GRASS STAND ESTABLISHMENT ON ROUGH, ROCKY, WOODED LANDS IN EASTERN OKLAHOMA

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CHAPTER I

INTRODUCTION

In eastern Oklahoma the Ouachita Highland Resource Area encompasses about 4½ million acres of rough, rocky, wooded lands; supporting approximately one cow on 40 acres. Because these lands produce little marketable timber, livestock provide the major source of income. Similar soils and vegetation in Arkansas and Missouri bring the total area to approximately 15 million acres.

The success of aerial chemical reduction of hardwood brush, especially oaks, have been reviewed by Ray (39), Nichols et al. (36), and Elwell (15). Two problems have emerged to reduce the effectiveness of these treatments. One has been the release of resistant woody species such as winged elm (Ulmus alata Michx.), hawthorn (Crataegus spp. L.), mulberry (Morus spp. L.), and hackberry (Celtis spp. L.). The other problem has been an increase in broomsedge (Andropogon virginicus L.) in sprayed areas. In Arkansas, Davis (11) observed that broomsedge comprised 3% of the forage produced before herbicide treatment and 34% after herbicide treatment; but before the application of herbicides, little bluestem (Andropogon scoparius Michx.) and broomsedge were present in about the same amounts. After the canopy was removed by herbicide, broomsedge became dominate for the three succeeding years. In the fourth year with careful grazing management, little bluestem took over as the most plentiful grass. Steer gains the year of the herbicide treatment (1958) were as low as four pounds per acre. Five years later, and without fertilizer, the steer gains were as high as 78 pounds per acre. The steady progress of plant succession on these sites soon produced a canopy of woody species which would require further herbicide treatment.

Boyle (5) described methods of aerial application of fertilizers as used in South Wales where 90% of the bulk fertilizer produced was applied with airplanes on rough hill country. One aircraft could spread about 300 tons of fertilizer in five working days.

Weeping lovegrass (*Eragrostis curvula* Schrad. Nees) and Plains bluestem (*Bothriochloa ischaemum* var. *ischaemum* (L.) Keng) were productive introduced grasses which responded to fertilizer in a study near Stillwater (27).

Weeping lovegrass commenced active spring growth earlier than native grass. Woody species also began growth earlier than native grasses and this early growth rapidly depleted the soil moisture which the native grasses could have used (16). An earlier vigorous grass growth should provide competition for the woody species and slow their growth. If these grass species could be established on such land in eastern Oklahoma, fertilizer could be aerially applied and the productivity of these lands should be increased manyfold.

The objective of this study was to investigate methods of establishment of introduced and native grasses following a herbicide treatment on brush infested rangeland.

CHAPTER II

LITERATURE REVIEW

Aerial Application

Aerial application of herbicides, fertilizer, and seeds have been utilized throughout the country. Corn, wheat, soybeans, rye, barley, oats, etc., have been aerial seeded in Kentucky, Missouri, Mississippi, Oklahoma, and Tennessee (8). Obtaining a uniform stand was the greatest difficulty and weak seedlings, which may die, necessitated a higher seeding rate than conventional methods. One consolation was that higher quality plants survived.

The requirements for successful aerial seeding as listed by Watts and Fink (43) were: (1) adequate moisture, (2) cool temperature, and (3) low light intensity. The best conditions for establishment of aerial sown pastures according to Campbell (7) were: (1) reliable and effective rainfall, (2) low temperatures and evaporation, and (3) soil surfaces frequently wet by rain, dew, snow, frost, and mist. These conditions are present in eastern Oklahoma for fall or early spring seeding on range previously sprayed for brush control.

Burning

Burning was included in this study to remove the leaf litter and permit better soil--seed contact for seed germination. Grelen and Epps (18) concluded that the beneficial effects of burning were attributed mainly to litter removal. However, the time of burning and the other effects of burning are important considerations if burning is to be used annually or anytime after establishment of the grass stand (4). Much work has been done in the study of burning and many reports are conflicting; however, when used correctly, burning apparently is a useful tool for higher forage production.

Penfound (38) found that an accidental fire caused an increase in herbage biomass initially, but in the season following the fire, a considerable reduction of forage resulted. Accidental forest fires not only destroy timber but expose the soil to erosion forces which can be checked by grass establishment. McClure (32) reported success in establishing grass by broadcast seeding immediately after a fire. After the establishment year, forage production was high for about two seasons, then dropped to 30-40% of that level and remained relatively stable. The initial production was attributed to more available soil nitrogen immediately following the burn. This same phenomenon of initial high forage production followed by a rapid decline over a few years was reported by McMurphy and Denman (34) and Langston and McMurphy (27), but adequate use of fertilizer maintained the high production.

Burning plus fertilization as a single treatment on native vegetation gave significantly higher forage yields than burning, fertilization, nonburning, or nonfertilization as single treatments (17). Big bluestem (Andropogon gerardi Vitman) and indiangrass (Sorghastrum nutans (L.) Nash) responded better than other species to the fertilizer plus burning treatment. A point of interest in this study was that it was conducted during a dry year. Generally burning and fertility studies are not very successful in dry years. However, removal of the mulch by burning may have allowed the light summer rains to penetrate the soil. Clark (9) studied this phenomenon and reported that a large percentage of the rain which fell upon an area covered with vegetation was held on the leaves and stems of plants. The amount of water intercepted or, conversely, the amount which reached the soil and became available to the plants depended upon the intensity of rainfall and the kind and density of the vegetation. During light showers or mists all but a very small percentage of the moisture might be held upon the plants and evaporated. Vegetation played a variable role in determining how much of the water precipitated finally entered the soil and became available for absorption by the roots.

The excellent response from burning plus fertilization might also be accounted for in the removal of mulch which is highly carbonaceous and low in nitrogen. It was postulated that soil microorganisms feeding on this mulch might compete for the applied nitrogen and thus keep it unavailable for plant growth until a later time (33).

Kucera et al. (26) suggested that beneficial effects of fire on prairie were only to be expected where rainfall was dependable and exceeded 18 inches. Moisture was very important in that heat damage to plants was lessened or eliminated when the soil surface moisture was adequate at the time of burning. During the growing season plots which had been burned earlier had higher soil temperatures, more evaporation, and lower soil moisture than unburned plots (23). In an area of adequate rainfall and soil moisture these effects may not be limiting to forage production.

Nitrogen in litter is generally unavailable for plant use until decomposed by soil microorganisms. Burning hastens litter decomposition. Mayland (31) noted that nitrogen availability was significantly higher on soils from burned than from unburned areas 10 months after burning. Increased soil-nitrogen concentrations were observed at all depths on the burned as compared with the unburned treatment. Total nitrogen in the mineral soil may be increased as a combined result of burning litter, and standing vegetation, and leaching of nitrogen--containing compounds. The relative availability of soil nutrients, especially nitrogen, may be enhanced as a result of burning.

Morris (35) reported that burning had no significant effect on soil nitrogen contents during a three year period. In a study by Vlamis et al. (44), soils under burning treatments showed an increased nitrogen supply over the unburned soil. The effect was greater in the surface soil than in the subsoil. The results were less pronounced on the two-year burn than on the one-year burn. Hulbert (23) reported that the short term effect of burning was due to removal of litter, rather than to direct heat or to fire-induced nutrient changes.

Beadle (3) and Lutz (29) found that burning caused no significant change in pH of soil. Barnette and Hester (2), Heyward and Barnette (21), Marshall and Averill (30), Mayland (31), and Wahlenberg et al. (41) found that burning produced an increased alkalinity of the surface soil.

Vlamis and Gowans (45) studied the effect of burning on soil properties, and stated, "Some of the changes noted have been a rise in surface reaction (pH), an increased nitrogen supply, greater phosphate availability, and higher base status, especially calcium and potassium." They speculated that the addition of fertilizers to a soil directly following a burn may be unnecessary. It may be more useful to make the application of fertilizer the following year when the stimulating effect of the burn has worn off. Vlamis concluded that burning a vegetative cover increased the supply of nitrogen, phosphorus, and sulfur available for plant growth in the soil.

The effect of fire on the original vegetation and on subsequent plant succession depended on the type and intensity of fire (38).

The time of burning was important because the percent of big bluestem and little bluestem remained essentially the same on an unburned pasture, decreased on an early burned pasture, and increased with mid and late spring burning (1). Burning, especially late spring burning favored big bluestem. Early and mid spring burning reduced little bluestem while late spring burning had no effect. Indiangrass increased in all treatments, and was best in late spring burning. Switchgrass (Panicum virgatum L.) decreased in all treatments, but decreased the least in the late spring burning.

Time of burning was also important in weed control. Morris (35) reported that burning provided more effective early weed control than mowing or herbicide treatments of Coastal Bermudagrass (Cynodon dactylon (L.) Pers.). Burning on January 1st was less effective for weed control but burning April 1st gave maximum weed control.

Hensel (20) concluded that in burned areas the vegetation started spring growth earlier, that weeds were reduced, and that little bluestem increased. In a conflicting report Penfound (38) observed that little bluestem was more susceptible to damage by fire and decreased.

Burning followed by establishment of perennial grasses may result in significant but often temporary increases in forage production.

However, while seeding has been somewhat successful in establishment of grass, the recovery of sprouting shrub live oak has been shown to be rapid (28).

Fertilization

Eckert and Bleak (13) determined that four mountain soils with 15 to 40 inches of annual precipitation were deficient in nitrogen, phosphorus, and lime. Hull (24) found that on some mountainous areas with high precipitation, fertilization gave erratic results, probably due to the soils ability or inability to retain nutrients. On new range seedings on six mountainous areas in the West where precipitation ranged from 12 to 40 inches annually, nitrogen increased seedling numbers, increased vigor of seeded and native plants, and at the high rates significantly increased the protein and nitrogen content of the herbage. Nitrogen applied in the fall was not in the top 42 inches of the soil the next June or August. Phosphorus applied in the fall or spring increased the phosphorus in the topsoil, but did not increase the phosphorus in the herbage.

Warnes and Newell (42) in Nebraska studied establishment and yield response of warm--season grass strains to fertilizer and found that annual nitrogen fertilization maintained superior stands and increased forage yields. Where not limited by soil moisture or shortness of season, the late maturing strains of switchgrass, indiangrass, and big bluestem produced larger yields than early maturing strains of these grasses. Problem soil sites with low organic matter, eroded slopes, or nutrient deficiencies needed proper fertilization for full success.

Measurements of the percentage grass stand revealed no differences associated with fertilization or weed control with the exception of switchgrass (6). However, Elder and Murphy (14) and Huffine and Elder (22), while studying the effect of fertilizer on native grasses in Oklahoma found that although total dry matter production increased with fertilization, the percentage of native grass in the production decreased. At the end of four years the portion of a native grass meadow which received no fertilizer consisted of about 71% native grass and 29% weeds while the portion fertilized with nitrogen, phosphate, and lime consisted of about 25% native grass, 47% annual grasses, and 28% weeds. Weeds and other grasses that initiated spring growth earlier than the native grasses utilized the nutrients and soil moisture present to the extent that when the native grasses started growth later, competition was more severe making dry summers more detrimental to the native grasses. The increase in weeds and annual grasses, primarily cool season species, has been a major problem with fertilization of tall grass prairie. Low yield response has also been a problem (19). Part of the problem may be that of limited regrowth potential which appears to be a result of selection through evolution (33).

Nichols and McMurphy (37) found that high levels of nitrogen and 2,4-D in combination significantly increased yields. The treatment effects were most pronounced three years after application.

Kneebone and Cremer (25) reported that the difference in seedling vigor within a given strain was partly attributed to a difference in seed size. Seed size had little effect on germination, but seedlings from large seeds emerged and grew faster than those from small seeds. The initial growth response of the various grasses to fertilizer also appeared to be directly related to their inherent seedling vigor.

Species with medium to high seedling vigor responded to fertilizer. Response of species with low vigor was so slow that fertilizer was of no apparent benefit.

CHAPTER III

MATERIALS AND METHODS

The study area was located near Lamar, Oklahoma, on the Sarkeys Foundation land (SW¼, SW¼, section 7, T.7N., R.12E.). The soil was of the Hector Complex in the Hector Series which are characterized by shallow, stony, excessively drained soils formed from acid sandstone and shale and having a slope range from 5 to 30%. Soil tests revealed a pH of 5.4, 11 lb/A of available phosphorus, 140 lb/A of available potassium, and 2% organic matter. The native vegetation was dominated by blackjack oak (*Quercus marilandica* Muenchh.), post oak (*Quercus stellata* Wang.), and hickory (*Carya* spp. Nutt.) trees, with an understory of brush plus big bluestem, little bluestem, switchgrass, indiangrass, and broomsedge.

The experimental design for methods of seeding establishment was a split plot with a factorial arrangement of subplots. Main plots (100 x 120 ft.) were burning vs. nonburning and the subplots (40 x 50 ft.) were three species seeding treatments at two fertility levels with five replications. Fertility levels were no fertilizer vs. fertilizer. Species seeding treatments are in Table I.

The burn treatments were applied to the plots on March 24, 1970. The mulch was approximately 95% oak leaves with 7060 lb/A and was determined by sampling with a 3 x 4 foot quadrat immediately prior to burning. At the time of the burn, the soil surface was moist, the wind

TABLE I

SPECIES SEEDING TREATMENTS

No.	Treatment Mixture	Seeding Rate
1.	Natural Recovery	None
2.	Native Seeded	
	'Kaw' Big Bluestem (*Andropogon gerardi* Vitman)	10 PLS/ft^{2*}
	'Caddo' Switchgrass (*Panicum virgatum* L.)	10 PLS/ft^2
	'Cheyenne' Indiangrass (*Sorghastrum nutans* (L.) Nash)	10 PLS/ft^2
3.	Lovegrass and Plains Bluestem	
	'Morpa' Weeping Lovegrass (*Eragrostis curvula* Schrad. Nees)	2 lb. seed/Acre
	Plains Bluestem (*Bothriochloa ischaemum* var. *ischaemum* (L.) Keng)	15 PLS/ft^2

* PLS is "pure live seed"

velocity was 5 to 15 miles per hour, the air temperature was 70° F, and the air humidity was 60%. The fire was of low intensity. The fire temperature was determined using Tempil sticks, which melt at 125, 150, 200, 350, 500, 700, and 900° F. Slices from each Tempil stick were suspended by a fine copper wire eight inches above ground level. Readings from the highest temperature stick which melted averaged 550° F and varied from 350 to 700° F.

The entire area was aerially sprayed on June 8, 1970, with a herbicide oil-water emulsion of Silvex (1.64 lb/A) and Picloram (0.8 lb/A) at a volume of 4.1 gallons per acre. Grass seed was broadcast on June 10, 1970. Fertilized plots were treated with 50 lbs. of nitrogen per acre as ammonium nitrate, and with 40 lbs. of P_2O_5 per acre using 0-46-0 on July 20, 1970.

The number of woody plants by species and size groups were counted in a 10 x 100 foot transect running from the southeast to northwest corner of each main plot in June, 1970. The percentage of defoliation by fire or herbicide of different woody species were recorded October 21, 1970, using the scale (0-10) where the digit 0 indicates no effect and the digit 10 indicates 100% effect or a killed tree.

Soil moisture conditions were excellent at the time of seeding but subsequent precipitation was much below normal (Table II). Poor seedling establishment occurred the first year; therefore, a second broadcast seeding was applied on March 26, 1971, and a second fertilizer application of 50 lbs. of N, 40 lbs. of P_2O_5, and 40 lbs. of K_2O per acre was made on June 3, 1971.

The success of the seedling establishment was evaluated using frequency of occurrence in a one foot square quadrat. A determination

TABLE II

PRECIPITATION AT HOLDENVILLE 20 MILES WEST OF THE STUDY AREA

Month	30-Yr. Mean	Inches of Precipitation	
		1970	1971
January	2.02	.20	.60
February	2.50	.37	1.10
March	3.06	-	.30
April	4.27	5.36	1.10
May	6.34	2.43	6.20
June	5.23	3.75	8.60
July	3.97	.84	5.60
August	3.10	.80	4.15
September	3.75	11.99	2.88
October	3.26	17.08	6.40
November	2.41	.60	1.60
December	2.30	.85	4.80

of species in each subplot was taken on July 27, 1971. Readings were taken with a one foot square quadrat with 20 random readings per subplot. Only the presence of the species was recorded for each reading. If the species was present within the quadrat, regardless of its quantity, it was given the value of one.

The forage of each subplot was harvested on August 4, 1971, by clipping five samples from an 18 x 36 inch quadrat from each plot.

Forage yields and brush defoliation were subjected to an analysis of variance but the frequencies of species occurrence were analyzed by the Friedman Two-Way Analysis of variance (40).

CHAPTER IV

RESULTS AND DISCUSSION

No data were obtained the first year due to poor stand establishment. Normal precipitation at Holdenville from June 1 to August 31 has been 12.3 inches. Soil moisture was excellent at seeding time (June 10, 1970) but after seeding only 3.13 inches of rain fell until September.

The second year was actually the seeding year and the forage production had not reached its potential. Many desirable grass seedlings contributed little to the forage production.

Burning in the same year prior to herbicide application has been known to decrease the effectiveness of herbicide although herbicidal defoliation of blackjack and post oak was greatly enhanced by spraying the year following a burn (12). This is probably true with a fire of high intensity but a fire of low intensity as in this study appeared to have no harmful effect on defoliation. There was no difference in the defoliation of blackjack, white oaks (*Quercus alba* L.), and winged elm between burned and unburned plots. The percent defoliation was significantly higher on burned plots for hickory and huckleberry (*Gaylussacia* spp. HBK) plants (Table III).

The number of woody sprouts was increased by burning as compared to nonburning (Table IV). These results corroborate data from Elwell et al. (16). However, a controlled burning program might prevent

TABLE III

EFFECT OF BURNING ON BRUSH DEFOLIATION
FROM AERIAL HERBICIDE APPLICATION

OCTOBER 21, 1970				
		Percent Defoliation		
Species	Size	Burned	Unburned	"F" test*
Blackjack Oak				
	Seedling	59	73	ns.
	Small	89	80	ns.
	Medium	84	87	ns.
	Large	81	90	ns.
White Oak				
	Seedling	77	82	ns.
	Small	89	84	ns.
	Medium	76	86	ns.
	Large	89	88	ns.
Hickory				
	Seedling	22	28	ns.
	Small	54	19	ns.
	Medium	42	23	**
	Large	28	25	ns.
Winged Elm				
	Any Size	90	70	ns.
Huckleberry				
	Any Size	83	36	**

* ns = not significant ** significant at 5% level

TABLE IV

EFFECT OF BURNING ON NUMBER OF WOODY PLANTS IN 10 x 100 FOOT TRANSECTS

JUNE, 1970			
Species	Size*	Unburned	Burned
Blackjack and White Oak	Sprouts	22	91
	Others	54	36
Hickory	Sprouts	5	10
	Others	5	6
Winged Elm	Any Size	8	0.4
Huckleberry	Any Size	12	27

* Sprouts are less than 15 mm or ½ inch diameter
Others are larger than 15 mm or ½ inch diameter

these larger numbers of sprouts from achieving canopy dominance. The establishment of weeping lovegrass may also help in reducing sprout growth rates because weeping lovegrass grows earlier than native grass, If weeping lovegrass can be established, this species should provide greater competition than native grasses against the brush.

The success of seeding treatments was evaluated by frequency of occurrence of the seeded species (Tables V and VI). Success was the presence of a single plant of one species per square foot. Lovegrass was successful especially on the burned and fertilized plots. Weeping lovegrass was present in 79% of the quadrats while Plains bluestem was present in 3% of the quadrats. Either weeping lovegrass or Plains bluestem was present in 82% of the quadrats. This means that none of the lovegrass quadrats had Plains bluestem present. The native seeded plots had only modest success with 38 to 56% of the quadrats containing the desired species. Natural recovery is a slow process as shown by only 3 to 6% of the quadrats having the desired species. These data are in agreement with Davis (11) and Crawford and Bjugstad (10).

Big bluestem and switchgrass were apparently unsuccessful since their seeding did not appreciably exceed the control. Seeding with indiangrass in the mixture increased the frequency of occurrence of indiangrass, but burning and fertilization had little effect on stand establishment. These data represent only one year's data, and further research should be evaluated before indiangrass can be favored over big bluestem and switchgrass. However, a study in the Missouri Ozarks by Crawford and Bjugstad (10) revealed that burned, fertilized plots seeded with tall fescue (<u>Festuca</u> <u>arundinacea</u> Schreb.) produced over 700 lb/A of desirable grass the first season. Seeded native plots took

TABLE V

SEEDING SUCCESS OF WEEPING LOVEGRASS AND PLAINS BLUESTEM AS FREQUENCY (%) OF OCCURRENCE IN FT^2 QUADRATS

JULY 27, 1971

Treatment	Frequency		
	Weeping Lovegrass	Plains Bluestem	Total Success[1]
Burn	48	6	51
Burn + Fertilizer	79	3	82
Nonburn	55	3	56
Nonburn + Fertilizer	42	8	50

1 Presence of either weeping lovegrass or plains bluestem in each quadrat. Treatment means were significantly different at P = .10 level.

TABLE VI

SUCCESS OF NATURAL RECOVERY COMPARED WITH NATIVE SEEDED PLOTS AS FREQUENCY (%) OF OCCURRENCE IN FT^2 QUADRATS

JULY 27, 1971								
	Frequency							
	Big Bluestem		Indiangrass		Switchgrass		Total Success[1]	
Treatment	Recovery	Seeded	Recovery	Seeded	Recovery	Seeded	Recovery	Seeded
Burn	1	4	2	37	0	4	3	44
Burn + Fertilizer	5	14	0	40	0	5	5	56
Nonburn	2	4	2	31	0	5	4	38
Nonburn + Fertilizer	0	7	4	31	2	12	6	49

1 Presence of either big bluestem or indiangrass or switchgrass in each quadrat. Treatment means were not significantly different at P = .10 level for each mixture.

two growing seasons to produce over 700 lb/A, with indiangrass being the most abundant species. Unseeded areas took four growing seasons to produce over 700 lb/A. Most unseeded plots failed to produce much more than 50 lb/A.

Seedling establishment was poor on unburned plots having dense leaf litter. Two unburned subplots produced no forage at all. Some burned plots where the litter was not completely burned also had poor seedling establishment. According to Campbell (7) rainfall and evaporation between the time the first root emerges from the seed until it enters the soil are the most critical factors in establishment. The leaf litter remains wet when humid conditions prevail but may dry too rapidly with dry winds. This may be the key to explaining why seedling establishment was poor on plots having dense leaf litter.

Forage production evaluated on August 4, 1971, revealed that fertilizer significantly increased yields (Table VII). The controlled burn had no significant value for improving production, and there was no evidence that the burning was detrimental to production. The lovegrass--Plains bluestem seeding treatment produced significantly more forage than the natural recovery treatment.

The greatest single treatment forage yield response occurred on native seeded plots which were burned and fertilized. However, the problem of cool season invaders has not had time to develop (14) (22).

TABLE VII

FORAGE PRODUCTION (LB/ACRE) AS INFLUENCED BY SEEDING TREATMENT, BURNING, AND FERTILIZATION

1971				
Treatment	Natural Recovery	Native Seeded	Lovegrass Plains Bluestem	Mean
Burn	1179	859	1666	1251 ab
Burn + Fertilizer	1065	2953	2002	2007 a
Nonburn	538	1001	1352	964 b
Nonburn + Fertilizer	1271	1570	2605	1815 a
Mean[1]	1013 b	1596 ab	1906 a	

1 Numbers with the same letter are not significantly different at the 0.05 level.

CHAPTER V

SUMMARY AND CONCLUSIONS

The objectives of this study were to investigate methods of establishment of native and introduced grasses on herbicide treated brush plots in the Ouachita Highland Resource Area of eastern Oklahoma.

A split plot with factorial arrangement of subplots in five replications was used. Main plots were burning and nonburning, and subplots were all possible combinations of two fertility levels with three species seeding treatments.

Burning did not have any adverse effects on herbicide defoliation of brush; however, burning did result in an increased number of brush sprouts. Statistical analysis showed that burning had little effect on establishment of species and forage production. Visual observations indicated the value of burning in removing leaf litter to permit seedling establishment.

Species seeding treatments significantly influenced forage production with the natural recovery plots having the lowest yields. The weeping lovegrass species was successful especially on the combination treatment of burning plus fertilizer. The seeding of indiangrass increased that species, but a maximum of 40% frequency was the best result.

Fertility treatments significantly increased forage yields. To adequately evaluate the introduced grasses and fertilizer treatments one more year will be required because much of these data probably represent only the seedling year.

The most promising treatment appeared to be burning to remove leaf litter, seeding with lovegrass, and fertilization.

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