9-2013

Establishing Permanent Vegetation after Highway Construction

John C. Soper
University of Nebraska - Lincoln

Walter H. Schacht
University of Nebraska - Lincoln, wschacht1@unl.edu

Establishing Permanent Vegetation after Highway Construction

Project RHE-06

Final Report

Submitted to the Nebraska Department of Roads on September 15, 2013

By

Walter Schacht and Jon Soper

Department of Agronomy and Horticulture

University of Nebraska-Lincoln

In Collaboration with

Ron Poe and

Carol Wienhold

Environmental Section

Nebraska Department of Roads

Introduction

The Nebraska Department of Roads (NDOR) has considerable challenges stabilizing soils on highway shoulders following construction activities. Exposed soils can be prone to erosion and offsite sediment flow during precipitation events. NDOR primarily uses perennial vegetation in concert with erosion control products to stabilize exposed soils. Unfortunately, establishment is often slow or unsuccessful because of a number of environmental and management variables. Once established, the stands of seeded species and some volunteer species provide good ground cover and persist. The main issue is the inconsistent time frame from the exposed site to a fully established and stable site.

NDOR staff members have suggested a few possible reasons for the slow establishment: inconsistent use of good topsoil and soil amendments, bare ground with limited plant litter/soil organic matter (mulch), poor soil moisture conditions, ineffective use of cover crops and disturbance of recently seeded areas by high levels of truck and agricultural equipment traffic. In some cases, topsoil is stockpiled and later re-applied to the site. However, this process does not replace all of the nutrients, soil structure and biological processes of the pre-construction soil conditions. While many of these conditions are the result construction activities, NDOR staff has recognized that current re-vegetation techniques could be improved to consistently produce stabilized roadsides.

Departments of Transportation in several states are using yard waste compost to improve the establishment of roadside vegetation. Composted yard waste, which is high in organic material and nutrients, has been used as an amendment for poor quality soils to improve re-vegetation efforts. Both Lincoln and Omaha have yard waste compost facilities and generate a product that could potentially be used to improve vegetation establishment. Preliminary research conducted by the City of Lincoln, in conjunction with the University of Nebraska-Lincoln, indicates that composted yard waste has the potential to enhance establishment of vegetation and reduce soil erosion. In the Sandhills, composted manure is mixed with topsoil from meadows and sand. This mixture is then top dressed on roadside shoulders and has been observed to improve establishment and stabilization of roadsides. However, composted manure is not always available in a quality and quantity suitable for regular use by NDOR.

NDOR uses a variety of techniques to re-vegetate roadside soils, utilizing both locally sourced and commercial products to stabilize soils. Hay and straw is the primary ground cover (mulch) used to protect the soil surface and enhance stand establishment following roadside seedings. The dry hay or straw is chopped and blown on to the seeded area followed by light disking to crimp the hay or straw into the soil. The crimped mulch rows act as barriers to lateral water movement; thereby, reducing the likelihood of soil erosion. Hay and straw mulches are used for a majority of shoulders and backslopes with shallow slopes because hay and straw are locally available, easy to apply, and relatively inexpensive (cost effective).

In areas with steeper slopes, commercial products, erosion control blankets and hydro-mulches are used to protect soils. Erosion control blankets, made of plastic netting interwoven with straw or coconut fibers, are laid over soils to reduce the impact of rain droplets and slow lateral flow of water down the slope. When erosion control blankets are laid over soils, the edges must be dug into the soil and landscape staples must be inserted to hold the blanket in place. The installation of erosion control blankets is done by hand, so the cost is significantly higher than crimped hay mulch. Hydro-mulch is a mixture of wood and paper pulp, along with a tackifying agent, that is combined with water and sprayed on to the soil surface. Hydro-mulch must be applied from two directions to produce the coverage matrix necessary to fully stabilize the soil. While not as labor intensive as ECB, hydro-mulch requires specialized equipment and the cost is still higher than the crimped hay mulch.

NDOR uses all of these techniques to stabilize roadsides, but most focus on holding the soil in place and not improving the establishment of perennial plants. While it is possible that these techniques improve establishment, there has been no research to compare the effectiveness of these methods. To better address the current issues with limited establishment of seeded perennial species, NDOR is supporting research focused on improving re-vegetation techniques and results.

Methods, Lincoln Area

Two sites were selected as study locations. Site 1 (I-80) was located in northwestern Lincoln along Intersate-80 west of the 14th Street overpass and was installed in August 2008. The area of Site 1 was a 3:1 backslope on the south side of the interstate and was part of an active construction area. Site 2 (Highway 34) was located northwest of the city of Lincoln, near the junction of US Highway 34 and Nebraska Highway 79 and was installed in October 2008. The area of Site 2 was a 3:1 backslope that was previously seeded according to NDOR specifications, but this seeding was a failure. Clay loam soils dominated both locations.

The experimental design at both locations was a completely randomized design, with three replications of nine treatments. The plots were 29.5 x 8.2 feet and were placed in a row along a single backslope at each location. The treatments applied were: crimped straw (CS), erosion control blanket (ECB), bonded fiber matrix (BFM), non-tilled composted yard waste applied at three different depths (1, 2, and 3 inches) and either tilled (T1, T2, and T3, respectively) or not tilled (NT1, NT2, and NT3, respectively) into the soil. The CS treatment was the control (commonly used method on NDOR seeding projects) and involved spreading straw or hay on the plot at a rate of 2 tons/acre before being crimped into the seedbed with a disk. The ECB was a plastic mesh interwoven with straw, which was rolled over the soil surface and anchored with landscape staples. The BFM was a commercial hydro-mulch product of finely-ground wood product that was sprayed onto the soil surface. The composted yard waste (hereafter compost blanket) was applied to the soil surface at the appropriate depth; the tilled treatment plots were then rototilled. For the purposes of this report, CS, ECB, and BFM are considered conventional treatments that have been used by NDOR for roadside re-vegetation. The compost blanket treatments are largely untested and the stand establishment results of the compost blanket treatments will be compared to CS, ECB, and BFM as the conventional treatments.

Prior to application of the above treatments, the entire area of each study location was rototilled to prepare the seedbed. The CS, BFM, or ECB treatment plots were seeded with a drill with the standard NDOR seeding mixture (Table 1) prior to treatment application. The compost blanket plots were broadcast seeded after the application of compost and tillage to avoid burying the seeds at greater than optimum seeding depths. Following seeding, the soil surface of the compost blanket plots was hand-raked to incorporate the seeds into the soil.

After the application of treatments, 10 metal rebar sections (12 inches in length) were placed at random locations in all plots. Each rebar section was installed vertically, with the top 3 inches of the rebar remaining above the soil surface. Prior to installation, the rebar sections were painted orange to increase visibility. The rebar sections were used to quantify soil movement in each plot and will be referred to as erosion pins in the remainder of this document.

Field measurements were taken in June and September of 2009, 2010 and 2011. A nested quadrat method (Smith et al. 1986) was used to estimate frequency of occurrence of each seeded species as well as weedy grasses and weedy forbs. The nested quadrat had 4 sub-quadrats and the sizes were 100 cm^2, 625 cm^2, 1225 cm^2, and 2,500 cm^2. Ten nested quadrats were randomly located in each plot. At each quadrat placement, the smallest sub-quadrat in which each of the species was first encountered was recorded. If a species was recorded in the smallest sub-quadrat, it was given a score of 10, 6 for the next largest, 3 for the next largest, and 1 if it were found only in the largest sub-quadrat. Frequency scores for each treatment were calculated for each seeded species and selected categories (e.g., all seeded perennial species and a native seeded species). Frequency scores provided an index of stand establishment. Well-established seeded grasslands in the Great Plains generally have a plant density of about 20 plants/m^2 (about 2 plants/ft^2) (Vogel and Masters 2001). Based on the area of the nested quadrats used in this study, a frequency score of 6.0 would be equivalent to about 16 plants/m^2 (about 1.5 plants/ft^2).

The height of each erosion pin above the soil surface was measured in September of 2009, 2010 and 2011. The average soil movement was calculated for each plot at both Lincoln locations.

Methods, Sandhills Site

The Sandhills site was located 3 miles west of Dunning on a south-facing, 3:1 backslope along Highway 2. The slope was previously seeded according to NDOR specifications, but this seeding was a failure. The soils were fine sands with very low organic matter content (0.2 to 0.4%) and near neutral pH (6.2 to 7.0). The experimental design was a completely randomized design, with three replications of six treatments. The plots were 16 x 35 feet and were placed in a row along the backslope.The six treatments were: crimped straw/hay (CS), bonded fiber matrix (BFM), erosion control blanket (ECB), corral manure (CM), NDOR maintenance mixture (MM), and meadow topsoil (MS). The first three treatments were applied as described in the Methods section for the Lincoln sites. The corral manure (not composted) was dry and taken from a corral in the Thedford area. The manure was applied to the CM plots at NDOR's standard rate of 0.08 $ft^3/ft^2$of surface area. We wanted to use composted manure rather than corral manure but it was not available within 100 miles of the study site. The NDOR maintenance mixture was made by staff of the NDOR district office in Mullen. The mixture was comprised of 33% corral manure, 33% topsoil from a local subirrigated meadow, and 34% sand. The topsoil for the MM treatment was taken from the same meadow as used for the MS treatment.

Prior to application of the above treatments, the study area was rototilled to prepare the seedbed and then fertilized at NDOR's standard levels. The plots that received CS, BFM, or ECB treatments were seeded with a drill with the standard NDOR seeding rate mixture (Table 2) prior to treatment application. The other plots were seeded after the manure, maintenance mixture, or topsoil were applied onto the plots. Plot preparation and seeding occurred on June 1 and 2, 2009.

Field measurements were taken in September 2009, 2010 and 2011using the same methods as described in the Methods section for the Lincoln sites.

Statistical Analysis

Data were analyzed using the Mixed Model Procedure in SAS (SAS Institute Inc., Cary, NC). Site (2), year (3), date (2) and treatment (9) were included in the model for the study established in 2008 at the two Lincoln sites. Year (3) and treatment (6) were included in the model for the study established in 2009 at the Dunning site. Treatment effects were considered significant at $P<0.05$ for all analyses. Tables in the main body of this report include only species or categories having detectable differences among treatments. Species with very low frequency scores and no treatment responses are in appendix tables in the appendix.

Results

Lincoln Sites

<u>Precipitation</u>

Precipitation during the growing season of seeding (2008) was above the long-term average; however, the first year (2009) following seeding was relatively dry (Figure 1). The cumulative precipitation from January through September 2009 was 57% of the long-term average for January through September. The low precipitation in 2009 likely affected the establishment of the seeded species on the Lincoln sites.

<u>Cool-Season Grasses</u>

Virginia wildrye. Frequency score of Virginia wildrye responded differently to treatment in the 3 years of study (Table 3) (i.e., significant year x treatment interaction) and on the 2 dates (Table 4) (i.e., significant date x treatment interaction). Frequency scores for most treatments were relatively high in the second year (2010) with T1 having the highest frequency score. Virginia wildrye generally had low frequency scores, especially in 2009 and 2011. Frequency scores were relatively high in June probably because Virginia wildrye is a cool-season grass and plants had largely senesced by September.

Intermediate wheatgrass. Frequency score of intermediate wheatgrass responded differently to treatment in the 3 years of study and on the two sites (i.e., significant site x year x treatment interaction). The frequency scores of the compost blanket treatments were comparable to or greater than the frequency scores for BFM, CS, and ECB in all years and at both sites (Tables 5 and 6). Frequency scores for NT2 and T1 at the I-80 site and T2, BFM, CS, and ECB at the Highway 34 site were consistently high in all 3 years; otherwise, frequency scores of the various treatments tended to decrease from 2010 to 2011. Frequency scores for BFM, CS, and ECB were relatively low at the I-80 site.

Slender wheatgrass. Frequency score of slender wheatgrass responded differently to treatment in the 3 years of study and on the 2 dates (i.e., significant year x date x treatment interaction). Frequency scores were at 5.1 or greater in September 2009 for all treatments except CS, ECB, and NT3 (Table 7), indicating that slender wheatgrass established quickly and well on both sites in the first year. Frequency scores remained fairly high in 2010 (4.5 to 6.1 in September) for the compost blanket treatments, whereas the frequency scores were 4.0 or less for BFM, CS, and ECB (Table 8). Frequency scores for all treatments in 2011 were very low for both sampling periods of June and September (scores of 0.1 to 1.0; Table 9).

Western wheatgrass. The frequency score of western wheatgrass was greater for the compost blanket treatments than for the conventional treatments (i.e., BFM, CS, and ECB) over all years and at both sites (Table 10). Frequency scores generally were low (<3.2) particularly for the conventional treatments.

Canada wildrye. Canada wildrye was detected during sampling, but its frequency was very low and did not result in detectable differences among treatments (see Appendix Tables A1 and A2).

Warm-Season Grasses

Big Bluestem. Frequency score of big bluestem on the two sites responded differently to treatment (i.e., site x treatment interaction). Frequency scores of big bluestem were less than 3.0 for all treatments at the Highway 34 site (Table 11). All treatments had very low frequency scores (<0.5) at the I-80 site except for BFM (2.4).Overall, frequency scores for big bluestem were low at both sites (0 to 2.4).

Indiangrass. Effect of treatment on frequency score of indiangrass differed by site and year (i.e., significant site x year x treatment interaction). Indiangrass frequency scores were low for all treatments (0 to 1.5) in all years at the I-80 site (Table 12). At the Hwy 34 site (Table 13), frequency scores for all treatments were less than 2.5 in 2009 and less than 3.0 in 2010 except for ECB which had the highest score in both 2009 (3.9) and 2010 (4.9). In 2011, frequency scores of indiangrass for BFM, T1, T2, and NT1 at the Highway 34 site were comparable and greater than 5; whereas, scores of CS, ECB, and NT2 were between 4.0 and 5.0 in 2011. NT3 was the only treatment with a low frequency score (<1.5) in all years.

Sideoats grama. Treatment affected frequency score of sideoats grama differently at the two sites (i.e., significant site x treatment interaction). Frequency scores of sideoats grama at the I-80 site were less than 0.5 for all treatments (Table 14) except for BFM (1.4). Sideoats grama scores were greater at the Highway 34 site but BFM (3.3) and ECB (3.2) were the only treatments with a score greater than 3.

Switchgrass and little bluestem. These grasses were detected during sampling, but frequencies of both grasses were very low and did not result in detectable differences among treatments (see Appendix Tables A3-A6).

Wildflowers

Prairie Coneflower. Frequency score of prairie coneflower (Table 15) responded differently to treatment at the two sites (i.e., significant site x treatment interaction). Frequency scores of prairie coneflower were greater at the I-80 site than the Highway 34 site for all treatments except ECB (Table 15). Scores at the I-80 site were greatest for BFM (4.6), with CS, NT1, NT2, NT3, T1, T2, and T3 at comparable scores of 2 to 3. Frequency score was less than 0.5 for ECB at both sites. Frequency scores were less than 1 for all treatments at the Highway 34 site.

Blackeyed Susan. Effect of treatment on frequency score of blackeyed Susan differed by site and year (i.e., significant site x year x treatment interaction). There were very few patterns of frequency score response of blackeyed Susan to treatments over the 3 years and two sites (Tables 16 and 17). Frequency scores ranged between 1 and 3 for most treatments in the 3 years and two sites except in 2010 (second year) at the Highway 34 site when scores for NT1, NT2, T1, T2, and BFM were between 3.5 and 6. BFM (4.7) was the only treatment with a score greater than 3.5 in 2010 at the I-80 site. In 2011, frequency scores ranged from 1 to 5 on both sites with scores for BFM and T1 being in the higher group of treatments at both sites.

Other seeded forbs were detected during sampling, but the frequencies of the species were very low and did not result in differences among treatments (see Appendix Tables A7-A16).

Non-Seeded Species

Weedy forbs. Effect of treatment on frequency score of weedy forbs differed by year (i.e., significant year x treatment interaction) (Table 18). Frequency scores for BFM, CS, and ECB were the lowest (4.1 to 4.5) in 2009 (first year) and remained relatively low throughout the 3 years. Frequency scores for the compost blanket treatments were relatively high in 2009 with scores for NT3 and T3 remaining between 6 and 7 in 2011. Scores of weedy forbs for NT1, T1, and T2 dropped below 5 in 2011, comparable to BFM, CS, and ECB.

Weedy grasses. Effect of treatment on frequency score of weedy grasses differed by site and year (i.e., significant site x year x treatment interaction). At the I-80 site (Table 19), frequency scores were low for all treatments in the first year (<2.0), increased slightly in the second year, and were 3.8 or greater for CS, ECB, NT1, and T2 in the third year. Frequency scores were less than 1.7 for BFM, T1, and T3 in the third year. There were no clear patterns of weedy grass frequency scores in response to the treatments in the first 2 years at the Highway 34 site (Table 20). In the third year, frequency scores of NT2 (6.3) and NT3 (6.8) were significantly greater than the other treatments and there were no weedy grasses on the BFM plots; the other treatments had intermediate scores.

Soil Movement

Soil loss or accumulation in the vicinity of the erosion pins was minimal at both sites and did not differ significantly among treatments (Tables 21 and 22) during the 3 years of study. Some irregular rill erosion was observed in a number of plots over the study period but the rills covered a very small percentage of the plots' soil surface.

Dunning Site

Precipitation

Precipitation during the growing season of seeding (2009) was near the long-term average (Figure 2). The first year (2010) following seeding was wet with 50% more precipitation than the long-term average. Precipitation in 2011 was similar to 2009 and the long-term average.

Cool-Season Grasses

These grasses were detected at only very low frequencies (see Appendix Tables A17-A21).

Warm-Season Grasses

Little bluestem. Frequency scores of little bluestem responded differently to treatment in the 3 years of study (i.e., significant year x treatment interaction). Little bluestem tended to appear most frequently on the ECB plots in the 3 years of study (Table 23). Little bluestem was not common in any of the plots in the third year, with a frequency score of 2 or less for all treatments.

Sand bluestem. Effect of treatment on frequency score of sand bluestem differed by year (i.e., significant year x treatment interaction). Frequency score of sand bluestem was low on the MS plots in the first year (0.4) but increased to 4.8 in the third year (Table 24). Conversely, sand bluestem score was high (4.3) on the BFM plots in the first year but decreased to 2.5 in the third year. Sand bluestem did not establish on CM plots and generally had low scores on CM, CS, ECB, and MM in all 3 years of study.

Switchgrass. The frequency of switchgrass on all plots was low throughout the 3 years of study. The highest frequency score was 1.3 for the ECB treatment (Table 25).

Sand dropseed. Treatment affected frequency score of sand dropseed differently in the 3 years of study (i.e., significant year x treatment interaction). Frequency scores of sand dropseed on the MM plots were relatively high over the 3 years of study (Table 26). By the third year, sand dropseed was not common on any of the plots and frequency scores for all treatments were 2.1 or less.

Sand lovegrass. Effect of treatment on frequency score of sand lovegrass differed by year (i.e., significant year x treatment interaction). The MM and MS treatments had the highest frequency scores of sand lovegrass by the second and third years (>6.5; Table 27). Frequency scores on ECB plots were relatively high throughout the study period with scores consistently greater than 4.2. Frequency scores of the other three treatments (BFM, CM, and CS) were lower than the others in the third year.

Sideoat grama. Frequency scores of sideoats grama were consistently greater for MM (5.1) and MS (5.1) over the 3 years of study (Table 28). The CM treatment had the lowest frequency score with BFM, CS, and ECB being intermediate.

Prairie sandreed. Frequency score response to treatment was different by year (significant year x treatment interaction). Prairie sandreed was uncommon on all plots through the first 2 years of the study (Table 29). By the third year, frequency score of prairie sandreed was 3.9 for the MM treatment and greater than the scores for CM and CS. Scores were intermediate for BFM, ECB, and MS.

Wildflowers

Purple prairieclover was uncommon on all treatment plots except on the MS plots (3.5; Table 30). Shell leaf penstemon had very low frequency scores for all treatments (<0.8; Table 31). Other seeded wildflower species also had very low frequency scores and differences among treatments were not detected (see Appendix Tables A22-A25).

Weedy Forbs

Treatment affected frequency score of weedy forbs differently in the 3 years of study (i.e., significant year x treatment interaction). Frequency scores of weedy forbs were very high on CM (8.0) and MM (7.3) in the first year (Table 32); whereas, scores for the other treatments were low (<2.0). Scores of weedy forbs remained very high through the remaining 2 years of the study (>9.0) and scores on MM decreased to 3.4 by the third year. Weedy forbs increased in frequency on the other treatment plots and had frequency scores similar to that of MM by the third year.

Weedy Grasses

Effect of treatment on frequency score of weedy grasses differed by year (i.e., significant year x treatment interaction). Weedy grasses were uncommon on all treatment plots except on MS plots in the first (9.7) and second year (6.7; Table 33). By the third year, frequency scores were low (<1.8) for all treatments.

Soil Movement

Soil loss or accumulation in the vicinity of the erosion pins was minimal on the Dunning site and did not differ significantly among treatments (Table 34) during the 3 years of study. Some irregular rill erosion was observed in a number of plots over the study period but the rills covered a very small percentage of the plots' soil surface.

Discussion

Lincoln Sites

Cool-Season Grasses

The principal four cool-season grasses acted differently over the 3 years of the study. Intermediate wheatgrass established fairly well (>4.0) in the first year in most treatment plots at both sites, generally maintained good scores between 4.0 and 7.0 in the second year, and dropped to scores between 2.0 and 4.0 on most treatment plots in the third year. Slender wheatgrass established well and maintained good frequency scores through the second year on most treatment plots on the Highway 34 site, but then it nearly disappeared from all treatment plots by the third year. Slender wheatgrass performed more poorly on the I-80 site and also was uncommon on all plots by the third year. Virginia wildrye had scores above 1.0 only in the second year and was uncommon on all plots in the third year. Western wheatgrass remained at low scores (1.0 to 3.0) throughout the study period.

Overall, there were minimal differences between the two sites in terms of cool-season grass establishment and persistence. Furthermore, regardless of the differences in the temporal dynamics of the four species, only intermediate wheatgrass was a common component on some treatment plots in the third year. Intermediate wheatgrass generally performed well on compost blanket treatment plots; T1, T2, and NT2 had the highest frequency scores of intermediate wheatgrass on the two sites. Intermediate wheatgrass scores were relatively low on BFM, CS, and ECB plots in all years except in the third year on the BFM plots. However, intermediate wheatgrass is no longer included in NDOR mixtures because it is not a native species.

Warm-Season Grasses

There was poor establishment (<2.0) of warm-season grasses on all I-80 treatment plots. The recommended seeding date for warm-season perennial grasses is April 1 to May 15 at the beginning of the growing season when soil moisture and ambient temperatures favor germination and the seedlings have the entire growing season to mature. The plots at the I-80 site were seeded in August 2008; warm-season grasses generally do not establish well when seeded in late-summer (O'Brien et al. 2008). Warm-season grasses seeded in the late summer will germinate with good soil moisture conditions, but will not be mature enough to survive the winter. Soil moisture in August 2008 was favorable for germination of warm-season grasses and we saw warm-season grass seedlings in fall 2008. We assume the seedlings were killed by the freezing temperatures of the 2008/2009 winter.

Plots at the Highway 34 site were seeded in October 2008, also a less than favorable seeding date for perennial warm-season grasses. The mostly poor establishment of big bluestem and sideoats grama at the Highway 34 site might have been a result of the fall seeding date. Frequency scores of indiangrass were low on most treatment plots until the third year when scores for all treatments were greater than 4 except for NT3. No conclusions can be made other than that indiangrass was well established (>6 frequency score) on NT1, T1, T2, and BFM plots at Highway 34 by the third year.

Wildflowers

Perennial wildflowers have lower likelihoods of establishment than do perennial grasses and this was verified by the results of this study. Most wildflower species did not establish well (<2.0 frequency scores) on either site. BFM and ECB generally had the highest and lowest frequency scores, respectively, for blackeyed Susan and prairie coneflower; establishment of wildflowers on CS plots was also relatively low. The compost blanket treatments with lower amounts of composted yard waste usually had similar scores to BFM.

Weedy Forbs

Non-seeded, weedy forbs were primarily annuals and included annual sunflower, marestail, and pepperweed. Weedy forbs were prevalent on all treatment plots (4.0 to 7.0) throughout the 3 years of the study. The density of weedy forbs was high and likely affected the establishment of seeded species on the plots. The experimental plots were seeded within an unseeded backslope at the I-80 site which had a dense, vigorous stand of annual forbs and a degraded backslope at the Highway 34 site which also had a dense stand of annual forbs. The site conditions surrounding the experimental plots likely affected annual forb invasion of the plots. In the third year, weedy forbs were most common on the compost blanket treatment plots with the greatest amounts of composted yard waste.

Weedy Grasses

Non-seeded, weedy grasses were primarily Kentucky bluegrass, smooth bromegrass, and annual grasses. The frequency scores of the weedy grasses tended to increase over time at both sites and were greater than 3.0 on most treatment plots by the third year. The establishment and gradual increase of weedy grasses might have affected the establishment and persistence of seeded species on some treatment plots. Weedy grasses were most common on CS and compost blanket treatments with greater amounts of composted yard waste (i.e., NT2, NT3, T2, and T3). BFM and ECB were the treatments most consistently effective in keeping weedy grasses at low frequencies.

Dunning Site

Cool-Season Grasses

The seeded cool-season grasses were practically non-existent on all treatment plots in the 3 years following seeding in June 2009. The poor establishment of cool-season grasses confirms that a June seeding is too late in the growing season to favor cool-season grass establishment. March 1 to April 15 is the recommended seeding date of perennial, cool-season grasses in Nebraska. Cool-season grass seedlings do not tolerate the high temperatures and relatively low soil moisture of the summer months.

Warm-Season Grasses

Most of the warm-season tall grasses did not establish well and remained at low frequencies through the 3 years of study. Little bluestem and switchgrass were uncommon on all treatment plots in the third year. Frequency of occurrence of sand bluestem and prairie sandreed were also low throughout the study period except on the MS plots for sand bluestem and the MM plots for prairie sandreed. The MM and MS treatments also favored sideoats grama and sand lovegrass. Frequency scores of these two grasses were low for the other treatments except that sand lovegrass scores were high for ECB. Sand dropseed also tended to do best on MM, MS, and ECB plots. Warm-season grasses tended to establish poorest on CM and CS plots with intermediate levels on BFM.

The relatively high frequency scores of warm-season grasses on MM and MS were as hypothesized. The meadow topsoil provides for a much better seedbed with greater soil moisture than the bare sand of most of the other treatments. The meadow topsoil also likely adds mycorrhizae to the site. A better response of the four major warm-season grasses (i.e., sand bluestem, little bluestem, prairie sandreed, and switchgrass) to MM and MS was expected but the lateness of the seeding date and the relatively low summer precipitation in the seeding year may partially explain the low frequency of the four grasses. Sideoats grama and sand lovegrass are known to establish more rapidly and under less favorable conditions than the other warm-season grasses, especially the tallgrasses. The frequency scores of the warm-season grasses were similar for MM and MS indicating that an amendment containing 33% meadow topsoil for seedbed improvement yields an equal response to a 100% topsoil amendment. This obviously is important because of the limited availability and cost of meadow topsoil. We cannot evaluate the importance of the corral manure in the MM treatment based on the results of this study. The corral manure likely added weed seeds to the mixture but we are not certain how else it may have affected stand establishment on roadsides. Warm-season grass establishment for the CM treatment, which was corral manure only, was generally poor. The MM mixture might be difficult to justify because the corral manure and sand components appear to have few, if any, attributes. Meadow topsoil had a positive impact on stand establishment without the corral manure and sand; perhaps a lower rate of meadow topsoil alone would provide the seedbed improvements needed for good stand establishment.

The CM and CS treatments consistently had the lowest frequency scores of warm-season grasses. The corral manure was a poor seedbed for the perennial grasses and forbs because its coarse, fibrous nature likely did not provide for good seed-to-soil contact. Establishment of seeded perennial grasses also was likely negatively impacted by the very high density of annual broadleaf weeds on CM plots. The density of seeded and non-seeded species was very low on the CS plots. The bare sand with some incorporated straw for soil surface protection was a poor seedbed in the relatively harsh conditions of a roadside in the Nebraska Sandhills. The BFM plots tended to have higher frequency of warm-season grasses than CM and CS; however, the BFM stands were not successful from a warm-season grass perspective.

Weedy Forbs

Non-seeded, weedy forbs were primarily annuals and included pigweed, lambsquarter, and marestail. The common characteristic of the two treatments (CM and MM) with very high frequency scores and dense stands of weedy forbs was the corral manure. The corral manure used in this study appeared to have a very high content of annual weed seeds. Most corrals have a high density of annual weeds growing in them during much of the growing season, resulting in a high weed seed bank in the manure. Weedy forb frequency remained very high throughout the 3 years in the CM plots and likely affected the establishment of seeded species. Weedy forb frequency declined over the 3 years on MM plots and likely had less of an effect on establishment of seeded species. By the third year, frequency scores of weedy forbs were greater than 3.0 for all treatments, indicating that the stands of seeded species did not provide full coverage of any treatment plots.

Weedy Grasses

The principal, non-seeded weedy grass was sixweeks fescue. In the first year of study, weedy grasses were not present or were very uncommon on the BFM, CM, CS, and ECB plots; whereas, they were present at intermediate or extremely high levels on the MM or MS plots, respectively. The common characteristic of MM and MS was meadow topsoil. The meadow topsoil apparently had seeds of annual grasses (i.e., sixweeks fescue). The weedy grasses did not remain competitive with other non-seeded and seeded species because they were uncommon on most plots, including the MM and MS plots, by the third year.

Conclusions

For sites in the Lincoln area seeded to the standard NDOR mixture in August and October on sites with a heavy weedy forb presence, we conclude the following.

- Compost blankets applied at a 1 inch depth resulted in better stands than the other compost blanket treatments, CS, and ECB.
    - The 1-inch compost blankets consistently had some of the higher scores for cool-season grasses, warm-season grasses, and wildflowers.
    - The 1-inch compost blankets had some of the lowest weedy forb and weedy grass frequency scores.
    - There was not a consistent difference in frequency scores between the non-tilled and tilled compost blankets.
- Compost blankets applied at a 3-inch depth resulted in relatively poor stands.

  - The 3-inch compost blankets had relatively low frequency scores for cool-season grasses, warm-season grasses, and wildflowers.
  - The 3-inch compost blankets had the highest weedy forb and weedy grass frequency scores.
  - There was not a consistent difference in frequency scores between the non-tilled and tilled compost blankets.
- Compost blankets applied at a 2-inch depth were generally intermediate between the 1-inch blankets and the 3-inch blankets in terms of stand success.
- Bonded fiber matrix resulted in seeded stands comparable to those of the 1-inch compost blankets.
  - Bonded fiber matrix consistently had some of the highest scores for warm-season grasses and wildflowers; whereas, it generally did not favor cool-season grasses.
  - Bonded fiber matrix had the lowest weedy forb and weedy frequency scores.
- The erosion control blanket resulted in seeded stands of intermediate quality compared to other treatments.
  - The erosion control blanket had high scores for warm-season grasses but low to intermediate scores for cool-season grasses and wildflowers.
  - The erosion control blanket had the lowest weedy forb and weedy grass frequency scores, similar to bonded fiber matrix.
- The crimped straw treatment did not produce good stands.
  - The crimped straw treatment had low scores for cool-season grasses and wildflowers and intermediate scores for warm-season grasses.
  - The crimped straw treatment was inconsistently effective in control of weedy forbs and weedy grasses.
- Overall, a non-tilled compost blanket applied at a 1-inch depth is a good alternative to the conventional practices in terms of producing a balanced mixture of cool-season grasses, warm-season grasses, and wildflowers. The vegetation cover/stand resulting from application of bonded fiber matrix was comparable to that of the 1-inch compost blankets. The crimped straw treatment was the weakest performer.
- The low frequency scores for big bluestem at the I-80 site demonstrate the poor establishment of warm-season grasses with an August seeding date. Even though an October seeding date is not recommended, the warm-season grass performance was much better on the Highway 34 site which was seeded in October.
- The warm-season grasses (especially indiangrass) tended to increase in frequency of occurrence during the 3 years of the study; whereas, the presence of cool-season grasses (especially slender wheatgrass) declined over time.
- Soil erosion was minimal and did not differ among treatments.

For the site in the central Sandhills seeded to the standard NDOR mixture in June, we conclude the following.

- Incorporating a layer of meadow topsoil into the seedbed prior to seeding appears to improve establishment of the seeded species.
- The advantages of adding corral manure to meadow topsoil to make the maintenance mixture is questionable.
  - Corral manure appears to add weed seed to the maintenance mixture.

- Corral manure does not appear to add to the physical quality of the seedbed.
    - The longer-term value of the manure is not apparent.
- Overall, the maintenance mixture did not perform better than the meadow topsoil treatment. The time and expense involved in making and hauling the mixture is not justified. The meadow topsoil appears to be the component of the maintenance mixture that is responsible for the improved establishment of seeded species.
- The optimum rate of application of meadow topsoil to roadside seedbeds in the Sandhills was not identified by the results of this study; however, the rate applied through the maintenance mixture had a positive response on stand establishment.
- Corral manure should not be used as a soil amendment. The weed pressure resulting from manure application likely affects establishment of seeded species. Composted manure could be considered a soil amendment but there is limited availability of good quality composted manure in the Sandhills.
- The erosion control blanket performed better than the crimped straw in terms of having a denser stand of warm-season grasses (primarily sand lovegrass) and better control of non-seeded species.
- Establishment of seeded species on the crimped straw plots was poor.
- The extra expense associated with hydro-mulching cannot be justified by the results of this study.
- Stockpiled topsoil from the construction site or topsoil from another source likely is needed to have consistent and rapid establishment of seeded species on roadsides in the Nebraska Sandhills.
- Soil erosion was minimal and did not differ among treatments

Literature Cited

O'Brien, T. R., L.E. Moser, R.A. Masters, and A.J. Smart. 2008. Morphological development and winter survival of switchgrass and big bluestem seedlings. Forage and Grazinglands doi: 10.1094/FG-2008-1103-01-RS.

Smith, B.H., M.L. Ronsheim, and K.R. Swartz. 1986. Reproductive ecology of *Jeffersonia diphylla* (Berberidaceae). American Journal of Botany 73:1416-1426.

Vogel, K. P. and R. A. Masters. 2001. Frequency grid-a simple tool for measuring grassland establishment. Journal of Range Management 54:653-655.

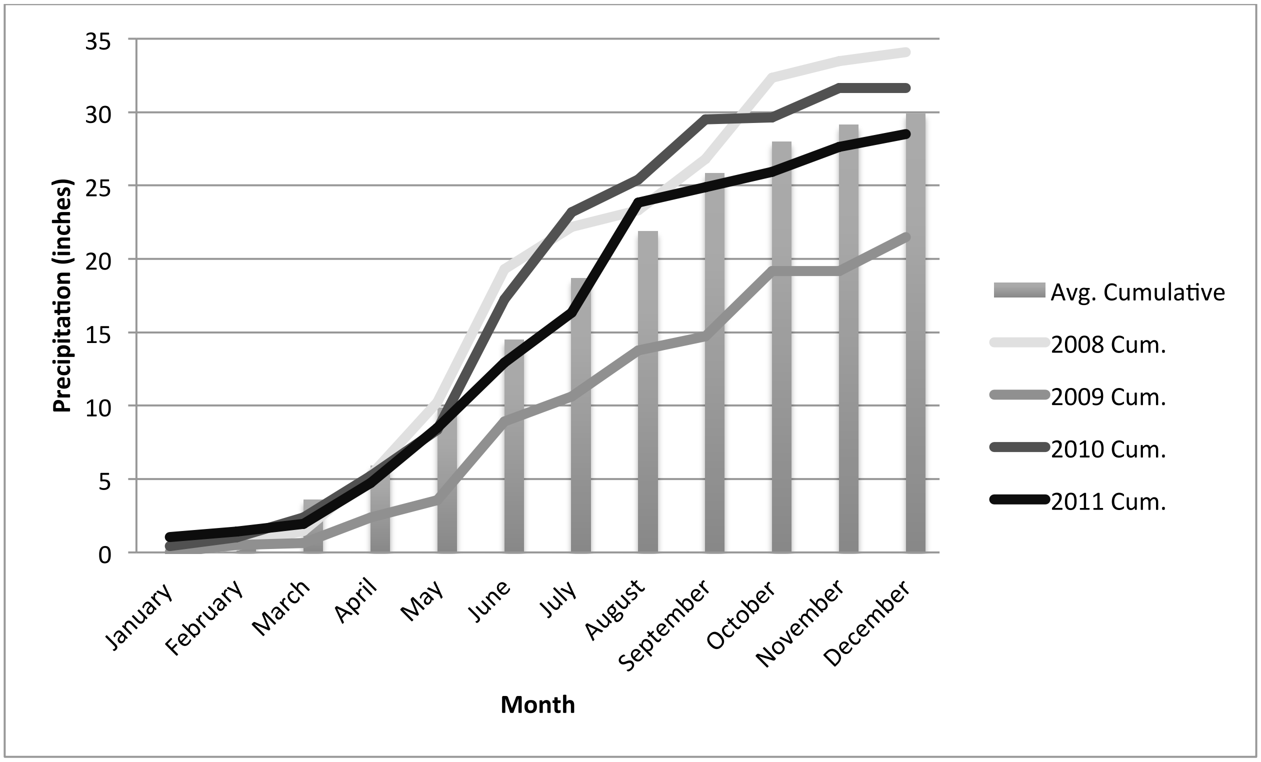

Figure 1.Average annual cumulative precipitation and annual cumulative precipitation for 2008-2011 at Lincoln, NE.

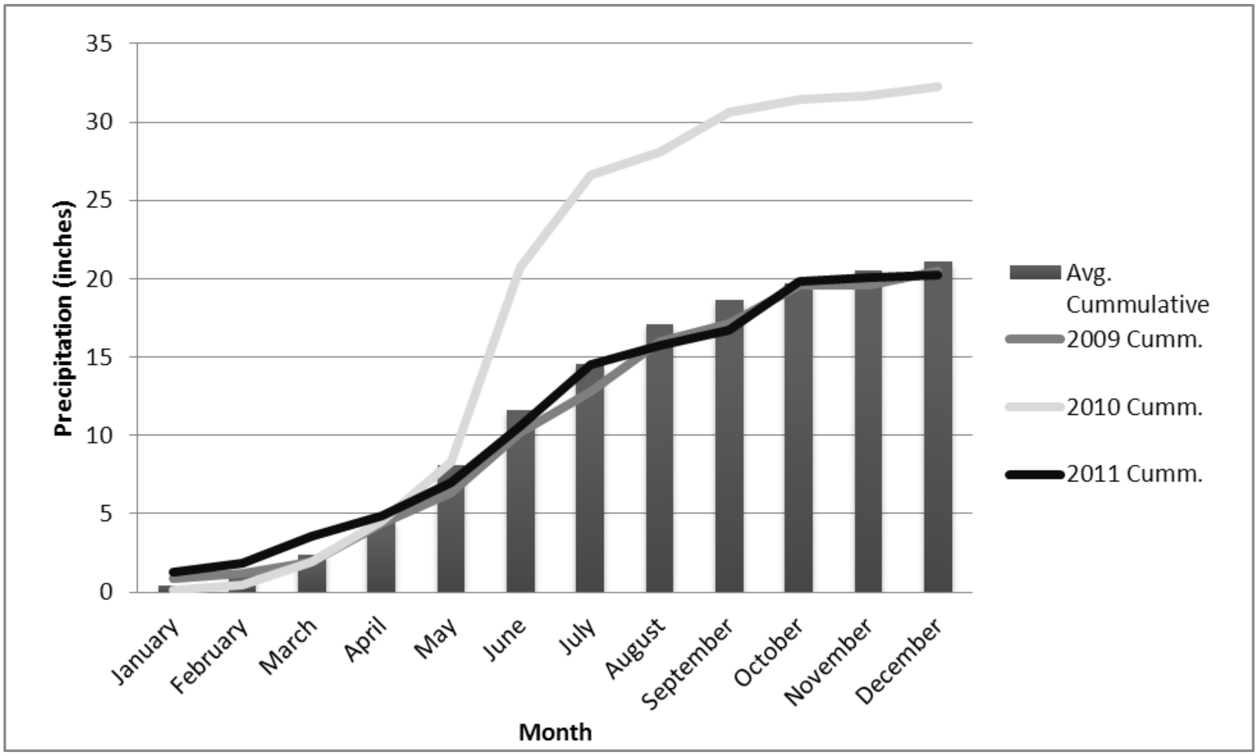

Figure 2. Average annual cumulative precipitation and annual cumulative precipitation for 2009-2011 in Blaine County, NE.

Table 1. Seeding mixture planted at I-80 and Highway 34 sites.

Species	Seeding Rate (Pounds of Pure Live Seed/Acre)
Virginia wildrye (*Elymys virginicus* L.)	6
Canda wildrye (*Elymus canadensis* L.)	4
Slender wheatgrass (*Elymus trachycaulus* (Link)/Shinners.)	4
Intermediate wheatgrass (*Elymus hispidu* (P.opiz) Melderis.)	4
Western wheatgrass (*Elymus smithii* (Rydb.) Gould.)	4
Switchgrass (*Panicum virgatum*L.)	1.5
Indiangrass (*Sorghastrum nutans* (L.) Nash.)	3
Big bluestem (*Andropogon gerardii* Vitman.)	3
Sideoats grama (*Bouteloua curtipendula* (Michx.))	3
Little bluestem (*Schizachyrium scoparium* (Michx.))	2
Illinois bundleflower (*Desmanthus illinoenisis* (Michx.) MacM.)	0.5
Purple prairie clover (*Dalea purpurea* Vent.)	0.5
Upright prairie coneflower (*Ratibida columnifera* (Nutt) Woot. &Standl.)	0.5
Mexican red hat (*Ratibida columnifera* (Nutt) Woot. & Standl.	0.75
New England aster (*Aster novae-angliae (*L.) G.L. Nesom)	0.1
Indian blanket (*Gallardia pulchella* Foug.)	1
Black-eyed Susan (*Rudbeckia hirta* L.)	0.5
Black Samson (*Echinacea angustifolia* DC*.)*	0.25
Oats (*Avena sativa* L.)	10

Table 2. Seeding mixture planted at Dunning Site.

Species List	Application Rate (Pounds of Pure Live Seed per Acre)
Canada wildrye (*Elymus canadensis* L.)	3.6
Thickspike wheatgrass (*Elymus lanceolatus* (Scribn. & J.G. Sm.) Gould ssp. *Lanceolatus)*	3.6
Slender wheatgrass (*Elymus trachycaulus* (Link)/Shinners.)	4.8
Western wheatgrass (*Elymus smithii*(Rydb.) Gould.)	7.3
Prairie junegrass (*Koeleria macrantha* (Ledeb.))	1.0
Prairie sandreed (*Sporobolus crytandrus* (Torr.))	1.5
Switchgrass (*Panicum virgatum* L.)	1.2
Sideoats grama(*Bouteloua curtipendula* (Michx.))	4.8
Sand lovegrass (*Eragrostis trichodes* (Nutt.) Wood)	1.0
Sand dropseed (*Sporobolus cryptandrus* Torr.)	0.5
Sand bluestem (*Andropogon hallii* Hack)	4.8
Little bluestem (*Schizachyrium scoparium* (Michx.))	2.4
Purple prairie clover (*Dalea purpurea* Vent.)	1.0
Leadplant (*Amorpha canescens* Pursch)	1.0
Shell-leaf penstemon (*Penstemon grandiflorus* Nutt)	0.5
Rocky Mountain bee plant (*Cleome serrulata* Pursh)	1.0
Upright coneflower (*Ratibida columnifera* (Nutt) Woot. &Srandl.)	1.0
Plains coreopsis (*Coreopsis tinctoria* Nutt.)	0.5
Rye (*Secale cereale* L.)	19.3

Table 3. Frequency of occurrence scores of Virginia wildrye by treatment during 2009-2011 averaged over sites (frequency responses to treatments did not differ by site).

Treatment[1]	**2009**	**2010**	**2011**
BFM	0.0	1.3[b]	0.6[ab]
CS	0.0	1.1[b]	0.5[ab]
ECB	0.0	2.3[ab]	0.4[ab]
NT1	0.0	2.1[ab]	0.5[ab]
NT2	0.2	2.3[ab]	0.6[ab]
NT3	0.0	1.7[ab]	0.3[ab]
T1	0.2	3.4[a]	0.9[a]
T2	0.1	2.1[ab]	0.7[ab]
T3	0.1	2.1[b]	0.2[b]

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 4. Frequency of occurrence scores of Virginia wildrye by treatment in June and September averaged over years and sites (frequency responses to treatments did not differ by year or site).

Treatment[1]	**June**	**September**
BFM	1.0[ab]	0.3[b]
CS	0.9[b]	0.2[b]
ECB	1.6[ab]	0.3[ab]
NT1	1.4[ab]	0.3[ab]
NT2	1.3[ab]	0.7[ab]
NT3	0.9[b]	0.5[ab]
T1	2.2[a]	0.7[ab]
T2	1.1[ab]	0.8[a]
T3	1.2[ab]	0.5[ab]

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 5. Frequency of occurrence scores of intermediate wheatgrass by treatment during 2009-2011 at the I-80 site.

Treatment[1]	**2009**	**2010**	**2011**
BFM	5.3[a]	2.4[c]	3.0[b]
CS	1.4[b]	2.1[c]	3.4[b]
ECB	3.8[ab]	4.0[bc]	2.1[b]
NT1	4.4[a]	6.6[a]	3.6[b]
NT2	5.1[a]	5.3[ab]	6.1[a]
NT3	3.5[ab]	5.8[ab]	3.7[b]
T1	4.7[a]	5.7[ab]	7.0[a]
T2	4.6[a]	5.6[ab]	3.0[b]
T3	2.5[ab]	6.3[a]	3.7[b]

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 6. Frequency of occurrence scores of intermediate wheatgrass by treatment during 2009-2011 at the Highway 34 site.

Treatment1	2009	2010	2011
BFM	4.5[bc]	5.1[b]	7.3[a]
CS	6.5[ab]	5.1[b]	2.4[b]
ECB	6.1[ab]	5.5[b]	0.6[c]
NT1	5.2[ab]	5.1[b]	3.6[b]
NT2	4.1[bc]	4.9[b]	3.6[b]
NT3	3.6[c]	4.8[b]	3.1[b]
T1	7.2[a]	7.6[a]	2.9[b]
T2	6.2[ab]	6.0[ab]	6.9[a]
T3	6.2[ab]	5.8[b]	3.4[b]

1 BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 7. Frequency of occurrence scores of slender wheatgrass by treatment for June and September 2009 averaged over sites (frequency responses to treatments did not differ by site).

Treatment[1]	June	September
BFM	3.8[ab]	7.3[ab]
CS	5.2[a]	2.6[cd]
ECB	2.4[b]	4.2[c]
NT1	1.8[bc]	5.3[bc]
NT2	2.3[bc]	6.0[ab]
NT3	0.0[c]	3.6[cd]
T1	5.6[a]	7.9[a]
T2	1.4[c]	7.3[ab]
T3	1.1[c]	5.1[bc]

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 8. Frequency of occurrence scores of slender wheatgrass by treatment for June and September 2010 averaged over sites (frequency responses to treatments did not differ by site).

Treatment[1]	**June**	**September**
BFM	2.3[b]	3.5[c]
CS	2.4[b]	3.8[bc]
ECB	2.6[b]	3.1[c]
NT1	3.4[ab]	5.4[ab]
NT2	4.3[a]	5.3[ab]
NT3	2.2[b]	6.1[a]
T1	4.5[a]	4.7[abc]
T2	4.4[a]	6.0[a]
T3	3.9[a]	4.5[abc]

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 9. Frequency of occurrence scores of slender wheatgrass by treatment for June and September 2011 averaged over sites (frequency responses to treatments did not differ by site).

Treatment[1]	June	September
BFM	0.3[ab]	0.9
CS	0.1[b]	0.1
ECB	0.4[ab]	0.1
NT1	0.7[ab]	0.8
NT2	0.4[ab]	0.0
NT3	1.0[a]	0.3
T1	0.7[ab]	0.0
T2	0.9[ab]	0.8
T3	0.5[ab]	0.1

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 10. Frequency of occurrence scores of western wheatgrass by treatment averaged over years and sites (frequency responses to treatments did not differ by year or site).

Treatment[1]	Frequency Score
BFM	1.3[c]
CS	1.0[c]
ECM	1.5[c]
NT1	2.2[b]
NT2	2.5[a]
NT3	2.8[b]
T1	2.1[b]
T2	3.2[ab]
T3	2.2[ab]

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 11. Frequency of occurrence scores of big bluestem by treatment at the I-80 and Highway 34 sites averaged over years (frequency responses to treatments did not differ by year).

Treatment[1]	I-80	Highway 34
BFM	2.4[a]	1.3[bc]
CS	0.1[b]	1.6[ab]
ECB	0.2[b]	2.0[a]
NT1	0.1[b]	0.7[cd]
NT2	0.1[b]	0.9[cd]
NT3	0.0[b]	0.4[d]
T1	0.3[b]	0.7[cd]
T2	0.1[b]	1.0[bc]
T3	0.0[b]	0.3[d]

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 12. Frequency of occurrence scores of indiangrass by treatment during 2009-2011 at the I-80 site.

Treatment[1]	2009	2010	2011
BFM	1.0[a]	1.0[a]	1.5[a]
CS	0.0[b]	0.3[abc]	0.4[bc]
ECB	0.0[b]	0.5[abc]	0.8[b]
NT1	0.2[b]	0.8[ab]	0.7[b]
NT2	0.0[b]	0.1[c]	0.4[bc]
NT3	0.0[b]	0.2[bc]	0.2[bc]
T1	0.1[b]	0.5[abc]	0.6[b]
T2	0.0[b]	0.4[abc]	0.6[b]
T3	0.0[b]	0.1[c]	0.1[c]

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 13. Frequency of occurrence scores of indiangrass by treatment during 2009-2011 at the Highway 34 site.

Treatment[1]	**2009**	**2010**	**2011**
BFM	0.8[b]	2.4[b]	6.5[a]
CS	1.4[ab]	2.4[b]	4.1[b]
ECB	2.5[a]	3.9[a]	4.9[ab]
NT1	1.4[ab]	2.0[b]	5.8[a]
NT2	0.4[b]	1.5[b]	3.7[b]
NT3	0.9[b]	0.5[c]	0.4[c]
T1	0.4[b]	1.9[b]	6.2[a]
T2	0.0[b]	1.5[b]	6.0[a]
T3	0.0[b]	0.5[c]	4.5b

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 14. Frequency of occurrence scores of sideoats grama by treatment at the I-80 and Highway 34 sites averaged over years (frequency response to treatments did not differ by year).

Treatment[1]	**I-80**	**Highway 34**
BFM	1.4[a]	3.3[a]
CS	0.3[bc]	3.0[a]
ECB	0.2[bc]	3.2[a]
NT1	0.3[bc]	1.9[b]
NT2	0.3[bc]	0.9[c]
NT3	0.1[c]	0.4[d]
T1	0.5[b]	1.0[bcd]
T2	0.0[c]	1.5[bc]
T3	0.2[c]	0.3[c]

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 15. Frequency of occurrence scores of upright prairie coneflower by treatment at the I-80 and Highway 34 sites averaged over years (frequency responses to treatments did not differ by year).

Treatment[1]	**I-80**	**Highway 34**
BFM	4.6[a]	1.2[a]
CS	1.1[c]	0.5[bc]
ECB	0.7[c]	0.3[bc]
NT1	2.0[b]	0.8[ab]
NT2	2.2[b]	0.5[bc]
NT3	1.2[c]	0.1[c]
T1	2.3[b]	0.5[bc]
T2	1.8[b]	0.7[b]
T3	0.7[c]	0.6[bc]

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 16. Frequency of occurrence scores of blackeyed Susan by treatment during 2009-2011 at the I-80 site.

Treatment[1]	**2009**	**2010**	**2011**
BFM	5.3[a]	4.7[a]	3.8[a]
CS	0.8[bc]	0.9[c]	1.5[bc]
ECB	0.7[c]	0.9[c]	0.9[b]
NT1	2.0[bc]	2.0[bc]	1.9[bc]
NT2	2.3[b]	2.3[b]	2.0[b]
NT3	1.6[bc]	1.5[bc]	0.6[c]
T1	2.5[b]	2.1[b]	2.2[b]
T2	1.8[bc]	2.8[b]	1.4[bc]
T3	0.9[bc]	0.9[c]	0.2[c]

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

[a]Means in a column followed by a different letter are different (P<0.05).

Table 17. Frequency of occurrence scores of blackeyed Susan by treatment during 2009-2011 at the Highway 34 site.

Treatment[1]	2009	2010	2011
BFM	0.2[b]	2.0[a]	1.4[a]
CS	0.4[a]	1.0[abc]	0.1[c]
ECB	0.0[b]	0.9[bc]	0.1[c]
NT1	0.0[b]	1.5[ab]	0.8[ab]
NT2	0.0[b]	0.8[bc]	0.7[b]
NT3	0.0[b]	0.1[c]	0.3[bc]
T1	0.0[b]	0.8[bc]	0.6[bc]
T2	0.0[b]	1.1[abc]	0.9[ab]
T3	0.0[b]	0.5[bc]	1.2[a]

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

[a]Means in a column followed by a different letter are different (P<0.05).

Table 18. Frequency of occurrence scores of weedy forbs by treatment during 2009-2011 averaged over sites (frequency responses to treatments did not differ by site).

Treatment[1]	**2009**	**2010**	**2011**
BFM	4.1[c]	4.3[c]	4.5[b]
CS	4.5[bc]	5.9[b]	5.3[b]
ECB	4.4[bc]	4.3[c]	4.5[b]
NT1	6.9[a]	5.6[bc]	2.0[b]
NT2	6.9[a]	6.3[ab]	6.0[ab]
NT3	5.9[b]	7.4[a]	7.2[a]
T1	5.9[b]	5.3[bc]	4.8[b]
T2	6.8[a]	5.5[bc]	4.7[b]
T3	7.9[a]	6.4[ab]	7.0[a]

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 19. Frequency of occurrence scores of weedy grasses by treatment during 2009-2011 at the I-80 site.

Treatment[1]	2009	2010	2011
BFM	0.8	0.7[b]	1.4[b]
CS	0.6	3.3[a]	3.8[a]
ECB	0.9	3.0[a]	4.1[b]
NT1	0.4	2.0[ab]	3.9[b]
NT2	1.5	2.1[ab]	3.1[a]
NT3	0.6	2.3[ab]	2.9[b]
T1	1.7	2.5[ab]	1.5[b]
T2	2.0	1.7[ab]	4.0[a]
T3	1.5	2.5[ab]	1.6[b]

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 20. Frequency of occurrence scores of weedy grasses by treatment during 2009-2011 at the Highway 34 site.

Treatment[1]	2009	2010	2011
BFM	3.5[ab]	1.2[cd]	0.0[d]
CS	4.6[a]	2.0[cd]	2.8[c]
ECB	3.3[ab]	2.4[bc]	2.6[c]
NT1	3.0[ab]	4.5[a]	2.9[c]
NT2	2.4[b]	5.1[a]	6.3[a]
NT3	0.4[c]	3.5[abc]	6.8[a]
T1	2.4[b]	1.6[c]	2.3[c]
T2	3.2[ab]	4.1[ab]	2.3[c]
T3	2.3[b]	4.2[ab]	4.4[b]

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

[a]Means in a column followed by a different letter are different (P<0.05).

Table 21. Change in erosion pin height (soil surface to pin apex) from an initial height of 3 inches at the time of application of treatments (August 2008) to project termination (September 2011) at the I-80 site.

Treatment	I-80
	(Inches)
BFM	+0.3
CS	+0.1
ECB	-0.3
NT1	+0.2
NT2	-0.1
NT3	-0.2
T1	0.0
T2	0.0
T3	+0.2

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

Table 22. Change in erosion pin height (soil surface to pin apex) from an initial height of 3 inches at the time of application of treatments (October 2008) to project termination (September 2011) at the Highway 34 site.

Treatment	Hwy 34
	(Inches)
BFM	+0.2
CS	+0.2
ECB	+0.1
NT1	-0.1
NT2	-0.6
NT3	-0.8
T1	+0.2
T2	-0.2
T3	-0.5

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

Table 23. Frequency of occurrence scores of little bluestem by treatment during 2009-2011 at the Dunning site.

Treatment[1]	**2009**	**2010**	**2011**
BFM	3.6[a]	2.4[b]	1.4[ab]
CM	0.0[b]	0.2[c]	0.0[b]
CS	0.1[b]	0.5[a]	0.6[b]
ECB	3.1[a]	4.6[a]	2.0[a]
MM	0.2[b]	0.5[c]	0.7[b]
MS	3.1[a]	1.6[bc]	0.9[b]

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil.

[a]Means in a column followed by a different letter are different (P<0.05).

Table 24. Frequency of occurrence scores of sand bluestem by treatment during 2009-2011 at the Dunning site.

Treatment[1]	2009	2010	2011
BFM	4.3[a]	1.3	2.5[b]
CM	0.0[b]	0.0	0.0[c]
CS	1.3[ab]	1.0	1.1[bc]
ECB	2.9[ab]	1.6	1.6[bc]
MM	1.1[b]	0.7	1.8[bc]
MS	0.4[b]	1.6	4.8[a]

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 25. Frequency of occurrence scores of switchgrass by treatment averaged over years at the Dunning site (frequency responses to treatments did not differ by year).

Treatment[1]	**Frequency Score**
BFM	0.9[ab]
CM	0.0[c]
CS	0.5[b]
ECB	1.3[a]
MM	0.1[c]
MS	0.2[c]

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 26. Frequency of occurrence scores of sand dropseed by treatment during 2009-2011 at the Dunning site.

Treatment[1]	2009	2010	2011
BFM	0.0[b]	1.0[bc]	1.1[ab]
CM	0.0[b]	0.5[c]	0.1[b]
CS	1.0[b]	0.7[bc]	0.5[b]
ECB	0.0[b]	0.4[c]	2.1[a]
MM	2.9[a]	3.5[a]	1.0[ab]
MS	1.1[b]	2.3[ab]	0.9[ab]

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil.

[a]Means in a column followed by a different letter are different (P<0.05).

Table 27. Frequency of occurrence scores of sand lovegrass by treatment during 2009-2011 at the Dunning site.

Treatment[1]	**2009**	**2010**	**2011**
BFM	6.8[ab]	4.3[bc]	3.7[c]
CM	0.0[b]	3.0[c]	1.9[d]
CS	1.9[b]	3.2[c]	2.8[cd]
ECB	7.1[a]	4.2[bc]	5.6[b]
MM	5.3[ab]	8.7[a]	7.9[a]
MS	4.5[b]	7.1[ab]	6.6[ab]

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 28. Frequency of occurrence scores of sideoats grama by treatment averaged over years at the Dunning site (frequency responses to treatments did not differ by year).

Treatment[1]	Frequency Score
BFM	2.2[b]
CM	0.2[c]
CS	2.0[b]
ECB	2.6[b]
MM	5.1[a]
MS	5.1[a]

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil.

[a]Means in a column followed by a different letter are different (P<0.05).

Table 29. Frequency of occurrence scores of prairie sandreed by treatment during 2009-2011 at the Dunning site.

Treatment[1]	2009	2010	2011
BFM	0.0[b]	0.9	1.4[ab]
CM	0.0[b]	0.0	0.0[b]
CS	0.0[b]	0.0	0.0[b]
ECB	0.5[a]	1.3	1.3[ab]
MM	0.0[b]	1.1	3.9[a]
MS	0.0[b]	0.1	2.6[ab]

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 30. Frequency of occurrence scores of purple prairie clover by treatment averaged over years at the Dunning site (frequency responses to treatments did not differ by year).

Treatment[1]	**Frequency Score**
BFM	1.0[b]
CM	0.0[b]
CS	0.1[b]
ECB	0.8[b]
MM	0.4[b]
MS	3.5[a]

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil

[a]Means in a column followed by a different letter are different (P<0.05).

Table 31. Frequency of occurrence scores of shell-leaf penstemon by treatment averaged over years at the Dunning site (frequency responses to treatments did not differ by year).

Treatment[1]	**Frequency Score**
BFM	0.1[b]
CM	0.0[b]
CS	0.0[b]
ECB	0.3[ab]
MM	0.1[b]
MS	0.8[a]

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 32. Frequency of occurrence scores of weedy forbs by treatment during 2009-2011 at the Dunning site.

Treatment[1]	**2009**	**2010**	**2011**
BFM	1.6[b]	2.9[b]	4.0[b]
CM	8.0[a]	9.1[a]	9.5[a]
CS	1.0[b]	2.9[b]	4.3[b]
ECB	1.6[b]	2.7[b]	3.1[b]
MM	7.3[a]	6.7[ab]	3.4[b]
MS	0.9[b]	3.9[b]	2.3[b]

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 33. Frequency of occurrence scores of weedy grasses by treatment during 2009-2011 at the Dunning site.

Treatment[1]	2009	2010	2011
BFM	0.0[c]	0.9[b]	1.2
CM	0.0[c]	1.4[b]	0.4
CS	0.4[c]	0.3[b]	1.7
ECB	0.0[c]	0.4[b]	0.8
MM	2.6[b]	0.9[b]	0.2
MS	9.7[a]	6.7[a]	0.4

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil.

[a]Means in a column followed by a different letter are different ($P<0.05$).

Table 34. Change in erosion pin height (soil surface to pin apex) from an initial height of 3 inches at the time of application of treatments (June 2009) to project termination (September 2011) at Dunning site.

Treatment	Dunning
	(Inches)
BFM	-0.31
CM	+0.11
CS	-0.08
ECB	-0.04
MM	+0.24
MS	-0.24

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil.

Appendix

Table A1. Frequency of occurrence scores of Canada wildrye by treatment during 2009-2011 at the I-80 site.

Treatment[1]	2009	2010	2011
BFM	0.0	0.7	0.4
CS	0.0	1.4	0.5
ECB	0.3	2.4	0.8
NT1	0.1	3.8	1.3
NT2	0.0	4.1	0.9
NT3	0.0	4.5	1.2
T1	0.0	3.5	1.0
T2	0.0	4.4	1.2
T3	0.0	5.3	0.4

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

Table A2. Frequency of occurrence scores of Canada wildrye by treatment during 2009-2011 at the Highway 34 site.

Treatment[1]	2009	2010	2011
BFM	1.5	0.8	3.3
CS	0.4	1.2	1.2
ECB	1.5	1.3	0.5
NT1	0.5	0.6	1.4
NT2	0.9	0.8	0.9
NT3	0.0	1.8	1.8
T1	1.0	1.6	2.3
T2	0.8	1.6	1.5
T3	0.4	2.2	1.3

1 BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

Table A3. Frequency of occurrence scores of switchgrass by treatment at the I-80 site.

Treatment[1]	**2009**	**2010**	**2011**
BFM	0.2	1.1	1.0
CS	0.0	0.3	0.8
ECB	0.0	1.1	1.9
NT1	0.1	0.5	1.4
NT2	0.1	0.3	1.0
NT3	0.0	0.2	1.0
T1	0.0	0.6	0.9
T2	0.0	0.3	0.8
T3	0.0	0.4	0.8

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

Table A4. Frequency of occurrence scores of switchgrass by treatment at the Highway 34 site.

Treatment[1]	**2009**	**2010**	**2011**
BFM	0.5	1.3	0.0
CS	1.6	0.8	1.2
ECB	1.4	2.9	0.6
NT1	1.4	1.3	0.2
NT2	0.6	1.5	0.6
NT3	0.5	0.4	0.2
T1	0.0	0.5	1.5
T2	0.0	0.6	0.2
T3	0.0	0.3	0.1

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

Table A5. Frequency of occurrence scores of little bluestem by treatment at the I-80 site.

Treatment[1]	**2009**	**2010**	**2011**
BFM	1.7	2.2	2.4
CS	0.3	0.2	0.3
ECB	0.3	0.0	0.8
NT1	0.7	0.4	0.4
NT2	0.0	0.5	0.1
NT3	0.0	0.3	0.1
T1	0.1	0.4	0.5
T2	0.0	0.2	0.7
T3	0.0	0.3	0.0

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

Table A6. Frequency of occurrence scores of little bluestem by treatment at the Highway 34 site.

Treatment[1]	**2009**	**2010**	**2011**
BFM	1.3	3.3	2.1
CS	0.8	1.5	1.1
ECB	1.3	2.9	2.6
NT1	0.3	1.6	1.5
NT2	0.0	0.5	0.9
NT3	0.0	0.1	0.0
T1	0.4	0.9	0.3
T2	0.0	0.7	0.6
T3	0.0	0.1	0.3

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

Table A7. Frequency of occurrence scores of Illinois bundleflower by treatment at the I-80 site.

Treatment[1]	2009	2010	2011
BFM	0.2	0.8	1.3
CS	0.0	0.0	0.1
ECB	0.0	0.2	0.1
NT1	0.0	0.3	0.2
NT2	0.0	0.1	0.1
NT3	0.0	0.1	0.2
T1	0.0	0.3	0.0
T2	0.0	0.1	0.1
T3	0.0	0.2	0.0

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

Table A8. Frequency of occurrence scores of Illinois bundleflower by treatment at the Highway 34 site.

Treatment[1]	2009	2010	2011
BFM	0.0	0.0	0.1
CS	0.0	0.0	0.0
ECB	0.0	0.0	0.3
NT1	0.0	0.1	0.0
NT2	0.0	0.0	0.0
NT3	0.0	0.0	0.0
T1	0.0	0.0	0.0
T2	0.0	0.1	0.0
T3	0.0	0.0	0.0

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

Table A9. Frequency of occurrence scores of purple prairieclover by treatment at the I-80 site.

Treatment[1]	2009	2010	2011
BFM	0.0	0.0	0.1
CS	0.0	0.0	0.0
ECB	0.0	0.0	0.0
NT1	0.0	0.0	0.0
NT2	0.3	0.0	0.0
NT3	0.0	0.0	0.0
T1	0.0	0.0	0.0
T2	0.0	0.0	0.0
T3	0.0	0.0	0.0

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

Table A10. Frequency of occurrence scores of purple prairieclover by treatment at the Highway 34 site.

Treatment[1]	2009	2010	2011
BFM	0.2	0.5	0.2
CS	0.0	0.5	0.2
ECB	0.2	0.4	0.1
NT1	0.1	0.1	0.1
NT2	0.0	0.0	0.0
NT3	0.0	0.0	0.0
T1	0.0	0.5	0.0
T2	0.1	0.2	0.0
T3	0.0	0.4	0.0

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

Table A11. Frequency of occurrence scores of New England aster by treatment at the I-80 site.

Treatment[1]	2009	2010	2011
BFM	0.0	0.0	0.0
CS	0.0	0.0	0.0
ECB	0.0	0.0	0.0
NT1	0.0	0.0	0.0
NT2	0.1	0.0	0.0
NT3	0.0	0.0	0.0
T1	0.0	0.0	0.0
T2	0.1	0.0	0.0
T3	0.0	0.0	0.0

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

Table A12. Frequency of occurrence scores of New England aster by treatment at the Highway 34 site.

Treatment[1]	2009	2010	2011
BFM	0.0	0.0	0.0
CS	0.0	0.0	0.0
ECB	0.2	0.0	0.0
NT1	0.0	0.0	0.0
NT2	0.0	0.0	0.0
NT3	0.0	0.0	0.0
T1	0.0	0.0	0.0
T2	0.2	0.0	0.0
T3	0.0	0.0	0.0

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

Table A13. Frequency of occurrence scores of Indian blanket by treatment at the I-80 site.

Treatment[1]	**2009**	**2010**	**2011**
BFM	0.4	0.0	0.2
CS	0.0	0.0	0.0
ECB	0.0	0.3	0.0
NT1	0.0	0.2	0.1
NT2	0.0	0.1	0.0
NT3	0.2	0.0	0.0
T1	0.2	0.5	0.0
T2	0.2	0.0	0.2
T3	0.0	0.0	0.0

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

Table A14. Frequency of occurrence scores of Indian blanket by treatment at the Highway 34 site.

Treatment[1]	**2009**	**2010**	**2011**
BFM	0.0	0.5	0.6
CS	0.0	0.9	0.0
ECB	0.0	0.7	0.2
NT1	0.0	0.4	0.0
NT2	0.0	0.3	0.4
NT3	0.0	0.3	0.0
T1	0.2	0.5	0.0
T2	0.0	0.3	0.2
T3	0.0	0.3	0.0

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

Table A15. Frequency of occurrence scores of black Samson by treatment at the I-80 site.

Treatment[1]	**2009**	**2010**	**2011**
BFM	1.1	0.9	0.5
CS	0.6	0.7	0.3
ECB	0.0	0.3	0.2
NT1	0.2	0.6	0.1
NT2	0.1	0.8	0.3
NT3	0.0	0.6	0.2
T1	1.3	0.7	0.5
T2	0.0	0.6	0.7
T3	0.0	0.4	0.0

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

Table A16. Frequency of occurrence scores of black Samson by treatment at the Highway 34 site.

Treatment[1]	**2009**	**2010**	**2011**
BFM	0.0	0.7	0.0
CS	0.1	0.3	1.0
ECB	0.1	0.4	2.0
NT1	0.0	0.6	0.9
NT2	0.0	0.5	1.4
NT3	0.0	0.6	0.0
T1	0.0	0.2	1.7
T2	0.0	0.3	0.0
T3	0.0	0.2	0.6

[1] BFM=bonded fiber matrix, CS=crimped straw, ECB=erosion control blanket, NT1=non-tilled compost 1 inch, NT2=Non-tilled compost 2 inches, NT3=non-tilled compost 3 inches, T1=tilled compost 1 inch, T2=tilled compost 2 inches and T3=tilled compost 3 inches.

Table A17. Frequency of occurrence scores of Canada wildrye by treatment at the Dunning site.

Treatment[1]	2009	2010	2011
BFM	0.1	0.1	0.0
CM	0.0	0.2	0.2
CS	0.0	0.0	0.3
ECB	0.2	0.1	0.0
MM	0.0	0.1	0.1
MS	0.0	0.2	0.1

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil.

Table A18. Frequency of occurrence scores of prairie Junegrass by treatment at the Dunning site.

Treatment[1]	2009	2010	2011
BFM	0.0	0.3	0.0
CM	0.0	0.0	0.0
CS	0.0	0.1	0.0
ECB	0.0	0.0	0.1
MM	0.0	0.0	0.0
MS	0.0	0.2	0.0

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil.

Table A19. Frequency of occurrence scores of slender wheatgrass by treatment at the Dunning site.

Treatment[1]	**2009**	**2010**	**2011**
BFM	2.2	0.0	0.0
CM	0.0	0.0	0.0
CS	0.0	0.0	0.0
ECB	1.5	0.0	0.2
MM	0.0	0.3	0.0
MS	0.5	0.2	0.0

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil.

Table A20. Frequency of occurrence scores of thickspike wheatgrass by treatment at the Dunning site.

Treatment[1]	**2009**	**2010**	**2011**
BFM	0.4	0.1	0.0
CM	0.0	0.0	0.1
CS	0.0	0.2	0.1
ECB	0.0	0.1	0.2
MM	0.0	0.1	0.0
MS	0.0	0.1	0.0

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil.

Table A21. Frequency of occurrence scores of western wheatgrass by treatment at the Dunning site.

Treatment[1]	2009	2010	2011
BFM	0.0	0.0	0.0
CM	0.0	0.1	0.0
CS	0.0	0.5	0.3
ECB	0.0	0.2	0.1
MM	0.0	0.1	0.0
MS	0.1	0.6	0.0

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil.

Table A22. Frequency of occurrence scores of leadplant by treatment at the Dunning site.

Treatment[1]	2009	2010	2011
BFM	0.0	0.1	0.0
CM	0.0	0.0	0.0
CS	0.0	0.0	0.0
ECB	0.0	0.0	0.4
MM	0.0	0.0	0.0
MS	0.0	0.0	0.0

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil.

Table A23. Frequency of occurrence scores of plains coreopsis by treatment at the Dunning site.

Treatment[1]	2009	2010	2011
BFM	0.2	0.0	0.1
CM	0.0	0.0	0.0
CS	0.1	0.0	0.0
ECB	1.0	0.1	0.0
MM	1.0	0.0	0.1
MS	0.7	0.0	0.1

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil.

Table A24. Frequency of occurrence scores of Rocky Mountain beeplant by treatment at the Dunning site.

Treatment[1]	2009	2010	2011
BFM	0.0	0.1	0.0
CM	0.0	0.0	0.0
CS	0.0	0.0	0.0
ECB	0.0	0.0	0.1
MM	0.0	0.0	0.0
MS	0.0	0.1	0.0

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil.

Table A25. Frequency of occurrence scores of upright prairie coneflower by treatment at the Dunning site.

Treatment[1]	**2009**	**2010**	**2011**
BFM	1.1	0.3	0.4
CM	0.0	0.0	0.0
CS	0.7	0.4	0.1
ECB	1.7	1.0	0.8
MM	0.1	0.2	0.1
MS	0.1	1.0	0.5

[1] BFM=bonded fiber matrix, CM=corral manure, CS=crimped straw, ECB=erosion control blanket, MM=maintenance mixture and MS=meadow topsoil.