USDA NRCS
Natural Resources Conservation Service

Materials Plant Program

Rose Lake, MI Plant Materials Center

Strawberry Island (Slag) Project

Final Report

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INTRODUCTION

Slag is the discarded material resulting from the production of metals from ore, in this case, steel from iron ore. The City of Hammond, Indiana has had a long association with the steel industry. Past practices have resulted in numerous poorly vegetated sites where the slag refuse was stockpiled. Many of these sites had uniquely diverse plant communities and were in areas historically used as resting sites by migratory birds.

In response to the situations created by the disposal of slag on these sites the City of Hammond, Parks Department in partnership with the United States Department of Agriculture – Natural Resources Conservation Service (NRCS) filed for and received a Great Lakes National Program Office (GLNPO) grant through the Environmental Protection Agency (EPA) to study site specific methodologies by which slag refuse areas could be revegetated with native plants. The hope of this study was to identify methodologies that would create a favorable environment for continued native plant succession, improve wildlife habitat and improve the aesthetic value of the site.

METHODS AND MATERIALS

The study was located in the City of Hammond within an area known as Strawberry Island at the southern end of Lake Michigan. The site was flat with a dense, slag-permeated surface and sparse weedy vegetation. An analysis of the slag content (see attachment) was completed to determine any inherent properties that may inhibit plant growth.

This study was developed as a split-plot design with 4 replications. The selection of treatments (Table 1) was based on practicality and previous experience in other critical area situations. A non-sterilized loamy topsoil was used in treatments receiving supplemental soil. Framework warm season grass species were chosen for the seed mix from available local genotypes collected by the Friends of Gibson Woods. Each was cleaned and tested for purity and viability to determine pure live seed (PLS) content. Information on the species mix is provided in Table 2.

Table 1. Treatment summary.

Treatments	Soil Component	Seed Component
1(control)	no top soil added	not seeded
2	no top soil added	seeded with warm season grass mix
3	4 inches of topsoil placed over slag	seeded with warm season grass mix
4	4 inch topsoil cap incorporated into top 4 inches of slag	seeded with warm season grass mix

Table 2. Warm season grass seed mix used in seeded plots.

Species	seeds/lb.	lbs. PLS/acre	PLS/plot	PLS/sq. ft.	% of mix
big bluestem	165,000	1.77	5841	6.7	9.5
little bluestem	240,000	.61	2928	3.4	4.8
indiangrass	175,000	.99	3465	4.0	5.7
prairie sandreed	274,000	.82	4494	5.2	7.4
switchgrass	389.000	5.73	44579	51.2	72.6
Total		9.92	61307	70.5	100.0

Treatment plots were disked to remove existing vegetation and established in early summer, 1996. Each plot measured 8.7' x 100' and was divided at the 50' mark into fertilized and not fertilized subplots. Seeded plots were hand broadcast with the mix at a PLS rate of approximately 10 lbs./acre and raked to provide better seed to soil contact. Fertilizer (phosphorus @ 30 lbs./acre, potash @ 50 lbs./acre) was then broadcast on the appropriate subplots. The study area was mowed several times during the first year and sprayed once with 2,4-D in October for weed control.

raking-in the seed mix

In October 1997 a line transect approach was used to obtain preliminary data on the site. Information was collected on plant type or species, and plant vigor at each of 50 points, spaced 1 foot apart, within each of the subplots. A total of 1600 points were sampled (50 points x 2 subplots x 4 treatments x 4 replications). A report on the 1997 findings was issued in early 1998. Results of consequence will also be discussed in this report.

vegetation during the 1997 line transect

Table 3. Summary of 1998 groundcover composition and warm season grass effectiveness on 4 land treatments.

Treatments	Foliar Cover (%)	(average count / square foot) Warm Season Grasses	Non-Seeded Species	Total Plants	Warm Season Grasses (% of total)	Warm Season Grass Effectiveness (Highest = 1, Lowest = 9)
	**	*	ns	ns	*	*
Control (no seed, no soil)	37.0	0.6	17.5	18.1	3.5	9.0
Seeded	38.1	0.9	21.8	22.8	4.0	7.1
Seeded with soil cap	68.4	4.0	13.5	17.5	22.9	1.6
Seeded with soil incorp.	68.1	3.4	15.4	18.9	18.2	2.6

* highly significant (1% level)
** significant (5% level)
ns not significant at the 5% level

In October 1998 a second collection of data was completed on the study. However, instead of a line transect, measurements were taken from 4 randomly located square foot sections in each of the subplots. Data was recorded on % foliar cover, number and type of planted species and the number of non-planted species for each of the sections. A visual observation was also taken for each subplot on the effectiveness of the planted species in providing improved wildlife habitat and aesthetic value to the land.

Results and Discussion

Since the method of collecting data changed from a line transect (one-dimensional view) in 1997 to an area transect (two-dimensional view) in 1998 there will be some difficulty in connecting the data. Also, considering the nature of the seeded species and the objectives of this study it is believed that the second year data is a more reliable picture of the site conditions and the potential for revegetating these slag sites. Although some correlations can be drawn, this report will center on the information gathered in 1998 (Table 3).

vegetation in 1998

Most apparent in these statistics for the categories that reached a level of significance (5% or greater) was the sharp distinction between the treatments where soil was added and those where soil was not added. Not only did the percent of foliar cover nearly doubled but the percent of warm season grasses and their average counts per square foot were 4 to 7 times greater in treatments with additional soil (Figures 1-3). Mean separation in each of these cases revealed a significant difference between those treatments receiving supplemental soil and those that had not.

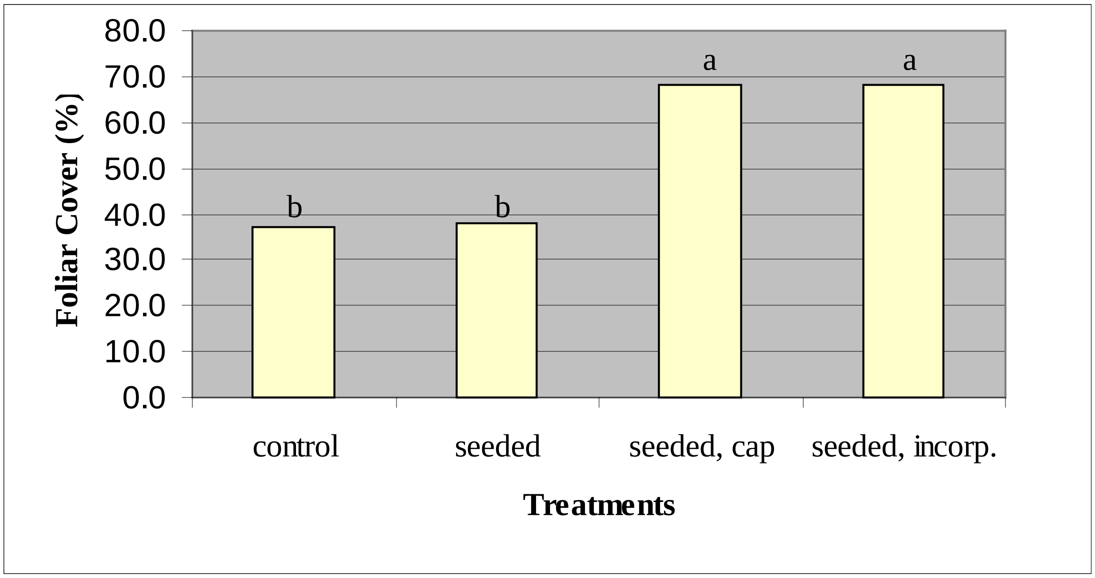

Figure 1. Average percent of ground covered by aerial portion of plants over 4 types of land treatments in 1998; bars with no common letters are significantly different by Duncan's multiple range test at the 5% level.

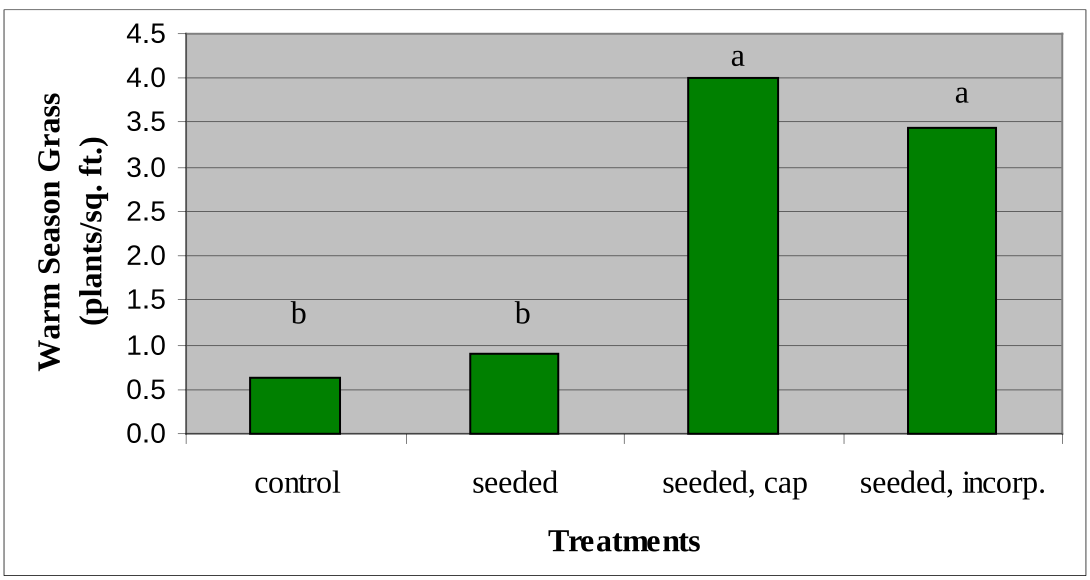

Figure 2. Average warm season grass plants per square foot over 4 types of land treatment in 1998: bars with no common letters are significantly different by Duncan's multiple range test at the 5% level.

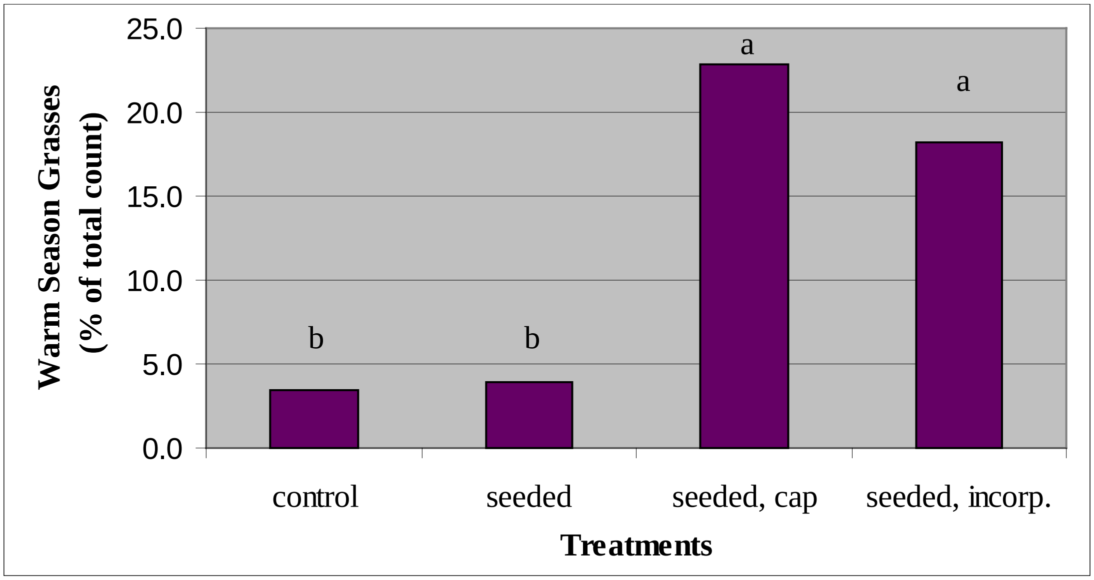

Figure 3. Average percent of warm season grasses in total plant count over 4 types of land treatment in 1998: bars with no common letters are significantly different by Duncan's multiple range test at the 5% level.

The 1997 data (Table 4) is consistent with the 1998 data. As in 1998 the percent vegetative cover (comparable to foliar cover), and warm season grass counts and percents of total vegetation were substantially higher in treatments with the soil additions.

Also of importance are the categories that were not significantly different in 1998, non-seeded species and total plant counts. Adding topsoil to the slag substantially increased the number of seeded warm season grasses but it did not statistically affect the non-planted or total vegetation counts (Figure 4).

Although visually there was a general increase in vigor of all plants in the plots with topsoil additions, it appeared much more pronounced in the warm season grasses. Each subplot was rated as to the effectiveness of the warm season grasses in improving wildlife habitat and aesthetic value to the site (Figure 5). This was essentially a rating on their number and health. The results were very consistent and very dramatic with the soil treated plots; again, fairing far better than those that had no soil additions.

As these statistics and observations are drawn together what emerges is that the seeded species progress in number and health much better than the non-seeded species in the situations where topsoil was supplemented. This likely accounts for the increase in foliar cover.

Table 4. 1997 vegetative cover and warm season grass data.

Treatments	Vegetative Cover (%)	Warm Season Grass Count (out of 400 observations)	Warm Season Grasses (% of total)
Control (no seed, no soil)	63.0	0	0
Seeded	61.5	8	3.3
Seeded with soil cap	86.7	108	31.1
Seeded with soil incorp.	92.2	69	18.7

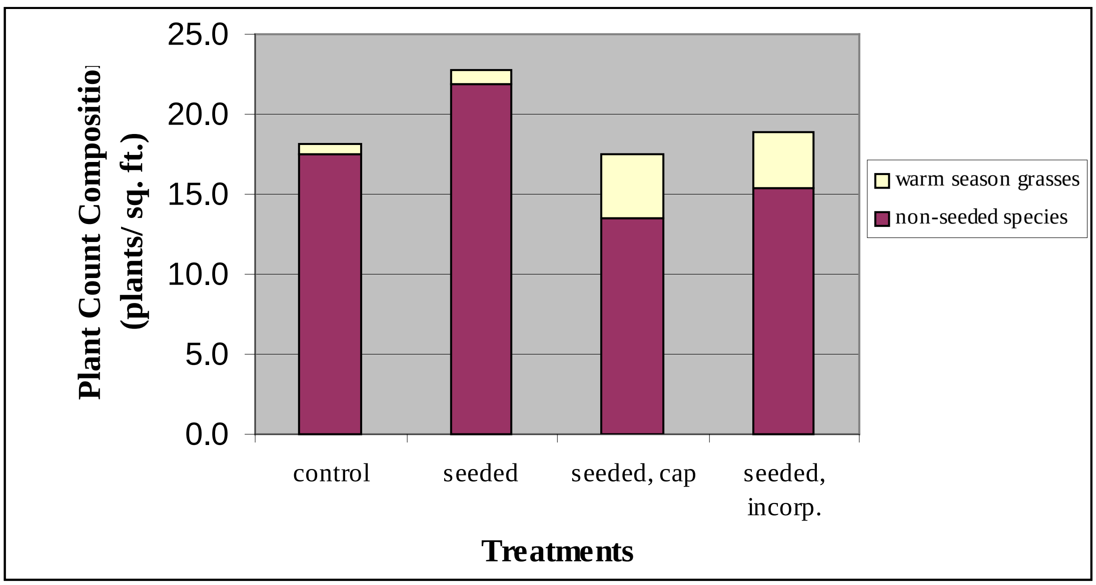

Figure 4. Composition of total plant counts on the 4 land treatments in 1998.

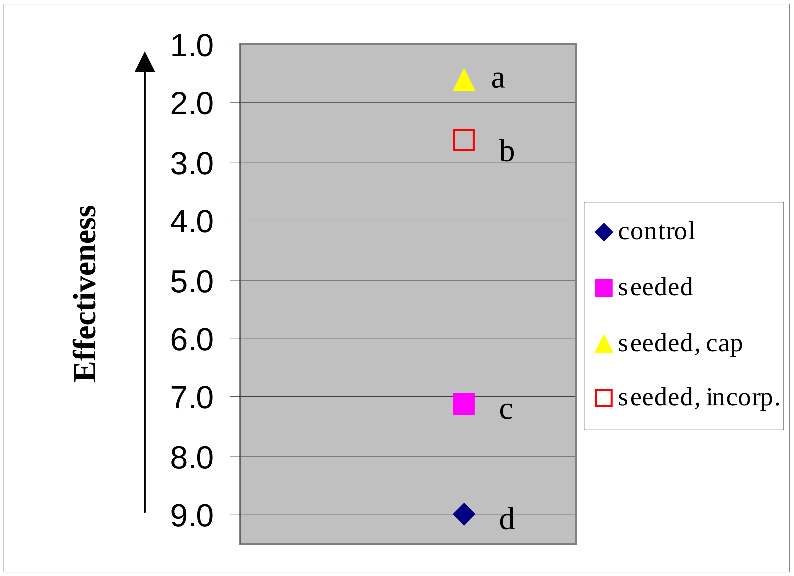

Figure 5. Comparative effectiveness of the warm season grasses in improving wildlife habitat and aesthetic value to the site on the 4 land treatments in 1998; treatments with no common letters are significantly different by Duncan's multiple range test at the 5% level.

Data recorded on the warm season grasses also included a breakdown by species. However to better understand these figures we have to consider the actual counts in relation to their individual proportions in the seed mix. Multiplying the total warm season count in a treatment by the proportion of a species in the mix (Table 2) gives the expected count for that species in a particular treatment. The values for actual and expected counts for each species in a total sample area of 32 square feet are provided in Table 5.

Table 5. Total warm season grass count, and actual and expected warm season grass counts by species on the 3 seeded treatments in 1998.

	32 square foot total sample area										
	Total	Big Bluestem		Little Bluestem		Switchgrass		Indiangrass		Prairie Sandreed	
Treatment	WSG Count	Actual Count	Expt. Count	Actual Count	Expt. Count	Actual Count	Expt. Count	Actual Count	Expt. Count	Actual Count	Expt. Count
seeded	29	4	2.8	**6	1.4	18	21.1	0	1.7	1	2.1
seeded, cap	128	14	12.2	**18	6.1	89	92.9	7	7.3	**0	9.5
seeded, incorp	110	* 3	10.5	**21	5.3	82	79.9	4	6.3	**0	8.1

* highly significant (1% level)
** significant (5% level)
all others are not significantly different

A Chi-square analysis was completed to determine if the actual counts were statistically the same as the expected counts. Big bluestem fell significantly (5% level) short of expected counts in the soil-incorporated treatment; prairie sandreed had significantly (highly at 1% level) fewer than expected in both supplemental soil treatments. Little bluestem was the only species that significantly (highly at 1% level) exceeded expected counts, and that was accomplished in all 3 seeded treatments.

Furthermore, looking at warm season grass counts per 100 seeds planted (Figure 6), most species performed better in one or both of the treatments where soil was added. Again, little bluestem had a comparatively higher percent than any other species in each of the seeded treatments. Because of possible self-reseeding and spread by rhizomes, as is evident from the existence of these species in the control (unseeded) plots, this most likely is not the percent of the seed that germinated and grew into plants. However it does indicate the relative success of the species under each of these conditions.

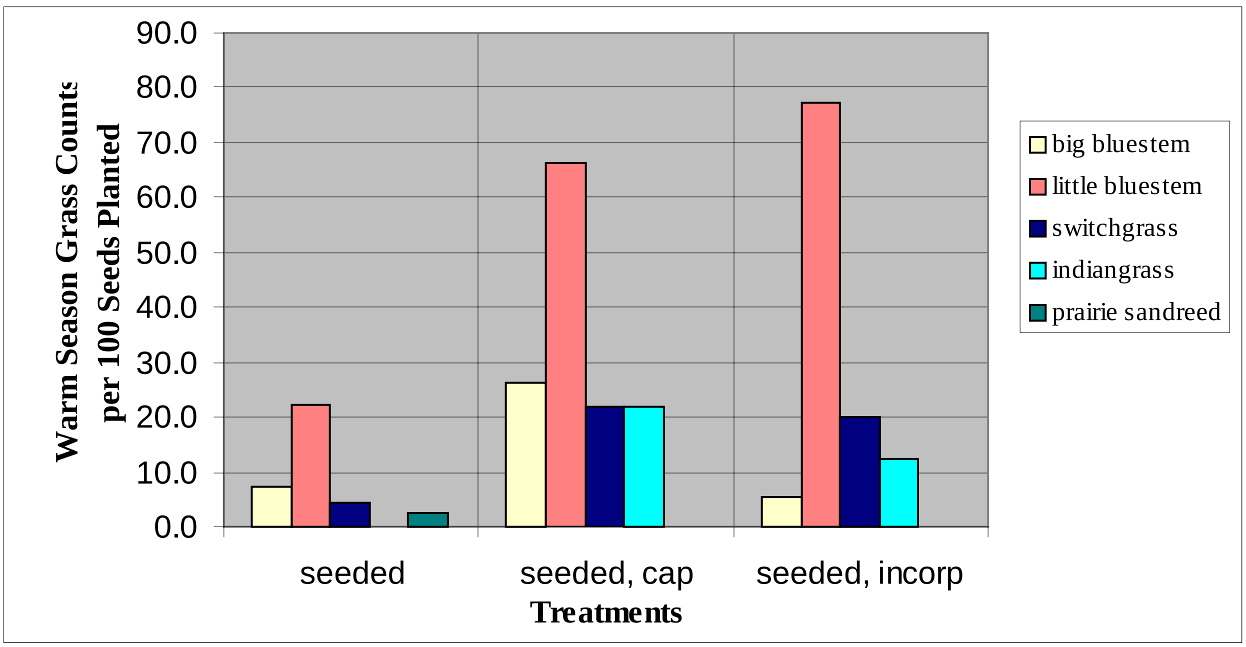

Figure 6. 1998 warm season grass counts per 100 seeds planted in the 3 seeded treatments.

Differences between the fertilized and non-fertilized subplots were virtually non-existent across all categories (Table 6). Likewise, the interaction between treatments and subplot factors was not significantly different in any category (Table 7). This indicates most, or all, of the differences resides in the treatment effect and not the subplot (fertilizer) effect or an interaction between the two.

Table 6. Summary of 1998 groundcover composition and warm season grass effectiveness on subplots.

Subplots	Foliar Cover (%)	(average count / square foot) Warm Season Grasses	Non-Seeded Species	Total Plants	Warm Season Grasses (% of total)	Warm Season Grass Effectiveness (Highest = 1, Lowest = 9)
	ns	ns	ns	ns	ns	ns
no fertilizer	50.6	2.3	17.8	20.2	11.6	5.1
Fertilizer	55.2	2.2	16.3	18.5	11.7	5.1

ns not significantly different at 5% level

Table 7. Summary of 1998 ground cover composition and warm season grass effectiveness on treatment and subplots interaction.

Treatments/ Subplots	Foliar Cover (%)	(average count / square foot) Warm Season Grasses	Non-Seeded Species	Total Plants	Warm Season Grasses (% of total)	Warm Season Grass Effectiveness (Highest = 1, Lowest = 9)
	ns	ns	ns	ns	ns	ns
No seed, no soil no fertilizer	34.7	0.9	18.9	19.9	4.7	9.0
No seed, no soil fertilizer	39.4	0.3	16.0	16.3	1.9	9.0
Seeded, no soil no fertilizer	39.1	0.8	23.6	24.3	3.1	7.3
Seeded, no soil fertilizer	37.2	1.1	20.1	21.2	5.0	7.0
Seeded, soil cap no fertilizer	61.6	3.9	15.5	19.4	20.3	1.8
Seeded, soil cap fertilizer	75.3	4.1	11.5	15.6	26.1	1.5
Seeded, soil incorp no fertilizer	67.2	3.7	13.3	17.0	21.7	2.5
Seeded, soil incorp fertilizer	69.1	3.2	17.6	20.8	15.4	2.8

ns not significantly different at 5% level

CONCLUSIONS

Much of the story on this site seems to be that the warm season grass mix performed far better, both in number and vigor, on the soil treated areas. Although the non-seeded species, mostly weeds, were somewhat improved in vigor on these same areas, their numbers did not. This suggests a strong competitive edge to the native grass mix where soil was added. The extensive root systems, typical of warm season grasses, probably figured greatly into these results but it is beyond the scope of this study to assess the possible soil-climate-plant interactions.

A rule of thumb is that a warm season grass planting will most likely be successful if it has two strong plants per square foot in the second year after planting (Dickerson, et. al. 1997). Although the overall bulk of the grasses were generally less than what would be found on a deep soil site, both of the treatments receiving supplemental soil doubled or nearly doubled that figure. The two treatments not receiving soil additions reached less than half that goal (Table 3, Figure 2). Enhanced wildlife benefits and aesthetic value to the land are, of course, commensurate with this improved development. As identifying methodologies that accomplish this task was the primary objective of this study, it appears we have gained some insight as to the approaches that work.

Discussion on the fertilizer application to the subplots can only be directed at this particular quantity and blend. The bottom line is that it did not affect the results of any measured feature. Although varying the application rates and blends would most likely produce different results, without fertilizer additions a successful warm season grasses was produced within a respectable period of time.

As to the individual species, little bluestem was the only one to statistically exceed expected counts, substantially outperforming all the others. At the other extreme, prairie sandreed fell severely short of expectations. The other species for the most part met expected counts. This suggests some species may not be appropriate for use under these growing conditions while others seem to flourish. However, keep in mind that plants are successional and develop at different rates, and the makeup of any community may change over time.

This brings us to a final consideration. The warm season grasses are long-lived but are also relatively slow in above ground development compared to other common species. Good pre-planting weed control and proper management, particularly in the first couple year after planting, will considerably improve the chances for a successful planting.

ACKNOWLEDGEMENT

Under the terms of Agreement No. 68-52KY-6-649 with the City of Hammond, NRCS, through the Rose Lake Plant Materials Center, designed and evaluated the methodologies used in this study.

This project was completed through the cooperation of the City of Hammond, Parks Dept.; USDA-NRCS, Rose Lake PMC and Lake County Field Office; GLNPO, EPA; The Nature Conservancy; Friends of Gibson Woods; Allen Landscape Construction; and the Lake County Soil and Water Conservation District.

REFERENCES

Dickerson J., et. al. 1997. *Vegetating with Native Grasses in Northeastern North America*. Ducks Unlimited Canada. 63 pp.