AN ABSTRACT OF THE THESIS OF

Craig M. Cavanaugh for the Master of Science Degree

in Biology presented on May 15, 1987

Title: Grass Seeding Old Fields in Kansas

Abstract approved: [signature]

In Lyon County, Kansas, there were 12,140 hectares (approximately 30,000 acres) of old fields (abandoned croplands). To reduce the 80 to 85 years of secondary succession required to establish tall grass prairie in old fields there are certain recommended mechanical methods of seeding old fields. These mechanical methods have disadvantages, including: erosion, phytotoxic effects from grain sorghum, and competition from the seed bank. To overcome the problems of the mechanical methods, this research was done to determine if a successful stand of desirable grasses including big bluestem, little bluestem, indian grass, switchgrass, and sideoats gramma could be established by spraying old fields with a herbicide then seeding directly into the dead weeds and litter. The method involved spraying the old fields with 1.75 liters "Roundup", 0.56 kilograms 2,4D, and 187.05 liters water carrier per hectare (24 ounces "Roundup", 8 ounces 2,4-D, and 20 gallons water per acre). The study areas were then seeded with the grass mixture at a rate of 8.52 kilograms per hectare (7.60 pounds per acre) at Study Area A (Whitney) and 11.22 kilograms per hectare (10.0 pounds per acre) at Study Area B (Senn) of pure live seed (PLS). At the end of the second growing season, the seedlings were counted. The results were: 1.87 seedlings per 929 square centimeters (one square foot) at Study Area A (Whitney); and 1.34 seedlings per 929 square centimeters (one square foot) at Study Area B (Senn). This rated a

good (the highest rating) according to the standards of the Great Plains Agricultural Council (1966). This method is successful as the results show. The planted species were not only successful, but they set seed during the second growing season. The only unwanted perennial grass remaining was smooth brome, which can be reduced in density by using an earlier spraying date prior to seeding or by post-seeding burning. Finally, this method should be a recommended alternative to the mechanical methods of establishing tall grass prairie in old fields.

Grass Seeding Old Fields in Kansas

A Thesis

Submitted to

the Division of Biological Sciences

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In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

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May 1987

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Approved for Major Department

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Approved for Graduate Council

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ACKNOWLEDGEMENTS

I am grateful for the help and assistance of a number of people. Among them are Mr. Leroy Pritchard who found the old fields for this study, Mr. Ron Whitney and Mr. Fred Senn who allowed me free access to study their fields, and Dr. Tom Eddy who was on my committee. Special thanks to Dr. James Mayo, whose help, time, and guidance made this study possible.

INTRODUCTION

The Resource Inventory of Lyon County, Kansas (United States Department of Agriculture, Soil Conservation Service, 1979) reports that there are 12,140 hectares (approximately 30,000 acres) of old fields in Lyon County. Old fields are croplands that are abandoned because of reduced productivity due to erosion (loss of the A horizon, i.e. top soil). In some areas, erosion has removed all of the A horizon. These fields cannot be profitably farmed because no amount of chemical fertilizer can restore the depleted soil. Rice (1974) states that many old fields (abandoned to agriculture) are in varying stages of secondary succession. Secondary succession occurs in four stages (seral). These are pioneer weed stage, annual grass stage, perennial bunch grass stage, and climax stage.

The pioneer weed stage lasts for two to three years. The pioneer weeds (invaders) include: annual sunflower (*Helianthus annuus*); crab grass (*Digitaria sanguinalis*); annual brome (*Bromus tectorum* and *Bromus japonicus*); ragweed (*Ambrosia psilostachya*); *Erigeron canadensis*; and *Amaranthus* sp.

The annual grass stage lasts nine to thirteen years, with exceptions lasting as long as 30 years. Three-awn grass (*Aristida oligantha*) is the major species of this stage.

The perennial bunch grass stage is next, and can last up to 50 years. The major species of this stage are little blue stem (*Andropogon scoparius*) and tall drop seed (*Sporobolus asper*).

Finally, after 80 to 85 years, if a seed source is present the climax community may be established. This community includes big bluestem (*Andropogon gerardi*), little bluestem (*Andropogon scoparius*), indian grass (*Sorghastrum nutans*), and switchgrass (*Panicum vergatum*).

In addition to these grasses, there are many forbs.

To reduce the time required to establish tall grass prairies in old fields, certain methods of seeding are recommended (United States Department of Agriculture, Soil Conservation Service, 1978; Vallentine, 1980). These methods are: seeding into standing cover; seeding into a clean tilled seed bed; and seeding into a surface mulch.

Seeding into a standing covers requires plowing the field, planting a residue producing crop, and seeding into the residue with no further seedbed preparation. The cover crop, usually grain sorghum (milo), is managed to prevent the production of viable seed and to prevent the crop from exceeding 30.48 centimeters (12 inches) in height. This is accomplished by either mowing, grazing, or late summer seeding. Pritchard (1984) states that farmers are reluctant to use this method because of the expense involved and because the soil is moderately stable with the existing weed cover. Rice (1974) reports that sorghum has a phytotoxic effect on plants grown in its stubble and litter. These effects are most noticeable under suboptimum conditions. The condition of old fields is suboptimal because of the reduction in top soil by erosion. This causes a reduction in available nitrogen, calcium, magnesium, and potassium (Brady, 1974).

Seeding into a clean tilled seedbed is another method for seeding old fields. This method requires using the necessary tillage implements to till the soil to a depth of 2.54 to 5.08 centimeters (one to two inches) just prior to seeding, resulting in a firm but friable seedbed. Vallentine (1980) states that wind and water erosion will occur under these conditions because there is nothing to hold the soil in place during seedling establishment. Also, some areas will remain bare ground because the seeds and seedlings are displaced during erosion. Another reason for not tilling the soil is the exposure to viable weed seeds from the seed bank. Harper (1977) and Lippert and Hopkins (1950) report that there are as many as 20,000 weed seeds per meter square in the top five centimeters (two inches) of soil. Some of the plants and the number of seeds that contribute to the seed bank are: Digitaria sanguinalis, 2,000 to 15,000 per plant; Setaria viridis, 370 per panicle; Solanum nigrum, 178,000 per plant (Radosevich and Holt, 1984). The viability of these seeds varies with the type of seed and soil conditions. Legume and weed seeds stay viable longer than grass seeds. Also, seeds that remain buried in the soil stay viable longer than seeds that are allowed to air dry (Radosevich and Holt, 1984).

A final method, which is experimental and not documented, is to seed into standing cover or surface mulch. This method requires seedbed preparation by killing the existing weedy vegetation with a herbicide and leaving it standing along with existing litter. The area is then seeded after laying fallow over winter. Vallentine (1980) states that a good herbicide for this treatment must kill a broad spectrum of the undesirable plants, dissipate rapidly after weed control is achieved, and be degraded before grass seedlings emerge. Vallentine (1980) reports that seedbed preparation by chemical means has many advantages over mechanical preparations. These are: leaving a firm seedbed for better grass establishment; preventing wind and water erosion because the weed stand and litter remain; avoiding the phytotoxic effects of a grain sorghum; preventing introduction of viable seed from the seed bank; and reducing the cost compared with mechanical preparation.

Vallentine (1980) lists the properties of herbicides used on rangeland or proposed for rangeland use. One herbicide that fits the requirements is N-phosphonomethyl glycine ("Roundup").

"Roundup" is a nonselective herbicide that kills a broad spectrum of plants. Unfortunately, it kills desirable grasses and forbs, too. It is translocated via the phloem. It interferes with amino acid synthesis and persists for one to three weeks in the soil.

The objective of this research was to determine if a successful stand of desirable grasses, including big bluestem, little bluestem, indian grass, and switchgrass could be established by spraying old fields with a herbicide then seeding directly into the dead weeds and litter.

DESCRIPTION OF STUDY AREAS

Area A was owned by Mr. Ron Whitney, Route 5, Emporia, Kansas at the time of this study.

It is an 8.9 hectare (22 acre) tract (Figure 1). There are two 0.40 hectare (one acre) controls included in this area. The study area is located in the center of the Northeast Quarter (NE 1/4) of Section 16-20-10 (Figure 2) in Lyon County.

The soil at this site is a Labette silty clay loam with a two percent slope. Labette is a fine, mixed mesic Udic Argiustoll. The typical A horizon of an uneroded Labette soil is 20.32 centimeters (eight inches) deep. The top soil, which is modified B horizon (Swanson, 1983), at this site ranges from 0 to 5.08 centimeters (zero to two inches). The current erosion rate of this study area is 15.69 metric tons per hectare (seven tons per acre) (Pritchard, 1984).

Area B was owned by Mr. Fred Senn, 2 Sylvan, Emporia, Kansas at the time of this study.

It is a 5.71 hectare (14.11 acre) tract (Figure 3). There are two 0.40 hectare (one acre) controls included in this area. The study area is located in the East 1/2 of the Southwest 1/4 of the Northeast Quarter (E 1/2 SW 1/4 NE 1/4) of Section 17-21-11 (Figure 2) in Lyon County.

The soil at this site is a Kenoma silty clay loam with a two percent slope. Kenoma is a fine montmorillonitic thermic Vertic Argiustoll. The typical A horizon of an uneroded Kenoma soil is 25.4 centimeters (ten inches) deep. The top soil, which is modified B horizon (Swanson, 1983), at this site ranges from 0 to 5.08 centimeters (zero to two inches). The current erosion rate of this study area is 29.14 metric tons per hectare (13 tons per acre) (Pritchard, 1984).

Neither of the sites has been farmed since the late 1940's.

Figure 1. Boundaries of Study Area A (Whitney) with controls and general view photograph.

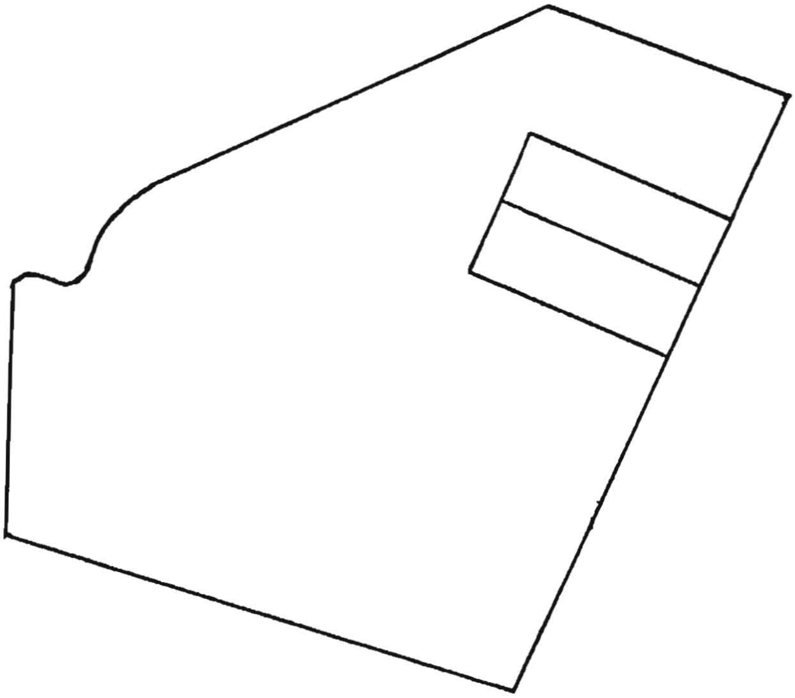


Figure 2. Location of study areas in Lyon County.

Study Area A (Whitney)
Study Area B (Senn)

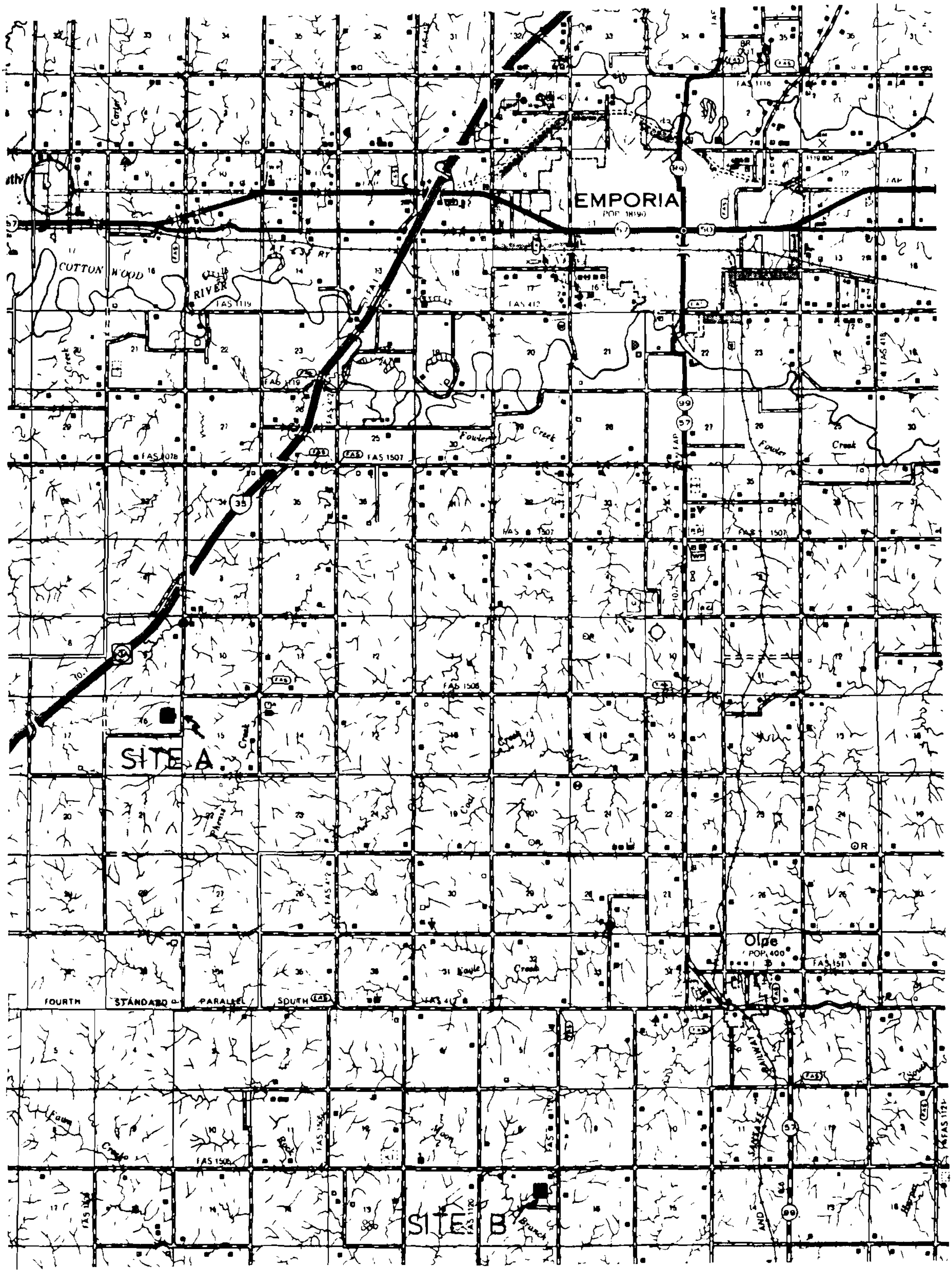
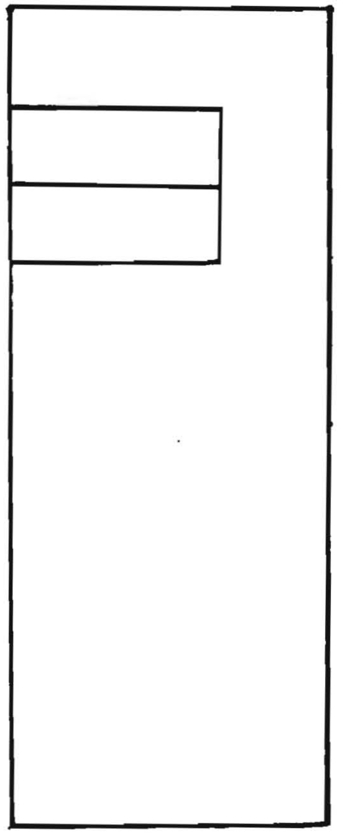

EMPORIA
POP. 18190
COTTON WOOD
RIVER
Fowler Creek
SITE A
SITE B
Olpe
POP. 400
FOURTH STANDARD PARALLEL SOUTH

Figure 3. Boundaries of Study Area B (Senn) with controls and general view photograph.



METHODS AND MATERIALS

The study areas boundries were determined and marked with steel posts (Figures 1 and 3). Also, two 0.40 hectare (one acre) control plots at each site were established.

At both sites, the controls were treated in the same manner. The north control plots were left as untreated controls (i.e. nothing was done to them). The south control plots were not sprayed with herbicide but were seeded with the grass mixture.

Randomly selected soil samples (Figures 4 and 5) were taken to determine the soil profile. The soil samples were taken by a Soil Scientist from the Soil Conservation Service.

A random number generator was used to determine the location of ten plots per study area to be studied (Figures 6 and 7). The plots were 0.9144 by 0.9144 meters (three feet by three feet). In addition, two plots were established in each of the controls. The plots were temporarily marked with wooden stakes, then permanently marked with reinforcing rod (Figure 8). Also, each plot was marked with a steel fence post located three meters south of the plot.

Species composition was determined by using a ten point frame (Figure 9). Ten sets per plot were taken to give 100 points per plot. An additional 400 points of data were collected from the treated areas. Also, plot and general view photographs were taken for visual comparison.

After all initial data was collected, the study areas were sprayed with the herbicide on July 19, 1984. The herbicide was applied at the rate of 1.75 liters "Roundup", 0.56 kilograms 2,4-D, and 187.05 liters of water carrier per hectare (24 ounces "Roundup", 8 ounces 2,4-D, and 20 gallons water per acre).

Figure 4. Locations of randomly selected soil samples at Study Area A (Whitney).

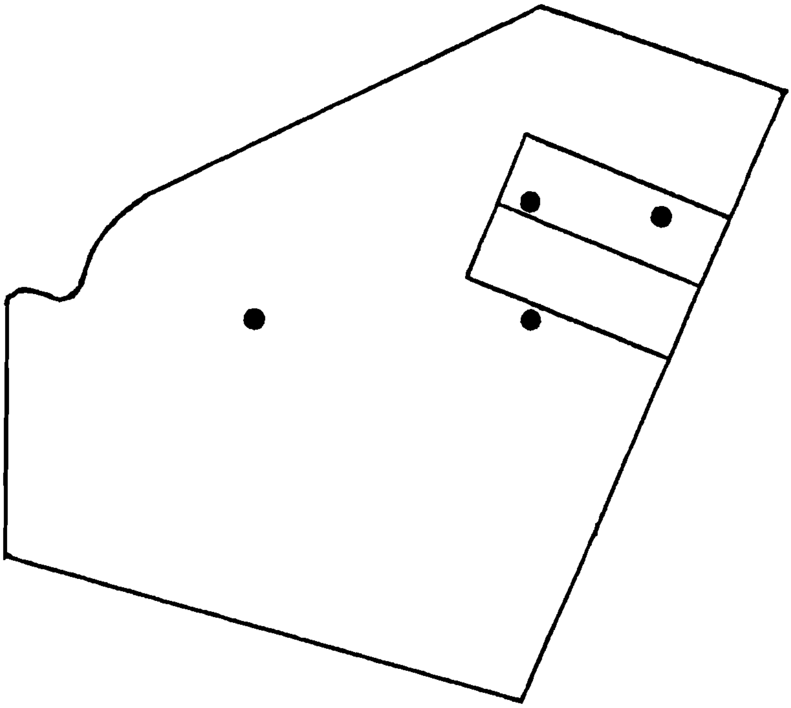


Figure 5. Locations of randomly selected soil samples at Study Area B (Senn).

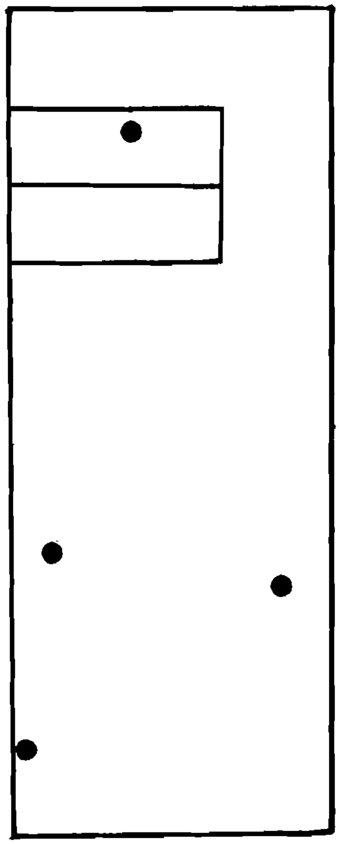
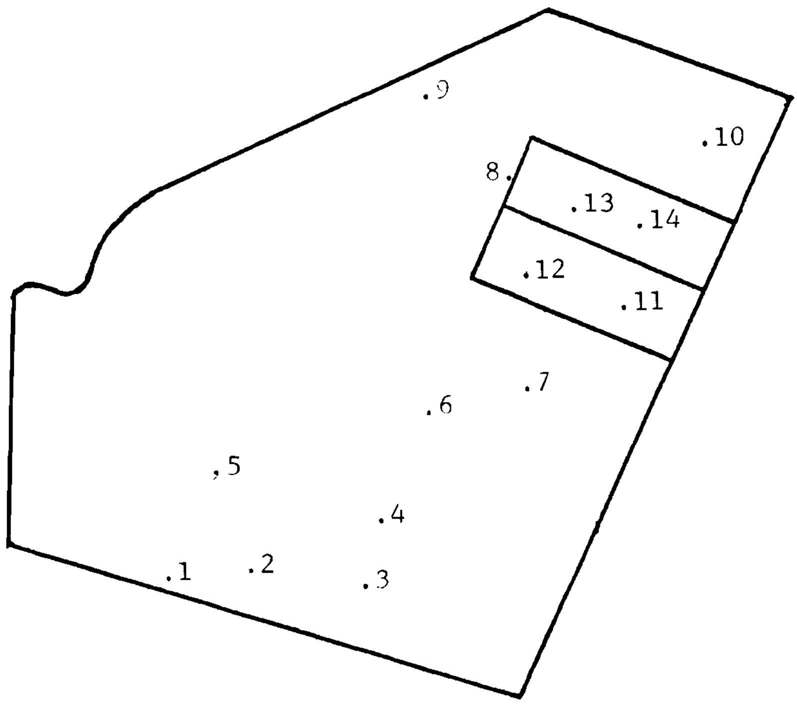


Figure 6. Locations of randomly selected study plots at Study Area A (Whitney).


.9
.10
8.
.13
.14
.12
.11
.7
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.2
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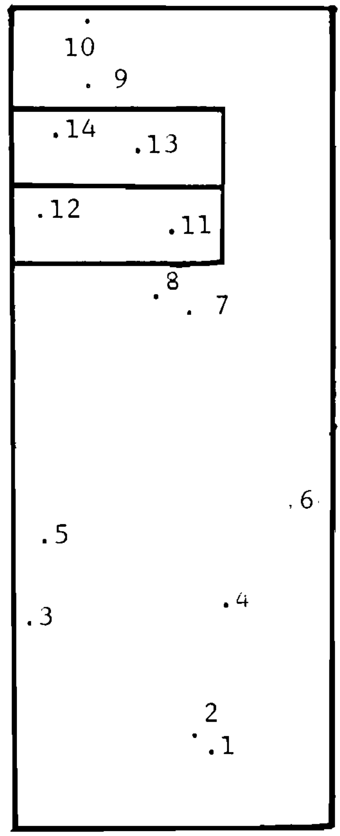
Figure 7. Locations of randomly selected study plots at Study Area B (Senn).


10
9
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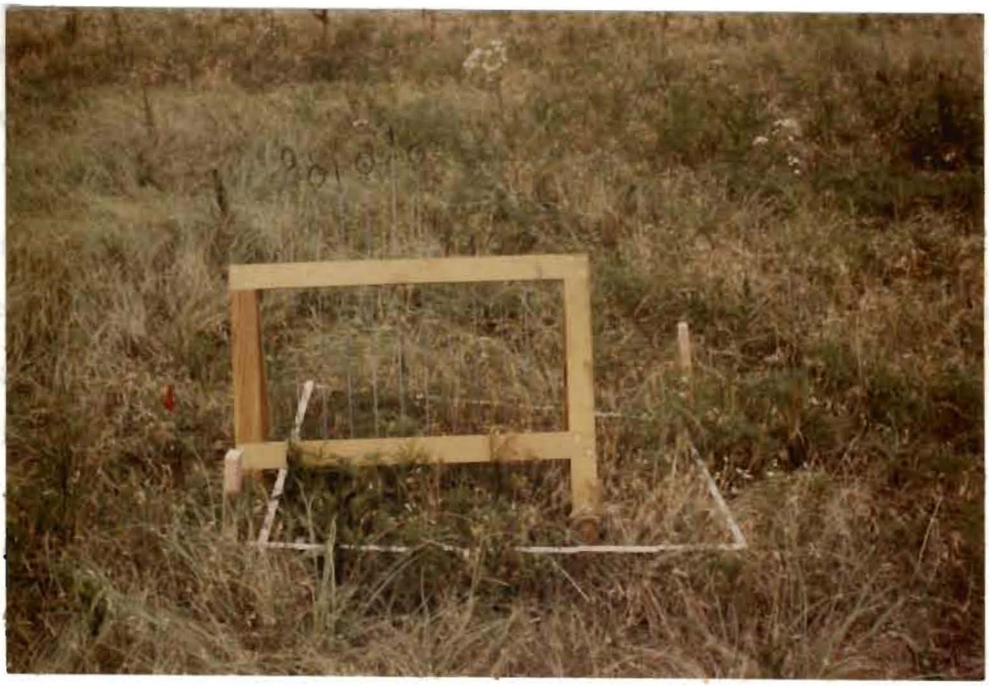
4
3
2
1

Figure 8. Permanently marked plot with reinforcing rod marking corners.

Figure 9. Ten point frame used in determining species composition.



The study areas were allowed to lay fallow, with no further treatment, until April, 1985, when they were seeded with a Nesbett grass drill. The seed was applied, in pure live seed (PLS), at the rate shown on Table 1.

Seedling counts were taken after the first growing season to determine seedling success. Each plot was counted to determine the number of total seedlings.

Each plot was again analyzed with the ten point frame and photographed at the end of the second growing season to determine if there was a change in species composition. The planted grasses were counted to determine if this treatment was successful.

The Great Plains Agricultural Council's (1966) recommendations for seedling success are: good (more than one seedling per 929 square centimeters [one square foot]); fair (0.5 to 1 seedling per 929 square centimeters); poor (less than 0.5 seedlings per 929 square centimeters).

The authority for all grasses was Hitchcock (1971). The authority for all forbs was Great Plains Flora Association (1986).

Table 1. Seeded species and amount planted.

	Area A (Whitney) Kilograms Per Hectare	Area B (Senn) Kilograms Per Hectare
Big Bluestem	1.85	2.47
Little Bluestem	1.91	2.47
Indian Grass	2.01	2.69
Switchgrass	0.90	1.12
Sideoats Gramma	1.85	2.47
Total	8.52	11.22
	Pounds Per Acre	Pounds Per Acre
Big Bluestem	1.65	2.2
Little Bluestem	1.70	2.2
Indian Grass	1.80	2.4
Switchgrass	0.80	1.0
Sideoats Gramma	1.65	2.2
Total	7.60	10.0

RESULTS AND DISCUSSION

Study Area A (Whitney)

The study of the plots to determine vegetation composition prior to spraying and seeding (Table 2) determined that there were no desirable grasses present. However, a seedling count after the first growing season showed that there was one seedling per 929 square centimeters (one square foot). This rated a fair for seedling according to the standards of the Great Plains Agricultural Council (1966).

The study of the treated area plots to determine vegetation composition at the end of the second growing season (Table 3) determined that there was a change in percent of bare ground and ground cover (plants and litter). The results from a paired t-test (Table 4) established that there was a significant decrease in the amount of bare ground, with a corresponding significant increase in the ground cover. Subjectively, there seemed to be more litter present (Figure 10 and 11; Appendix A), but the results of the paired t-test failed to show a significant change. Although there was not a significant change in the percentage of litter, the litter that was present was deeper and capable of carrying a fire for management purposes.

There was also a change in the species composition. There was an increase in graminoids with a decrease in forbes. Of the graminoides, there was a significant increase in the amount of Aristida oligantha and the seeded species (Table 4).

A seedling count at the end of the second growing season showed that there were 1.87 seedlings per 929 square centimeters (one square foot). This rated a good for seedling success according to the standards of the Great Plains Agricultural Council (1966).

Table 2. Vegetation composition of Study Area A (Whitney) prior to spraying and seeding (1984).

	Percent Composition Total Points	Percent Composition of Species	Frequency Species Hit in 180 Frames (In Percent)	Mean/Quadrat Treated Area	Standard Deviation
Bare Ground	48.94			49.7	11.79
Litter	30.56			32.2	11.11
Rock	0.22				
Plants	20.28				
Graminoids				9.9	3.57
Bromus sp.		9.04	12.22		
Bromus inermis		16.16	27.22		
Bromus japonicus		12.60	12.78		
Buchloe dactyloides		1.10	0.56		
Poa pratensis		0.55	1.11		
Schedonnardus paniculatus		7.40	13.33		
Sporobolus asper		10.13	12.22		
Total		56.98			

Table 2. (Continued)

	Percent Composition Total Points	Percent Composition of Species	Frequency Species Hit in 180 Frames (In Percent)	Mean/Quadrat Treated Area	Standard Deviation
Forbs				8.0	2.87
Ambrosia artemisiifolia		5.48	10.00		
Convolvulus sepium		0.27	0.56		
Helianthus grosseserratus		0.82	1.67		
Helianthus salicifolius		2.75	5.00		
Lepidium sp.		0.27	0.56		
Lespedeza sp.		10.42	16.67		
Melilotus sp.		0.82	1.67		
Oxalis stricta		10.42	17.78		
Solidago sp.		2.19	4.44		
Solidago missouriensis		1.92	3.33		
Solidago rigida		1.92	3.89		
Unknown 1		2.19	2.22		
Unknown 2		0.27	0.56		
Unknown 3		0.27	0.56		
Unknown 4		0.55	1.11		
Unknown 5		0.82	1.67		
Unknown 6		0.82	1.11		
Xanthocephalum dracunculoides		0.82	1.67		
Total		43.02			

Table 3. Vegetation composition of Study Area A (Whitney) at the end of second growing [illegible]

	Percent Composition Total Points	Percent Composition of Species	Frequency Species Hit in 180 Frames (In Percent)	Mean/Quadrat Treated Area	Standard Deviation
Bare Ground	14.8			14.8	16.34
Litter	38.4			38.4	17.84
Plant	46.8			46.8	10.25
Graminoid					
Andropogon gerardi		1.07	5		
Andropogon scoparius		8.12	26	3.8	3.46
Aristida oligantha		24.36	49	11.4	13.75
Bouteloua curtipendula		14.11	38	6.6	5.83
Bromus inermis		10.68	30	5.0	7.64
Bromus japonicus		4.06	10		
Chloris verticillata		0.21	1		
Eriochloa contracta		0.21	1		
Panicum virgatum		0.86	4		
Schedonnardus paniculatus		17.09	48	8.0	7.33
Setaria sp.		0.43	2		
Sorghastrum nutans		2.78	9		
Sporobolus asper		1.92	6		
Sporobolus neglectus		13.89	27	6.5	10.94
Total		99.97			
Forbs					
Lespedeza sp.		0.21	1		

Seeded species were _Andropogon gerardi_, _Andropogon scoparius_, _Bouteloua curtipendula_, _Panicum virgatum_ and _Sorghastrun nutans_. Since these were not present in the plots priot to seeding, the frequency and % composition all represent the effects of seeding.

Table 4. Results of paired plot t-test for Study Area A (Whitney) and Study Area B (Senn). D = A significant decrease after treatment at 0.05 level of significants; I = A significant increase after treatment at 0.5 level of significants; N = No significant change after treatment at 0.50 level of significants.

	Calculated t's A	Calculated t's B
Treated Areas		
Bare Ground	6.420 (D)	12.530 (D)
Litter	1.378 (N)	1.619 (N)
Litter and Perennial Grasses	4.690 (I)	2.656 (I)
Litter and All Plants	6.346 (I)	4.054 (I)
Aristida oligantha	2.62 (I)	1.042 (N)
Seeded Species (desirable)	6.010 (I)	6.531 (I)
	df-9 Table-t 0.05 2.262	
North Central		
Bare Ground	17.000 (D)	5.667 (N)
Litter	1.698 (N)	37.000 (D)
Plants	5.000 (N)	27.000 (I)
Litter and Plants	17.000 (I)	
	df-1 Table-t 0.05 = 12.706	

Uneven t-Test between south control (seeded but not sprayed) and treated area comparing seeded species.

	A	B
	2.247	2.293
Table t - 0.05	df-10 = 2.228	df-11 2.201

Significant difference indicates that seeding alone does not produce results as good as spraying prior to seeding.

Figure 10. Before and after photographs of Plot 2 showing increase in litter at Study Area A (Whitney).


Whitney #2
MAY 23 '84


Whitney
Plot #2
9-26-96

Figure 11. Before and after photographs of Plot 6 showing increase in litter at Study Area A (Whitney)


Whitney #6
June 21,

The north control, which received no treatment, had a significant decrease in bare ground, with a significant increase in litter and plants (Table 4). There were no desirable species present at the end of the second growing season.

The south control, which was seeded but not sprayed, had some seeded species established. However, the results of an uneven t-test (Table 4) showed that the area that was sprayed with the herbicide prior to seeding had significantly more seedlings than the control that was only seeded.

Study Area B (Senn)

The study of the plots to determine vegetation composition prior to spraying and seeding (Table 5) determined that there were no desirable grasses present. However, a seedling count at the end of the first growing season showed that there were 1.16 seedlings per 929 square centimeters (one square foot). This rated a good for seedling success according to the standards of the Great Plains Agricultural Council (1966).

The study of the treated area plots to determine vegetation composition at the end of the second growing season (Table 6) determined that there was a change in the percent of bare ground and ground cover (plants and litter). The results of a paired t-test (Table 4) established that there was a significant decrease in the amount of bare ground, with a corresponding significant increase in the ground cover. Subjectively, there seemed to be more litter present (Figure 12 and 13; Appendix B), but the results from the paired t-test failed to show a significant change. However, the litter that was present was deeper and capable of carrying a fire for management purposes.

There was also a change in the species composition. There was an

Table 5. Vegetation composition of Study Area B (Senn) prior to spraying and seeding (1984).

	Percent Composition Total Points	Percent Composition of Species	Frequency Species Hit in 180 Frames (In Percent)	Mean/Quadrat Treated Area	Standard Deviation
Bare Ground	43.00			39.5	23.18
Litter	29.33			34.4	14.44
Plants	27.67				
Graminoids				22.1	10.79
Aristida oligantha		9.44	16.11		
Bromus inermis		0.40	1.11		
Bromus japonicus		14.26	21.67		
Carex sp.		4.22	8.89		
Chloris verticillata		6.02	11.67		
Hordeum pusillum		0.20	0.56		
Poa pratensis		36.76	37.78		
Schedonnardus paniculatus		4.42	10.56		
Scirpus sp.		1.61	2.22		
Sporobolus asper		8.23	15.56		
Total		85.56			

Table 5. (Continued)

	Percent Composition Total Points	Percent Composition of Species	Frequency Species Hit in 180 Frames (In Percent)	Mean/Quadrat Treated Area	Standard Deviation
Forbs				4.00	4.14
Achillea millefolium		0.40	1.11		
Ambrosia artemisiifolia		2.41	6.11		
Asclepias sp.		0.20	0.56		
Erigeron strigosus		0.80	2.22		
Euphorbia sp.		2.21	5.56		
Euphorbia esula		1.20	3.33		
Lespedeza sp.		1.20	2.78		
Oxalis stricta		1.00	2.22		
Salsola kali		3.01	5.56		
Solanum carolinense		0.70	0.56		
Xanthium pensylvanicum		1.61	4.44		
Xanthocephalum dracunculcoides		0.20	0.56		
Total		14.44			

Table 6. Vegetation composition of Study Area B (Senn) at [illegible]

	Percent Composition Total Points	Percent Composition of Species	Frequency Species Hit in 180 Frames (In Percent)	Mean/Quadrat Treated Area	Standard Deviation
Bare Ground	16.6			16.6	15.46
Litter	43.0			43.0	15.19
Plants	40.4			40.4	12.83
Graminoids					
Andropogon gerardi		2.23	7		
Andropogon scoparius		3.47	10		
Aristida oligantha		7.92	17		
Bouteloua curtipendula		4.70	11		
Bromus inermis		0.25	1		
Bromus japonicus		4.94	14		
Carex sp.		0.73	3		
Chloris verticillata		18.81	38	7.6	7.37
Digitaria sp.		0.25	1		
Panicum virgatum		0.25	1		
Poa pratensis		33.91	54	13.7	14.72
Schedonnardus paniculatus		4.95	15		
Setaria sp.		0.25	1		
Sorghastrum nutans		6.19	14		
Sporobolus asper		9.16	20		
Total		98.01			

Table 6. (Continued)

	Percent Composition Total Points	Percent Composition of Species	Frequency Species Hit in 180 Frames (In Percent)	Mean/Quadrat Treated Area	Standard Deviation
Forbs					
Achillea millefolium		0.25	1		
Oxalis stricta		1.24	5		
Polygonum sp.		0.25	1		
Solanum carolinense		0.25	1		
Total		1.99			

Seeded species were *Andropogon gerardi*, *Andropogon scoparius*, *Bouteloua curtipendula*, *Panicum virgatum*, and *Sorghastrum nutans*. Since these were not present in the plots prior to seeding, the frequency and % composition all represent the effects of seeding.

Figure 12. Before and after photographs of Plot 3 showing increase in litter at Study Area B (Senn).


SENN #5
July 8
1984


Senn
#3
2-12-87

Figure 13. Before and after photographs of Plot 5 showing increase in litter at Study Area B (Senn).


SENN #5
July 8
1984


SENN
#5
2-12-87

increase in graminoids and a decrease in forbs. Of the graminoids, there was a significant increase in the seeded species (Table 4).

A seedling count at the end of the second growing season showed that there were 1.34 seedlings per 929 square centimeters (one square foot). This rated a good for seedling success according to the standards of the Great Plains Agricultural Council (1966).

A paired t-test (Table 4) of the north control, which received no treatment, established that there was no significant change in the amount of bare ground. There were no desirable species present (Figure 14), but there was a significant increase in the amount of plants, with a corresponding significant decrease in the amount of litter present (Table 4).

The south control, which was seeded but not sprayed, had some seeded species established. However, the results of an uneven t-test (Table 4) showed that the area that was sprayed with the herbicide prior to seeding had significantly more seedlings than the control that was only seeded.

Figure 14. Photograph showing the lack of desirable species in the North Control (Foreground) and desirable species in Treated Area (background). Study Area B (Senn).

CONCLUSIONS

That the seeding method is successful is clearly shown by the ts, although during the study period there was above average ipitation. In the second year of this study, the planted species not only successful, but they set seed. With management, such as per burning, the stands should thicken until desirable grasses inate the site.

The only unwanted perennial grass remaining was smooth brome, hich can be reduced or killed by an earlier spraying date prior to eeding or by post seeding burning. Additionally, the annual bromes and bluegrass can be reduced by burning.

As seen by the variances, the seeded species were not evenly distributed. This was caused by the seed drill not placing the seed properly in the soil. The use of a power seed drill would have eliminated this problem and resulted in a better and more even stand of grass.

Annual sunflower, which preceeds three-awn grass in the succession, was not present. However, there were perennial sunflowers present at Study Area A. After the perennial sunflowers were killed by the herbicide, three-awn grass became the dominant species. Study Area B, which had a different species composition, i.e. perennial sunflowers, had some three-awn grass before spraying, but it had not increased significantly by the end of this study. This gave rise to the hypothesis that possibly the perennial sunflowers suppressed the three-awn.

Also, the appearance of the three-awn and other annual grasses illustrates the importance of seed banks in old fields. This supports the idea that the less an area is disturbed, the less competition will from the seed bank.

Finally, this method should be a recommended alternative to the anical methods of establishing tall grass prairie in old fields. overcomes the problems of erosion, the seed bank, and the phytotoxic ects of grain sorghum.

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LITERATURE CITED

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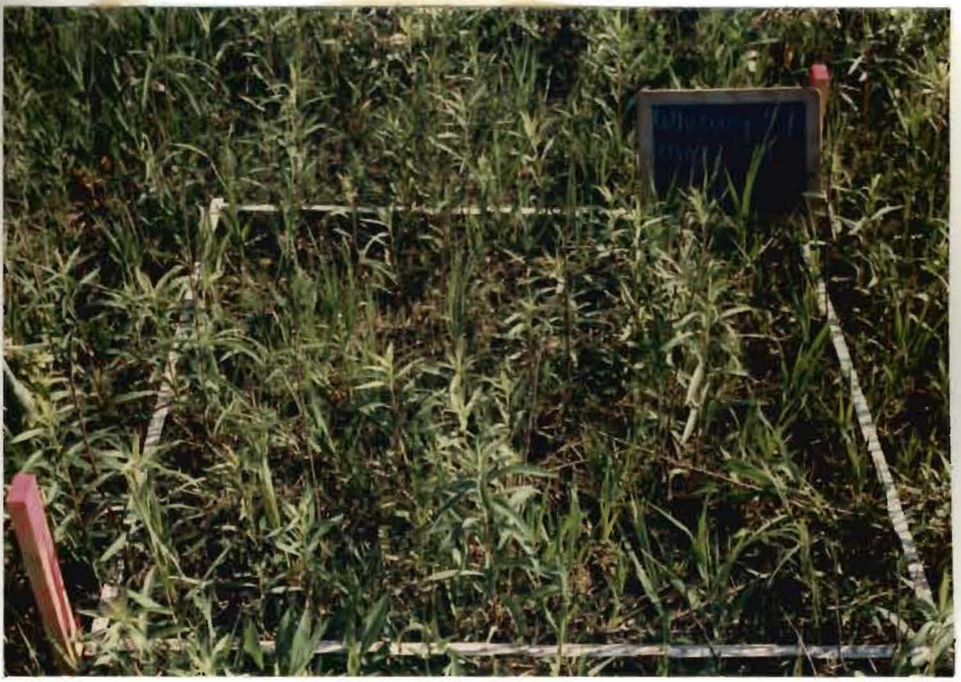
APPENDIX A

Before and after photographs of Plot 1, Study Area A (Whitney).




Whitney
Plot #1

Before and after general view photographs from Plot 1, Study Area A (Whitney).

Before and after photographs of Plot 2, Study Area A (Whitney).


Whitney #2
MAY 22 84


Whitney
Plot #2

Before and after general view photographs from Plot 2, Study Area A (Whitney).

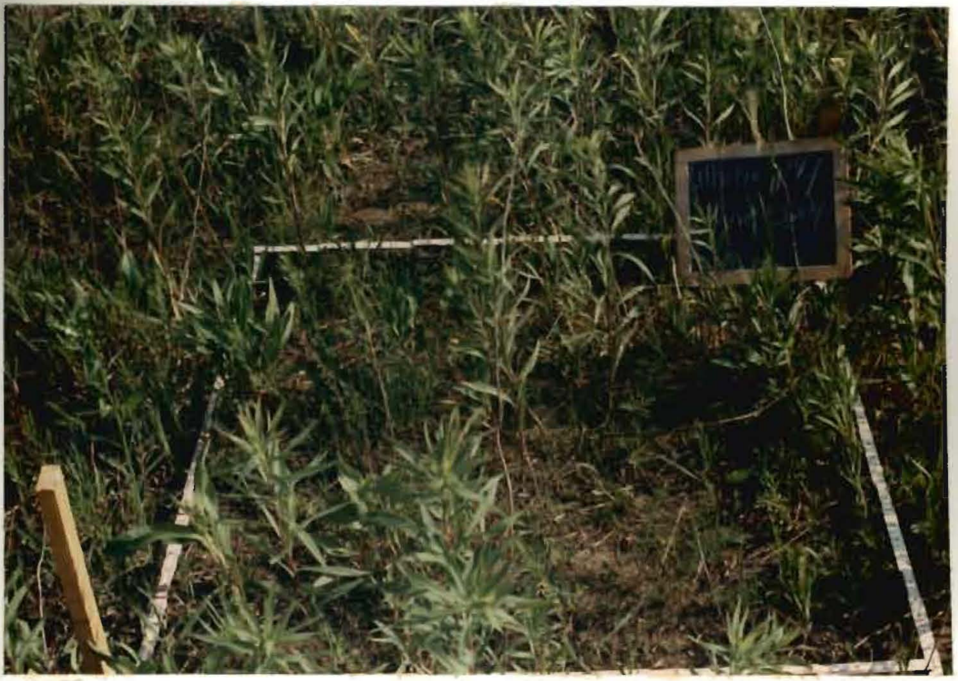
Before and after photographs of Plot 3, Study Area A (Whitney).


Whitney #3


Whitney
Plot 3
9-26-86

Before and after general view photographs from Plot 3, Study Area A (Whitney).

Before and after photographs of Plot 4, Study Area A (Whitney).




Whitney
Plot 4
9-26-86

Before and after general view photographs from Plot 4, Study Area A (Whitney).

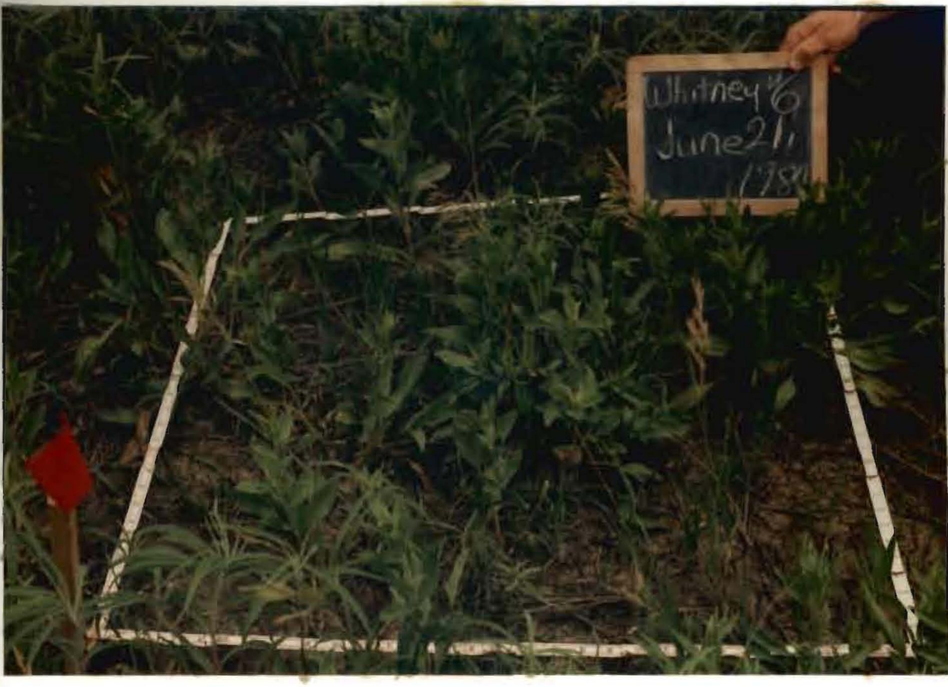
Before and after photographs of Plot 5, Study Area A (Whitney).


Whitney #5


Whitney
Plot #5
9-26-86

Before and after general view photographs from Plot 5, Study Area A (Whitney).

Before and after photographs of Plot 6, Study Area A (Whitney).


Whitney #6
June 21,
1980


Plot #6
9-24-80

Before and after general view photographs from Plot 6, Study Area A (Whitney).

Before and after photographs of Plot 7, Study Area A (Whitney).


Whitney #7
June 24,


Whitney
No 7
9-24-86

Before and after general view photographs from Plot 7, Study Area A (Whitney).

Before and after photographs of Plot 8, Study Area A (Whitney).


Whitney #8
June 21,


Whitney
#8

Before and after general view photographs from Plot 8, Study Area A (Whitney).

Before and after photographs of Plot 9, Study Area A (Whitney).

Whitney
ne21,

Whitney
No 9
9-29-86

Before and after general view photographs from Plot 9,
Study Area A (Whitney).

Before and after photographs of Plot 10, Study Area A (Whitney).


Plot 10

Before and after general view photographs from Plot 10, Study Area A (Whitney).

Before photograph of Plot 11, Study Area A (Whitney).

Before general view photograph from Plot 11, Study Area A (Whitney).

Before photograph of Plot 12, Study Area A (Whitney).

Before general view photograph from Plot 12, Study Area A (Whitney).

Before photograph of Plot 13, Study Area A (Whitney).

Before general view photograph from Plot 13, Study Area A (Whitney).

Before photograph of Plot 14, Study Area A (Whitney).

Before general view photograph from Plot 14, Study Area A (Whitney).

APPENDIX B

Before photograph of Plot 1, Study Area B (Senn).

Before and after general view photograph from Plot 1, Study Area B (Senn).

Before photograph of Plot 2, Study Area B (Senn).


SENN°2
July 8
1989

Before and after general view photographs from Plot 2, Study Area B (Senn).

Before and after photographs of Plot 3, Study Area B (Senn).


SEAN #3
July 8
1984


Sean
#3
2-12-87

Before and after general view photographs from Plot 3, Study Area B (Senn).

Before and after photographs of Plot 4, Study Area B (Senn).


SENN #4
July 8-1


SENN
#4
2-12-87

Before and after general view photographs from Plot 4, Study Area B (Senn).

Before and after photographs of Plot 5. Study Area B (Senn).

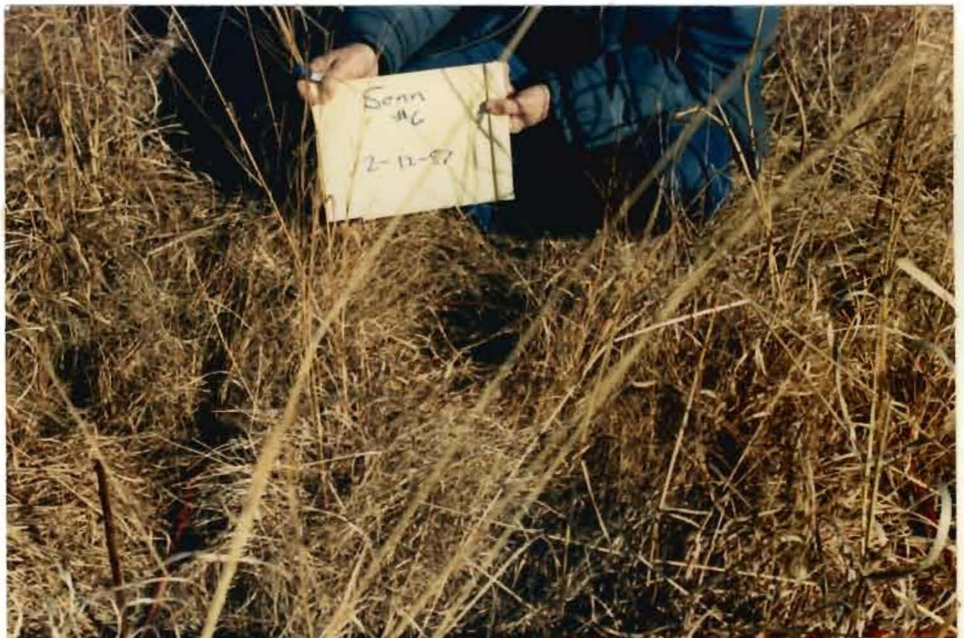

SENN #5
July 8
1984


SENN
#5
2-12-87

Before and after general view photographs from Plot 5, Study Area B (Senn).

Before and after photographs of Plot 6, Study Area B (Senn).


SENN #6
July 13,
1984


Senn
#6
2-12-87

Before and after general view photographs from Plot 6, Study Area B (Senn).

Before and after photographs of Plot 7, Study Area B (Senn).


SENN 7
July 13
1984


Senn
#7
2-17-87

Before and after general view photographs from Plot 7, Study Area B (Senn).

Before and after photographs of Plot 8, Study Area B (Senn).

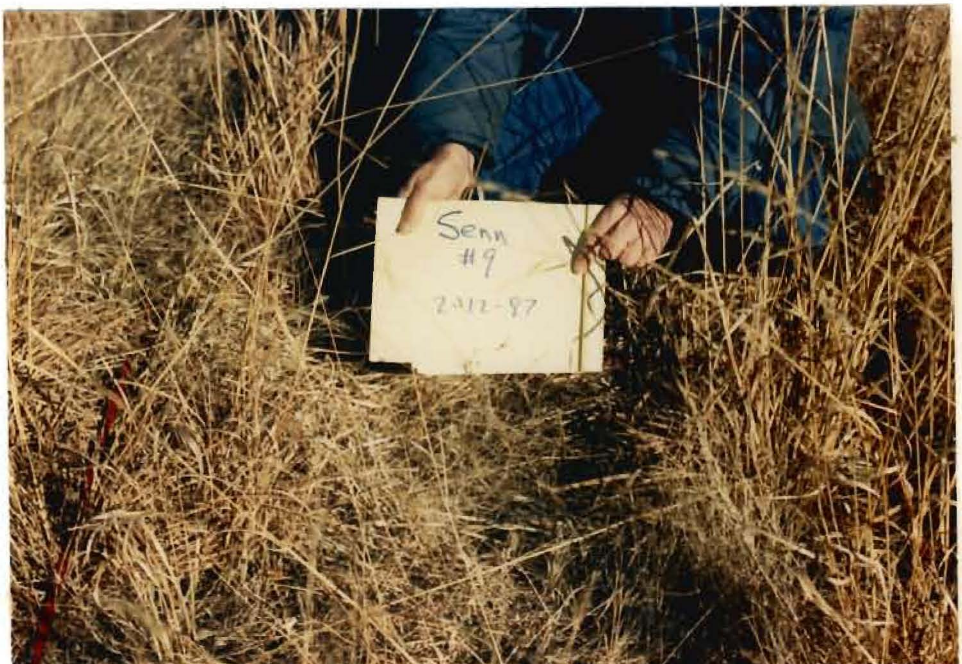

SENN #8


#8

Before and after general view photographs from Plot 8, Study Area B (Senn).

Before and after photographs of Plot 9, Study Area B (Senn).


SENN 9
July 13


Senn
#9

Before and after general view photographs from Plot 9, Study Area B (Senn).

Before and after photographs of Plot 10, Study Area B (Senn).


SENN


Senn

Before and after general view photographs from Plot 10, Study Area B (Senn).

Before and after photographs of Plot 11, Study Area B (Senn).


SENN #1
July 15,
1984


Senn
South
Control
#1
2-12-87

Before and after general view photographs from Plot 11, Study Area B (Senn).

Before and after photographs of Plot 12, Study Area B (Senn).

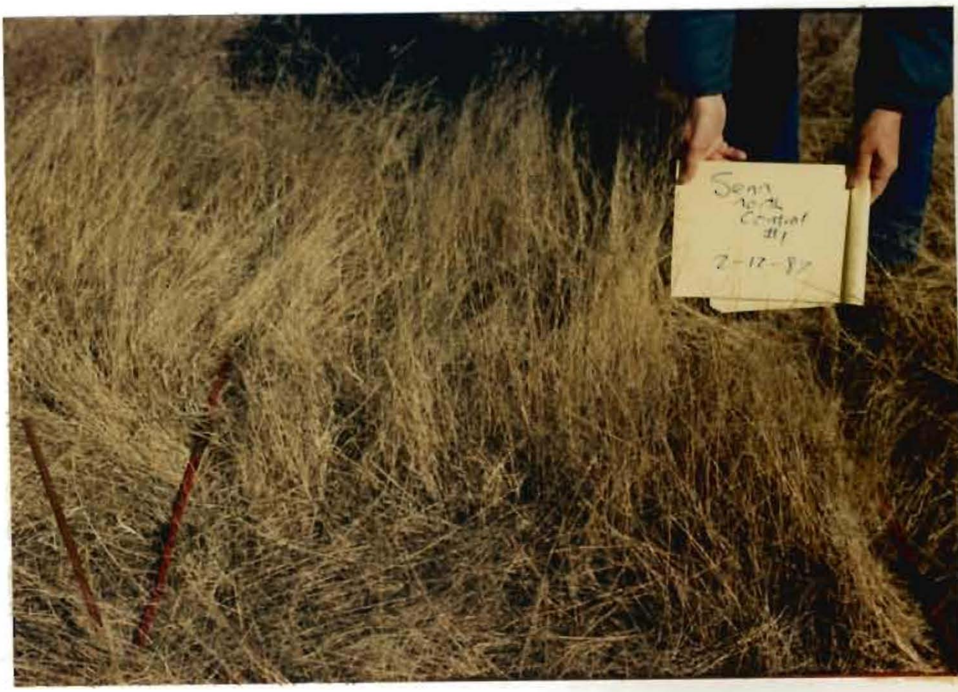

SENN
15
1984


Senn
#2

Before and after general view photographs from Plot 12, Study Area B (Senn).

Before and after photographs of Plot 13, Study Area B (Senn).

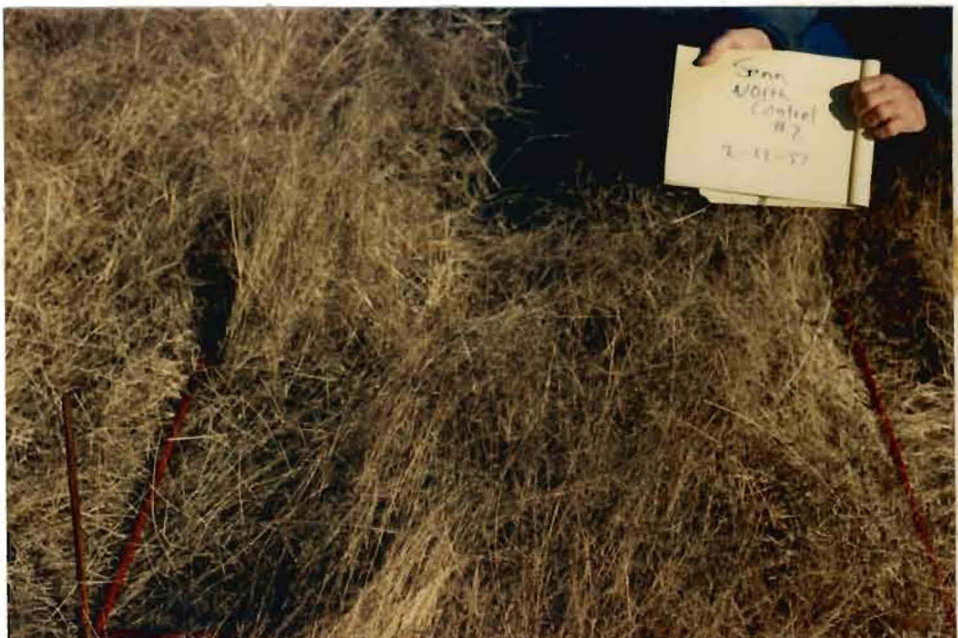

SENN
July 15


Senn

Before and after general view photographs from Plot 13, Study Area B (Senn).

Before and after photographs of Plot 14, Study Area B (Senn).


SENN#4
July 15
1984


Control

Before and after general view photographs from Plot 14, Study Area B (Senn).