Effects of Picloram and Tebuthiuron Pellets on Sand Shinnery Oak Communities

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Abstract

Picloram and tebuthiuron pellets (10% a.e.) were broadcast onto fair to low-good condition range supporting sand shinnery oak in west Texas. The Sands range site has traditionally been overgrazed and soils are very susceptible to wind erosion. Picloram at 7 kg/ha (a.i) resulted in excessive oak control in 1971. In 1973, 1975, and 1976, herbage yields on the treated plots were the same as on untreated plots. Herbicide application on this site dramatically changed species composition. Applications of tebuthiuron at 1 kg/ha (a.i.), in late spring and winter killed most of the oak. Grass responses to this herbicide were good, but at rates higher than 1 kg/ha some of the better forages were killed allowing false buffalograss, an undesirable annual, to become dominant. Picloram pellets, at 3, 5, and 7 kg/ha, killed all the oak. However, picloram at 1 kg/ha only partially controlled the oak. Picloram pellets were not as detrimental to the plant community as the tebuthiuron. One kg/ha of tebuthiuron or 2 kg/ha of picloram totally controlled the sand shinnery oak on the Brownfield soil.

Sand shinnery oak (*Quercus havardii* Rydb.), an undesirable shrub seldom exceeding 1 m tall, grows on more than 1.4 million ha of coarse-textured soils in north and west Texas. It also occurs on large acreages in southeastern New Mexico and west central Oklahoma. Because of the oak's toxic properties, livestock poisoning in the spring, following dry winters when other plants stay dormant later than usual, is a particular problem.

Total plant kill from aerially applied liquid herbicides is rare. Typical results are foliage "browning" with little herbicide translocation into the oak's extensive system of roots and underground stems. Pettit and Deering (1971) estimated that the root: shoot ratio of this shrub exceeded 10:1. Also, the leaf cuticle is hardened and thickened by the time of full expansion possibly prohibiting maximum absorption of foliar-applied herbicides (unpublished personal data).

Top kill of sand shinnery oak with aerial sprays is relatively easy (McIlvain and Armstrong 1959; Robison and Fisher 1968); but root kill is usually low. New shoots may arise from buds along the more shallow rhizomes following top growth disturbance resulting in only temporary control.

Scifres (1972) reported that picloram (4-amino-3,5,6-trichloropicolinic acid) pellets at rates less than 2.2 kg/ha were ineffective in reducing sand shinnery oak density in the Rolling Plains land resource area of Texas. The ineffectiveness was attributed partially to the inherent resistance of sandy shinnery oak to soil-applied picloram.

Early research to control sand shinnery oak involved applications of phenoxy herbicides such as 2,4-D [(2,4,-dichlorophenoxy)acetic acid], 2,4,5-T[(2,4,5-trichlorophenoxy) acetic acid] or silvex [2-(2,4,5-trichlorophenoxy) proprionic acid]. These herbicides often resulted in only temporary sand shinnery oak control. When herbicides were applied too late (June), very few plants were top killed. Young leaf or dormant stages of oak phenology were not considered in the timing of application. The standard recommendation for sand shinnery oak control was to use 0.5 kg/ha of 2,4,5-T or silvex with 3.8 liters of diesel oil with water to make a 17.6 liter per .405 ha solution. The herbicide was to be applied as a foliar spray with swath widths to ensure complete coverage. Two or three applications in successive years were considered necessary.

Many ranchers were not happy with temporary control. On much of this semiarid land, the expected benefits would not justify the costs of oak spraying.

Thus, a serious need exists for an effective method of increasing the root kill of sand shinnery oak over conventional methods. This research reports the effects of two pelleted herbicides, picloram and tebuthiuron N-[5-1, 1-dimethethyl)-1,3,4-thiadiazol-2-yl]-N,N′-dimethylurea) on sand shinnery oak and associated species.

Methods and Procedures

Research initiated in 1971 was located 15 km north of Plains, Texas, and was continued in 1974 and 1975 about 27 km south of Whiteface, Texas. Both study areas are within a continuous sand dunal system originating in New Mexico. Allred (1956) classified these areas as being a portion of the post-climax High Plains Bluestem Community. Although tall grasses would dominate climax, overgrazing has eliminated much of the grass cover. Subsequently, the grasses have been replaced by sand shinnery oak, sand sagebrush (*Artemisia filifolia*), and by broom snakeweed (*Xanthocephalum sarothrae*) on the shallower sands. Sand dropseed (*Sporobolus cryptandrus*), red lovegrass (*Erogrostis oxylepis*), sand paspalum (*Paspalum setaceum*), and purple three-awn (*Aristida purpurea*) are the most common grasses on these ranges following heavy grazing.

The soil on these study areas is a Brownfield fine sand. It is classified as an Arenic Aridic Paleustalf and is characterized by having over 50 cm of fine sand overlying a sandy clay loam B horizon. The surface soil varies from 93 to 96% sand, and infiltration rates exceed 70 cm/hr of water. During high intensity precipitation events, water may "perch" on the finer textured subsoil. Fine oak roots proliferate at this contact zone.

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Climate of the area is continental with an average precipitation of 40 cm. Much of this precipitation results from short and intense spring and late summer thunderstorms. Temperature extremes range from 44 to −30°C with a frost-free growing season of nearly 200 days. Winds from the west-southwest during the winter and early spring are important in that exposed dune crests without grass cover begin moving. Because of this oak's deciduous character, it affords incomplete soil protection to the dunes.

Research reported herein applies only to the broad interdune areas. Herbicides were not applied to relatively grass-free dunes as blowouts are common in these (Tivoli) soils.

Exploratory work began in May 1971 when picloram (10% a.i.) pellets were broadcast with a hand seeder onto a 0.5-ha plot. The area was dominated by sand shinnery oak with sand dropseed being the most abundant grass. Following guidelines suggested for other white oaks, 7 kg/ha (a.i.) of chemical was initially applied.

In 1973, 1975, and 1976, when sand shinnery oak top growth was maximum, fifteen 1-m^2 quadrats were randomly placed in the treated and adjacent untreated area. All vegetation was clipped to ground level, separated by species, and oven dried. Concomitant with the clipping, density and canopy cover were estimated by species, from twenty-five 1-m^2 quadrats on each treatment.

Results from the initial demonstration indicated the herbicide rate used was higher than required to effect oak kill. Thus, a new experiment was designed to apply picloram and tebuthiuron pellets (10% a.i.) at 1, 3, 5, and 7 kg/ha onto 20 m^2 plots in June 1974. Tebuthiuron and picloram pellets were used to provide a contrast to the effectiveness of these herbicides. All site factors were relatively homogeneous. A completely randomized design with three replications of each treatment was used.

In a third experiment, tebuthiuron was broadcast during the winter dormant season (in mid-January, 1975). Frequency data were taken from 0.5-m^2 quadrats in mid-1977 on all the above plots. Herbage yields from twenty-four 1-m^2 plots per treatment were taken in August, 1977.

In the sand shinnery oak ecosystem, the author considers herbage yields following herbicide application to be the best indicator of herbicide effectiveness. Frequency, cover, and density provide a measure of the herbicidal effects upon individual species in the area. In this report, only statistical analysis of herbage yield data are given.

Results and Discussion

The results presented here show that sand shinnery oak can be killed but the lowest rate of herbicide needed to effect total oak control has not been determined.

At the time of picloram application, the area was characterized by a canopy cover of sand shinnery oak which exceeded 10%. At the end of the first growing season, few living aboveground oak stems were present. In 1972, few new oak shoots had emerged. Grasses and forbs surviving treatment were gaining vigor, so intensive sampling was initiated in 1973 to measure herbage attributes following application of picloram at 7 kg/ha. Experience has shown that even a low cover of oak exerts a strong competitive effect on associated species. The oak will leaf even during drought, but forbs and grasses remain dormant until rains occur.

Picloram pellets applied at 7 kg/ha dramatically increased the better forages on the sandy range site (Table 1). All grasses except purple threeawn responded favorably to the treatment. Many of the threeawn plants were killed as were many of the forbs. Sand dropseed showed most vigor after the second year. Sand paspalum was the most vigorous after the second year. Sand paspalum, red lovegrass, and sideoats grama *Bouteloua curtipendula*) increased in abundance but are not as prolific seed producers as sand dropseed. Fall witchgrass (*Leptoloma cognatum*), a low growing rhizomatous species, became more dispersed.

Although little bluestem (*Schizachyrium scoparium*) had a relatively low frequency and density following treatment, its size allowed it to be the fourth contributor to herbaceous cover. False buffalograss (*Munroa squarrosa*), an invading annual rarely found in undisturbed sand shinnery oak communities, was common on the area.

Several perennial forbs were killed by 7 kg/ha of picloram pellets. Western ragweed (*Ambrosia psilostachya*), four o'clock (*Miarabilis linearis*), hairy evolvulus (*Evolvulus

Table 1. Frequency, density, and canopy cover of the 17 most abundant plants[1] on a Sandy range site in west Texas as affected by 7 kg/ha of picloram (P) pellets.

Species	Frequency (%)				Density (No/m^2)		Canopy cover (%)	
	1973		1976		1976		1976	
	P	C[2]	P	C	P	C	P	C
Grasses								
Sand paspalum (*Paspalum setaceum*)	72	52	96	88	8.2	3.0	7.4	3.5
Sand dropseed (*Sporobolus cryptandrus*)	100	68	84	58	4.5	2.7	6.0	3.7
Purple threeawn (*Aristida purpurea*)	32	72	64	64	2.3	2.7	8.1	4.5
Red lovegrass (*Eragrostis oxylepis*)	28	16	44	48	1.6	1.6	1.2	1.8
Sideoats grama (*Bouteloua curtipendula*)	56	16	44	36	2.2	2.2	1.6	1.3
Fall witchgrass (*Leptoloma cognatum*)	56	24	52	20	2.2	0.8	1.6	0.9
Tumble lovegrass (*Eragrostis sessilispica*)	16	4	36	8	—	0.2	1.8	0.2
Little bluestem (*Schizachyrium scoparium*)	36	16	20	20	0.5	0.5	4.2	1.5
False buffalograss (*Munroa squarrosa*)	8	—	20	—	1.8	—	2.0	—
Forbs								
Greenthread (*Thelesperma megapotimicum*)	8	16	24	60	1.1	3.0	0.4	1.0
Nailwort (*Paronychia jamesii*)	8	24	4	24	0.6	1.2	0.2	0.5
Gromwell (*Lithospermum incisum*)	24	8	—	8	—	0.5	0.3	0.1
Dayflower (*Commelina erecta*)	16	8	16	16	0.5	0.3	0.4	0.2
Spiny haplopappus (*Haplopappus spinulosus*)	—	12	12	12	0.6	0.5	0.3	0.2
Four o'clock (*Mirabilis linearis*)	—	40	—	12	—	0.2	—	0.1
Shrubs								
Broom snakeweed (*Xanthocephalum sarothrae*)	44	96	56	100	1.8	9.4	2.7	13.4
Sand shinnery oak (*Quercus havardii*)	—	100	—	64	—	7.4	—	9.1

[1] A total of 52 species were found in the study areas.
[2] Represents the control plot.

nuttallianus), and several other perennials were eliminated by the picloram. The forb in the sand shinnery oak community most tolerant of the high rate of picloram was toad flax (*Linaria texana*). This annual was dominant in April and early May of 1972 and 1973, then was rare on the treated plot for the duration of this study.

Based on shrub frequency, density, and canopy cover, sand shinnery oak was apparently much more susceptible to picloram at 7 kg/ha than was broom snakeweed (Table 1). Although the frequency of broom snakeweed was reduced by 50%, its density and canopy cover exceeded that of sandy shinnery oak in 1976. This difference in root systems could explain why the herbicide more effectively killed the oak than snakeweed. Most small absorbing roots of the oak occur at the sand-subsoil contact zone, which should make this shrub susceptible to root-absorbed herbicides. The taproot of snakeweed penetrates into the subsoil then branches prolifically. Consequently, it may have escaped the concentration of chemical.

Second, it appears that snakeweed is cyclic in vigor and abundance on these soils. We may have seen a natural increase in this plant's density and cover until disease and/or insects cause it to decline.

Year-to-year variability in herbage yields was high (Table 2). Yields varied from 1,218 kg/ha in 1973 to 1,990 kg/ha in 1976 following application of picloram at 7 kg/ha in 1971. Similarly, the untreated plots yielded from 1,199 kg/ha in 1973 to 1,998 kg/ha in 1976. Within-year yield comparisons show no statistical difference between the herbicide and untreated plot. Since annuals complete their life cycles quickly following infrequent thunder showers, this community is very dynamic. Mare'stail conyza (*Conyza canadensis*) best reflects this phenomena.

Table 2. Herbage yields (kg/ha) at peak biomass on a Sandy range site in west Texas as effected by a 1971 broadcast application of 7 kg/ha of picloram pellets.

	1973		1975		1976	
Species	P[1]	C[1]	P	C	P	C
Purple threeawn	88	146	82	66	138	103
Sand paspalum	250	7	152	27	410	40
Sand dropseed	280	8	236	50	326	130
Fall witchgrass	117	0	64	19	54	11
Sideoats grama	—[2]	—	—	—	78	3
Red lovegrass	53	0	77	68	66	47
Little bluestem	–	–	126	0	186	33
Other grasses	365	122	223	249	104	19
Forbs	51	94	705	331	184	71
Broom snakeweed[3]	—	—	—	—	444	565
Sand shinnery oak[3]	4	823	131	1129	0	976
Totals[4]	1218	1199	1796	1939	1990	1998
% Shrubs	0.3	68.6	7.3	58.2	22.3	77.1

[1] (P) represents picloram; (C) is the control.
[2] Sideoats grama and little bluestem were not abundant enough to be clipped separately and were placed in other grasses.
[3] In 1973 and 1975 broom snakeweed and sand shinnery oak herbage was not separated.
[4] Within-year yields between treatments are not significantly different at the .05 level of significance.

More precipitation was received in August 1975 than was received that month in other years of the study. The high forb yield, mostly of annuals, caused the total herbage yield to approach the 1976 yield. Similarly, other grasses, consisting of eight less abundant species, gained most vigor 2 years following treatment.

At the beginning of the study, broom snakeweed was not abundant on the study area. Therefore, broom snakeweed yields were not measured in 1973 and 1975. The precipitation in August 1975 apparently stimulated broom snakeweed seed germination. Although the sand shinnery oak will probably be permanently removed from the picloram plot, a severe broom snakeweed problem may develop within a few years.

Regardless of the presence of sand shinnery oak, yields were similar between plots. It seems likely that in most arid and semiarid systems, water is so limiting to plant productivity that removal of one or more species allows the survivors to respond only to a given production level. Observations in 1977 support this hypothesis. The landowner then faces a "tradeoff" situation, that of exchanging one group of forages for another group of plants with ⅔ of their dry matter being undesirable for grazing.

Range condition on the Whiteface area was lower than on the area near Plains. Grazing had been more severe, sand shinnery oak canopy cover was higher, and sand surface depth was greater than with the earlier experiment.

Tebuthiuron and picloram-treated plants exhibited different symptoms of phytotoxicity. Picloram immediately turned oak leaves brown and little resprouting occurred. Tebuthiuron caused the oak to defoliate three times the season of application. By the third refoliation, the plants were apparently nearly dead. An examination of sand shinnery oak rhizomes from herbicide-treated plots showed roots from picloram-treated plants to have a "whitish" inner color whereas oak roots from the tebuthiuron treated plots, when broken, were brown. This indicated the rhizomes from tebuthiuron-treated plants were dead; while those from picloram-treated plots might resprout. The only significant resprouting that occurred after 2 years was in the plots treated with 1 kg/ha of picloram.

Tebuthiuron rates above 3 kg/ha essentially "cleaned out" the plant community, since many forbs were killed and some perennial grasses were injured (Table 3). False buffalograss dominated the plots where tebuthiuron was applied at higher rates. Picloram applied at 5 or 7 kg/ha did not kill all forbs and few grasses were damaged by lower rates. False buffalograss was also less abundant in the picloram-treated plots.

Mare'stail conyza and camphorweed (*Heterotheca latifolia*) were the most abundant forbs in late June on the plots treated with 1 kg/ha of picloram, whereas toad flax dominated in April. The toad flax in the 3 kg/ha treatment had the highest frequency but no single forb dominated the aspect. Beebalm (*Monarda punctata*) and spectaclepod (*Dithyraea wislizenii*) were co-dominant forbs where 5 kg/ha of the chemical had been applied; however, toad flax and gromwell (*Lithospermum incisum*) were very abundant. Forb cover and frequency at the highest application rate were drastically reduced. Sedge (*Cyperus* sp.) was the most abundant plant on these plots.

A contrast of the plant composition where tebuthiuron had been applied showed toad flax and bluet (*Hedyotis humifosa*) to dominate plots following application of 1 kg/ha of tebuthiuron. Most forbs that survived after 1 year were apparently near death. Most forbs were absent from the 3 kg/ha of tebuthiuron plots. Where 5 kg/ha of this herbicide had been applied, few forbs had a frequency over 10%. Similarly, at 7 kg/ha only three forb species were present.

Frequency of shrubs 1 year after treatment did not accurately reflect mortality from the pelleted herbicides. Sand sagebrush succumbed rapidly to tebuthiuron, but picloram did not kill the occasional plants present. Sand shinnery oak frequency had

Table 3. Frequency (%) of plants on plots treated with picloram (P) and tebuthiuron (T) pellets in Yoakum County Texas. This Sandy range site was sampled June 16, 1975, and data are averaged from thirty, 1 m^2-quadrats per treatment.

		Treatment							
		1 kg/ha		3 kg/ha		5 kg/ha		7 kg/ha	
Species	Control[1]	P	T	P	T	P	T	P	T
Grasses									
Sand dropseed (*Sporobolus cryptandrus*)	80	97	76	67	90	53	90	60	87
Purple threeawn (*Aristida purpurea*)	97	83	97	63	63	50	40	53	20
Sand paspalum (*Paspalum setaceum*)	40	7	47	33	43	10	37	23	27
Sedges (*Cyperus spp.*)	67	70	97	70	83	63	83	87	63
Red lovegrass (*Eragrostis oxylepis*)	27	63	73	80	77	47	40	67	7
Fall witchgrass (*Leptoloma cognatum*)	17	30	47	7	40	3	7	13	17
Little bluestem (*Schizachyrium scoparium*)	17	10	13	27	30	27	3	13	7
Hairy grama (*Bouteloua hirsuta*)	17	20	20	10	30	3	20	7	13
False buffalograss (*Munroa squarrosa*)	0[1]	3	3	0	37	23	43	10	70
Perennial forbs									
Gromwell (*Lithospermum incisum*)	27	63	100	33	3	33	3	17	0
Groundsel (*Senecia riddellii*)	50	83	37	27	0	33	0	13	0
Milkwort (*Polygala alba*)	17	17	0	23	0	0	0	7	0
Gaura (*Gaura coccinea*)	13	23	3	27	0	23	0	17	0
Cryptantha (*Cryptantha jamesii*)	17	0	17	17	7	3	7	7	0
Fleabane (*Erigeron modestus*)	13	27	7	7	3	10	0	3	0
Annual forbs									
Camphorweed (*Heterotheca litifolia*)	60	70	47	23	13	13	3	37	0
Toadflax (*Linaria texana*)	73	63	100	53	47	57	27	67	7
Marestail conyza (*Conyza canadensis*)	32	53	33	30	17	10	0	10	0
Wild flax (*Linum rigidum*)	23	37	40	50	53	3	10	23	3
Bluet (*Hedyotis humifosa*)	57	17	70	3	17	3	3	37	7
Beebalm (*Monarda pectinata*)	60	37	50	33	27	67	7	40	0
Spectaclepod (*Dithyraea wislizenii*)	53	43	13	47	0	57	0	47	0
Annual buckwheat (*Eriogonum annuum*)	17	50	7	23	3	20	0	17	0
Shrubs									
Sand shinnery oak (*Quercus havardii*)[3]	100	87	100	20	97	17	97	7	100
Sand sagebrush (*Artemisia filifolia*)	3	10	0	10	0	3	0	17	0

[1] One untreated series was used for both of these treatments.
[2] False buffalograss is not found on undisturbed rangelands.
[3] Living oak sprouts were found in the tebuthiuron plots on this date. Analysis in 1976 showed them to be dead.

been reduced drastically by picloram applied at 3 kg/ha or higher. Living sand shinnery oak plants persisted in all tebuthiuron plots 1 year after application. Data for 1976, not presented here, show no oak to be living in any of the tebuthiuron plots, and approximately 50% of the oak was dead of the 1 kg/ha of picloram plots. Three kg/ha of picloram killed all sand shinnery oak on this site.

Tebuthiuron only was applied in January 1975 to check its seasonal effectiveness in killing oak. Inadequate moisture was received to move the herbicide into the soil until April. Shrub, forb, and grass responses to all rates of tebuthiuron were identical to results from applications in the spring.

Grass yields on all treated plots had increased by three to nine times at 2 years after herbicide application (Fig. 1). Very few grasses or forbs could be observed on untreated plots, because of small stature and low vigor. As soon as the sand shinnery oak declined, grasses and forbs to 1 m tall were common in all plots. Grass yields in plots treated with picloram at rates of 3, 5, and 7 kg/ha during May were not significantly different. Likewise, grass yields in the tebuthiuron plots applied in May were similar. Sand dropseed and false buffalograss were the most abundant herbages in the plots receiving 7 kg/ha tebuthiuron, whereas sand dropseed and purple threeawn comprised most of the biomass in the 7 kg/ha picloram plots.

Tebuthiuron application in January effectively reduced all forb and shrub biomass on the plots. Grass yield in the 1 kg/ha treatment was significantly less than in the 3, 5, and 7 kg/ha plots. False buffalograss contributed a large part of the grass

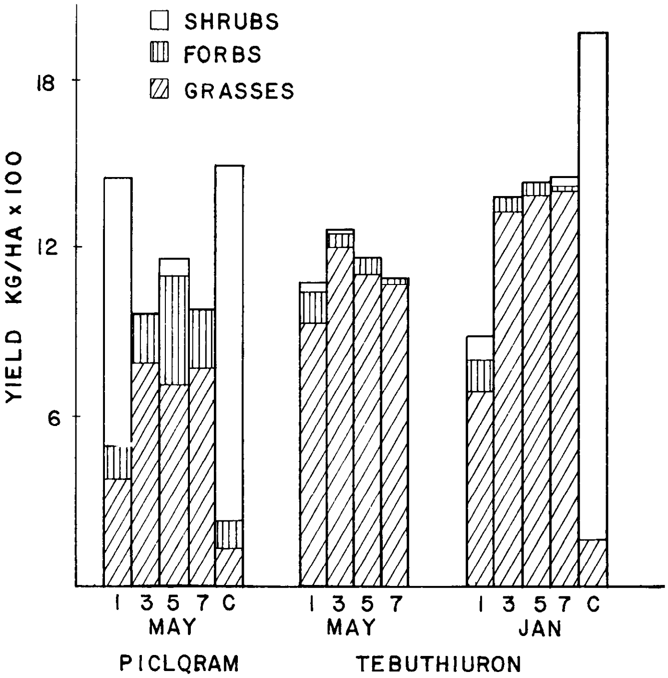

Fig. 1. *Yields of herbage components harvested from a Sandy range site in west Texas. The check plot (C) for the May picloram treatment was also the check for the May tebuthiuron treatment. Shinnery oak averaged 90% of the current year's growth in all check plots.*

yield in the plots receiving more than 1 kg/ha of tebuthiuron.

On sandy soils in west Texas it is difficult to obtain a high canopy cover of plants after sand shinnery oak is removed. During wet periods annuals and a few perennials germinate, but in many cases survival is low. Pettit and Deering (1974) showed that herbage yields could be increased by the use of fertilizer in the oak community, but low precipitation following fertilizer application did not increase forage production.

Conclusions

Data reported in this study are inadequate to formulate appropriate management plans for shinnery oak land as no grazing trials have begun. According to many ranchers, total removal of oak from this soil may not be advisable as drought is common in the area and the oak is a more dependable forage source during these periods than grasses and forbs. Additionally, wildlife in the area depend upon this oak for cover and food.

Specific recommendations that can be made about sandy shinnery oak control based upon completed research are:

(1) The pelleted herbicides, tebuthiuron and picloram, will kill sand shinnery oak on the Brownfield fine sand soil.

(2) To obtain a specific percentage kill, tebuthiuron at 1 kg/ha is much more effective than picloram at a comparable rate. To effect total oak kill, 1 kg/ha of tebuthiuron or 2 kg/ha of picloram is suggested.

(3) These herbicides are not recommended for oak on Tivoli dunes if a good ground cover of perennial grasses is absent.

(4) Tebuthiuron can be applied in the winter or spring with equal success in killing sand shinnery oak. I speculate that picloram could be broadcast with similar results providing enough precipitation is received to move the chemical into the soil.

(5) As with other herbicides, plots should not be grazed for at least a year following treatment. When the sand shinnery oak defoliates, ground cover is needed immediately because the soil is so susceptible to wind erosion.

(6) Grass yields increase dramatically following oak kill; however, very judicious grazing management with occasional deferment would be needed to retain a healthy plant cover.

(7) These herbicides are not recommended for application to an oak community in poor range condition. These lands are perhaps the most fragile of all ecosystems on the southern High Plains of Texas and the landowner cannot afford to abuse them.

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