THE USE OF WARM SEASON GRASSES FOR REVEGETATING SANDS AND GRAVELS IN NEW HAMPSHIRE, VERMONT, AND NEW YORK

John Dickerson, Theodore Kelsey, and Raymond Godfrey[1]

Abstract.--Sand and gravel mines and other droughty sites were planted with warm season (C_4) grasses as single species plots and mixtures. Treatments included planting methods, i.e. drilling, broadcasting with bulldozer "tracking", and hydroseeding. Nitrogen was applied as urea, ammonium nitrate, or isobutylidene diurea. Plantings of C_4 grass mixtures with legumes were evaluated after one year's growth. C_4 grass cultivars and species with best growth and percent cover at 6, 18, and 30 months after planting were 'Blackwell' switchgrass (Panicum virgatum L.), 'Niagara' big bluestem (Andropogon gerardi Vitman), 'Aldous' little bluestem [Schizachyrium scoparium (Michx.) Nash], and 'Goldstrike' sand bluestem (Andropogn hallii Hack.). Indiangrass (Sorghastrum nutans (L.) Nash), sideoats grama [Bouteloua curtipendula (Michx.) Torr.], and deertongue (Dichanthelium clandestinum (L.) Gould) were less successful species. Nitrogen applied in slow release form appeared to benefit seedling development of switchgrass and sand lovegrass (Eragrostis trichodes (Nutt.) Wood) on a sand bank during the first growing season. No-till drilling and broadcasting with incorporation by bulldozer tracking were successful methods of planting C_4 grasses on droughty sites. At one location, inclusion of hairy vetch (Vicia villosa Roth) with the C_4 grasses resulted in improved first year ground cover.

INTRODUCTION

Sand and gravel borrow pits cover about 200,000 acres in Pennsylvania, New York, and the New England states (USDA-SCS 1981). In most operations the overburden material is seldom stockpiled for reclamation. After mining ceases, the extremely droughty spoils on these sites strongly inhibit the reestablishment of indigenous vegetation. A rapid transition from biennial and perennial plants (Andreae and Cavers 1981) to very open stands of birch (Betula spp.) and pine (Pinus spp.) is common with very little soil profile development. The few trees that result are stunted, low value specimens which accumulate most of the very limited onsite nutrients in their biomass (Odum 1971). Excessive drainage, very low organic matter,

[1]John Dickerson is Plant Materials Specialist for NY, VT, NH, and ME for the USDA-Soil Conservation Service, Syracuse, NY, and Theodore Kelsey and Raymond Godfrey are Resource Conservationists for the USDA-SCS in Durham, NH and Winooski, VT, respectively.

Proceedings America Society of Mining and Reclamation, 1988 pp 2-8
DOI: 10.21000/JASMR88020002

and low percentage of soil fines further inhibit herbaceous plant establishment.

Typically, when seedings are made to revegetate these mines, mixtures include such species as ryegrass (Lolium perenne L. and L. multiflorum Lam.), Kentucky bluegrass (Poa pratensis L.), and red or tall fescue (Festuca rubra L. or F. arundinacea Schreb.). Good initial establishment usually results when a timely, well mulched seeding receives fertilizer and favorable rainfall. Unfortunately, the lush growth declines to a sparse plant population within 3 to 4 years, resulting in the need for replanting. The need for effective cover led to a series of test plantings throughout New England and New York in 1975-1977 (Gaffney and Dickerson 1987). Of the materials tested in that study, native warm-season (C_4)[2] grasses were superior to cool-season (C_3)[2] grasses and legumes for establishing effective, long-term cover, where surface layer fines[3] were below 15 percent.

Though C_4 grasses were superior, only a few species and cultivars were tested, and their cover developed slowly. Generally they required 3-4 years to become effective. Objectives of this study were: 1) to identify species and cultivars of C_4 grasses that are suited for reclamation of sand and gravel spoils in New England and New York, and 2) to determine agronomic practices that would promote rapid establishment of effective grass cover.

STUDY METHODS

Ten field plantings were made in New Hampshire, Vermont, and New York from 1984 to 1987 (table 1). Cultivars of several C_4 grass species were compared in replicated tests at two sites. Seven sites were sown with mixtures of species and a number of different agronomic practices were compared. The final planting was a replicated fertility trial on a droughty sand roadbank. The methods used at each location are described below and in table 1. Species and cultivars for each site are listed in tables 2 and 3.

Franklin Falls and Ossipee, NH, Small Plots

Warm-season grass evaluation plantings were established in Franklin and Ossipee, New Hampshire in 1984 and 1985 respectively.

The Franklin site is located on the Franklin Falls flood control dam borrow area. This area was stripped in the 1938 to 1943 era. The only vegetation occupying the site in 1984 was lichen, a few birch (Betula spp.) and stunted white pine (Pinus strobus L.) trees. In May, 1984, a planting site of 1/4 acre was back-dragged with a dozer and seeded to selected warm season grasses. The test consisted of 13 entries seeded in 12 ft. by 19 ft. plots, replicated twice. Species and cultivars used are listed in table 2.

Table 1.—Ten plantings made in New Hampshire, Vermont, and New York during 1984-1987.

Location	Date Planted	Type of Site	Gravel	Sand	Fines	pH	Planting Type	Method of Planting	No. of Varieties
			Percent[a]						
Franklin Falls,NH	4/84	Borrow pit	23	75	2	5.0	monoculture, small plots	broadcast,raked in, mulched	13
Ossipee,NH	5/85	Borrow pit	11	87	2		monoculture small plots	broadcast, raked in	13
Franklin Falls,NH	4/84	Borrow pit	23	75	2	5.0	monoculture large plots	drilled, mulched	4
Bennington,VT	5/13/85	Commercial mine	56	35	9	7.2	mixture large plots	broadcast, tracked in	-
Alton,NH	6/84	Sand bank					mixture large plots	hydroseeded	-
S.Woodbury,VT	6/5/85	Commerical mine	31	52	17	7.2	mixture large plots	broadcast, tracked in	3
Bennington,VT	5/8/87	Sand & Gravel mine	34	54	12	6.6	grass/legume mixture,large plots	broadcast, tracked in	10
Watson, NY	5/20/87	Borrow pit					grass/legume mixture,large plots	broadcast, tracked in	8
Speculator,NY	5/22/87	Borrow pit	6	84	10	5.4	grass/legume mixture,large plots	broadcast, tracked in	8
Concord,NH	4/22/87	Sand bank	7	91	2	5.2	grass mixture fertility plots	broadcast, raked in	6

[a] Percent by weight in surface 4" passing 200-mesh sieve.

[2] C_3 and C_4 refer to photosynthetic pathways which determine the seasonality of plant growth.

[3] Percent by weight passing a 200-mesh sieve.

Table 2.—Species and cultivars used in two small plot trials in Ossipee and Franklin Falls, NH

Species		Cultivars	Origin	Developed At
Switchgrass	Panicum virgatum L.	Blackwell	Oklahoma	USDA-SCS, Manhattan, KS
Big bluestem	Andropogon gerardi Vitman	Niagara	New York	USDA-SCS, Big Flats, NY
		Champ	Nebraska	Univ. Nebr., Lincoln, NE
Sand bluestem	Andropogon hallii Hack.	Goldstrike	Nebraska	Univ. Nebr., Lincoln, NE
Little bluestem	Schizachyrium scoparium (Michx.) Nash	Aldous	Kansas	USDA-SCS, Manhattan, KS
		Cimarron	Kansas	USDA-SCS, Manhattan, KS
Sand lovegrass	Eragrostis trichodes (Nutt.) Wood	NE-27	Nebraska	Univ. Nebr., Lincoln, NE
Indiangrass	Sorghastrum nutans (L.) Nash	Holt	Nebraska	Univ. Nebr., Lincoln, NE
		NE-54	Nebraska	Univ. Nebr., Lincoln, NE
		Oto	Nebraska	Univ. Nebr., Lincoln, NE
Sideosts grama	Bouteloua curtipendula (Michx.) Torr.	El Reno	Oklahoma	USDA-SCS, Manhattan, KS
		Trailway	Nebraska	Univ. Nebr., Lincoln, NE
Deertongue	Dichanthelium clandestinum (L.) Gould	Tioga	Pennsylvania	USDA-SCS, Big Flats, NY

Table 3.—Seeding rates (lb/acre), species and cultivars used in eight mixtures sown in New Hampshire, Vermont, and New York during 1984–1987.

Location/Year	Switch-grass	Big Bluestem	Little Bluestem	Sand Bluestem	Sand Love-grass	Deer-tongue	Indian-grass	Birdsfoot Trefoil	Hairy Vetch	Flat-pea	Perennial pea
Franklin Falls,NH	Blackwell	Niagara	Aldous	-	-	-	NE-54	-	-	-	-
1984	4.0	6.0	6.0				6.0				
Bennington,VT	Blackwell	Niagara	Aldous	-	-	-	-	-	-	-	-
1985	6.0	4.0	2.0								
Alton,NH	Blackwell	Niagara	Aldous	-	-	Tioga	NE-54	Viking	-	-	-
1984	2.0	3.0	3.0			1.0	3.0	2.0			
S.Woodbury,VT	Blackwell	Niagara	Cimmaron	-	-	-	-	-	-	-	-
1985	6.0	3.0	2.5								
Bennington,VT	Blackwell	Niagara	Aldous	Goldstrike	NE-27	-	KY-591	Viking	Common	Lathco	Lancer
1987	3.0	2.0	2.0	1.0	1.5		2.0	1.5	3.0	3.0	3.0
Watson,NY	Blackwell	Niagara	-	Goldstrike	NE-27	-	KY-591	Viking	Common	Lathco	-
1987	3.0	2.0		1.0	1.5		2.0	1.5	2.0	2.0	
Speculator,NY	Blackwell	Niagara	-	Goldstrike	NE-27	-	KY-591	Viking	Common	Lathco	-
1987	3.0	2.0		1.0	1.5		2.0	1.5	2.0	2.0	
Concord,NH	Blackwell	Niagara	Aldous	Goldstrike	NE-27	-	NE-54	-	-	-	
1987	4.0	4.0	2.0	2.0	2.0		2.0				

The test site was limed at 1 ton/acre, fertilized with 0-25-25 at 478 lb/acre, hand seeded, hand raked, and mulched with straw at a rate of 1,500 lb/acre.

The Ossipee site is located on a log storage area at the S.D. Warren facility. It was forested until 1983 when it was stripped of timber, topsoil, and most subsoil, then used to store logs through 1984. The soil material consists of sands more than 5 ft deep, with bark residue on the surface. The seasonal high water table is between 3-6 ft below the ground surface.

Thirty, 12.5-ft by 25-ft plots were limed at 1,000 lb/acre, fertilized with 320 lb/acre of 0-10-40, hand seeded, and hand raked. The residual bark raked in with the seed, lime, and fertilizer negated the need for mulch. The area was seeded on May 29, 1985. It was top dressed with urea fertilizer in June of 1987.

Franklin Falls, NH, Large Plots

'Blackwell' switchgrass, 'Niagara' big bluestem, 'NE-54' indiangrass, and 'Aldous' little bluestem (table 3) were planted with a no-till drill. Each species was planted separately in two randomly assigned strips 13-ft by 300-ft in size with an 8-in row spacing. Phosphorus (P_2O_5) and potassium (K_2O) were both banded at 25 lb/acre with minimal incorporation; lime was spread at 2 tons/acre. Problems with the feeding of the indiangrass and little bluestem seed through the drill resulted in uneven seed distribution. The switchgrass and de-bearded big bluestem planted acceptably at about 2 inches deep. The plantings were mulched for 2/3 of the strip length with rye straw, but most of it blew off the plot area.

Bennington, Vt, 1985 Planting

A depleted section of an active gravel mine was selected for this planting. The site has two different surface conditions; the uphill half has a coarser texture with larger stones while the remainder has smaller stones and more sand-sized material. The aspect is east.

A mixture of 'Blackwell' switchgrass, 'Niagara' big bluestem, and 'Aldous' little bluestem (table 3) was broadcast seeded and tracked. Tracking amounted to running a bulldozer back and forth over the site, overlapping the tracks so that the area was completely covered. Tracking was less effective in scoring the surface of the ground on the uphill part of the site. Fertilizer was applied at 24 lb/acre each of N, P_2O_5, and K_2O; the N source was ammonium nitrate. The planting was not mulched.

Alton, NH, Hydroseeding

This site was a cut sand bank which had been bare for several years, with active sloughing occurring in places due to foot traffic and washing from heavy rain. 'Niagara' big bluestem, 'Blackwell' switchgrass, 'NE-54' indiangrass, 'Aldous' little bluestem, and 'Tioga' deertongue, along with 'Viking' birdsfoot trefoil were hydroseeded with 800 lb/acre of 8-16-16 fertilizer and 4,000 lb/acre of lime. No methods of incorporation were used, but the bank was mulched with hay and tackified. Within a week of planting a very intense rain caused extensive sand movement in spite of the mulch.

South Woodbury, VT, 1985 Planting

A site in South Woodbury at 1,150 ft above sea level had been used as a sand and gravel pit for years. By 1984, the sand and gravel resources were exhausted in two areas of the pit. The same soil material existed at each of the 1.5 acre sites, but one site had a northern exposure while the other had a southern exposure.

Both sites were seeded on June 5, 1985. Prior to seeding, the owner smoothed and graded the sites with a bulldozer, leaving the banks at a slope of 25%. A hand broadcast mix of 'Blackwell' switchgrass, 'Niagara' big bluestem, and 'Cimarron' little bluestem (table 3) was applied at the rate of 8 lbs/acre. Fertilizer was applied at both sites as 0-20-20 at the rate of 400 lb/acre. A hay mulch was spread over the northerly exposed site only, at the rate of 1,000 lb/acre. After the materials were spread, the owner 'tracked' each site with a bulldozer to incorporate the seed and to anchor the mulch.

Bennington, VT; Watson and Speculator, NY, 1987 Plantings

These plantings were made to evaluate long-term cover under low maintenance. Legumes were added to the basic C_4 grass mix to provide a nitrogen source (table 3). A level 1-acre site near Bennington, which had been mined until 1972, was selected for planting. It was devoid of vegetation. After 480 lb/acre of 6-24-24 fertilizer was applied, the seed was broadcast and the entire site was tracked with a bulldozer. The Watson site was located in a town borrow pit. The surface material consisted of sand and fines with little gravel. The same conditions existed at the Speculator site, but instead of a flat area, part of the seeding went on sideslopes of the pit.

The legumes were added to the grass mix as single species in 25-ft wide strips across the planting site. One winter annual (hairy vetch) and 3 perennials ('Lathco' flatpea, 'Lancer' perennial pea, and 'Viking' birdsfoot trefoil) were used. See table 3 for details regarding species, cultivars and seeding rates.

Concord, NH, Fertility Trial

At Concord, a sandy, droughty slope was planted to a C_4 mixture of 'Blackwell' switchgrass, 'Niagara' big bluestem, 'Garden' sand bluestem, 'Aldous' little bluestem, 'NE-27' sand lovegrass, and 'NE-54' indiangrass. Five fertility treatments were replicated twice. They are detailed in table 4. After hand raking, the entire site was mulched with 2,100 lb/acre of straw.

Table 4.—Fertility treatments at Rt. 106, Concord, NH

Treatment No.	Urea	NH_4NO_3	IBDU[a]	P_2O_5	K_2O	$CaCO_3$
	lb/acre					
1	75	--	--	62	62	2090
2	31	--	36	62	104	2090
3	15	57	--	62	62	2090
4	15	--	--	62	62	2090
5	41	--	61	62	132	2090

[a] Water insoluble N source, isobutylidene diurea.

RESULTS AND DISCUSSION

Franklin Falls and Ossipee, NH, Small Plots

The tests of C_4 grasses were conducted to identify species and cultivars which might be as effective as 'Blackwell' switchgrass and 'Niagara' big bluestem. The trials were by no means exhaustive. Many other C_4 grass cultivars should be tested.

At the Ossipee plots, there was organic matter (bark) present on the surface, and the plants responded with good growth. At Franklin Falls, two problems affected the perimeter plots. Competing trees (white pine and birch), though very sparse and stunted, were not removed far enough away from the plots. Grass growth on the closest plots was reduced. Also off-road recreational vehicles damaged some plots. Plants on the remaining plots developed slowly until fertilized with urea in 1986.

Although more testing is needed, two previously untried species, sand bluestem and sand lovegrass, show considerable promise (table 5). These two species have performed very well despite fears that they would not be winterhardy or would succumb to leaf diseases. The performance of sand lovegrass is of special interest because the species has tiny seeds - a potential advantage where seed is to be broadcast and incorporation will be incomplete. 'Blackwell' switchgrass, 'Niagara' big bluestem, and 'Aldous' little bluestem have also provided good to excellent cover.

Table 5.—Performance of C_4 Cultivars at Ossipee and Franklin Falls, NH, Percent Cover. Average of 2 replications.

		Ossipee			Franklin Falls			
Species	Cultivar	1985	1986[a]	1987[a]	1985	1986[a]	1987[a]	1987 Aver.
Switchgrass	Blackwell[b]	35	70	80	19	60	80	80
Big bluestem	Niagara[b]	36	70	80	6	50	70	75
	Champ	22	50	50	6	20	30	40
Sand bluestem	Goldstrike	20	60	70	20	60	70	70
Little bluestem	Aldous	22	70	80	20	60	80	80
	Cimarron	25	80	90	1	10	30	60
Sand lovegrass	NE-27	60	70	85	43	80	80	82
Indiangrass	Holt	20	40	50	3	20	50	50
	NE-54	27	50	70	8	30	45	57
	Oto	12	30	40	10	40	50	45
Sideoats Grama	El Reno	20	50	60	8	20	30	45
	Trailway	15	35	50	1	10	20	35
Deertongue	Tioga	5	10	30	1	5	10	20
Control Plots		0	10[c]	15[c]	0	0	0	8[c]

[a] Estimates made from photo documentation.
[b] Blackwell and Niagara, 4 reps at each location.
[c] Blackberries, herbaceous weeds.

Indiangrass and deertongue have been a disappointment on these droughty sites. Both species have been slow to establish and have had poor vigor. The relatively poor performance of deertongue is especially noticeable because the species does volunteer readily on droughty sites throughout the Northeast.

Cultivars with inconsistent performance between replications included 'El Reno' sideoats grama, 'Cimarron' little bluestem, 'Holt', 'Oto' and 'NE-54' indiangrass, 'Champ' big bluestem and 'Tioga' deertongue.

Franklin Falls, NH, Large Plots

This discussion will focus on results with 'Blackwell' switchgrass and 'Niagara' big bluestem. As noted earlier, planting problems with little bluestem and indiangrass greatly affected the performance of those species.

Populations of 'Blackwell' and 'Niagara' exceeding 12 seedlings/ft of row, developed in 1985 and have remained through 1987. Where mulch did not blow off, the seedlings appeared to develop more slowly than in unmulched areas. Until the plots were top-dressed with 80 lb/acre of urea in 1986, both cultivars grew slowly. By October of 1987 the 'Blackwell' and 'Niagara' had leaf canopy heights of 36 and 30 inches respectively.

Bennington, VT, 1985 Planting

Seedlings of three species (switchgrass, big and little bluestem) developed rapidly. At the end of 1986 the mixture was providing 60 percent cover on the lower half of the site, where there were fewer stones. In the upper section with heavy surface stones, the cover estimate was 40 percent.

Alton, NH, Hydroseeding

Switchgrass, big bluestem, and little bluestem have estahlished very effective cover on the lower half of the sand bank. The upper half was washed severely by heavy rain just after the planting was completed in 1984, however the cover is improving steadily. Individual switchgrass plant bases have spread to 8 inches in diameter, and new seedlings are emerging each year. Deertongue and birdsfoot trefoil have established only at the base of the slope. Only a few indiangrass plants have established, but they have vigor equal to the big bluestem.

South Woodbury, VT, 1985 Planting

The mixture of switchgrass, big bluestem, and little bluestem produced markedly different growth and cover on the north vs. south facing slopes. The north slope had a 40 percent cover (predominantly switchgrass)in 1986, but has not improved significantly since. The owner began using the center of the plot for a roadway to the top of the slope in 1987, so future improvement may be unlikely.

The south slope has had exceptional cover since the summer of 1986. About 50 percent cover was achieved in 1985, 70 percent in 1986, and 85 percent was the estimate by the end of 1987. All three species are strongly represented, but big bluestem and switchgrass provide most of the cover.

Bennington, VT, Watson and Speculator, NY, 1987 Plantings

First year data on establishment have been recorded for these three test sites. The C_4 grass mix has established at all sites in sufficient numbers to achieve acceptable cover in 1988. The establishment of legumes varied among the three sites. At Bennington, 'Lathco' flatpea had the most seedlings present, followed by hairy vetch, with few birdsfoot trefoil seedlings (less than 1/per yd^2. The Speculator planting had good establishment of the trefoil and hairy vetch, but the flatpea was present at less than $1/yd^2$. The Watson site had exceptional growth from the hairy vetch; it may crowd out the C_4 grasses in 1988. Trefoil and flatpea plant populations were low at $1\text{-}2/yd^2$.

Concord, NH, Fertility Trial

The purpose of this study is to determine if a slow-release nitrogen source, isobutylidene diurea (IBDU), would encourage plant growth and establishment of C_4 grass seedlings during the seeding year. After one growing season, seedlings of 'Blackwell' switchgrass and 'NE-27' sand lovegrass are 3 to 4 times more numerous than the other species planted. Treatments 2,3, and 5 contain seedlings which are 3-4 inches taller and a darker green than those in treatments 1 and 4 (table 4). Treatment 2 utilized IBDU for 54 percent of the total N complement, while treatment 5 had 60 percent of the N as IBDU. Treatment 3 had no IBDU, but did have 79 percent of the N as ammonium nitrate.

Treatments 2 and 5 appeared to result in slightly better growth than treatment 3. The green color of the plants in treatments 2, 3, and 5 in October has caused concern about winterkill. Future observation will be needed to determine any lasting effects.

SUMMARY AND CONCLUSIONS

The small plot work has helped to identify two species and cultivars that may be worthy of inclusion in warm-season grass mixtures for sand and gravel mine revegetation in the Northeast. 'Goldstrike' sand bluestem and 'NE-27' sand lovegrass have been impressive at two locations in New Hampshire. In mixtures, they should be added to 'Blackwell' switchgrass, 'Niagara' big bluestem, and 'Aldous' little bluestem for the most rapid, effective cover tested to date.

For even seed distribution and proper placement a no-till drill provided the best results. Broadcast seedings have been successful where the seed and fertilizer were tracked into the surface with a bulldozer. The technique was not beneficial where large surface rocks prohibited penetration by the track cleats. Hydroseeding was moderately successful at one test site.

In northern Vermont, warm-season grasses grew far more vigorously on a slope with southern exposure than on a north-facing slope. This differential response suggests that there may be sites which cannot be successfully vegetated with C_4 grasses due to microclimatic factors in northern New England and New York.

One seeding which included hairy vetch with warm-season grasses had improved first year cover compared to the grasses used alone. However, the second and third year impacts need to be evaluated before this practice can be recommended.

A warm-season grass mixture fertilized with a slow-release nitrogen source exhibited better first year growth than the same mixture treated with urea. Slow-release nitrogen fertilizers should be used in future trials to find ways of establishing C_4 grass cover quickly on droughty sites.

LITERATURE CITED

Andreae, M.I., and P.B. Cavers. 1981. The significance of natural vegetation in abandoned gravel pits. In Proc., Symp. Revegetation of Pits and Quarries, Univ. Guelph, Guelph, Ont.

Gaffney, F.B., and J.A. Dickerson. 1987. Species selection for revegetating sand and gravel mines in the Northeast. Journal of Soil and Water Conservation. 42:358-361.

Odum, E.P. 1971. Fundamentals of ecology, pp. 256-257, W.B. Saunders. Philadelphia, PA.

Soil Conservation Service, U.S. Department of Agriculture. 1981. RCA Appraisal, Part 1, Agency Review Draft. Washington, D.C.