VEGETATIVE REHABILITATION OF HIGHWAY CUT SLOPES IN EASTERN OKLAHOMA

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16. ABSTRACT

Areas of moderate to severe erosion are occurring on highway rights of way in eastern Oklahoma. The silt from this erosion is filling ditch bottoms causing drainage problems ranging from slight to severe. Current vegetative practices call for bermudagrass slab sod and seeded introduced species of grasses on newly constructed highway rights of way slopes. These practices work well for a limited time (2-3 years). The species begin to die from drought stress, allowing erosion to begin. This study identified species of native warm season grasses that will control erosion, and survive harsh conditions found on disturbed slopes along Oklahoma highways. Along with species tests, planting dates, planting rates, mulch materials, and mulch rates were explored. Three sites were selected by ODOT to perform these tests. The first site is one mile south of the maintenance facility in Poteau, Ok. The second site is 5 miles north of Heavener, on the east side of the highway, and the third is at Sugar Creek on SH-128. Site characterizations were performed at each test site prior to planting dates. Soil amendments were applied for medium production of each species tested. The objective of this study is to test and prepare planting specifications for ODOT to use when contracting vegetative cover establishment on newly constructed highway rights of way in eastern Oklahoma.

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I* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS				
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
LENGTH				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
AREA				
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
VOLUME				
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
NOTE: volumes greater than 1000 L shall be shown in m^3				
MASS				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
TEMPERATURE (exact degrees)				
^oF	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	^oC
ILLUMINATION				
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	candela/m^2	cd/m^2
FORCE and PRESSURE or STRESS				
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS				
SYMBOL	**WHEN YOU KNOW**	**MULTIPLY BY**	**TO FIND**	**SYMBOL**
LENGTH				
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
AREA				
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
VOLUME				
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
MASS				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2000 lb)	T
TEMPERATURE (exact degrees)				
^oC	Celsius	1.8C+32	Fahrenheit	^oF
ILLUMINATION				
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m^2	0.2919	foot-Lamberts	fl
FORCE and PRESSURE or STRESS				
N	newtons	0.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised March 2003)

Disclaimer

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Introduction

The Oklahoma Department of Transportation (ODOT) is seeking solutions to soil erosion problems on highway rights of way in eastern Oklahoma. The United States Department of Agriculture: Natural Resources Conservation Service, Booneville Plant Materials Center (PMC) in Booneville, Arkansas, specializes in critical area establishment and rehabilitation of critical areas with native warm season grasses (nwsg).

The purpose of this study was to identify and test species of nwsg on highway rights of way in eastern Oklahoma. Three sites were selected by ODOT on which to perform these tests over a period of 5 years. Mulch rates and mulch application methods were also evaluated.

This document contains the details of the five year study, along with proven specifications for establishing nwsg on Oklahoma's rights of way.

ODOT will be able to include these specifications in future bid solicitations for vegetating new highway construction areas in eastern Oklahoma.

Objectives

1. Identify native warm season grass species suited for highway rights of way
2. Establish mulch materials
3. Establish mulch rates
4. Establish fertility levels to achieve 100% ground cover within a reasonable timeframe
5. Incorporate results of the study into planting specifications for ODOT

Tasks

1. Identify sites for the study
2. Procure needed materials to establish study plots
3. Prepare seedbed(s) for studies
4. Plant nwsg(s)
5. Mulch sites
6. Determine germination dates
7. Monitor ground cover percentages
8. Monitor effect of tillage vs. no-tillage plots on stand establishment percentages
9. Monitor effect of mulch rates on germination and stand establishment percentages
10. Monitor the effect of fertility on ground cover percentages

Background

In the past the ODOT has used bermudagrass slab sod extensively. It is a very expensive means to establish permanent cover on highway rights of way. It does a good job where adequate moisture is available during dry parts of the growing season in eastern Oklahoma. Moisture availability is a serious issue on many shallow soils in eastern Oklahoma. Disturbance of these shallow soils weakens their moisture holding capacity even further. Native warm season grasses (nwsg) are known for their deep fibrous root system and drought tolerance. Since these areas are along highway rights of way, they are characteristically steep and become highly susceptible to erosion when disturbed. 'Alamo' switchgrass, 'Cheyenne' indiangrass, 'Kaw' big bluestem, and 'Aldous' little bluestem were the native warm season grass species chosen for this study.

Three sites for the study were chosen by the ODOT. Two sites (Heavener and Poteau Sites) were chosen to test seedbed preparation methods. These two sites compared conventional tillage to no-till establishment methods, different levels of mulch rates, and use of supplemental fertility additions.

Site Layout

Prior to planting trials at the sites, baseline soil nutrient levels were determined. Soil samples were collected from each research site in March 2006 and analyzed by the Soils Lab at the University of Arkansas, Fayetteville (See Table 1.)

Heavener & Poteau Sites

Soil nutrient samples did not indicate any deficiencies at the Heavener site. The Heavener site was prepared and planted April 17 and 18, 2007. The Poteau site was prepared and planted on April 19 and 20, 2007. Site preparation was tillage (8' tractor mounted tiller was used) of half of each plot (300' X 60'). A mixture of 'Cheyenne' indiangrass, 'Kaw' big bluestem, 'Aldous' little bluestem, and 'Alamo' switchgrass was applied by means of a hydro-seeder. The seeding rate was: big bluestem @ 4 lb Pure Live Seed (PLS)/acre, switchgrass @ 4 lb PLS/ac, indiangrass @ 4 lb PLS/ac and little bluestem @ 4 lb PLS/ac.

The sites were mulched immediately after seeding with ½ ton and 1 ton of wood fiber mulch. Each mulch treatment was replicated three times at each site, on both tilled and non tilled plots.

Data was collected from the Heavener and Poteau sites on 10 day intervals (for 1 month, post planting) to record germination dates, plant vigor, and stand percentages.

The native grasses germinated (in tilled plots) within 15 days of planting. The stands averaged 85% on the tilled plots. Germination took 25 days in no-till plots. The grasses in the tilled plots have grown at twice the rate of plants in the no-till plots. This is a function of inter-species competition for light, moisture, and nutrients. The PMC staff evaluated these plots 12 times during October, November, and December, 2007. Stand success for native warm season grasses was measured by plant density percentages.

The fall evaluations produced data that indicated medium to high success for tilled treatments, and zero to poor success where seed was applied with the no-till treatment.

The pH of soils at both sites was within the range for establishment of nwsg; however, soil test results recommended phosphorus and potassium application (See Table 1). ODOT does not currently include fertilizer treatments in revegetation practices. Fertilizer treatments were applied in this study to provide options for improving success rates in future revegetation efforts. Improving soil nutrients will improve native warm season grass planting success rates in critical areas such as cut slopes. While fertilizing all plantings may be cost-prohibitive, fertilization of only particularly difficult areas to establish may prove worthwhile. The Heavener and Poteau plots received phosphorus and potassium fertilizer (200 lbs/ac of 0-60-60) in April of 2008. These plots were evaluated by PMC staff 10 times during March, April, May, and June of 2008.

The tilled plots were consistently producing 80-85% cover while the no-till treatments have only 0-5% cover. Competition from weed species has contributed to the failure of the no-till treatments. Weed species were present in the tilled treatments, but over the next 2-3 growing seasons, the native grasses eliminated most competition without herbicide treatment.

Evaluations conducted between August 1, and September 30, 2008, indicated native grasses at both Heavener and Poteau (tilled plots) matured to the point of producing seed. This seed germinated in the spring of 2009 and increased the stand density significantly (5-10%). The native species grasses broke dormancy several weeks prior to weed seed germination, allowing the grasses to suppress weed infestation. On May 12, 2009 a complete fertilizer (13-13-13) was applied at rates of 100, 200, and 300 lb. /acre, replicated three times at each site to plots that were established on tilled seedbeds. Though ODOT currently does not apply fertilizer to plantings, treatments were included in this study in an effort to provide options to improve success rates.

Evaluations were made during June and July to determine what effect, if any, the added fertility had on grass density, soil protection, and weed populations (See Table 2).

Sugar Creek SH-128 Site

The PMC staff performed site characterization on SH-128 at Sugar Creek, during March 2006. Soil samples were collected at the site and analyzed by the University of Arkansas, Fayetteville. There was no recommendation for lime, based on species to be planted, but phosphorus and potassium were required. These elements were applied in the spring of 2008, at the rate of 150 lbs. per acre of 0-60-60 (P2O5 and K20).

PMC staff laid out the research area (approx. 600' X 100'). Supplies (seed, fiber mulch, soils amendments, etc.) were purchased for the research plot in October. On November 5, 6, 7, and 8, the entire slope was hydro-seeded with 5 lb (PLS) /ac each of 'Alamo' switchgrass, 'Kaw' big bluestem, 'Aldous' little bluestem, and 'Cheyenne' indiangrass. The top 20' of the site was mulched with wheat straw at a rate of 1.5 tons / ac, while the lower 80' of the slope was hydro-mulched, at a rate of 1 ton/acre. This planting was deemed a failure in early April 2008, due to torrential rains in late winter that caused seed and mulch to be washed from the slope.

A contract modification for FY 2009 allowed the PMC to re-establish this planting. Fall 2008 evaluations of SH-128 indicate germination and survival of planted native grass species along the top of the slope on the west end of the plot. This area was also hydro-seeded, and mulched with wheat straw instead of wood fiber hydro-mulch. The wheat straw survived the rains of spring 2008. This is the reason for germination and survival of the grasses planted near the top of the slope. The PMC staff hydro-seeded the slope again in the spring of 2009 with drought-tolerant grass and legume species, and used grass hay mulch at a rate of 2 tons per acre over the entire area. The grass hay mulch was treated, after placement, with a 'tacking' substance to insure it remained in place until the seed germinated.

Seeding rates were increased to 8 pounds PLS per acre for the 2009 planting. Drought-tolerant grass and legume species planted included: sericea lespedeza, bahiagrass, crown vetch, switchgrass, indiangrass, and big bluestem. Spring temperatures were cooler than normal, and germination took longer than predicted. Germination was rated fair to good on all species with the exception of crown vetch, three weeks after seeding. Crown vetch has a high percentage of "hard seed." This means a significant amount of the seed has a thick seed coat, which slows penetration of moisture needed for germination.

Evaluations 4 and 6 weeks after planting averaged nearly 5% per week improvement in ground cover (germination). Approximately 8 weeks after planting, the slope failed destroying 1/3 of the planting.

Results

The no-till component of the study, both at Poteau and Heavener, was a failure. Germination was below 10 percent at both sites, and under both mulch rates. The prepared seedbed plots of the test at both sites were a success, under one ton and one and a half tons of mulch per acre.

The predominant species in all plantings is 'Alamo' switchgrass. It had the best germination and best seedling vigor in all treatments across replications. Next, in terms of germination, were 'Cheyenne' indiangrass, 'Kaw' big bluestem, and 'Aldous' little bluestem.

Fertility rates affected stand density, but areas of low fertility, and 'check' plots, receiving no fertility, performed very well. The conclusion drawn from 3 years of data collection is that the native warm season grasses will provide 80-90% ground cover without fertilizer application. The significant benefit of applied fertilizer to native warm season grass stands along highway rights of way, based on our research, is the time in which 80-90% stand density is achieved.

Two rates (200 lb. / ac. And 300 lb. / ac) of 13-13-13 (N-P2O5-K20) complete fertilizer was applied to replicated plots of native warm season grasses (nwsg) in the spring of 2009 and 2010. All plots, prior to the first application, were approx. 65% stand density. Plots receiving fertilizer (both rates) achieved 80-90% density during the summer of 2009. Plots receiving no additional fertility achieved 80% density the spring of 2010.

The second planting at Sugar Creek was a success. Switchgrass and bahiagrass are performing well under the severe drought conditions. Succession is taking place on the slope presently, with volunteer pine and sycamore trees germinating along the entire slope.

Conclusions

Characterization of the planting site is probably the most important task in success of establishing nwsg on highway rights of way in eastern OK. Soil samples should be analyzed and recommendations made for application of soil amendments. Every site is different, so each should be characterized.

Soil Nutrient Recommendations

- Phosphorus soil levels should be near 150-200 pounds per acre, and potassium should be 300-350 pounds per acre with the soil pH of 5.0-6.5.
- Nitrogen shouldn't be added during the establishment year.

Seedbed Preparation & Planting Recommendations

- A prepared seedbed is a requirement for successful establishment of nwsg. Normal seedbed preparation equipment (disk, grain drill, roller, etc.) may be used on 3:1 or flatter slopes. Use tractor with dual rear wheels on all slope work. Use concrete or water filled roller to firm the seedbed before and after planting. This ensures a firm seedbed so seed will be placed at a uniform depth of ¼ inch. Planting deeper than ¼ inch will result in failure. Rolling after planting ensures good seed-to-soil contact for improved germination.
- The ideal dates for planting nwsg are from Feb. 1 thru May 15. That date may be extended when adequate moisture is present.
- Planting rates should be 4 pounds Pure Live Seed (PLS) each/acre for indiangrass, switchgrass, and big bluestem. Sericea lespedeza, bahiagrass, and crown vetch should be seeded at 8 pounds Pure Live Seed (PLS) each/acre (See Table 3). 'Aldous' little bluestem performed poorly in all tests and should be dropped out of the mix.

Mulching Recommendations

- Use 1.5 tons/acre of wood fiber or grass hay mulch for best establishment results. Use wood fiber mulch on 3:1 or flatter slopes, and grass hay mulch on slopes steeper than 3:1. Hydro-seeding is recommended for slopes steeper than 3:1.
- When use of a hydro-seeder is required, and slopes are too steep for use of a roller, seeding rates should be doubled (8 pounds PLS/acre instead of 4 to encourage adequate seed-to-soil contact.)

Maintenance Considerations

- Native warm season grasses are slow to establish (3-5 years under the best conditions). Once established, they will withstand nearly any conditions (with the exception of close mowing between mid July and the first killing frost).
- Under fair to good conditions, an 80% stand may be achieved in 3 years without post establishment nitrogen fertilization. To speed up ground cover percentage, apply 250 pounds/ acre of complete fertilizer (13-13-13) in April each year.
- Rights of way may be mowed to 4 inches until July 15, when height must be maintained at 8-10 inches. Mowers may remove all residue after killing frost each fall.

Tables

Table 1. Site Soil Analysis Results (Mehlich III at 1:10 ratio)

Soil samples collected from sites in March 2006. Lab analysis was performed by the University of Arkansas in Fayetteville, Arkansas
Highlighted pounds per acre values are below recommended levels

Measurements	Poteau	lb/acre	Heavener	lb/acre	Sugar Creek	lb/acre
pH	5.28	-	6.37	-	5.76	-
Ec (micro mhos/cm)	94	-	68	-	60	-
P, mg/kg	7.6	15.2	14.3	28.6	9.5	19
K, mg/kg	142	284	179	358	121	242
Ca, mg/kg	799	1598	1387	2774	862	1724
Mg, mg/kg	610	1220	465	930	336	672
S, mg/kg	23.6	47.2	6.6	13.2	8.6	17.2
Na, mg/kg	78	156	22	44	13	26
Fe, mg/kg	79	158	99	198	113	226
Mn, mg/kg	71	142	111	222	78	156
Zn, mg/kg	1.8	3.6	2.7	5.4	2.9	5.8
Cu, mg/kg	1.1	2.2	1.7	3.4	1.1	2.2
B, mg/kg	0.1	0.2	0.3	0.6	0.08	0.16

Table 2. Effects of Fertilizer Application on Plant Density

Poteau (measured June-July 2009 & June-July 2010)						
Treatment (lbs of 13-13-13)	**2009 Plant Density (% Cover)**			**2010 Plant Density (% cover)**		
	Rep 1	**Rep 2**	**Rep 3**	**Rep 1**	**Rep 2**	**Rep 3**
0 lb	78	82	72	84	81	84
100 lb	88	81	83	92	85	86
200 lb	87	90	86	90	90	88
300 lb	92	90	94	95	98	99
Heavener (measured Jun-July 2009 & June-July 2010)						
Treatment (lbs of 13-13-13)	**2009 Plant Density (% Cover)**			**2010 Plant Density (% cover)**		
	Rep 1	**Rep 2**	**Rep 3**	**Rep 1**	**Rep 2**	**Rep 3**
0 lb	80	76	82	82	80	76
100 lb	80	78	84	85	84	87
200 lb	83	86	79	93	95	90
300 lb	90	97	88	94	100	98

Table 3. ODOT Plant Materials Study Species

Common Name	Scientific Name	Cultivar	(PLS)/ac
Indiangrass	*Sorghastrum nutans* (L.) Nash	Cheyenne	4
Switchgrass	*Panicum virgatum* (L.)	Alamo	4
Big Bluestem	*Andropogon gerardii* Vitman	Kaw	4
Little Bluestem	*Schizachyrium scoparium* (Michx.) Nash	Aldous	4
Sericea Lespedeza	*Lespedeza cuneata* (Dum. Cours.) G. Don	common	8
Bahiagrass	*Paspalum notatum* Flueggé	Pensacola	8
Crown Vetch	*Securigera varia* (L.) Lassen	common	8

Photos

Heavener Site Preparation, 2007

Heavener Site Vegetation, 2010

Mulching at Sugar Creek Site, April 2007

Sugar Creek Site Vegetation, September 2010

PMC Technician fertilizing slope

Loss of seed and mulch due to heavy spring rains

PMC staff hydro-seeding Sugar Creek Site