Evaluation of Rangeland Seedings Following Mechanical Brush Control in Texas

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Highlight: *Seeding success was evaluated on 62 ranches in Texas to compare relative success and costs of various treatments as affected by range site. Effects of precipitation and temperature were studied. Seeding during rootplow-rollerchop operations gave consistently better stands at a lower cost on all but the very shallow sites where seeding during treedozing treatments proved more economical. Relationships between site and factors affecting success differed distinctly between the wetter and drier portions of the study area. In the drier area, as soil depth decreased the amount of rainfall received close to the planting date aided seedling establishment more than did seedbed preparation. Cool temperatures favored seeding success on very shallow sites, but they were detrimental to seeding success on loamy bottomland sites. In the wetter area, degree of seedbed preparation was more important on all sites as long as sufficient rains for germination occurred within 90 days after planting. Mechanical brush control techniques that destroy most of the existing grass proved a hazardous undertaking, as half of the follow-up seedings were considered poor or total failures. This study separates those brush control practices and seeding techniques most likely to result in successful grassland restoration on west Texas brush-infested ranges from those less likely to provide successful seeded stands.*

Because successful seeding following brush control is so dependent on climate and weather conditions, research limited to two or three seasons on one or two ranches usually provides little information that may be applicable on a regional basis. If work with a variety of equipment and under a variety of situations is available, some form of survey may be possible to serve as a guide for more basic research. For example, Launchbaugh ed. (1966) with assistance from the Soil Conservation Service (SCS) conducted an extensive stand establishment survey in the Great Plains. They found that 18% of the stands evaluated had fewer than 0.5 plants/ft^2, and these were considered failures. Seedings from the Rolling Plains and Edwards Plateau in Texas had 23% and 33% failures, respectively, according to this survey. A similar study with crested wheatgrass (*Agropyron desertorum*) plantings in sagebrush (*Artemisia* sp.) areas conducted with assistance from the Bureau of Land Management found 46% failures over a seven state area (Shown et al., 1969). Only 34% of the rootplowed and seeded area in the Rio Grande Plains of Texas were successful (Boykin, 1960).

The purpose of this study was to compare relative success and relative costs of various mechanical brush control and seedbed modification techniques for grass establishment. Thus it would serve as a guide to ranchers so they might improve their chances for obtaining a successful seeding at the lowest cost, following mechanical brush control.

Seeding success was evaluated on 62 ranches in west central Texas at the northern edge of the Edwards Plateau and the southern edge of the Rolling Plains. Grass stands on ranches in Tom Green county were evaluated during the summer of 1970 and those in Runnels and Concho counties were evaluated in the summer of 1971.

Study Area and Sampling Procedures

Annual precipitation varies from 19 inches in western Tom Green county to 23 inches in eastern Runnels county. Seasonal precipitation peaks occur in May and September. Frost free days average about 230.

Principal range sites in the area are: Low Stoney Hill—shallow soils less than 10 inches deep with rocks on the surface and with pockets of deep productive soils; Very Shallow—soils less than 10 inches deep which may have pockets of deeper soils; Shallow—soils 10 to 20 inches deep which may have pockets of deeper soil; "Deeper" sites (Clay Loam, Deep Upland, Valley)—fertile soils over 20 inches deep not subject to overflow; Loamy Bottomland—fertile soils over 20 inches deep, subject to overflow (North Concho Board of Supervisors, 1967; Wiedenfeld et al., 1970).

To assure as much uniformity in treatment application and follow-up management as possible, only cooperators in the Great Plains Conservation Program (GPCP) administered by

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the SCS were used. All stands evaluated were 2 to 6 years old.

Preliminary data on each ranch came from GPCP files at the SCS district work units in the study area. Ten pace transects consisting of 25 observations each were made on each range site within each seeded area on each ranch to obtain vegetative composition. The plant nearest a mark on the toe of the right boot was recorded at each pace. Range condition scores were determined for each site using the appropriate SCS range condition guides for the area seeded. All seeded native species were designated decreasers or increasers as indicated on the range condition guide. Introduced species not used as filler grasses were counted as decreasers. Blue panic (*Panicum antidotale*) was considered an increaser with 5% allowable on all sites. *Sorghum almum* was counted as an invader on all sites. Sideoats grama (*Bouteloua curtipendula*) made up the largest component of all seed mixtures; green sprangletop (*Leptochloa dubia*) was usually included as a filler grass. Others commonly included were plains bristlegrass (*Setaria leucopila*) and King Ranch bluestem (*Bothriochloa ischaemun* var. *songarica*). Less consistently used were: Blue panic, switchgrass (*Panicum virgatum*), Lehman lovegrass (*Eragrostis lehmanniana*), Caucasian bluestem (*Bothriochloa intermedia*), Indiangrass (*Sorgastrum nutans*), little bluestem (*Schizachyrium scoparium*), blue grama (*Bouteloua gracilis*), buffalograss (*Buchloe dactyloides*), cane bluestem (*Bothriochloa barbinodis*), Kleingrass (*Panicum coloratum*), and *Sorghum almum*.

Grazing capacity before and after treatment was determined for each site using SCS stocking rate guides.

Costs of the entire operation were amortized over a 20-year period uisng 4, 8, and 12% interest rates to arrive at a prorated cost per acre. Amortization is the extinguishing or paying of a financial obligation in equal installments (Parker, 1956).

$$\text{Amortization formula: } a = \frac{So\ [i\,(1+i)^n]}{(1+i)^n - 1}$$

Where a equals the amount of periodic payment; So equals the principle involved; i equals the interest rate; n equals the number of years amortized. Items included in the total annual amortized cost/acre of the seeding were brush removal, seedbed modification, seeding operation, seed, deferment, interest on the initial investment accumulated during nonuse, stand maintenance, and interest during the amortization period. We assumed that treedoze treatments would require retreatment in 7 years and that rootplow treatments would require retreatment in 12 years.

The most valid comparison of costs among treatments is to compare them from the basis of cost per unit increase in grazing capacity. Therefore, an annual cost per animal unit was determined to provide a means of comparing the treatments from an economic standpoint (grazing capacity after treatment times the total annual amortized cost/acre of the seeding). However, the costs required to maintain any additional animals allowed as a result of increased grazing capacity was not included.

Step-wise multiple regression was used to evaluate the combination of variables most important to seeding success. The dependent variable used was the number of total hits of seeded species per 250 paces. All climatic variables were extrapolated from U.S. Weather Bureau records for the area according to

Table 1. Rating system used to evaluate seeding success.

Rating class	% Composition seeded species
Failure	<10%
Poor	10–20%
Marginal	20–30%
Good	30–50%
Excellent	>50%

Table 2. Percent of the stands evaluated that fell into each range condition class for the four most used treatments.

	Range condition class			
Treatment	Poor	Fair	Good	Excellent
Treedoze-seed pits (35)*	31	53	17	–
Treedoze-rake (33)	27	50	24	–
Rootplow-rollershop (22)	–	26	52	22
Rootplow-rake (26)	29	38	33	–

*Number of stands evaluated.

the following formula:

$$c = \frac{AC}{AB}(b) + \frac{BC}{AB}(a)$$

c = the estimated variable X_n occurring at seeded area C.
AB = the distance from station A to station B.
AC = the distance from station A to seeded area C.
BC = the distance from station B to seeded area C.
a = variable X_n recorded at station A.
b = variable X_n recorded at station B.

Results and Discussion

Thirteen treatment combinations were evaluated (Fig. 1), but discussion is largely limited to the four more widely used treatments—treedoze-seed pits; treedoze-rake; rootplow-rollerchop; and rootplow-rake.

The percent composition of the seeded species was used to evaluate the treatments (Table 1). Approximately half of all stands evaluated were unsuccessful, i.e., poor or failures, one-third were good to excellent, and 15% were marginal. Root-

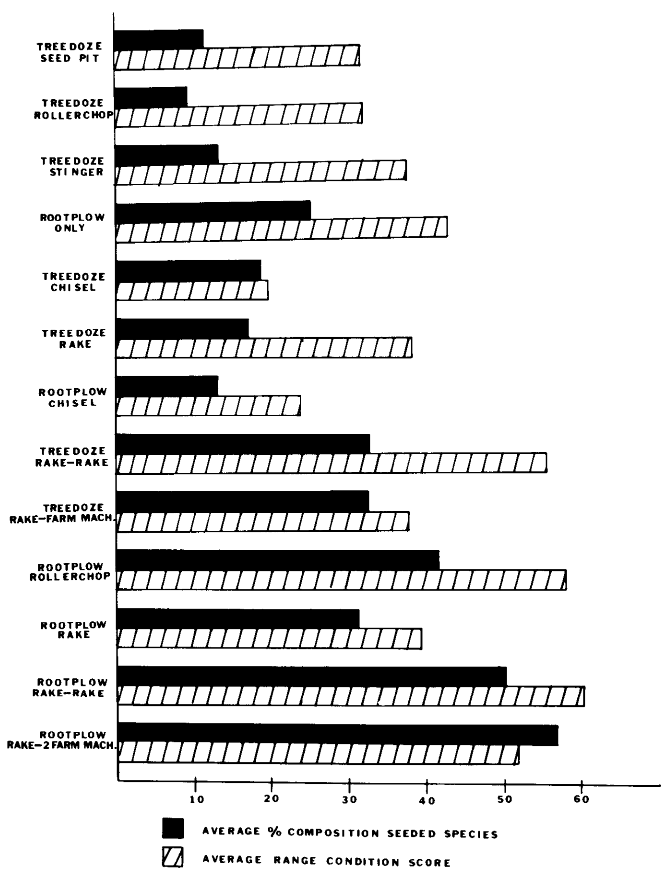

Fig. 1. *Comparison of all treatments evaluated by average percent composition of the seeded species and average range condition score.*

plow-rollerchop gave the most successful stands (78%) and the lowest proportion of stand failures (13%). Rootplow-rake was second best with 55% successful stands. Treedoze-rake and treedoze-seed pits had 9% and 3% success, respectively. Poor seeding success resulted from treedozing because competing vegetation between trees was not sufficiently removed. However, if the treated pits only had been considered, treedozing would have rated much higher. To more fairly evaluate treedozing vs root plowing, comparisons were also made on the basis of range condition. Improvement in overall range condition following mechanical treatment also favored the rootplow-rollerchop treatment (Table 2).

Considering all 13 treatments, grass stands obtained from rootplow-rollerchop were exceeded only by those from the most intensive treatments (rootplow-rake twice and rootplow-rake-2 workings with farm machinery) regardless of evaluation technique (Fig. 1). When individual sites were considered, rootplow-rollerchop gave the highest values for both the seeded species and range condition on all sites except the low stoney hill site when no rootplowing was done.

Factors Affecting Seeding Success

We distinguished among the factors thought to affect seeding success using multiple correlation techniques. Since half the study area receives 19-21 inches precipitation annually (dry end), and the other half receives 21-23 inches precipitation annually (wet end), those areas were analyzed separately. Index values which increased proportionally to the amount of weed-free seedbed and depth of disturbance were developed for the treatments.

All interpretations from multiple regression analyses were restricted to the two most important values because biological interpretation becomes difficult if more than two variables are included.

The relationships between site and factors affecting seeding success differed distinctly for the two divisions of the study area. For the dry end, as soil depth decreased, the amount of rainfall received closer to the planting date was more important for seeding success than degree of seedbed preparation, except for the bottomland site where rainfall 15 days prior to planting was more important. Close examination of this phenomenon revealed that air temperature affected seeding success on the very shallow and bottomland sites. For example, the successful stands on the very shallow site averaged 87 heating degree days (obtained from Weather Bureau records) the month after planting with 2.15 inches of rainfall two weeks after planting, whereas, five heating degree days with 0.26 inches of rain occurred in the same time periods for those stands which failed. (A heating degree day is the number of degrees the average daily temperature is below 65°F). This points to the need for more constant levels of soil moisture and the presence of cool temperatures to help reduce moisture evaporation on the very shallow sites. This phenomenon was reversed for the bottomland sites. Successful stands received 46 heating degree days and six inches of rainfall during the two months after planting, whereas 233 heating degree days and 3 inches rainfall were recorded for the same time period for the stand that failed. Cool, moist soil following planting apparently delayed germination forcing the seedlings into conditions of increased weed competition and increased chances for competition for soil moisture in the bottomland sites. Ellern and Tadmor (1966) found low soil temperatures delayed germination notably in perennial warm-season grasses. Shaidaee et al. (1969) also indicated that cool, moist seedbeds reduced field germination of warm season grass seeds disproportionately from that obtained in laboratory germination trials. Early planting is recommended on all sites except for the bottomland sites where high soil moisture prevents the early warming of soils necessary for germination of warm season grass seeds.

For the wet end of the study area, degree of seedbed preparation was more important than rainfall on all sites as long as sufficient rains for germination occurred within 90 days after planting. Cool temperatures and significant rainfall prior to planting reduced seedling establishment on the bottomland site but not to the same extent as in the dry end.

Seeding success depended largely on the type of brush control, seedbed preparation, precipitation after planting, and soil temperature. The relative importance of each depended on the range site and the annual precipitation of the area. The findings in this study indicate the point where seedbed preparation and precipitation change roles as limiting factors for seeding success.

Table 3. Average initial cost ($) per acre and average decrease in acres required per animal unit for the four most used treatments.

Treatment	Initial cost/acre		Avg decrease in acres/AU
	w/o govt	w/govt	
Treedoze-seed pits	16.76	5.14	5.6
Treedoze-rake	22.39	6.70	5.0
Rootplow-rollerchop	24.65	7.70	9.4
Rootplow-rake	23.58	7.43	5.5

Economics

As expected, initial costs per acre increased as the degree of soil disturbance increased. Rootplow-rollerchop increased grazing capacity most when compared to the other commonly used treatments (Table 3).

When all treatments were compared according to annual cost/animal unit regardless of site, rootplow-rollerchop proved

Table 4. Economic comparison by site of the four most used treatments based on the average annual cost ($) per animal unit* at 8% interest with government help.**

Treatment	Range site					
	Low Stoney Hill	Very Shallow	Shallow	Deeper	Bottomland	Avg
Treedoze-seed pits	35.76	35.93	34.11	31.15	31.75	33.05
Treedoze-rake	33.31	43.68	38.93	32.80	30.28	35.80
Rootplow-rollerchop	–	37.06	33.28	29.46	26.47	31.57
Rootplow-rake	–	41.59	39.30	35.65	–	38.85

* Cost of maintaining additional animals due to increased grazing capacity not included.
**Amount of federal cost sharing is given in Table 3.

Table 5. Total annual cost/acre ($) amortized over 20 years for the four most used treatments.

Treatment	4% Interest		8% Interest		12% Interest	
	w/o govt	w/govt	w/o govt	w/govt	w/o govt	w/govt
Treedoze-seed pits	2.07	0.94	2.98	1.33	4.09	1.81
Treedoze-rake	2.53	1.08	3.67	1.54	4.97	2.10
Rootplow-rollerchop	2.70	1.16	3.85	1.63	5.29	2.20
Rootplow-rake	2.54	1.07	3.66	1.52	5.01	2.05

least costly per unit of improvement in grazing capacity. However, when evaluated by site, the treedozing treatments cost less per animal unit on the shallower sites; on the deeper sites rootplow-rollerchop was more economical. The annual cost/AU decreased as soil depth increased, due to the greater increase in grazing capacity as soil depth increased (Table 4).

The results in Table 5 are average annual costs/acre amortized at 4, 8, and 12% interest for the four most used treatments. An example of how to use these values with and without government assistance is presented below. Rootplow-rollerchop is used. All figures are on a 640 acre per section basis. Note that the income figures cited are gross values. For realistic net returns the cost of maintaining additional animals due to increased grazing capacity will have to be deducted.

Example:

Grazing capacity before treatment	21 AU/section
Grazing capacity after treatment	31 AU/section
Annual production/animal unit	400 lb/AU
Sale price/lb	X $0.55/lb
Annual gross income/animal unit	= $220 /AU
Total annual gross income per section after treatment (31 AU/section X $220/AU)	$6820.00/section
Total annual gross income per section before treatment (21 AU/section X $220/AU)	$4620.00/section
Additional gross annual income/ section due to treatment	$2200.00/section
Total annual amortized cost per section at 8% interest w/o govt. help ($3.85/acre [Table 5] X 640 acres)	$2464.00/section
Total annual amortized cost per section at 8% interest w/govt. help ($1.63/acre [Table 5] X 640 acres)	$1043.20/section
Gross annual income/section due to treatment w/o govt. help (Additional annual income per section–total annual amortized cost/section w/o govt. help)	-$264.00/section
Gross annual income/section due to treatment w/govt. help (Additional annual income per section–total annual amortized cost/section w/govt. help)	$1156.80/section

Conclusions and Recommendations

This study indicated no shortcuts to successful revegetation following mechanical brush control. Degree of seedbed preparation, rainfall, and temperature were major items affecting grass establishment. Recommendations from this study that appear valid are enumerated as follows:

1) Relatively weed-free seed beds are a necessity for grass establishment on all range sites.

2) The more shallow sites should be seeded earlier in the year than the deeper sites where frequent rains before and after planting coupled with cool temperatures help reduce evaporation and seedling death from dessication.

3) On the other hand, seeding of loamy bottomland sites should be delayed, as rainfall received during the 15 days preceding planting proved detrimental due to cold, moist soil that delayed germination of warm-season grass seeds. Consequently, seedlings which did emerge had increased competition for moisture with emerging weeds.

4) Brush on sites with deeper soils is best removed with a rootplow and followed by a rollerchopper for obtaining optimum seeded grass stand, for greatest increase in grazing capacity, and for the least cost per unit increase in grazing capacity.

5) Brush on shallow sites is best removed by tree dozing and the pits seeded to obtain the greatest increase in grazing capacity for the least cost per unit increase.

6) The practice of rootplowing and seeding without further seedbed modification would not be recommended generally, because our data showed only 25% of areas treated this way resulted in good and excellent stands vs 78% for rootplow-rollerchop applications.

7) When range condition is so poor on brush infested ranges that broadcast seeding is required, rootplow-rollerchop would be recommended over treedoze treatments. The pits themselves make excellent seedbeds, but insufficient competing vegetation overall is removed for grass establishment except in the pits. Conversely, when range condition is sufficiently high that only the trees need be removed, tree dozing would be preferred.

8) Surprisingly, rootplow-rollerchop treatments gave better results in all respects than did rootplow-rake operations.

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