert holly) forbs and tebuthiuron conceivably could have a phytotoxic effect upon them. Densities of hairyseed bahia and desert holly were lower on the treated area the first season after treatment, and desert holly did not reach densities in post-treatment years equal to that found during the year of treatment (Table 4). An alternative explanation for reduced numbers of desert holly is that its best development depends upon shrub canopy cover. However, using 1981 data, no relationship was found between canopy cover, as measured by line point hits, and number of desert holly plants in 1.53-m transect segments (N = 309, $R^2 = 0.04$).

Seasonal rainfall distribution influenced the number of rhizomatous species which developed in a given year, i.e., the heliotrope density declined sharply in 1985 on both the treated and nontreated areas (Table 4). Heliotrope appears to grow best after large rainfall events (>25 mm) during the spring and early summer months and there were no events of this magnitude before September in 1985. Annual forbs, which had low densities in the relatively dry years of 1981 and 1982, were abundant on both treated and nontreated areas in 1983, 1984, and 1985.

*Table 4.* Number of forbs per m$^2$ (mean ± SD) on a tebuthiuron-treated and untreated area. Tebuthiuron at 0.4 kg/ha was applied in June 1981, and forbs were counted in July 1981 and in August–September 1982-85.

| | 1981 | 1982 | | 1983 | | 1984 | | 1985 | |
|---|---|---|---|---|---|---|---|---|---|
| Species | Treated | Treated | Untreated | Treated | Untreated | Treated | Untreated | Treated | Untreated |
| | (plants/m$^2$ ± SD) | | | | | | | | |
| Hairyseed bahia | 2.08 ± 1.72 | 0.7 ± 0.6 | 1.38 ± 1.39 | 0.91 ± 0.55 | 6.42 ± 5.91 | 0.81 ± 0.35 | 2.66 ± 1.99 | 1.25 ± 0.96 | 2.23 ± 1.38 |
| Heliotrope | 6.36 ± 8.0 | 6.34 ± 8.55 | 12.92 ± 8.77 | 2.67 ± 3.23 | 14.74 ± 1.21 | 1.25 ± 1.35 | 19.70 ± 14.31 | 0.42 ± 0.81 | 4.00 ± 4.91 |
| Desert holly | 1.31 ± 1.04 | 0.20 ± 0.29 | 1.09 ± 1.12 | 0.08 ± 0.16 | 1.21 ± 1.09 | 0.08 ± 0.12 | 1.33 ± 1.12 | 0.08 ± 0.11 | 0.78 ± 0.84 |
| Other perennial forbs | 0.68 ± 1.08 | 0.31 ± 0.67 | 0.21 ± 0.24 | 0.47 ± 0.80 | 0.86 ± 1.92 | 0.43 ± 0.71 | 0.74 ± 1.12 | 0.81 ± 1.37 | 0.94 ± 1.49 |
| Annual forbs | 0.01 ± 0.02 | <0.01 | 0.08 ± 0.15 | 0.82 ± 0.74 | 3.04 ± 4.15 | 1.74 ± 1.42 | 0.56 ± 0.60 | 6.24 ± 2.85 | 8.38 ± 8.10 |

*Table 5.* Above-ground production (mean ± SD) of plant categories in 1985 on an area treated with tebuthiuron at 0.4 kg/ha in 1981 and on an adjacent untreated area.

| Category | Biomass production | |
|---|---|---|
| | Treated | Untreated |
| | (kg/ha) | |
| Perennial grass | 530 ± 820 | 50 ± 410 |
| Annual grass | <1 | 0 |
| Perennial forb | 50 ± 120 | 50 ± 230 |
| Annual forb | 280 ± 780 | 40 ± 60 |
| Total | 860 ± 1110 | 140 ± 470 |

Total herbaceous production in 1985 was 6-fold greater on the treated area than on the untreated area (Table 5). The large standard errors indicate the extreme variability in above-ground herbaceous production. Perennial grass production was nearly 11-fold greater on the treated area than on the untreated area. However, 43% of the perennial grass production on the treated area was fluffgrass [*Erioneuron pulchellum* (H.B.K.) Tateoka] which has little forage value although it does provide protection from erosion. Bush muhly made up 33% and 84% of perennial grass production on the treated and untreated areas, respectively, but its production was three times greater on the treated area than on the untreated area. Other forage grasses on the treated area included red threeawn (*Aristida longiseta* Steud. # ARKLS), plains bristlegrass (*Setaria macrostachya* H.B.K.), alkali sacaton (*Sporobolus airoides* Torr. # SPZAI), and spike dropseed (*S. contractus* Hitchc.).

Production of perennial forbs was similar on both treated and untreated areas (Table 5). Hairyseed bahia, heliotrope, and Fendler spurge (*Euphorbia fendleri* T.&G.) made up 40% and 99% of the perennial forb production on the untreated and treated areas, respectively.

Annual forb production was nearly 7-fold greater on the treated than on the untreated area (Table 5). Desert baileya (*Baileya multiradiata* Harv. & Gray), roundleaf wildbuckwheat (*Eriogonum rotundifolium* Benth.), and Russian thistle (*Salsola iberica* Sennen & Pau # SASKR) made up 81% of annual forb production on the treated area. Russian thistle was not present on the untreated area, and desert baileya and wildbuckwheat made up 91% of the annual forb production. Further increases in herbaceous production probably will occur on the treated area, subject to fluctuations from erratic precipitation patterns.

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