Revegetating Slag Refuse Areas with Native Warm Season Grasses

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Photo by Thomas G Barnes

Little bluestem (Schizachyrium scoparium *(Michx.) Nash).*

The City of Hammond, Indiana, has had a long association with the steel industry. Slag is discarded material after processing iron ore into steel. Past disposal practices have resulted in numerous poorly vegetated sites where slag refuse was stockpiled. Many such sites originally had uniquely diverse plant communities that included native warm season grasses, and were in areas historically used as resting sites by migratory birds (Lin and others 1996).

Abstract

Our study was designed to determine how topsoil and fertilizer supplements affect the establishment of native warm season grasses on a northwestern Indiana slag refuse site. We seeded a mix of 5 locally collected warm season grass species (big bluestem, *Andropogon gerardii* Vitman; little bluestem, *Schizachyrium scoparium* (Michx.) Nash; indiangrass, *Sorghastrum nutans* (L.) Nash; prairie sandreed, *Calamovilfa longifolia* (Hook.) Scribn.; switchgrass, *Panicum virgatum* L.) to plots with and without topsoil additions; split plots were either treated with a balanced fertilizer at 1120 kg/ha (1000 lb/ac) or left unfertilized. Adding topsoil to slag significantly ($P < 0.05$) increased the percent foliar cover, number of warm season grass plants, percentage of warm season grasses, and relative effectiveness rating for improving wildlife habitat and aesthetic value compared to non-amended slag. No significant differences ($P > 0.05$) were found between fertilized and non-fertilized plots. Based on comparisons between individual seeded warm season grasses, little bluestem had the highest plant counts relative to its proportion in the mix and exceeded expectation ($P = 0.1$) across all seeded treatments.

KEYWORDS: Poaceae, reclamation, fertilizer, seeding

NOMENCLATURE: USDA NRCS (1999)

In response to situations created by slag disposal, the City of Hammond Parks Department in partnership with the US Department of Agriculture—Natural Resources Conservation Service filed for and received a Great Lakes National Program Office grant through the Environmental Protection Agency to study site specific methods by which slag refuse areas could be revegetated with native plants. Our objective was to identify methods that would create a favorable environment for continued native plant succession, improve wildlife habitat, and improve the aesthetic value of the site.

TABLE 1

Treatments

Soil Component	Seed Component
No topsoil added (control)	Not seeded (control)
No topsoil added	Warm season grass mix
10 cm (4 in) of topsoil placed over slag soil (topsoil cap)	Warm season grass mix
10 cm (4 in) topsoil cap incorporated into top 10 cm of slag soil	Warm season grass mix

Materials and Methods

The study was located in the City of Hammond within an area known as Strawberry Island at the southern end of Lake Michigan. Formerly a wetland area, the site was flat with a dense, slag-permeated surface and sparse weedy vegetation. An analysis of the slag content indicated there were no inherent toxicities that would inhibit plant growth. The disturbed nature of this site, however, intrinsically prohibits consideration as a deep soil site, compromising the soil's nutrient base and water-holding capacity (Diboll 1986; Stout and Jung 1995).

We used a split-plot design with 4 replications. A non-sterilized loamy topsoil was used in main plot treatments receiving supplemental soil. Previous research demonstrated the addition of a thin layer of top soil expedited native plant development on altered sites (Conover and Geiger 1989). Native warm season grass species, common to this area prior to development, were chosen for the seed mix from available local genotypes collected by the Friends of Gibson Woods. Soil and seed components of each treatment are listed in Table 1. Seeds were cleaned and tested for purity and viability to determine pure live seed (PLS) content. The quantities collected, seeds per kilogram (Dickenson and others 1997), and percentage PLS were used to determine the percentage (by number, not weight) of each species in the mix (Table 2).

The site was disked to remove existing vegetation and treatment plots were established in early summer 1996. Each plot was 2.6 x 30 m (8.7 x 100 ft) and was divided at the 15-m (50-ft) mark into fertilized and non-fertilized subplots. Half of the plots were capped with 10 cm (4 in) of topsoil. Half of the capped plots were disked to incorporate the topsoil into the top 10 cm (4 in) of slag soil. Seeded plots were hand broadcast with a mix (Table 2) of 5 warm season grasses at a rate of approximately 11 kg PLS/ha (10 lb PLS/ac) and raked to provide better seed to soil contact (Figure 1). After seeding, 12N:12P_2O_5:12K_2O fertilizer was broadcast on the appropriate subplots at a rate of 1120 kg/ha (1000 lb/ac). To control the weeds during the first year, the study area was mowed several times and sprayed once with 2,4-D in October.

In October 1997, using a line transect approach within each subplot, we collected preliminary data on groundcover type (non-planted grass, forb, moss, planted species and bare ground) and plant vigor at each of 50 points, spaced 30 cm (1 ft) apart. Vigor ratings were visual observations grading plant health and growth as indicated by color and volume. A total of 1600 points were sampled (50 points x 2 subplots x 4 treatments x 4 replications).

In October 1998, data were collected again. However, instead of a line transect, measurements were taken from 4 randomly located 0.09-m^2 (1-ft^2) areas in each subplot. Data were recorded on percent foliar cover, number and type of planted species present, and the number of non-planted species present in each sampled area. Effectiveness of the planted species to provide improved wildlife habitat and aesthetic value to the land was also taken on each subplot. This was a visual rating indicated by vigor and frequency of planted species.

Results and Discussion

Because the method of collecting data from a line transect (one-dimensional view) in 1997 changed to an area transect (two-dimensional view) in 1998, it is difficult to compare

TABLE 2

Warm season grass (Poaceae) seed mix used in seeded plots

Species	Seeds per kg (lb)	kg PLS per ha (lb/ac)	% of mix[a]
Andropogon gerardii Vitman (big bluestem)	363,000 (165,000)	1.98 (1.77)	9.5
Schizachyrium scoparium (Michx.) Nash (little bluestem)	528,000 (240,000)	0.68 (0.61)	4.8
Sorghastrum nutans (L.) Nash (indiangrass)	385,000 (175,000)	1.11 (0.99)	5.7
Calamovilfa longifolia (Hook.) Scribn. (prairie sandreed)	602,800 (274,000)	0.92 (0.82)	7.4
Panicum virgatum L. (switchgrass)	875,000 (389,000)	6.42 (5.73)	72.6
Total		***11.11 (9.92)***	***100.0***

[a] By PLS number.

these data directly. Also, considering the study objectives, we believe that the second year data are a more reliable picture of site conditions and potential for revegetating these slag sites. Data collected within sample areas will relate directly to plant and species density within larger areas, not simply percentages as indicated from a line transect. As such, our focus will be on information gathered in 1998 (Table 3).

Most apparent in statistics for categories that reached a level of significance ($P < 0.05$) was the sharp distinction between treatments where soil was added and those where soil was not added (Table 3). Not only did the percentage of foliar cover nearly double, but the percentage of warm season grasses and their average frequency per square meter were 4X to 7X greater in treatments with additional topsoil. Also of importance are the categories that were not significantly different in 1998: non-seeded species and total plant counts. Adding topsoil to slag substantially increased the number of seeded warm season grasses but it failed to effect ($P > 0.05$) the non-seeded or total vegetation counts (Table 3).

The 1997 data (Table 4) are similar to the 1998 data. As in 1998, the percentage vegetative cover (comparable to foliar cover), warm season grass counts, and percentages of total vegetation were substantially higher ($P = 0.01$) in treatments with the soil additions.

Although we noted a general increase in vigor of all plants where topsoil was added, this was 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 adding aesthetic value to the site (Table 3). As previously noted, this was essentially a rating on the frequency and vigor of warm season grasses. Results were consistent and dramatic among soil treated plots, again, faring significantly better ($P < 0.01$) than those without soil additions.

Data recorded on warm season grasses also included a breakdown by species. However, to better understand these figures we needed to consider the actual counts in relation to their individual proportions in the seed mix. Multiplying the total warm season count of all species in a treatment by the proportion of a species in the mix (Table 2) gave 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 2.9 m^2 (32 ft^2) are provided in Table 5.

A Chi-square analysis was completed to determine if the actual counts differed statistically from the expected counts based on each species contribution to the seed mix. Big

Photo by Rose Lake Plant Materials Program

Figure 1 • Raking seeds into plots to improve seed-to-soil contact.

TABLE 3

1998 mean groundcover composition and warm season grass effectiveness

Treatments	Foliar cover (%)	Count per m^2 (ft^2): Warm season grasses	Count per m^2 (ft^2): Non-seeded species	Count per m^2 (ft^2): Total plants	Warm season grass (% of total)	Warm season grasses effectiveness (Highest = 1, Lowest = 9)
Control (no seed, no soil)	37 b	6 (0.6) b	189 (18)	195 (18)	4 b	9 d
Seeded	38 b	10 (0.9) b	235 (22)	246 (23)	4 b	7 c
Seeded with soil cap	68 a	43 (4.0) a	146 (14)	189 (18)	23 a	2 a
Seeded with soil incorp.	68 a	37 (3.4) a	166 (15)	204 (19)	18 a	3 b
P value	**≤ 0.05**	**≤ 0.01**	**> 0.05**	**> 0.05**	**≤ 0.01**	**≤ 0.01**

Within columns, treatment means without a common letter are significantly different using Duncan's multiple range test ($P = 0.05$).

TABLE 4

1997 vegetative cover and warm season grass data

Treatments	Vegetative cover (%) [a]	Warm season grasses (Count) [b]	Warm season grasses (% of total vegetation) [a]
Control (no seed, no soil)	63 b	0 b	0 b
Seeded	62 b	8 b	3 b
Seeded with soil cap	87 a	108 a	31 a
Seeded with soil incorp.	92 a	69 a	19 a

Treatments with no common letters are significantly different by Duncan's multiple range test at the 1% level.
[a] Average of 4 replication.
[b] Out of 400 observations.

bluestem fell significantly ($P = 0.05$) short of expected counts in the soil-incorporated treatment; prairie sandreed had significantly ($P = 0.01$) fewer plants than expected in both supplemental soil treatments. Little bluestem was the only species that significantly ($P = 0.01$) exceeded expected counts, and that was accomplished in all 3 seeded treatments. Furthermore, looking at extrapolated warm season grass counts per 100 seeds sown (Figure 2), most species exhibited higher frequencies in one or both of the treatments where soil was added. Again, little bluestem had a comparatively higher percentage 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 warm season grasses in unseeded plots, the number of plants growing in each plot is most likely not the percentage of seeds that grew into plants. However, it does indicative the relative success of the species in each treatment.

We detected no significant differences between fertilized and non-fertilized subplots, nor did we find an interaction between treatments and subplot factors (data not shown).

Conclusions

Warm season grasses grew better, both in number and vigor, on soil-amended plots. Although non-seeded species were somewhat improved in vigor on soil-amended plots, the number of individual plants of these species failed to increase over time, suggesting a strong competitive edge to the native grass mix where soil was added. The extensive root systems, typical of warm season grasses, were probably a competitive factor against the non-seeded species.

A general operating rule in northern Indiana is that a warm season grass planting will most likely be successful if it has 22 vigorous plants per m^2 ($2/ft^2$) in the second year after planting (Dickerson and others 1997). Although the overall biomass of the grasses was generally less than what would be expected on a deep soil site where the nutrient base and water-holding capacity would be higher (Diboll 1986; Stout and Jung 1995), both treatments receiving supplemental soil doubled or nearly doubled the plant count. Both treatments without soil additions reached less than half that goal (Table 3). Wildlife habitat and land aesthetics will be improved by converting slag sites to native grasslands.

Fertilizer did not affect the results of the any measured feature. Varying the application rate or blend may produce different results. However, a successful stand of warm season grasses was produced within 2 full growing seasons without fertilizer additions.

Little bluestem was the only species to statistically exceed expected counts, substantially outperforming all others. At the other extreme,

TABLE 5

Total warm season grass count, and actual and expected warm season grass (WSG) counts by species on the 3 seeded treatments in 1998

2.9 m^2 (32 ft^2)

Treatment	Total WSG Count	Big bluestem Actual	Big bluestem Exptected	Little bluestem Actual	Little bluestem Exptected	Switchgrass Actual	Switchgrass Exptected	Indiangrass Actual	Indiangrass Exptected	Prairie sandreed Actual	Prairie sandreed Exptected
Seeded	29	4	2.8	6*	1.4	18	21.1	0	1.7	1	2.1
Seeded with soil cap	128	14	12.2	18*	6.1	89	92.9	7	7.3	0 *	9.5
Seeded with soil incorp.	110	3 **	10.5	21*	5.3	82	79.9	4	6.3	0 *	8.1

* For each species and treatment, the actual count is significantly ($P < 0.01$) different than the expected count.
** For each species and treatment, the actual count is significantly ($P < 0.05$) different than the expected count.

prairie sandreed fell severely short of expectations. The other species met expected counts in at least 2 of the 3 seeding treatments. Our results suggest some species may not be appropriate for use on Indiana slag sites. However, keep in mind that plants are successional and develop at different rates, and the makeup of any community may change over time.

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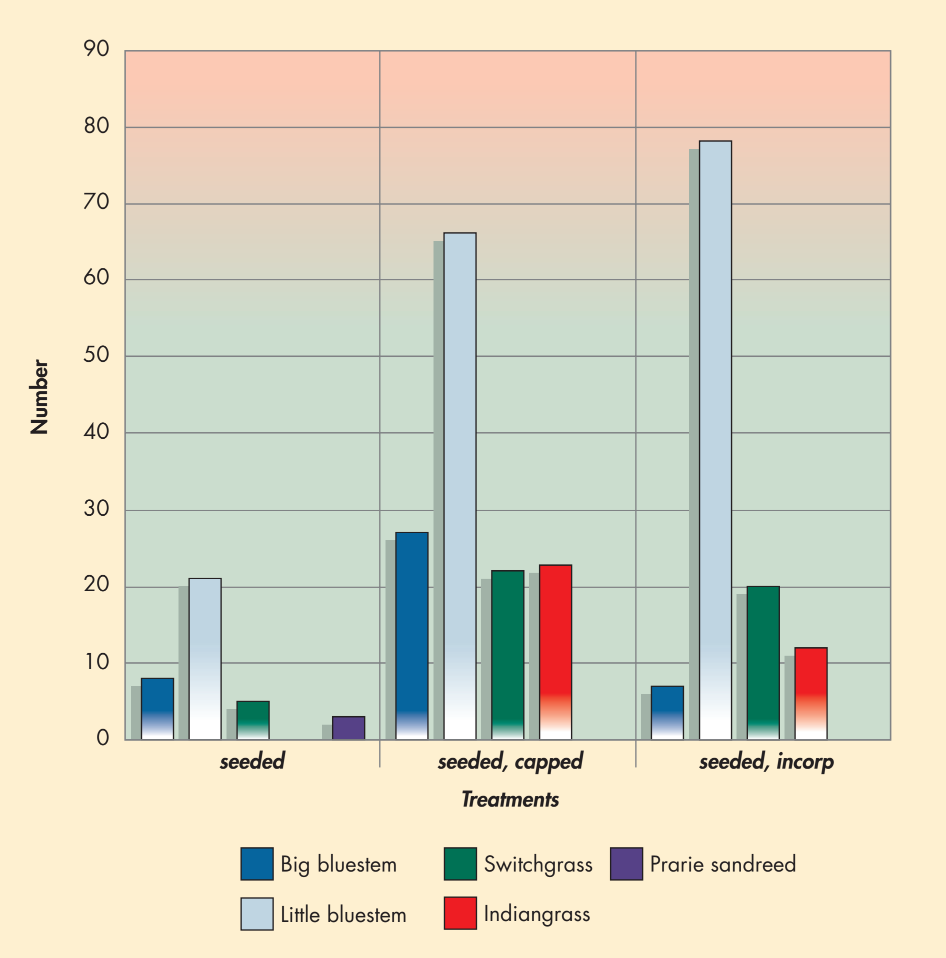

Figure 2 • Warm season grass counts per 100 seeds planted in the seeded treatments.