STEEP CUT SLOPE COMPOSTING: *FIELD TRIALS AND EVALUATION*

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THE STATE OF MONTANA
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April 2011

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RESEARCH PROGRAMS

MDT

Steep Cut Slope Composting: Field Trials and Evaluation

by

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16. Abstract: Three different depths of compost and five compost retention techniques were tested to determine their efficacy and cost effectiveness for increasing the establishment of native grass seedings and decreasing erosion on steep roadside cut slopes in southwest Montana. The depths of compost selected were: 0.32 cm (0.13 in), 0.64 cm (0.25 in) and 1.27 cm (0.5 in). The compost retention methods utilized a coconut-straw fiber fabric, lightweight plastic netting and three commercially available tackifiers: 1) a polymer emulsion liquid, 2) a guar-based water dispersible formulation, and 3) a *Plantago*-based seed husk powder. Compost application rates of 1.27–2.54 cm (0.5–1 inch) are recommended for establishment of sufficient vegetation cover, estimated to result in 16–26 percent native bunchgrass cover in arid climates in Montana. These recommended application rates are estimated to cost between $41,160 and $82,171/hectare ($16,657 and $33,254/acre) based on plot construction methods from this study using a blower truck. Compost retention treatments employing physical retention of compost such as coconut-straw fiber fabric or lightweight plastic netting were effective in limiting the loss of applied compost. The tackifiers gave confounding results on their ability to retain compost.		
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EXECUTIVE SUMMARY

This project was conducted to evaluate various approaches to improve revegetation of steep highway cut slopes in Montana. Three different depths of compost and five compost retention techniques were tested to determine their efficacy and cost effectiveness for increasing the establishment of native grass seedings and to decrease erosion.

Twenty-two test plots of varying sizes were constructed on steep north- and south-facing roadside cut along Montana (MT) Highway 84 approximately 25 kilometers (15 miles) west of Bozeman in southwest Montana. Slopes varied between 64 and 71 percent. At this location, MT Highway 84 is aligned on an east-west axis and provided the opportunity for the establishment of test plots on both north-facing and south-facing slopes. The test site is typified by semi-consolidated sand, silt, clay, and intermittent fine gravel deposits. Laboratory analyses determined the slopes had a silt loam texture. Analyses before treatment confirmed the site soils exhibited low levels of organic matter, nitrogen (N) and phosphorus (P) consistent with a road cut through fresh parent material lacking soil horizon development. In this report the rooting zone materials will be called “soil,” recognizing that these materials have little, if any, soil horizon development characteristic of an entisol.

A grass seed mix appropriate for the environmental conditions and geologic materials at the research site was broadcast prior to application of compost and/or compost retention treatments. The seed mix contained six native bunchgrass species. The compost used for the experiment was standard reclamation compost, slightly basic (reactivity (pH) of 7.9), and was screened so that pieces were smaller than 1 centimeter (cm) (3/8 inch (in)). A chemical analysis of the compost indicated high total levels of N, P, and potassium (K), macronutrients that generally support plant response when applied to nutrient-poor soils like those found at the research site.

Three depths of compost were selected to be placed on seeded plots on both south-facing and north-facing cut slopes: 0.32 cm (0.13 in), 0.64 cm (0.25 in) and 1.27 cm (0.5 in). The five compost retention methods were employed only on the environmentally harsher south-facing slopes, with a compost depth of 1.27 cm. The five retention measures were a coconut-straw fiber erosion control blanket, lightweight plastic netting and three commercially available tackifiers. The three tackifiers were 1) a polymer emulsion liquid, 2) a guar-based water dispersible formulation and 3) a *Plantago*-based seed husk powder. These treatments were compared to seeded control plots.

Monitoring and evaluation results indicate the lower compost rates of 0.32 cm and 0.64 cm result in less than 10 percent perennial grass cover and appear to have limited effect on erosion control. Compost rates between 1.27 cm (tested in this study) and 2.54 cm (1 in) based on an earlier study (Jennings *et al*. 2007) are recommended and can be expected to yield approximately 16–26 percent live perennial grass cover on south-facing steep cut slopes with a semi-arid climate in Montana.

The addition of compost improved soil chemical characteristics at the test site. Organic matter content increased as well as the plant macronutrients N, P and K. Only a portion of the total nutrient pool was available to plants during the final soil monitoring event that occurred in August 2010, suggesting a long-term supply of nutrients would be available for plant growth over a period of many years.

Compost retention treatments employing physical retention of compost such as coconut-straw fiber fabric or lightweight plastic netting were effective in limiting the loss of applied compost. Treatments lacking a physical method of retention were more subject to wind removal. The three tackifiers that were evaluated gave confounding results. This was due to a severe wind gradient from the top (western side) to the bottom (eastern side) of the study site. Only two replications of each treatment were implemented and dissimilar compost retention values were recorded for the same treatment depending on the test plot's location. As a result, no recommendations can be offered with respect to the most effective tackifier treatment.

Wind removal of compost is likely to be a recurring problem. Coconut-straw fiber fabric or lightweight plastic netting, preferably biodegradable netting if available, are recommended for use in windy cut slope reclamation areas. In addition, future reclamation efforts that limit the duration of time the compost is vulnerable to wind erosion before the growing season is encouraged. A preferable method would be to seed and install compost and physical retention treatments in the spring, immediately prior to the growing season.

Overall, compost application to steep cut slopes created by highway construction resulted in increased establishment of seeded species when sufficient compost depth was applied to the soil surface using a blower truck. Compost application rates of 1.27-2.54 cm are recommended for establishment of sufficient vegetation cover to control erosion. These recommended application rates are estimated to cost between $41,160/hectare (ha) ($16,657/acre (ac)) and $82,171/ha ($33,254/ac) based on the plot construction methods from this study using a blower truck. Costs may vary in other locations and using other methods. The 1.27 cm compost application with plastic netting utilized for retention is estimated to cost $65,069/ ha ($26,333/ac).

1. INTRODUCTION

This project is a continuation of earlier work performed by Montana State University (Jennings *et al*. 2007) evaluating compost application on, and incorporation into, soils on steep cut slopes for MDT. The earlier work evaluated compost application at rates of 2.54 cm and 5.08 cm. It also evaluated the relative effectiveness of surface-applied compost blankets versus compost incorporated into the surface soil. In the earlier work, test plots were constructed in northwest Montana on glacial till and in southeast Montana on marine shale parent material. Prior to construction of these field plots in 2003 a literature review and equipment assessment was conducted to evaluate approaches to revegetation of steep highway cut slopes (Jennings *et al*. 2007). Regional variation was observed in revegetation techniques using compost, but in all cases the need for sufficient vegetation establishment to control erosion and provide slope stability was recognized. The overall research goal was to develop effective techniques suited to the unique climate and parent materials of Montana. The 2003–2006 research found that both the 2.54 and 5.08 cm (1 and 2 in) application rates yielded good plant growth of seeded species in research plots in northwest Montana. Less effective treatment results were observed at the drier southeast Montana research location, where loss of surface-applied compost due to wind erosion limited plant response of the seeded native bunchgrass species. Plant response to surface-applied compost blanket treatments compared to compost incorporated into the soil was similar at the northwest Montana research sites. Given that similar vegetation response could be achieved with surface-applied compost blankets without the added cost and complexity of compost incorporation on steep slopes, emphasis in the research investigation described in this report shifted to techniques that retained compost against loss to wind and water erosion and also treatments using lower rates of compost to reduce costs.

2. RESEARCH OBJECTIVES

This research project has several objectives:

- Evaluate vegetation performance on seeded plots using surface-applied compost with thicknesses between 0.32 cm and 1.27 cm;
- Assess the effectiveness of various tackifiers, erosion control fabric and netting in retarding loss of compost from wind and water erosion;
- Conduct a cost–benefit analysis of the various rates of compost applied in conjunction with the various compost retention techniques; and
- Make final recommendations for compost application rates and preferred stabilization techniques.

3. EXPERIMENTAL DESIGN

A series of test plots was constructed to test a combination of compost depths and compost retention techniques (Table 1). Three different depths of compost blankets were evaluated (0.32 cm, 0.64 cm and 1.27 cm) to determine if these relatively thin layers of compost would be sufficient to help seeded native grasses establish and persist on steep slopes. These applications are less than the 2.5 cm and 5.1 cm tests conducted during an earlier study (Jennings *et al*. 2007). These varying depths of compost were applied on both north- and south-facing slopes. Control plots were also constructed on both north- and south-facing slopes. The control plots had only the native seed mix applied.

The five compost retention techniques selected for evaluation were applied on seeded plots with 1.27 cm compost blankets. These test plots were constructed only on the south-facing slopes. The five compost retention techniques included a coconut-straw fiber erosion control fabric applied and secured with stakes over the compost blanket. This is a typical erosion control method used by MDT. The four other experimental retention techniques included a lightweight non-biodegradable plastic netting material, which was also applied and secured with stakes over the compost blankets, and three different tackifiers that were mixed with water and sprayed onto the compost blankets. The three tackifier treatments consisted of a polymer emulsion liquid, a water dispersible guar-based powder and a *Plantago*-based powdered mulch. All three tackifiers were mixed according to manufacturer specifications and sprayed from a hydromulch truck.

Table 1: Experimental design for research plots along MT Highway 84.

Treatment[1]	No. of Plots	Plot Aspect
Control Plots		
Control – no treatment	2	South-facing
Control – no treatment	1	North-facing
Varying Depths of Compost		
0.32 cm thick compost blanket	2	South-facing
0.64 cm thick compost blanket	2	South-facing
1.27 cm thick compost blanket	2	South-facing
0.32 cm thick compost blanket	1	North-facing
0.64 cm thick compost blanket	1	North-facing
1.27 cm thick compost blanket	1	North-facing
Compost Retention Treatments		
1.27 cm thick compost blanket + polymer emulsion liquid tackifier	2	South-facing
1.27 cm thick compost blanket + guar-based tackifier	2	South-facing
1.27 cm thick compost blanket + *Plantago*-based tackifier	2	South-facing
1.27 cm thick compost blanket + plastic netting	2	South-facing
1.27 cm thick compost blanket + coconut-straw fiber fabric	2	South-facing

[1] All plots were seeded with same native bunchgrass mixture.

4. TEST SITE LOCATION AND DESCRIPTION

The test site was located approximately 25 kilometers (15 miles) west of Bozeman on MT Highway 84 (Figure 1). This road reconstruction project was completed in 2002. Steep slopes were cut into Tertiary-age sedimentary parent material. Slopes did not receive a soil application during post-construction reclamation. In 2008, these slopes were nearly devoid of vegetation; approximate canopy cover ranged between 1 and 5 percent across the test plots.

At this location, MT Highway 84 is aligned on an east–west axis, providing the opportunity for establishing test plots on both north-facing and south-facing slopes. The cut slopes where test plots were constructed are between 64 and 71 percent slope in steepness. Slope length ranged between 12.2 and 18.3 meters (m) (40–60 feet (ft)). It was determined the 22 test plots required by the project could be constructed in this location with spacing of at least 1.5 m (5 ft) between each of the plots.

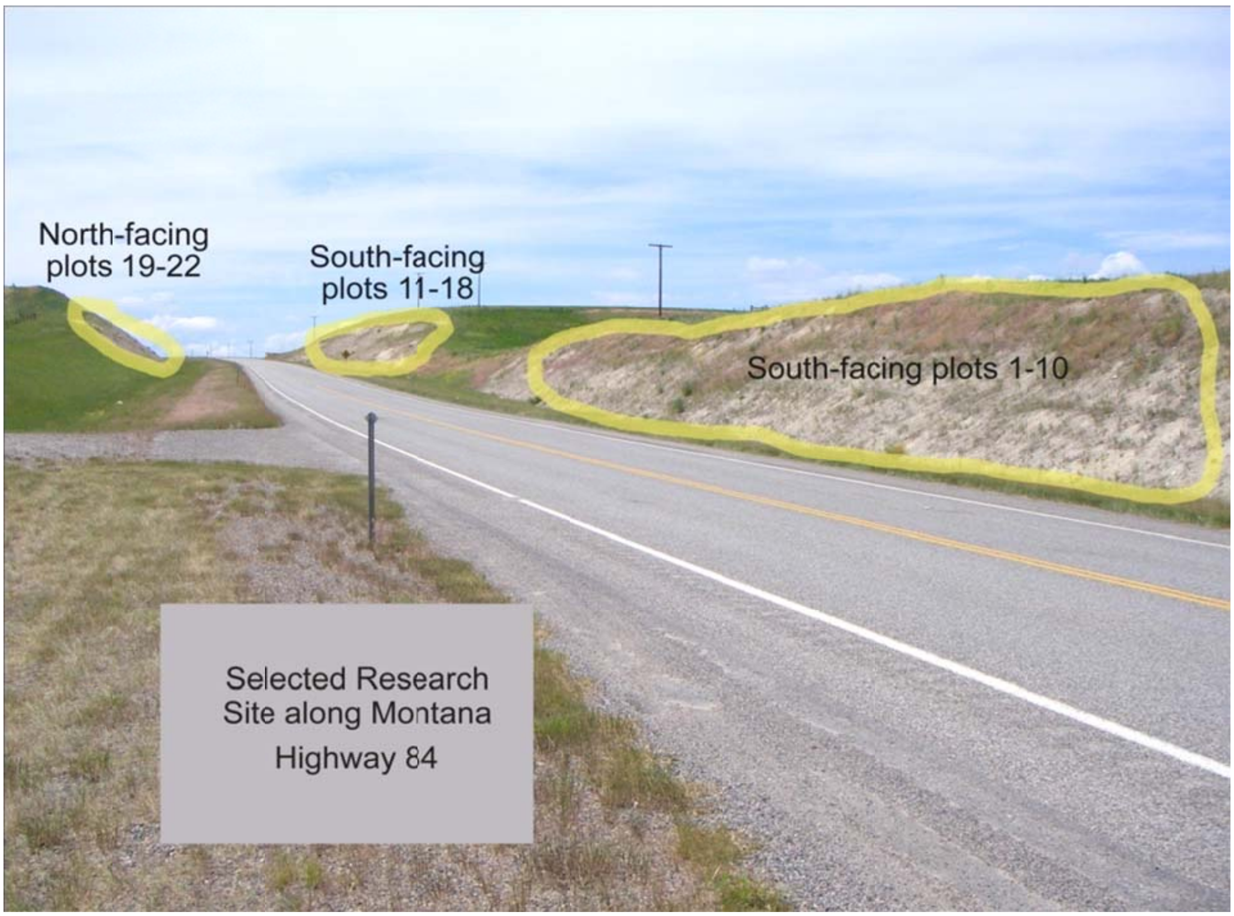

Figure 1: Roadside overview of research site location along MT Highway 84.

The landscape adjacent to the research site is characterized by gently rolling terrain with well-developed agricultural soil currently used for small grain crops or rangeland (Figure 2). Soil was not placed on the steep cut slopes used for the test plots following highway construction or as part of this research project.

4.1. Research Site Soils

The underlying geologic substrate at the test site is valley fill sediment deposited during the Tertiary period between 2.5 and 65 million years ago and is typified by semi-consolidated sand, silt, clay, and intermittent fine gravel deposits (English 2007). Rich agricultural soil found on the adjacent landscape is characterized by abundant organic matter built up over the past 10,000 years since the retreat of the glaciers. The light-colored semi-consolidated rock is characteristic of the road cuts in the area that exhibit limited vegetation development and active erosion. The Gallatin Valley is filled with as much as 1,829 m (6,000 ft) of Tertiary and Quaternary sediment with the water table located between 1 and 150 m (3 and 392 ft) below ground level (Slagle 1995).

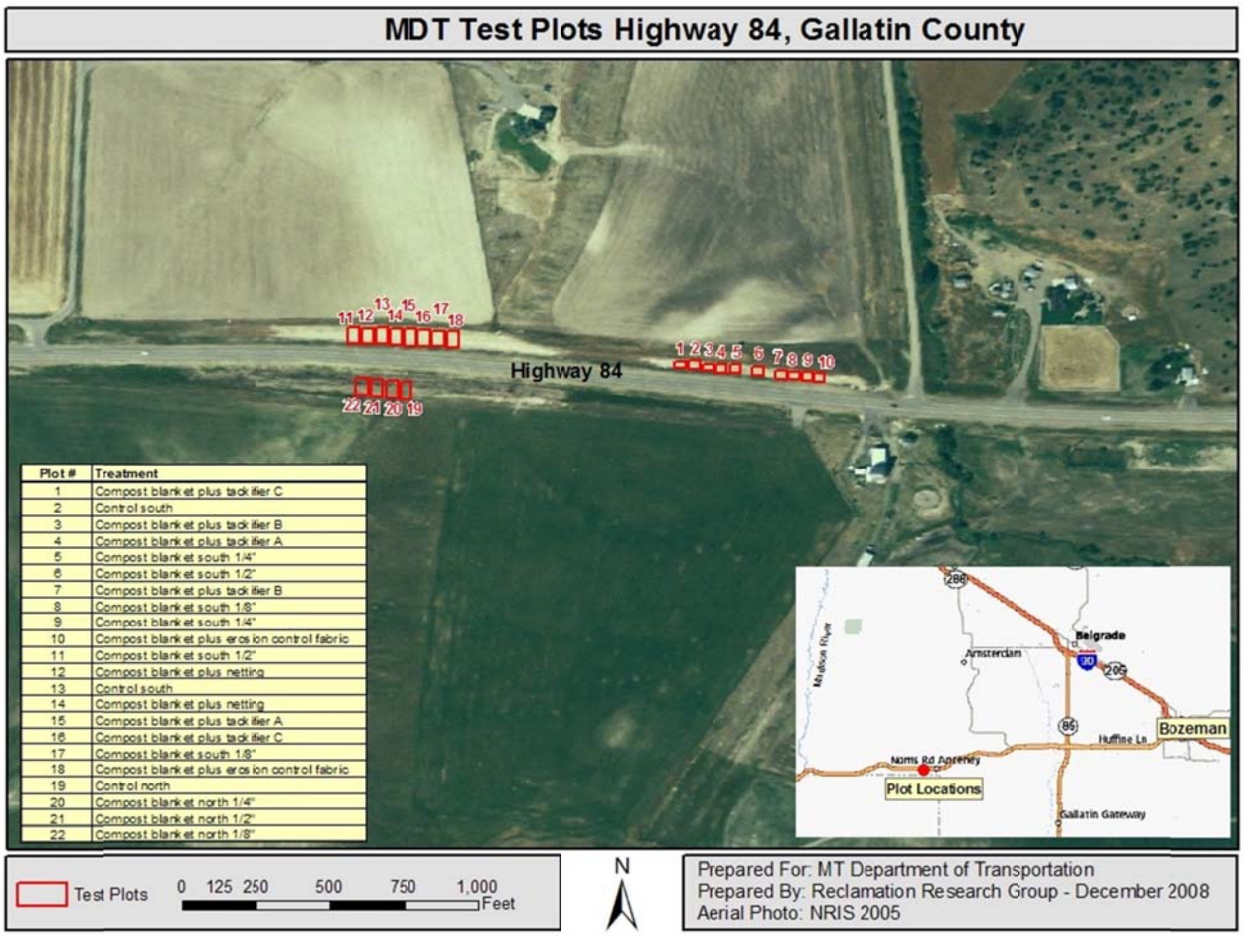

Figure 2: Site location map and test plot layout at research site on MT Highway 84.

4.1.1. Pre-Treatment and Post-Treatment Soil and Compost Sampling and Analyses

Soil samples were collected in November 2008 from each test plot prior to seeding and the application of compost blanket treatments. They represent the pre-treatment condition of the soil. Soil samples were again collected in August 2010 following the final monitoring event. During each soil sampling event, five sub-samples were randomly collected in each test plot from the 0–

10 cm (0–4 in) soil interval. The five sub-samples were mixed together as a representative soil sample of each test plot.

Control plots 2 and 13 on the south-facing slope were not sampled independently because no compost amendment was to be added to these two test plots and their chemical characteristics were not expected to change during the research study. Similarly, the four north-facing plots were not analyzed because the effect of aspect was only a secondary objective of the research.

Each of the 16 test plot soil samples was placed in a plastic bag and shipped to an Environmental Protection Agency approved soil testing laboratory for analysis of reactivity (pH), electrical conductivity (EC), sodium adsorption ratio (SAR), total organic carbon, and organic matter (OM). Nutrient availability for each test plot was determined by measuring water soluble levels of the elements calcium (Ca), magnesium (Mg), and sodium (Na), and available macronutrients including N, P, and K. Heavy metals (*i.e.*, selenium, mercury, arsenic) were not anticipated to be present at levels of concern and were not analyzed.

In addition to soil samples, one compost sample was submitted for analysis of pH; EC; SAR; water soluble levels of Ca, Mg and Na; total organic carbon; OM; available macronutrients N, P, and K; and total nitrogen. Another test was conducted to determine the maximum particle size of the compost. The soil sample analyses results are presented in Section 7, Results and Discussion.

5. TEST PLOT CONSTRUCTION

Based on the experimental design for this research project (Table 1), 22 plots were laid out at the research site. Plot construction and treatment applications occurred on 11–14 November 2008. Four plots were located on the north-facing slope (Figure 3) and 18 were located on two separate south-facing slopes. Eight of the south-facing plots were placed across the highway from the four north-facing plots (Figure 4) and the 10 other south-facing plots were located together approximately 200 m (656 ft) to the east (on the right in Figure 5).

Plot layout and dimensions were adjusted to reflect the amount of the slope available for each of the 22 test plots. Typical plot widths were 9.1 m (30 ft) with a 1.5 m (5 ft) buffer between adjacent plots. Each test plot was built along the entire length of the slope from just above the roadside ditch at the bottom to either the top of the slope or to the edge of existing vegetation near the top. Some of the cut slopes had enough soil pushed down from the top to allow for the establishment of perennial grasses on the steep cut slope. Test plots were bounded at the top to exclude most of this existing vegetation, requiring the slope length for the test plots to be of varying dimensions.

Several steep cut slope areas were omitted from research plot utilization when bedrock outcrops were near the surface or where perennial vegetation occurred in patches throughout the slope. Images of each test plot before and after implementation of the experimental treatments are shown in Appendix A.

The selection of test plots to receive the various experimental treatments was randomized. The 18 south-facing plots were chosen to receive experimental treatments or serve as control plots based on the use of random-number-generating software. Similarly, the four north-facing plots were selected for different depths of compost or as the control plot based on the use of random-number-generating software.

Figure 3: View of four north-facing plots, directly across the highway from the eight south-facing plots. The plot furthest to the east (left) is a control plot without compost application.

A plot construction contract was let to Quality Landscape Seeding, Inc., of Plains, MT (Quality). Quality provided the compost, tackifiers, netting, erosion control fabric, stakes, equipment (hydromulch and blower trucks) and laborers for the project.

Figure 4: View of eight south-facing plots that are across highway from the four north-facing plots (western plots). Plot 11 is shown furthest to the left in the image (dark colored) while plot 18 is most distant (to the right or east) covered by a tan colored erosion control blanket.

Figure 5: View of 10 south-facing plots that are on the east end of the research site. Plot 1 is furthest to the left in the image (dark colored) and plot 10 is most distant (to the right or east) with a tan colored erosion control blanket.

The test plots receiving experimental compost retention measures were constructed using a four-step process:

- Seedbed preparation;
- Seeding of plots with a native grass seed mix via a broadcast seeder;
- Compost applied using the blower truck; and
- Compost retention measure applied to the compost blanket.

For test plots evaluating different compost thicknesses and not employing a compost retention measure, only the first three steps were conducted. For the three control plots, only the first two steps were conducted.

5.1. Seedbed Preparation

The cut slopes of the MT Highway 84 lane-widening road project were seeded in the fall of 2002. By the autumn of 2008, these slopes remained nearly devoid of vegetation. In 2008, some sparse vegetation was evident on the test site (Figure 6). The MDT reclamation specialist conducted an ocular sampling to characterize the vegetation on the site on 4 November 2008. In November 2008, all vegetation was senescent at the time of seedbed preparation. Existing vegetation canopy cover was less than 5 percent and was dominated by weedy species. Some perennial grasses that were remnants of the mix seeded in 2002 were also observed. The dominant desirable native grass species observed was slender wheatgrass, *Elymus trachycaulus*. These plants were widely spaced and comprised less than 1 percent canopy cover. The dominant invasive species observed were cheatgrass, *Bromus tectorum,* and spotted knapweed, *Centaurea maculosa*. Trace amounts of other species were observed. Plant cover was insufficient to control erosion and provide soil stabilization.

Due to the erosiveness of the steep cut slopes and lack of stabilizing post-construction vegetation cover, rilling was common on the test site. After a field review, it was determined that additional raking or smoothing of the test site to prepare the seedbed was not necessary since the exposed seedbed material was loose and friable.

The two test plots that received the plastic netting treatment, plots 12 and 14, were prepared by removing the aboveground portion of all existing vegetation to facilitate the spreading and securing of the netting over the compost blanket. These two test plots were cleared of vegetation with a gas-powered weed trimmer. The remaining 20 test plots did not receive any preseeding preparation except for the removal of the occasional noxious weed, spotted knapweed. Cheatgrass was present across the test site but these small ubiquitous plants were not removed. Young cheatgrass plants had germinated and established on several of the plots and adjacent land by the time the plots were constructed.

Figure 6: Evidence of erosion and sparse vegetation on the westernmost section of the south-facing cut slope, prior to test plot construction.

5.2. Seeding of Test Plots

A native grass seed mix appropriate for the environmental conditions and soils at the research site was provided by the MDT reclamation specialist (Table 2). The seed mix was broadcast on each plot before the compost blanket was applied. Seed was broadcast using a handheld broadcast seeder to more readily adjust to variations in plot size and slope. Seed was weighed in individual bags for each test plot based on its area.

The seeding rate was identical for each of the 22 test plots. The bulk application rate was 0.45 kilogram (kg) or one pound of seed mix per 111.5 square (sq) m (1,200 sq ft). This is the equivalent of 36.3 pounds of seed mix per acre. In consultation with the MDT reclamation specialist, it was determined that bulk rates would not need to be adjusted for percent live seed due to the high seed viability percentages in the mix. Seed viability for the six native grass species varied from 90 to 99 percent (Table 2). This rate is comparable to broadcast seeding rates typically specified on MDT projects. Seed was supplied by Bruce Seed Farm, Townsend, MT.

Table 2: Seed mix provided by MDT for use on test plots.

Species	Scientific Name	Cultivar	% of Mix by Weight	Viability	Application Rate lbs/ac // kgs/ha
Slender Wheatgrass	*Elymus trachycaulus*	Pryor	12.77	97	4.64 // 5.20
Canada Wildrye	*Elymus canadensis*		20.64	90	7.49 // 8.39
Sheep Fescue	*Festuca ovina*	Covar	6.45	96	2.34 // 2.62
Bluebunch Wheatgrass	*Pseudoroegneria spicata*	Goldar	32.93	94	11.95 // 13.39
Green Needlegrass	*Stipa viridula*	Lodorm	9.38	99	3.4 // 3.81
Indian Ricegrass	*Achnatherum hymenoides*	Nezpar	16.29	95	5.91 // 6.62

5.3. Compost

5.3.1. Compost Quantities

Compost was procured from Rocky Mountain Compost in Billings, MT, by Quality. The total amount of compost required for the test plots was approximately 26.8 m^3 (35 yd^3). The compost procured was standard reclamation compost screened so that pieces were smaller than 1 cm (less than 3/8 in).

5.3.2. Compost Characteristics

A key objective for this project was to assess the effectiveness of various techniques for retaining compost on steep cut slopes. One bulk sample of the compost used in all treated test plots was collected and submitted for chemical analysis to Energy Laboratories. Table 3 reports the chemical characteristics of the compost and the particle size. The compost was slightly basic (pH of 7.9), consistent with the use of livestock manure as feedstock in compost preparation. The EC was 9.2 deciSiemens per meter (dS/m). This EC level indicates moderate salinity. Elevated EC in an organic amendment is not uncommon. While compost salinity (9.2 dS/m) might be inhibitory if plants were grown directly in the compost, salinity is rarely a problem at the low application rates used to amend the soil for this study. Sodium and the SAR were both elevated in the compost, yet were not expected to inhibit germination and plant growth at the rates used in construction of the test plots. Soil EC in amended plots is discussed in Section 7, Results and Discussion.

Total carbon in the compost was 31.2 percent, while organic carbon was 26.8 percent (Table 3). Organic matter was 46.2 percent, indicative of good quality compost. Most high-quality commercial compost is approximately 50 percent organic matter. High total levels of the macronutrients N, P and K were found in the compost. Macronutrients generally provide a positive plant response when applied to nutrient-poor soils like that found at the research site. The compost is expected to provide a long-term source of fertility for plant growth because only 293 milligrams/kilogram (mg/kg) of nitrate–nitrogen are available to plants, or 3.4 percent of the total pool of nitrogen measured. The total nitrogen level in the compost was 8,570 mg/kg, suggesting the presence of a long-term source for soil N and a foundation for subsequent nutrient cycling by microbial processes.

Table 3: Chemical and physical characteristics of compost used on test plots.

pH s.u.[4]	**EC[1]** dS/m[5]	**Calcium** meq/L[6]	**Magnesium** meq/L	**Sodium** meq/L	**SAR[2]** N/A[7]	**Total Carbon** dry weight %	**OM[3]** dry weight %
7.9	9.20	9.74	8.00	23.40	7.86	31.20	46.2

Organic C[8] dry weight %	**Phosphorus** mg/kg[10]	**Total N[9]** mg/kg	**Nitrate N[9]** mg/kg	**Potassium** mg/kg	**Particle Size Distribution**	
					Coarse Fraction (>1.00 in Sieve)	**Fine Fraction (<1.0 in Sieve)**
					dry weight %	dry weight %
26.8	209	8,570	293	8,700	0	100

[1] EC = electrical conductivity; [2] SAR = sodium adsorption ratio; [3] OM = organic matter; [4]s.u. = standard units; [5]dS/m = deciSiemens/meter; [6]meq/L = milliequivalents/liter; [7] N/A = not applicable; [8] Organic C = organic carbon; [9] N = nitrogen; [10] mg/kg = milligrams/kilogram.

Compost was applied with the use of a blower truck (Figure 7). The amount required for each plot was calculated based on plot area and the depth of the compost blanket to be applied. Compost depth on the test plots was controlled by operator/applicator experience and judgment. Before the applicator left the plot, the plot's compost depth was tested in random locations within the plot to assure appropriate rate of application.

Figure 7: Application of compost on a test plot using a blower truck.

5.4. Compost Retention Measures

Compost retention methods implemented included three different tackifiers, one natural fiber erosion control blanket, and one plastic netting product. For all five types of compost retention measures, the compost application depth was 1.27 cm. First the plot was seeded, then the compost was applied and, finally, the compost retention material was installed. All test plot combinations of compost and retention treatments are presented in Table 4.

Table 4: Test plot orientation, dimensions, treatments, and steepness.

PLOT NUMBER	ASPECT facing slope	PLOT DIMENSION ft/m	PLOT AREA sq ft/sq m	TREATMENT	COMPOST DEPTH in/cm	COMPOST VOLUME[1] yd^3/m^3	STEEPNESS % slope
1	south	27 x 31 / 8.2 x 9.4	837 / 77.8	*Plantago* -based tackifier	0.5 / 1.27	1.5 / 1.1	71
2	south	30 x 32.5 / 9.1 x 9.9	975 / 90.6	Control	N/A[2]	N/A	70
3	south	21 x 40 / 6.4 x 12.2	840 / 78.0	Polymer emulsion liquid tackifier	0.5 / 1.27	1.5 / 1.1	66
4	south	30 x 28 / 9.1 x 8.5	840 / 78.0	Guar-based tackifier	0.5 / 1.27	1.5 / 1.1	64
5	south	29 x 30 / 8.8 x 9.1	870 / 80.8	Compost blanket only	0.25 / 0.64	0.8 / 0.6	64
6	south	27 x 30 / 8.2 x 9.1	810 / 75.3	Compost blanket only	0.5 / 1.27	1.5 / 1.1	65
7	south	27.5 x 30 / 8.4 x 9.1	825 / 76.6	Polymer emulsion liquid tackifier	0.5 / 1.27	1.5 / 1.1	66
8	south	28 x 30 / 8.5 x 9.1	840 / 78.0	Compost blanket only	0.125/ 0.32	0.4 / 0.3	66
9	south	29 x 30 / 8.8 x 9.1	870 / 80.8	Compost blanket only	0.25 / 0.64	0.8 / 0.6	66
10	south	30.5 x 30 / 9.3 x 9.1	915 / 85.0	Coconut-straw fiber fabric	0.5 / 1.27	1.5 / 1.1	66
11	south	30 x 56.5 / 9.1 x 17.2	1695 / 157.5	Compost blanket only	0.5 / 1.27	1.5 / 1.1	69
12	south	30 x 57 / 9.1 x 17.4	1710 / 158.9	Plastic netting	0.5 / 1.27	1.5 / 1.1	67
13	south	30 x 59.5 / 9.1 x 18.1	1785 / 165.8	Control	N/A	N/A	69
14	south	30 x 62 / 9.1 x 18.9	1860 / 172.8	Plastic netting	0.5 / 1.27	1.5 / 1.1	68
15	south	30 x 60.5 / 9.1 x 18.4	1815 / 168.6	Guar-based tackifier	0.5 / 1.27	1.5 / 1.1	66
16	south	30 x 57.5 / 9.1 x 17.5	1725 / 160.3	*Plantago* -based tackifier	0.5 / 1.27	1.5 / 1.1	68
17	south	30 x 53.5 / 9.1 x 16.3	1605 / 149.1	Compost blanket only	0.125/ 0.32	0.4 / 0.3	68
18	south	30 x 65 / 9.1 x 19.8	1950 / 180.2	Coconut-straw fiber fabric	0.5 / 1.27	1.5 / 1.1	70
19	north	30 x 67 / 9.1 x 20.4	2010 / 186.7	Control	N/A	N/A	65
20	north	30 x 65.5 / 9.1 x 20.0	1965 / 182.6	Compost blanket only	0.25 / 0.64	0.8 / 0.6	64
21	north	30 x 65 / 9.1 x 19.8	1950 / 180.2	Compost blanket only	0.5 / 1.27	1.5 / 1.1	65
22	north	30 x 65 / 9.1 x 19.8	1950 / 180.2	Compost blanket only	0.125/ 0.32	0.4 / 0.3	65

[1] Compost volume as applied at a rate per 1,000 sq ft (92.9 sq m); [2] N/A: not applicable

The first compost retention measure was an erosion control blanket composed of straw and coconut fiber. It meets federal specifications for an extended-term erosion control blanket. According to the manufacturer's technical data, this erosion control blanket is a 100 percent biodegradable blanket composed of a 70 percent agricultural straw–30 percent coconut fiber blend matrix with a functional longevity of up to 18 months. It meets the requirements established by the Erosion Control Technology Council and the U.S. Department of Transportation, Federal Highway Administration's standard specifications for construction of roads and bridges on federal highway projects [FP-03 2003 Section 713.17, Type 3.B].

Rolls of the coconut-straw fiber fabric were placed on top of the compost in overlapping applications and secured to the surface on test plots 10 and 18. The uppermost edge of the fabric was secured using wooden stakes and buried in an anchor trench.

The second compost retention measure was a lightweight plastic green netting material that is not biodegradable. It was placed on top of the compost and held in place with metal sod staples. The manufacturer asserts that as roots penetrate the compost and netting layer and grow in to the substrate, they help stabilize the system. Once fully rooted, the netting and vegetation provide long-term stability. Plots 12 and 14 received this compost retention treatment.

The netting manufacturer recommends applying the netting directly to the soil and blowing the compost on top of the netting. The co-principal investigators concurred that placing the netting on top of the compost blanket rather than under the compost blanket was likely to provide similar results. This allowed the five compost retention methods to be applied consistently.

The remaining three compost retention measures used three commercial hydromulch tackifiers applied on 1.27 cm compost blankets. Based on the experimental design (Table 1 and Table 4) the three tackifiers were:

- A polymer emulsion with bonding agents specifically engineered and formulated to bond soil particles together. According to the manufacturer, this adhesive forms a protective, flexible film that eliminates dust, prevents mud, and controls erosion.
- A water-dispersible guar-based tackifier composed of a complex formulation of high quality water soluble polysaccharide and other proprietary ingredients made from natural non-toxic materials. According to the manufacturer, this adhesive forms a protective, flexible film that eliminates dust, prevents mud, and controls erosion.
- A water-soluble powder derived from sand plantain, *Plantago psyllium*, seed husks. *Plantago psyllium* husk powder contains a naturally evolved mucilloid that is an effective adhesive when applied as a slurry with fiber or paper mulch or as an overspray to bond straw fiber.

Both the guar-based and *Plantago*-based adhesives were dry powders while the polymer was a thick liquid. The manufacturers' specifications listed the amount of product to be applied per area of treatment. The manufacturers gave broad guidelines for the volume of water needed to dissolve and deliver the tackifier solution. It was determined by the principal investigators to use a base application rate of liquid solution—a mix of water and the tackifier—at 378 liters (l) (100 gallons (gal)) of mixture per 92 sq m (1,000 sq ft) to allow the compost blanket to be adequately saturated by the solution. The volume of liquid solution was adjusted for each test plot based on the area of the plot (Table 5).

Table 5: Tackifier treatments for test plots.

Plot Number	Tackifier	Product Quantity	Tackifier and Water Volume Applied	Plot Area
1	*Plantago* - based husk powder	1.25 kg (2.75 lbs)	306 l (81 gal)	77.8 sq m (837 sq ft)
3	guar-based powder	1.25 kg (2.75 lbs)	306 l (81 gal)	78 sq m (840 sq ft)
4	polymer emulsion liquid	23.5 l (6.2 gal)	341 l (90 gal)	78 sq m (840 sq ft)
7	guar-based powder	1.25 kg (2.75 lbs)	306 l (81 gal)	76.6 sq m (825 sq ft)
15	polymer emulsion liquid	49.2 l (13 gal)	715 l (189 gal)	168.6 sq m (1815 sq ft)
16	*Plantago* - based husk powder	2.9 kg (6.37 lbs)	715 l (189 gal)	160.3 sq m (1725 sq ft)

For each of the test plots using a tackifier, the plot was seeded and then the compost was applied using the blower truck. This was followed by spraying the tackifier solution over the compost blanket. The tackifier solution was applied using a hose on the hydromulch truck. It was applied in amounts that required several passes back and forth over the compost blanket; this allowed time for the tackifier solution to be absorbed by the compost and minimized any runoff of the solution from the steep slope. The application rate and technique successfully allowed the solution to saturate the compost blanket as well as seep through the blanket to create a bond with the soil surface of the cut slope.

6. DATA COLLECTION METHODS

Different methods were used to collect data to evaluate vegetation establishment, compost retention, and soil erosion on the test plots. Randomized quadrats along a transect were used to measure the percent cover of live vegetation, compost, plant litter, rock, and bare ground. Ocular estimation was used for an early measurement of compost to evaluate retention after plot construction and before vegetation growth in the first year. Erosion was measured using the Bureau of Land Management's (BLM) numeric scoring system (BLM 1996). In addition, photographs of each plot were taken throughout the two-year project. The data collection, timing, and methods are summarized in Table 6.

Table 6: Summary of data collection events and methods.

Data Collection Event	Date	Method			
		Randomized quadrats	Ocular estimate	Photos	Numeric erosion system
Plot Construction	November 11–14, 2008	_	_	X	_
Soil Samples	November 11–14, 2008	N/A[1]	N/A	N/A	N/A
Compost Cover Only	April 8, 2009	_	X	X	_
Veg/Comp/Erosion[2]	July 28–30, 2009	X	X	X	X
Veg/Comp/Erosion	June 22 and 25, 2010	X	X	X	X
Soil Samples	August 24 and 25, 2010	N/A	N/A	N/A	N/A
Veg/Comp/Erosion	August 24 and 25, 2010	X	X	X	_

[1] N/A: not applicable; [2] Veg/Comp/Erosion: vegetation and compost cover, erosion values

6.1. Transect and Sampling Locations

Transects were permanently located within each plot in the spring of 2009. A stake was hammered into the ground at the lower southeast and upper northwest corners of plots 1–18 (south-facing) and the lower northwest and upper southeast corners of plots 19–22 (north-facing). A 30.5 m (100 ft) tape was stretched between the two stakes, starting at the lower corner. A 20 cm by 50 cm quadrat frame was used to read cover of the vegetation, compost, and other parameters at 10 predetermined locations along each plot's transect. Frame locations along the transect alternated between the left and the right side of the transect. Data were recorded using data sheets (Appendix B). Plots were located in three distinct areas within the project boundary (Figure 2) and each area has different-sized plots; therefore, the randomized frame locations for each of the three areas are different (Table 7).

Table 7: Sampling frame locations along transects.

Plots 1–10	**Plots 11–18**	**Plots 19–22**
Transect length: 12.5 m (41 ft)	**Transect length: 20.1 m (66 ft)**	**Transect length: 22 m (72 ft)**
1.5 m	1.8 m	2.4 m
2.1 m	3.4 m	3.7 m
3.4 m	4.6 m	4.6 m
4.3 m	6.1 m	7.6 m
5.2 m	7.0 m	9.1 m
6.4 m	9.1 m	11.3 m
7.6 m	10.7 m	14.6 m
8.2 m	12.2 m	15.5 m
9.5 m	15.5 m	16.2 m
10.4 m	16.2 m	20.1 m

6.2. Measurement Methods for Vegetation and other Ground Cover Parameters

Ground cover is generally referred to as the percentage of ground surface covered by the attributes of interests (*e.g.*, live vegetation, litter, coarse fragments, moss/lichens) (BLM 1996). For the purposes of this project, vegetation cover was measured by morphological classes, which included perennial grasses, perennial forbs, annual grasses, annual forbs and shrubs. A special category for noxious weeds was also created. The other ground cover attributes measured were compost, litter, rock, and bare soil.

Foliar cover of live vegetation and the percent of the ground covered by other attributes were measured using 20 cm x 50 cm quadrat frames (Daubenmire 1968) at 10 randomly predetermined transect locations within each treatment plot. Foliar cover is the area of ground covered by the vertical projection of the aerial portions of the plants. Small openings in the canopy and intraspecific overlap are excluded (BLM 1996). Ground cover attributes were recorded during the peak growing season (mid-July) of 2009 and again in June and August of 2010 using the same transect each time. All ground cover attributes were estimated to the nearest percent.

6.3. Compost Measurement Methods

Assessment of compost retention for each test plot was performed quantitatively and also documented using digital photographs. The amount of each test plot covered by compost was determined using the same quadrat frames used to estimate vegetation cover within each treatment plot and conducted at the same time as the vegetation measurements.

In addition, a compost cover measurement was conducted in early spring of 2009 to estimate the amount of compost remaining on each plot following the first winter after plot construction in November 2008. This early season monitoring event was used to determine compost retention in each plot prior to plant establishment. Thus, plants had not grown through the compost blanket at that time, which may have caused some fracturing and disintegration of the compost blanket. Researchers used ocular estimates rather than establishing transects so that minimal disturbance and trampling occurred to the emerging seedlings on each test plot.

6.4. Erosion Measurement Methods

Erosion was qualitatively evaluated using the BLM “Erosion Condition Class Determination” method (Clark 1980). The erosion assessment method uses a numeric scoring system to estimate the frequency and distribution of rilling, gullying, surface soil movement, pedestalling, litter movement and presence of surface flow patterns. The evaluator circles the numerical value that best describes the site conditions for each attribute. These values are then used to categorize the area into an erosion condition class. These erosion condition classes are as follows: stable, slight, moderate, critical and severe, with severe being the most erosive. Appendix C includes the erosion scores for each plot and a sample form describing the evaluation protocol. Erosion monitoring occurred at the same time as vegetation monitoring in July 2009 and June 2010. During the course of the research project, the research team did not conduct opportunistic monitoring in response to severe weather events.

6.5. Photograph Documentation

In addition to the ground cover measurements along transects and ocular estimates of compost retention, digital photographs were taken to document compost cover retention, vegetation establishment, and erosion. Photographs were taken of each plot from the edge of the roadway during each monitoring event to provide a chronological photographic history of compost retention, vegetation maturation, and slope stability (Appendix A). In addition, companion photographs were taken before and immediately following completion of each plot’s construction (Ament and Jennings 2009).

7. RESULTS AND DISCUSSION

7.1. Soil and Compost Chemistry

Soil samples were collected before construction of the research plots and again following the last monitoring event. In November 2008, soil samples were collected from each plot prior to any amendment and thus represent the pre-treatment condition. The August 2010 samples were collected following the final plot monitoring activities. During each sampling event, five composite sub-samples were collected in each plot location from the 0–10 cm (0–4 in) soil interval. Sixteen samples were placed in sealed plastic bags and shipped to Energy Laboratories for analysis of pH; EC; SAR; water soluble levels of Ca, Mg and Na; total organic carbon; OM; and available macronutrients N, P and K. Pre-treatment and post-treatment soil chemical characteristics of each plot are reported in Table 8.

Table 8: Soil characteristics of south-facing plots sampled before (2008) and after (2010) compost treatments.

Plot #	Year	pH	Conductivity	Calcium	Magnesium	Sodium	SAR[1]	Organic Carbon	Phosphorus	Nitrate-N	OM[2]	Potassium
		s.u.[3]	dS/m[4]	meq/L[5]	meq/L	meq/L	N/A[6]	wt%[7]	mg/kg[8]	mg/kg	%	mg/kg
1	2008	7.7	0.48	1.69	0.72	2.68	2.44	0.28	3	1	0.48	900
	2010	7.2	1.01	6.11	2.85	3.08	1.45	3.87	63	5	6.67	1300
3	2008	7.8	0.45	1.71	0.65	2.46	2.27	0.21	3	3	0.36	940
	2010	7.5	0.68	4.15	1.62	1.78	1.05	1.54	20	3	2.65	900
4	2008	7.8	0.66	2.75	1.00	3.73	2.72	0.16	2	2	0.28	1100
	2010	7.2	0.98	6.47	2.75	3.03	1.41	4.15	50	4	7.15	1300
5	2008	7.9	0.73	3.11	1.18	4.40	3.00	0.36	4	2	0.62	950
	2010	7.4	0.82	4.76	1.88	2.80	1.54	2.98	38	5	5.14	1000
6	2008	7.9	0.60	2.48	0.82	3.44	2.67	0.35	3	2	0.60	940
	2010	7.5	0.85	4.59	1.66	3.73	2.11	2.53	34	3	4.36	1100
7	2008	7.9	0.57	2.06	0.69	3.71	3.16	0.25	4	3	0.43	930
	2010	7.4	0.86	4.95	1.74	3.81	2.08	2.57	32	4	4.43	1200
8	2008	8.0	0.55	2.83	0.79	2.63	1.95	0.36	4	2	0.62	870
	2010	7.7	0.60	3.19	0.99	2.42	1.68	1.20	16	3	2.07	820
9	2008	8.0	0.57	2.32	0.70	3.33	2.71	0.30	6	3	0.52	830
	2010	7.7	0.68	4.09	1.29	2.12	1.29	1.83	23	2	3.15	910
10	2008	8.0	0.58	3.10	0.99	2.37	1.66	0.37	5	5	0.64	780
	2010	7.5	0.73	4.46	1.43	2.48	1.44	3.65	33	2	6.29	1100
11	2008	8.1	0.62	2.10	1.11	3.42	2.70	0.13	2	1	0.22	940
	2010	7.7	1.14	5.08	3.04	4.48	2.22	1.50	20	2	2.59	900
12	2008	7.9	1.60	8.35	4.11	6.59	2.64	0.30	4	2	0.52	990
	2010	7.5	1.57	8.64	5.30	4.39	1.66	3.59	49	3	6.19	1100
14	2008	8.1	0.80	3.49	1.77	3.72	2.29	0.35	4	2	0.60	910
	2010	7.6	1.01	5.32	3.10	3.89	1.90	2.94	38	3	5.07	1000
15	2008	8.0	0.87	3.01	1.71	4.47	2.91	0.17	3	2	0.29	980
	2010	7.7	1.12	5.01	2.92	3.85	1.93	1.59	23	2	2.74	830
16	2008	8.1	0.99	4.37	2.29	4.59	2.52	0.19	3	1	0.33	890
	2010	8.0	0.77	2.61	1.08	4.52	3.32	0.70	19	2	1.21	750
17	2008	8.0	1.00	4.30	2.32	4.95	2.72	0.14	3	2	0.24	880
	2010	7.9	0.83	2.97	1.38	4.55	3.09	0.36	10	1	0.62	600
18	2008	8.1	0.99	4.18	2.08	4.73	2.67	0.19	3	2	0.33	870
	2010	7.5	1.07	6.57	3.47	3.65	1.63	2.52	49	1	4.34	980

[1]SAR = sodium adsorption ratio; [2]OM = organic matter; [3] s.u = standard units; [4]deciSiemens/meter; [5]meq/L = milliequivalents/liter; [6] N/A = not applicable; [7]wt% = percent by weight; [8] mg/kg = milligrams/kilogram.

The pre-treatment (2008) chemical characteristics of soils reported in Table 8 are consistent with a nutrient-poor geologic material/young soil with limited potential for supporting plant cover. Little variation was observed between individual test plots. Alkaline soil chemistry of the 16 plots had a mean pH of 8.0. Mean saturated paste soil EC was 0.80 dS/m. Sodium was not elevated in the material compared to calcium and magnesium, resulting in a mean sodium adsorption ratio of 2.6 for the 16 plots that were sampled. No plant growth inhibitory effect was evident based on the soil samples' pH, EC, or SAR. Macronutrients were low before compost treatments were applied. Plant macronutrients were present at such low levels that only sparse vegetation development could reasonably be expected (Table 8). Mean soil nitrate-nitrogen was 2.2 mg/kg, placing available nitrogen in the very low fertility range (Table 9). Similarly, mean soil phosphorous was 3.5 mg/kg, indicating very low soil fertility. Potassium was not limiting with a mean 920 mg/kg available for plant growth.

Table 9: Soil analysis fertility guidelines (Energy Laboratories 2003).

Soil Fertility Rating	NO_3-N[1] (mg/kg)[2]	Phosphorous (mg/kg)	Potassium (mg/kg)	Organic Matter (%)
Very Low	0-17	0-4	0-75	0-1.9
Low	17-30	4-8	75-125	2.0-3.5
Medium	30-45	8-11	125-250	3.6-4.9

[1]NO_3 – N = nitrate–nitrogen; [2]mg/kg = milligrams per kilogram

The OM analyses varied between a low of 0.22 percent in plot 11 to a high of 0.64 percent in plot 10. The mean of all 16 test plots was 0.40 percent for OM (Table 8). Growth media with an OM percentage between 2.0 and 3.5 percent is considered low in fertility, while 3.6–4.9 percent is classified as medium in fertility (Table 9).

The low levels of fertility reported for nitrogen and phosphorous are consistent with the visual observation of the road cut as young soil material lacking an overlying topsoil horizon. In portions of several of the test plots unweathered, consolidated bedrock is visible. Most of the test plot area consists of sedimentary geologic material/young soil and unconsolidated bedrock that becomes more consolidated with depth.

Post-treatment soil samples showed the effect of the organic amendment with compost. Organic matter was elevated in the treated plots (Table 8). For example, plot 1 possessed 0.48 percent OM prior to compost application and 6.67 percent OM after completion of two growing seasons. Similar increases in OM were noted for all plots receiving compost treatments, regardless of the depth of the compost blanket.

Nutrients also increased in the soil after two years in every plot where compost was applied. The increase in macronutrients was most evident in phosphorous data. Plot 3 showed an increase in P from 3 mg/kg pre-treatment, to 20 mg/kg post-treatment. Potassium showed modest increases such as in plot 1 where K increased from 900 mg/kg before treatment to 1,300 mg/kg two years after compost was applied. In Plot 3, K decreased from 940 mg/kg pre-treatment to 900 mg/kg after treatment. Potassium and phosphorous were present at elevated levels suggesting they are not plant limiting (Table 9).

Nitrogen levels are likely the critical plant-limiting macronutrient in the parent material. Pre-treatment nitrate-nitrogen (NO_3-N) levels were present at very low levels, typically less than 5 mg/kg. Most native grasses are best adapted to low levels of NO_3-N, or approximately 17–30 mg/kg (Table 9), but will tolerate higher levels of fertility. At agronomic rates of fertility (greater than 45 mg/kg NO_3-N) native grasses may become less competitive than introduced species. Soil monitoring data from 2010 suggest that fertility, with respect to NO_3-N, was unchanged compared with pre-treatment conditions. NO_3-N was likely at a seasonal low level at the end of the growing season. A pool of total N was added to the plots via the compost treatments as reported by the pre-treatment compost analysis (Table 3). Of the total amount of nitrogen added (8,570 mg/kg) only 3.4 percent of the total was available to plants as nitrate (293 mg/kg). Nitrogen availability to plants should increase by the beginning of the next growing season and trend toward adequate levels of NO_3-N in the treated plots with abundant OM amendments. More frequent soil monitoring would be required to conclusively demonstrate this hypothesis. Often when compost is added to nutrient-poor soil, NO_3-N levels dramatically increase in the first growing season resulting in increased vigor and growth rates, followed by less dramatic vegetation response in following years. A similar trend was observed in treated plots constructed previously by the authors for MDT on U.S. Highway 2 near Happy's Inn (Jennings *et al*. 2007).

Soil EC remained at low levels before and after treatment and is reflected in the minimal changes in measured water soluble calcium, magnesium, and sodium. All soil EC values were less than 2.0 dS/m, and most were less than 1 dS/m. The pure compost EC added 9.2 dS/m salts, yet when applied at the light rates used in the experimental plots the compost yielded little effect on overall soil EC. It is likely that appreciable amounts of the initial salinity were associated with soluble NO_3-N, which was available to plants during the first growing season.

Soil texture was characterized before plot construction in 2008 and again in 2010 after compost treatments at five randomly selected plots. The results from each sampling event were similar in that all five samples were characterized to have a silt loam (SiL) texture (Table 10). Silt loam has excellent water holding capacity and is well suited to plant growth when adequate moisture and nutrients are present.

Table 10: Soil texture for select south-facing plots, sampled before (2008) and after (2010) compost treatments.

Plot No.	% Sand		% Silt		% Clay		Texture
	2008	2010	2008	2010	2008	2010	2008/2010
4	28	34	57	50	15	16	SiL*
5	24	26	61	57	15	17	SiL
8	20	32	62	51	18	17	SiL
14	26	28	59	57	15	15	SiL
17	26	32	59	53	15	15	SiL

* SiL: Silt Loam

7.2. Vegetation

For the first monitoring event in July of 2009, the vegetation assessment team was given the option of measuring seedling density or vegetation cover for determining new perennial grass establishment. First season plant growth is often limited and density measures are commonly used to capture plant establishment. However, there was notable first-year germination and establishment on the experimental test plots, therefore vegetation cover was the only measure used to determine vegetation establishment (Table 11). All monitoring data is located in Appendix B, which includes data for all of the ground cover attributes measured.

Total vegetation cover on the majority of the research plots was greater during the first growing season than the second growing season due to the large number of annual weeds that emerged the first year. During the second growing season, the cover of annual weeds generally declined. Vegetation cover during the final August 2010 monitoring event on the south-facing plots ranged from 10.2 to 38.4 percent.

Wind likely played a major role in compost loss (See Section 7.3), affecting vegetation establishment. Wind speed was greater in the western portion of the project due to prevailing winds and the angle and direction of the road cut (Figure 1 and Figure 2 west is on the left side of both figures). This created a "wind tunnel" effect for those plots in the western portion of the project. Results from the August 2010 monitoring event show that plots located in the eastern portion of the project tended to have more vegetation cover, on average, than those in the western portion. Eastern plots averaged 23.2 percent vegetation cover while the western plots averaged 13.8 percent cover. Since there were only two replicates per treatment, there was no opportunity to analyze the plot data statistically.

Table 11: Percent (%) vegetation cover by plot in 2009 and 2010. Plots 1–10 are south-facing on the western portion of the site, Plots 11–18 are south-facing on the eastern portion of the site and Plots 19–22 are north-facing plots (see Figure 2).

Plot	Perennial Grass			Annual Grass			Perennial Forb			Annual Forb			Total Vegetation Cover		
	July 2009	June 2010	August 2010	July 2009	June 2010	August 2010	July 2009	June 2010	August 2010	July 2009	June 2010	August 2010	July 2009	June 2010	August 2010
1	16.6	23.6	18.2	3.0	15.2	7.1	0.0	0.0	0.0	6.4	5.0	1.8	26.0	43.8	27.1
2	12.5	7.4	9.3	5.3	5.7	3.4	0.0	0.0	0.3	1.7	1.5	1.3	19.5	14.6	14.3
3	5.5	5.4	9.1	6.0	14.4	5.8	0.5	2.0	0.0	11.0	6.4	3.4	23.0	28.2	18.3
4	9.9	22.4	17.9	5.0	10.5	6.0	0.6	6.5	6.6	9.9	1.6	0.9	25.4	41.0	31.4
5	8.0	10.5	6.7	0.5	1.5	0.4	2.6	5.2	5.5	11.4	5.8	3.6	22.5	23.0	16.2
6	8.2	22.7	16.4	1.1	2.5	1.8	0.0	0.0	0.0	16.9	4.4	4.2	26.2	29.6	22.4
7	20.5	23.6	19.2	15.6	21.1	18.3	1.0	0.0	0.0	5.2	7.0	0.9	42.3	51.7	38.4
8	14.5	19.3	16.1	7.4	7.4	3.0	0.0	0.0	0.1	7.4	2.3	3.2	29.3	29.0	22.4
9	15.7	19.9	14.7	2.1	2.0	0.3	1.2	0.0	0.8	13.5	2.5	1.3	32.5	24.4	17.1
10	7.3	8.6	8.3	7.8	21.7	14.3	0.0	0.0	0.0	7.3	1.5	2.2	22.4	31.8	24.8
11	7.8	12.9	7.6	0.9	0.3	0.0	0.0	0.0	0.0	13.9	10.1	8.8	22.6	23.3	16.4
12	6.9	8.5	3.8	0.0	0.0	1.0	0.0	0.0	0.0	17.3	12.8	11.5	24.2	21.3	16.3
13	6.8	3.0	2.2	0.0	0.0	0.0	2.0	1.8	2.5	3.5	8.6	5.5	12.3	13.4	10.2
14	11.5	11.4	9.7	2.7	7.6	2.6	0.0	0.0	0.0	15.0	8.3	8.9	29.2	27.3	21.2
15	10.1	6.0	4.1	0.3	0.0	0.0	0.0	0.0	0.0	11.2	12.1	6.9	21.6	18.1	11.0
16	15.3	10.0	8.4	0.2	0.0	0.0	0.0	0.0	0.0	6.6	2.2	3.1	22.1	12.2	11.5
17	12.7	12.3	10.1	0.0	0.0	0.0	0.0	0.0	0.0	7.1	0.8	1.9	19.8	13.1	12.0
18	21.4	11.6	9.6	0.0	0.2	0.0	0.0	0.0	0.0	8.6	7.0	2.5	30.0	18.8	12.1
19	7.9	4.8	4.1	0.3	0.0	0.1	0.0	0.0	0.0	3.0	2.6	3.7	11.2	7.4	7.9
20	14.6	11.7	12.0	0.5	0.0	0.0	0.0	0.0	0.0	4.5	4.7	9.9	19.6	16.4	21.9
21	19.0	14.5	12.0	0.7	0.0	0.0	0.5	0.0	1.0	5.7	1.8	5.9	25.9	16.3	18.9
22	23.6	18.7	15.2	0.0	0.0	0.0	0.0	0.0	0.0	4.3	2.4	6.9	27.9	21.1	22.1

Each time one plot for a particular treatment was located in the eastern portion of the project (plots 11–18) and the replicate for that treatment was located in the western portion (plots 1–10), the amount of vegetation cover recorded on the western plot was considerably less than the eastern plot (Table 12). When averaged, the vegetation cover of the western plot reduced the vegetation cover of the treatment. This made it difficult to make inferences regarding the vegetation cover as related to specific treatments.

Table 12: Comparison of treatments based on location of test plot within the study site.

Treatment	Plot Numbers/Location	Total Vegetation Cover - August 2010	
	Eastern versus Western	Eastern Plot	Western Plot
1.27 cm compost + plastic netting	1 and 16	27.1	11.5
1.27 cm compost + guar-based tackifier	4 and 15	31.4	11
1.27 compost blanket	6 and 11	22.4	16.4
0.64 compost blanket	8 and 17	22.4	12
1.27 compost blanket + coconut-straw fabric	10 and 18	24.8	12.1

Since averaging of the two replicate plots for each treatment was not realistic due to the location effect, it is more useful to compare the treatment plots in each area (east and west) to the control in their respective areas. It should be noted that when this project was designed, it was unknown that the prevailing winds would have such a major impact. The location of each of the 18 plots on the south-facing slopes were randomly selected, therefore some treatments may have had two replicates on either the east or the west. For example, at the eastern location there were two 0.64 cm compost blanket treatments and no 0.64 cm compost blanket treatments at the western location. However, it is still possible to discuss the vegetation response to treatments by comparing treated plots to the control in the area (Table 13).

shows the August 2010 total vegetation cover for each plot. The plots are grouped according to eastern or western location on the south-facing slopes and the north-facing slopes.

The total vegetation cover measurements from the final monitoring event (August 2010) indicated that the control plots in all three locations (eastern, western and north-facing) had the lowest amount of cover when compared to the treated plots in their respective locations.

At the eastern location on the south-facing slopes, plot 7 (guar-based tackifier) had the highest total vegetation cover at 38.4 percent. However, the replicate plot for the guar-based tackifier (plot 3) was also located in the eastern location and the vegetation cover on this plot was quite low at 18.3 percent. Only the two 0.64 cm compost blanket plots and the control had lower total vegetation cover than plot 3 in the eastern location. The two 0.64 cm compost blanket plots (plots 5 and 9) had slightly lower total vegetation cover than the 0.32 cm compost blanket plot, which was unexpected. The coconut-straw fiber fabric treated plot (plot 10) had vegetation cover of 24.8 percent, placing it about midway between the plots with the highest and lowest percent of vegetation cover. Overall, the plots treated with tackifier had higher vegetation cover than the other treatments in the eastern sections (with the exception of plot 3). The polymer emulsion liquid tackifier treated plot had 31.4 percent vegetation cover while the *Plantago*-based tackifier had 27.1 percent vegetation cover.

Table 13: Total vegetation cover and compost retention recorded in August 2010 for each test plot.

Eastern South-facing Plots	Treatment	August 2010 Total Vegetation Cover (%)	August 2010 Compost Retention (%)
1	*Plantago*-based tackifier	27.1	65.0
2	control	14.3	control
3	guar-based tackifier	18.3	23.0
4	polymer emulsion liquid tackifier	31.4	35.7
5	0.64 cm compost blanket	16.2	20.2
6	1.27 cm compost blanket	22.4	35.3
7	guar-based tackifier	38.4	29.6
8	0.32 cm compost blanket	22.4	10.3
9	0.64 cm compost blanket	17.1	9.5
10	coconut-straw fiber fabric	24.8	92.2
Western South-facing Plots	**Treatment**	**August 2010 Total Vegetation Cover (%)**	**August 2010 Compost Retention (%)**
11	1.27 cm compost blanket	16.4	11.1
12	plastic netting	16.3	36.7
13	control	10.2	control
14	plastic netting	21.2	32.8
15	polymer emulsion liquid tackifier	11.0	4.9
16	*Plantago*-based tackifier	11.5	4.6
17	0.32 cm compost blanket	12.0	5.0
18	coconut-straw fiber fabric	12.1	69.6
North-facing Plots	**Treatment**	**August 2010 Total Vegetation Cover (%)**	**August 2010 Compost Retention (%)**
19	control	7.9	control
20	0.64 cm compost blanket	21.9	11.2
21	1.27 cm compost blanket	18.9	24.9
22	0.32 cm compost blanket	22.1	4.3

The south-facing plots at the western location tended to have lower vegetation cover than those at the eastern location; this is likely due to stronger winds at the western location. Both of the plastic netting plots were located in this area and had higher vegetation cover (16.3 percent and 21.2 percent) than all of the other treated plots, with the exception of the 1.27 cm compost blanket (16.4 percent). The tackifiers did not perform as well at the western location as the eastern location. Even the 0.32 cm compost blanket (12.0 percent) had higher vegetation cover when compared to the polymer emulsion liquid tackifier (11.0 percent) and the *Plantago*-based tackifier (11.5 percent).

When comparing vegetation cover on the north-facing plots, all of the treated plots out-performed the control plot (7.9 percent). The 0.32 cm compost blanket had 22.1 percent cover, the 0.64 cm compost blanket had 21.9 percent cover and the 1.27 cm compost blanket plot had 18.9 percent vegetation cover.

For the south-facing plots, despite plot location effect, results indicate that the addition of compost is beneficial in the establishment and vigor of desirable vegetation. No overall pattern was apparent when comparing the different plot treatments. However, the three tackifier treated plots had the greatest amount of vegetation cover at the eastern location while the plastic netting plots performed the best at the western location. The north-facing plots showed a significant treatment response as compared to the control; all three compost blanket depths increased vegetation cover.

7.3. Compost Retention

Compost remaining on each plot was measured at the same time as the other ground cover measurements (July 2009, June 2010 and August 2010). Cover frames measuring 20 x 50 cm were used in each test plot to determine the percent of the ground covered by compost (see Section 6). Table 13 shows the percent of compost retained on the treated plots during the last monitoring event (August 2010). Data from all of the monitoring events are included in Appendix B.

As expected, the amount of compost retained on the treatment plots decreased over time. The research site is situated in a harsh environment (strong winds and steep slopes) and it was expected that much of the compost would erode from the site due to wind, rain and snowmelt. Compost retention tended to be greater on the eastern plots (average compost retention was 35.6 percent) than on the western plots (average compost retention was 23.5 percent). Compost retention at the eastern location was greatest on plot 10 (coconut-straw fiber fabric) at 92.2 percent, and the coconut-straw fiber fabric also retained the greatest amount of compost on the western plots (69.6 percent). The 0.32 cm and 0.64 cm compost blankets had the lowest compost retention on the eastern plots at 10.3 percent and 9.5 percent, respectively. The two tackifier treatments on the western location had the lowest compost retention. The *Plantago*-based tackifier had 4.6 percent retention while the polymer emulsion liquid tackifier had 4.9 percent compost retention.

The two treatments using coconut-straw fiber fabric (plots 10 and 18) and plastic netting (plots 12 and 14) had the highest compost retention rates at the end of the project. However, they did not have the highest vegetation cover at the end of the project (Table 13). Plots 12 and 14 with the plastic netting were both located in the western portion of the project site, which may explain why the amount of compost retained on the plots were similar. The coconut-straw blanket plots 10 and 18 retained the most compost, with an average of 81 percent; however, the average vegetation cover for these plots was only 18.5 percent (Table 11 and Table 12). There was no apparent pattern associated with vegetation cover and compost retention, which was unexpected. Compost remaining on each plot was measured at the same time as the other ground cover measurements (July 2009, June 2010 and August 2010). Cover frames measuring 20 cm x 50 cm were used in each test plot to determine the percent of the ground covered by compost (see Section 6 and Table 13).

shows the compost cover results of each of these monitoring events and the August 2010 vegetation cover results.

7.4. Erosion

The research site was not re-graded prior to test plot construction and a dense network of rills several inches deep were present. Rills formed over a six-year period due to steep slopes, erosive surface material and limited vegetation cover. Erosion monitoring was not conducted prior to construction of the plots and implementation of treatments. It is difficult to determine how much erosion was related to effects of experimental treatments and how much was present prior to initiation of the study. Erosion indices were qualitatively estimated during the 2009 growing season. The same erosion evaluation was conducted in June 2010 (Table 13). It was anticipated that the treated plots would become less erosive over time due to the application of compost, erosion control methods, and the resulting improved vegetation conditions. These erosion condition classes are as follows: stable, slight, moderate, critical and severe, with severe being the most erosive. Scores for each erosion evaluation are included in Appendix C and are summarized in Table 14. Erosion on the set of eastern plots 4–7 decreased from critical to moderate due to the retention of compost, tackifier and establishment of vegetation. Because the tackifier, vegetation and retained compost have acted to slow the velocity of water movement down the slope, some rills have begun to fill in. However, the steep slopes are still erosive and it is difficult to determine if on-going erosion can be correlated with conditions existing prior to the project versus what erosion has occurred since the inception of the project.

Table 14: Qualitative erosion monitoring results from 2009 and 2010.

Plot Number	**Rating** (evaluated in 2009)	**Rating** (evaluated in 2010)
1	Moderate	Moderate
2	Critical	Critical
3	Moderate	Moderate
4	Critical	Moderate
5	Critical	Moderate
6	Critical	Moderate
7	Critical	Moderate
8	Critical	Critical
9	Critical	Critical
10	ecf [1]	ecf
11	Critical	Critical
12	Critical	Critical
13	Critical	Critical
14	Moderate	Moderate
15	Critical	Critical
16	Critical	Critical
17	Critical	Critical
18	ecf	ecf
19	Severe	Severe
20	Severe	Severe
21	Severe	Severe
22	Severe	Severe

[1]ecf: erosion control fabric was opaque and could not rate erosion.

8. COST–BENEFIT ANALYSIS

The application of compost can be directly correlated to reduced erosion and increased establishment and vigor of both seeded and colonizing plants. Too little compost may result in persistent erosion and lack of vegetation establishment, while too much compost results in higher reclamation costs and not necessarily better vegetation establishment. In the 2003–2006 research work, rates of 2.54 cm (1 in) and 5.08 cm (2 in) were evaluated at research plots along U.S. Highway 2 (Jennings *et al*. 2007). Vegetation cover on both the 2.54 and 5.08 cm (1 and 2 in) plots increased compared to the control plot, which had sparse (<2 %) vegetation cover. Mean perennial grass cover was 30 percent in the 2.54 cm (1 in) compost blanket plot and 42.5 percent in the 5.08 cm (2 in) plot after three growing seasons at the Middle Thompson Lake research site. At this same site the mean perennial grass cover after two growing seasons was 24.5 percent on the 2.54 cm (1 in) treatment and 34.8 percent on the 5.08 cm (2 in) treatment. In all cases, erosion was reduced to low levels. In this recently completed research project (2008–2010) research was conducted to develop optimal rates of compost to provide adequate perennial grass cover, control erosion, and at an acceptable and economically feasible cost.

Figure 8 integrates findings from the 2003–2006 research (Jennings *et al*. 2007) with this investigation and shows the linear relationship between perennial grass cover and compost addition. The 1.27 cm (0.5 in) compost rate was normalized by increasing perennial grass cover to reflect the loss of compost due to wind erosion prior to vegetation development. The linear regression intersects the Y-axis at 6.6 percent perennial grass cover, showing the result of broadcast seeding without compost addition.

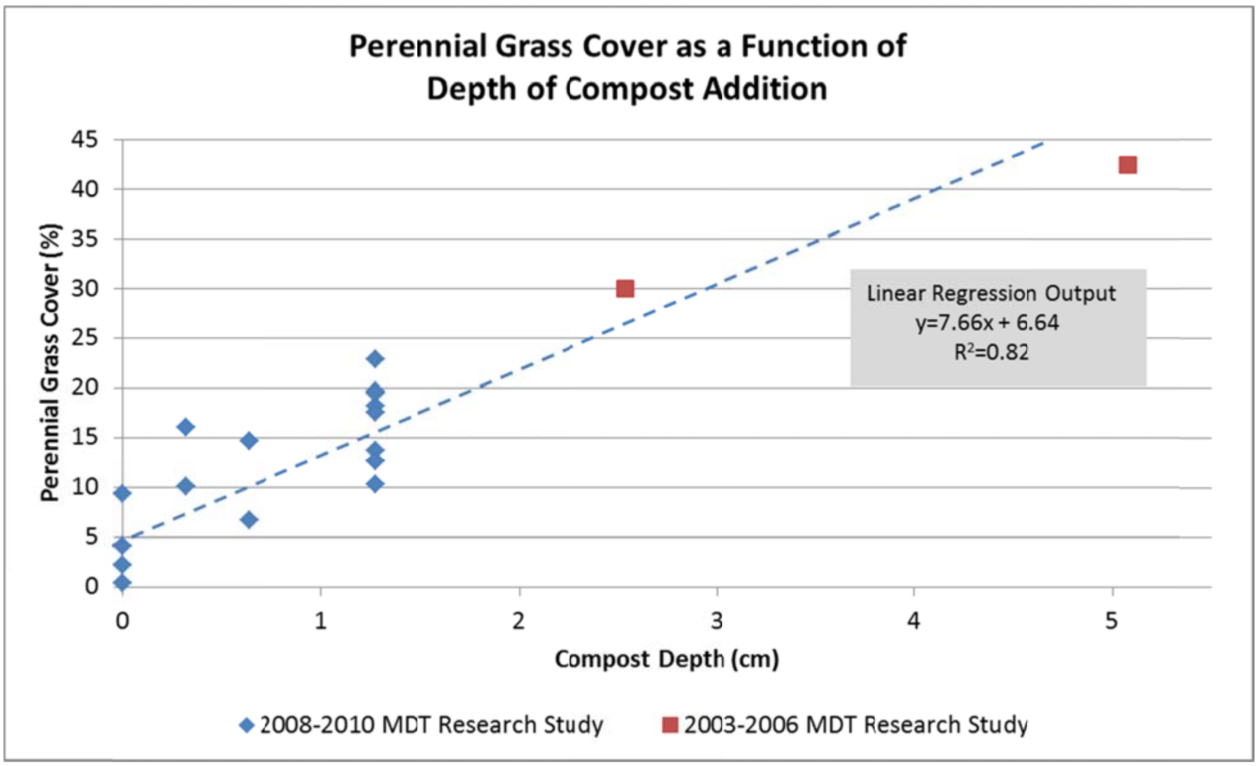

Figure 8: Linear regression of compost depth versus perennial grass cover resulting from varying depths of compost addition in August 2010.

Very high rates of erosion were observed on all research plots without compost addition (2003–2006 study and 2008–2010 study). Very low rates of erosion were observed when perennial grass cover was greater than 30 percent (2003–2006 study). The degree of erosion control in the 2008–2010 study through compost addition is difficult to quantify due to the severely eroded soil surface the plots were constructed into in 2008. These rills have persisted and will take years to heal if sufficient vegetation cover persists. Vegetation cover established in the 2008–2010 study was generally between 10 and 30 percent and provides a modest amount of stabilization and soil protection from rainfall impact.

The linear trend of the August 2010 perennial grass cover for the 18 plots in Figure 8 suggests the amount of perennial grass that can be reasonably expected on a south-facing cut slope with a semi-arid climate receiving 250–500 mm (10–20 in) of annual precipitation. The perennial grass cover can be approximated by Equation 1:

Equation 1: Perennial Grass Cover (%) = 7.66 * (Compost Depth (cm)) + 6.64

Using the regression relationship as a predictor and Equation 1, the tabular results presented in Table 15 show increments of 5 percent perennial grass cover and the amount of compost required for that level of grass establishment.

Table 15: Predicted vegetation response to different depths of compost addition based on a regression analysis (see Equation 1).

Predicted Perennial Grass Cover (%)	Compost Required (cm)	Compost Required (in)
5	0	0
10	0.44	0.17
15	1.09	0.43
20	1.74	0.69
25	2.40	0.94
30	3.05	1.20
35	3.70	1.46
40	4.36	1.71

Compost application costs were investigated and itemized to support the cost–benefit analysis. Recognizing costs for each project are unique and vary, approximate unit costs were obtained from multiple industry sources to facilitate the analysis. Table 16 compares rates of compost addition and associated costs per treatment using netting, fiber erosion control blanket, tackifier, and compost alone. Treatment combinations with low effectiveness due to poor vegetation establishment and high erosion are not recommended. Treatments with good vegetation establishment yet high cost are not recommended solely due to cost. Treatments with good vegetation response and costs of less than $100,000 per hectare (ha) ($40,469 per acre (ac)) are recommended. Several treatments in the middle of the range and with lower costs are attractive and include the 1.27 cm compost addition rate without netting or erosion control fabric, $41,160/ha ($16,657/ac). Such a treatment is predicted to yield 16.4 percent perennial grass cover using the regression relationship shown in Figure 8. The amount of erosion associated with 16.4 percent vegetation cover will vary depending on slope steepness, soil texture and rainfall intensity, yet on many range sites in Montana with comparable vegetation cover notable amounts of erosion have been observed. In terms of cost, the 0.64 cm compost depth with coconut-straw fiber fabric or netting is competitive with the 1.27 cm compost blanket without fabric or netting, yet it is expected to yield marginally effective perennial grass cover of 11.5 percent.

Table 16: Cost–benefit analysis for varying rates of compost and multiple methods to retain compost against erosion. Costs are based on typical Montana compost procurement and delivery costs plus installation of compost on-slope using a blower truck and two laborers.

Compost Depth (cm)	Predicted Native Grass Cover (%)	Predicted Erosion	Broadcast Seed ($/ha)	Compost Blanket[1] ($/ha)	Compost Blanket[1] + Coconut-Straw Fiber Fabric ($/ha)	Compost Blanket[1] + Plastic Netting ($/ha)	Compost Blanket[1] + Water Applied Tackifier ($/ha)
0	6.6	very high	$325	-	-	-	-
0.32	9.1	very high	-	$10,401	$58,220	$34,311	$11,389
0.64	11.5	high	-	$20,654	$68,473	$44,564	$21,642
1.27	16.4	moderate-high	-	$41,160	$88,979	$65,069	$42,148
2.54	26.1	low	-	$82,171	$129,990	$106,081	$83,159
5.08	45.6	very low	-	$164,194	$212,013	$188,104	$165,182

[1] All compost blankets include the cost of broadcast seeding.

9. CONCLUSIONS AND RECOMMENDATIONS

Application of compost to steep cut slopes was demonstrated in research plots developed for the Montana Department of Transportation in two companion research studies during 2003–2006 (Jennings *et al*. 2007) and this project (2008–2010). Varying rates of compost were applied to nutrient-poor parent materials lacking organic matter. Compost was applied to slopes up to 40 m in length and up to 70 percent in steepness by a compost blower truck.

Establishment of perennial grass species from seed was successful when broadcast seeded prior to compost application. Increasing vegetation canopy cover was observed with increasing rates of compost. Construction methods that limit the duration of time compost is exposed to wind and water erosion before the seedings can establish vegetation is encouraged.

Desirable growth media characteristics were improved by compost addition at all depths. Organic matter was increased as were plant macronutrients nitrogen, phosphorous, and potassium. Only a fraction of the total nutrient pool was available to plants during the final soil monitoring event occurring in August 2010, suggesting a long-term supply of nutrients would be available for plant growth over a period of many years.

Erosion decreased with increased compost blanket thickness, particularly when the compost thickness exceeded 2.54 cm (1 in).

Light compost application rates of 0.32 and 0.64 cm resulted in less than 10 percent perennial grass cover and had a limited positive effect on erosion control. Although lower rates resulted in reduced costs, the vegetation establishment was less than ideal. Compost rates between 1.27 and 2.54 cm are recommended and can be expected to yield approximately 16–26 percent live perennial grass cover in a semi-arid climate in Montana. These are the recommended rates since they balance erosion control, vegetation establishment, and cost.

Erosion control blankets or mesh netting are recommended for use in windy areas. Both physical retention treatments - coconut-straw fiber erosion control blanket or lightweight plastic netting - were effective in limiting the loss of applied compost. Plastic netting is recommended since it was more cost effective. Although not used in this study, biodegradable mesh netting could also be used. The 1.27 cm compost application with plastic netting utilized for retention at this project site was estimated to cost $65,069/ha ($26,333/ac).

The three tackifiers evaluated - polymer emulsion liquid, guar-based water dispersible formulation and *Plantago*-based seed husk powder - gave confounding results due to a large wind gradient present at the site, so no recommendation can be made.

Compost application rates between 1.27 and 2.54 cm are recommended for establishment of sufficient vegetation cover to control erosion. These recommended application rates are estimated to cost between $41,160/ha ($16,657/ac) and $82,171/ha ($33,254/ac) based on the plot construction methods from this study using a blower truck. Costs may vary in other locations and by using other methods.

10.REFERENCES

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11. APPENDIX A – PHOTOGRAPHS

Plot 1 before Treatment

Plot 1 after Treatment

Plot 1 April 2009

Plot 1 July 2009

Plot 1 June 2010

Plot 1 August 2010

Plot 2 before Treatment

Plot 2 after Treatment

Plot 2 April 2009

Plot 2 July 2009

Plot 2 June 2010

Plot 2 August 2010

Plot 3 before Treatment

Plot 3 after Treatment

Plot 3 April 2009

Plot 3 July 2009

Plot 3 June 2010

Plot 3 August 2010

Plot 4 before Treatment

Plot 4 after Treatment

Plot 4 April 2009

 Plot 4 July 2009	 Plot 4 June 2010	 Plot 4 August 2010

 Plot 5 before Treatment	 Plot 5 after Treatment	 Plot 5 April 2009
 Plot 5 July 2009	 Plot 5 June 2010	 Plot 5 August 2010

Plot 6 before Treatment

Plot 6 after Treatment

Plot 6 April 2009

Plot 6 July 2009

Plot 6 June 2010

Plot 6 August 2010

Plot 7 before Treatment

Plot 7 after Treatment

Plot 7 April 2009

Plot 7 July 2009

Plot 7 June 2010

Plot 7 August 2010

Plot 8 before Treatment

Plot 8 after Treatment

Plot 8 April 2009

Plot 8 July 2009

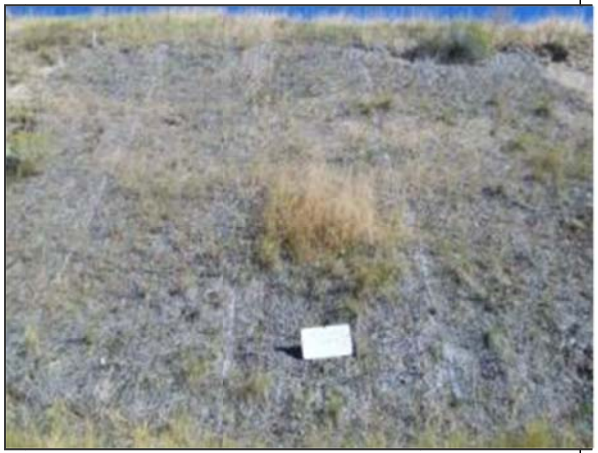
Plot 8 June 2010

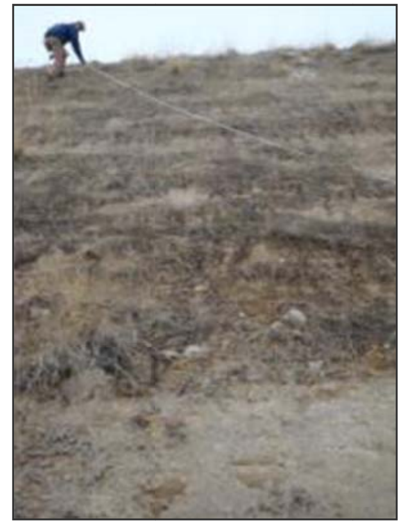
Plot 8 August 2010

		
Plot 9 before Treatment	Plot 9 after Treatment	Plot 9 April 2009

 Plot 9 July 2009	 Plot 9 June 2010	 Plot 9 August 2010

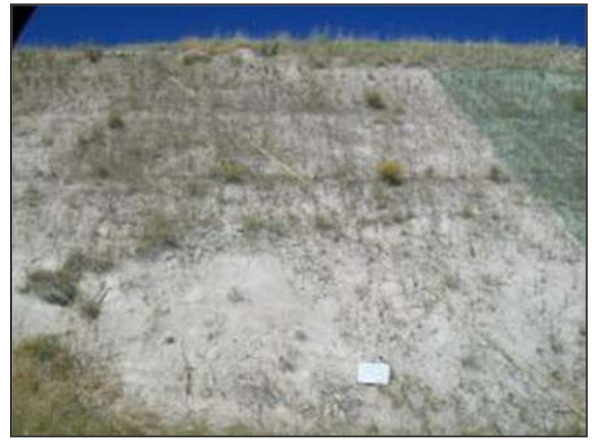
 Plot 10 before Treatment	 Plot 10 after Treatment	 Plot 10 April 2009

 Plot 10 July 2009	 Plot 10 June 2010	 Plot 10 August 2010

 Plot 11 before Treatment	 Plot 11 after Treatment	 Plot 11 April 2009

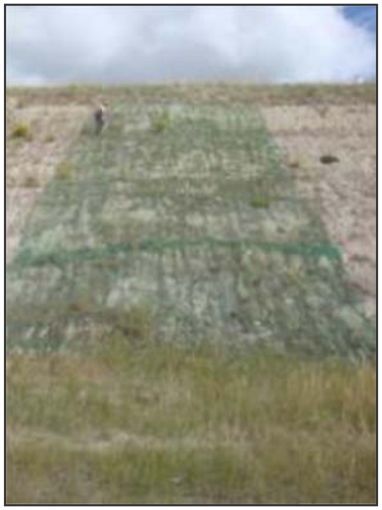
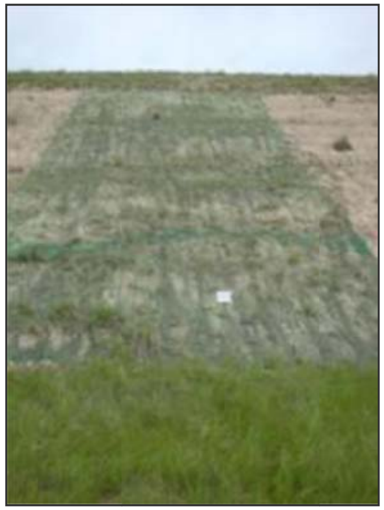
Plot 11 July 2009

Plot 11 June 2010

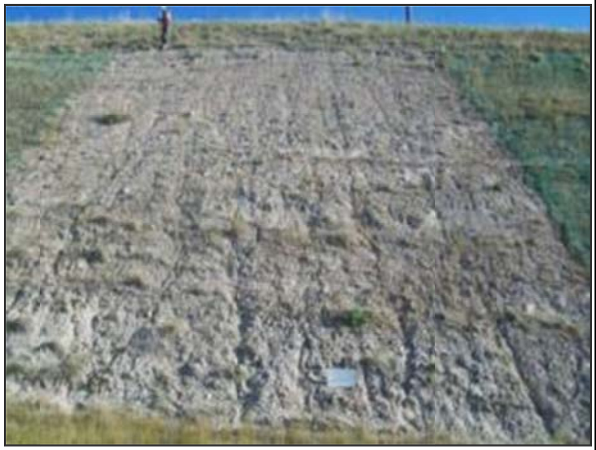


Plot 11 August 2010

 Plot 12 before Treatment	 Plot 12 after Treatment	 Plot 12 April 2009

 Plot 12 July 2009	 Plot 12 June 2010	 Plot 12 August 2010

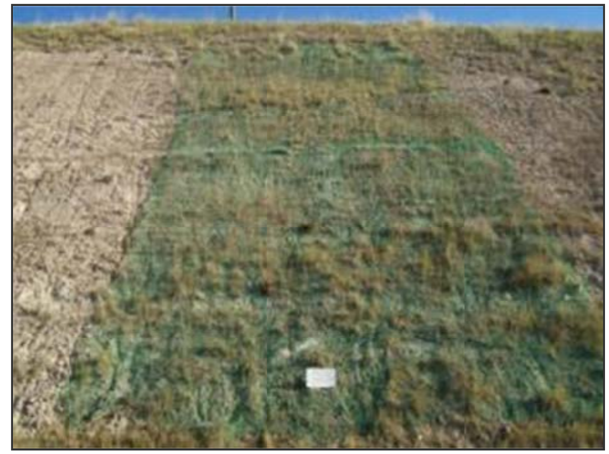
 Plot 13 before Treatment	 Plot 13 after Treatment	 Plot 13 April 2009

 Plot 13 July 2009	 Plot 13 June 2010	 Plot 13 August 2010

 Plot 14 before Treatment	 Plot 14 after Treatment	 Plot 14 April 2009

Plot 14 July 2009

Plot 14 June 2010



Plot 14 August 2010

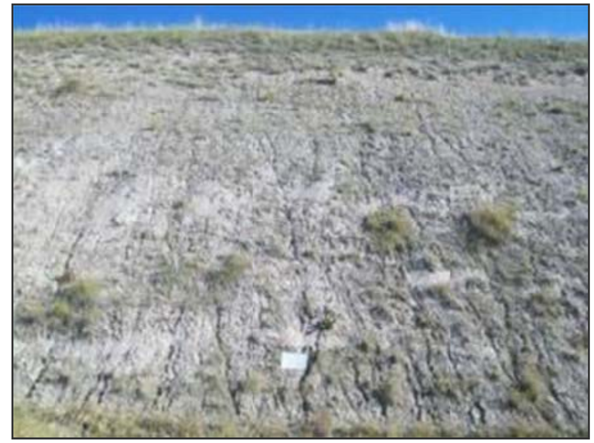
 Plot 15 before Treatment	 Plot 15 after Treatment	 Plot 15 April 2009

Plot 15 July 2009

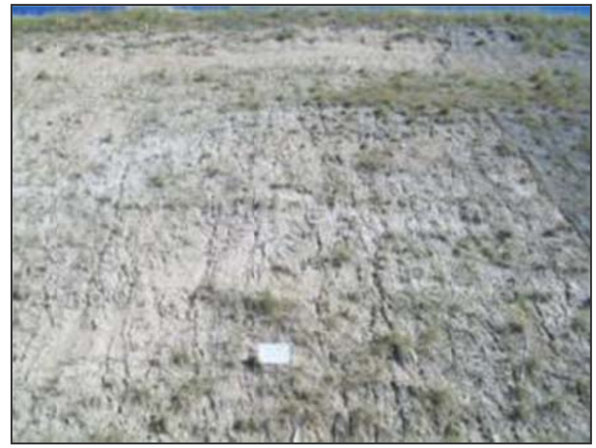
Plot 15 June 2010

Plot 15 August 2010

 Plot 16 before Treatment	 Plot 16 after Treatment	 Plot 16 April 2009

 Plot 16 July 2009	 Plot 16 June 2010	 Plot 16 August 2010

 Plot 17 before Treatment	 Plot 17 after Treatment	 Plot 17 April 2009

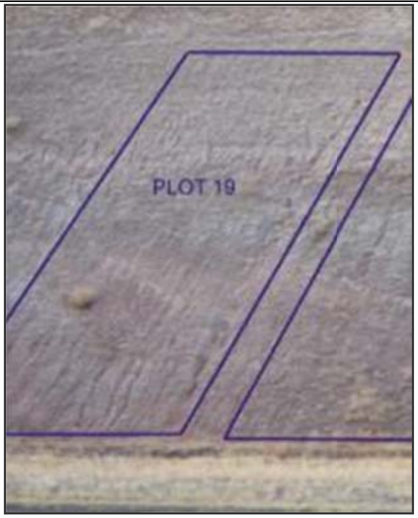
 Plot 17 July 2009	 Plot 17 June 2010	 Plot 17 August 2010

 Plot 18 before Treatment	 Plot 18 after Treatment	 Plot 18 April 2009

Plot 18 July 2009

Plot 18 June 2010

Plot 18 August 2010



Plot 19 before Treatment

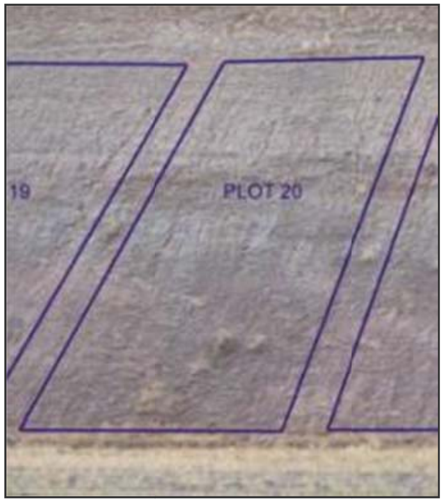
Plot 19 after Treatment

Plot 19-21 May 2009

Plot 19 June 2009

Plot 19 June 2010

Plot 19 August 2010



Plot 20 before Treatment

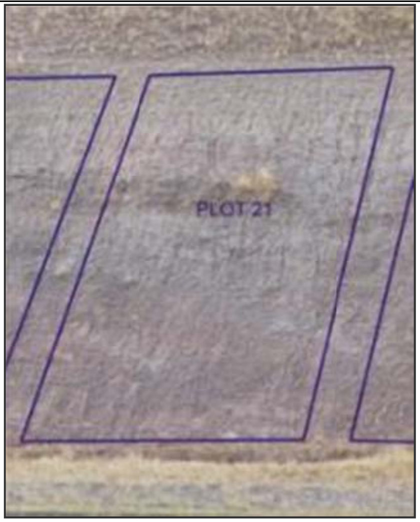
Plot 20 after Treatment

Plot 20 May 2009

Plot 20 June 2009

Plot 20 June 2010

Plot 20 August 2010



Plot 21 before Treatment

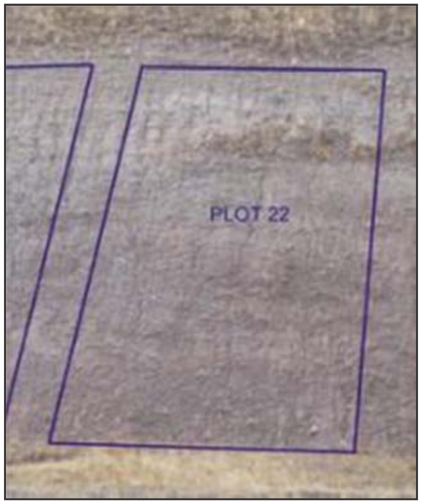
Plot 21 after Treatment

Plot 21 May 2009

Plot 21 June 2009

Plot 21 June 2010

Plot 21 August 2010



Plot 22 before Treatment


Plot 22 after Treatment


Plot 22 May 2009


Plot 22 June 2009


Plot 22 June 2010


Plot 22 August 2010

12. APPENDIX B – VEGETATION AND COMPOST MONITORING DATA

Date July 28 to 30, 2009			Field Team: Pam Blicker, Don Jackson, Loren Barber			Conditions: Partly Cloudy to sunny, slight breeze, 60 to 85°F						
Plot No.	**Frame No.**	**Frame location (ft)**	**Perennial Grass**	**Annual Grass**	**Perennial Forb**	**Annual Forb**	**Shrub**	**Nox. Weeds**	**Compost**	**Litter**	**Rock**	**Bare**
1	1	5R	10	4	0	5	0	0	90	5	1	8
	2	7L	10	0	0	0	0	0	70	3	2	28
	3	11R	30	8	0	8	0	0	95	3	0	3
	4	14L	30	3	0	12	0	0	95	7	0	1
	5	17R	18	0	0	8	0	0	90	5	1	6
	6	21L	30	5	0	8	0	0	95	5	1	
	7	25R	10	0	0	8	0	0	80	25	1	10
	8	27L	5	7	0	8	0	0	50	15	0	20
	9	31R	8	3	0	3	0	0	95	2	0	3
	10	34L	15	0	0	4	0	0	40	15	1	40
		Average	16.6	3	0	6.4	0	0	80	8.5	0.7	13.2
2	1	5R	5	5	0	0	0	0	0	4	1	95
	2	7L	8	1	0	0	0	0	0	10	1	90
	3	11R	12	8	0	1	0	0	0	5	0	90
	4	14L	8	0	0	0	0	0	0	4	0	95
	5	17R	10	0	0	2	0	0	0	7	3	90
	6	21L	10	4	0	4	0	0	0	10	0	90
	7	25R	2	12	0	8	0	0	0	10	0	87
	8	27L	0	15	0	0	0	0	0	35	5	60
	9	31R	0	0	0	2	0	0	0	5	0	93
	10	34L	70	8	0	0	0	0	0	45	0	25
		Average	12.5	5.3	0	1.7	0	0	0	13.5	1	81.5

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare
3	1	5R	12	0	0	7	0	0	55	10	3	40
	2	7L	10	0	0	17	0	0	85	3	3	12
	3	11R	10	0	0	0	0	0	100	4	0	0
	4	14L	0	4	0	7	0	0	65	8	1	30
	5	17R	4	3	0	4	0	0	85	1	3	12
	6	21L	8	8	0	13	0	0	90	4	3	5
	7	25R	2	10	0	15	0	0	40	10	2	45
	8	27L	3	20	0	10	0	0	60	25	3	15
	9	31R	2	0	5	35	0	0	3	30	0	65
	10	34L	4	15	0	2	0	0	3	35	0	60
		Average	5.5	6	0.5	11	0	0	58.6	13	1.8	28.4
4	1	5R	7	0	0	35	0	0	95	5	3	2
	2	7L	20	8	0	15	0	0	98	5	0	2
	3	11R	8	0	0	12	0	0	25	3	3	65
	4	14L	15	0	0	12	0	0	50	2	3	40
	5	17R	7	0	0	8	0	0	20	3	2	75
	6	21L	4	0	0	3	0	0	7	10	1	80
	7	25R	15	7	2	10	0	0	90	12	0	7
	8	27L	20	5	0	0	0	0	85	15	0	5
	9	31R	0	20	3	4	0	0	50	10	1	45
	10	34L	3	10	1	0	0	0	35	10	3	60
		Average	9.9	5	0.6	9.9	0	0	55.5	7.5	1.6	38.1

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare
5	1	5R	4	2	2	18	0	0	25	7	5	60
	2	7L	4	0	0	17	0	0	80	5	2	10
	3	11R	3	0	0	15	0	15	10	4	0	80
	4	14L	5	0	0	12	0	0	40	7	0	45
	5	17R	20	0	0	10	0	0	10	10	3	8
	6	21L	8	0	8	7	0	0	90	5	0	5
	7	25R	20	0	0	13	0	2	93	12	0	3
	8	27L	3	0	16	9	0	0	80	4	0	16
	9	31R	10	2	0	3	0	0	10	3	4	85
	10	34L	3	1	0	10	0	0	7	4	2	85
		Average	8	0.5	2.6	11.4	0	1.7	44.5	6.1	1.6	39.7

6	1	5R	15	0	0	5	0	0	85	5	2	8
	2	7L	8	0	0	20	0	0	50	5	5	40
	3	11R	8	0	0	8	0	0	95	1	6	1
	4	14L	18	0	0	20	0	0	95	15	2	2
	5	17R	10	0	0	30	0	0	98	4	0	1
	6	21L	15	0	0	20	0	0	60	5	3	35
	7	25R	0	3	0	10	0	0	25	7	3	70
	8	27L	5	3	0	40	0	0	55	25	3	25
	9	31R	3	3	0	4	0	0	3	10	3	90
	10	34L	0	2	0	12	0	0	2	20	2	80
		Average	8.2	1.1	0	16.9	0	0	56.8	9.7	2.9	35.2

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare
7	1	5R	30	2	0	2	0	0	75	8	10	10
	2	7L	20	0	0	7	0	0	55	10	5	25
	3	11R	20	0	0	5	0	0	75	8	3	20
	4	14L	15	4	0	2	0	0	60	20	3	15
	5	17R	20	5	0	13	0	0	10	4	2	80
	6	21L	18	0	8	12	0	0	90	10	2	3
	7	25R	80	10	2	3	0	0	50	35	2	5
	8	27L	2	5	0	8	0	0	30	3	3	60
	9	31R	0	70	0	0	0	0	5	60	2	25
	10	34L	0	60	0	0	0	0	5	55	4	15
		Average	20.5	15.6	1	5.2	0	0	45.5	21.3	3.6	25.8
8	1	5R	0	0	0	8	0	0	20	10	10	70
	2	7L	3	0	0	3	0	0	3	2	2	93
	3	11R	7	2	0	6	0	0	20	8	10	70
	4	14L	20	0	0	8	0	0	60	8	10	15
	5	17R	7	0	0	7	0	0	20	3	20	60
	6	21L	10	2	0	20	0	0	20	5	25	50
	7	25R	50	20	0	3	0	0	10	50	10	15
	8	27L	0	0	0	15	0	0	1	5	5	90
	9	31R	8	20	0	4	0	0	0	40	40	20
	10	34L	40	30	0	0	0	0	0	60	5	10
		Average	14.5	7.4	0	7.4	0	0	15.4	19.1	13.7	49.3

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare
9	1	5R	3	3	0	20	0	0	50	17	30	20
	2	7L	35	0	0	10	0	0	50	17	15	25
	3	11R	18	3	0	12	0	0	5	5	18	60
	4	14L	0	0	0	0	0	0	2	2	3	93
	5	17R	65	7	0	5	0	0	70	40	20	5
	6	21L	8	4	0	7	0	0	45	2	30	25
	7	25R	5		0	60	0	0	50	5	20	25
	8	27L	8	2	0	15	0	0	2	2	20	80
	9	31R	5	2	0	6	0	0	3	3	65	35
	10	34L	10	0	12	0	0	0	12	7	50	35
		Average	15.7	2.3	1.2	13.5	0	0	28.9	10	27.1	40.3
10	1	5R	3	0	0	12			100	3	0	
	2	7L	2	0	0	8	0	0	95	2	0	5
	3	11R	10	3	0	5	0	0	0	0	0	0
	4	14L	5	0	0	3	0	0	0	2	0	0
	5	17R	7	25	0	5	0	0	0	2	0	0
	6	21L	20	5	0	0	0	0	0	2	0	0
	7	25R	8	15	0	0	0	0	0	1	0	0
	8	27L	8	2	0	3	0	0	0	1	0	0
	9	31R	2	8	0	30	0	0	0	2	0	0
	10	34L	8	20	0	7	0	0	0	2	0	0
		Average	7.3	7.8	0	7.3	0	0	19.5	1.7	0	0.56

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare
11	1	6R	15	0	0	0	0	0	7	3	0	90
	2	11L	2	0	0	0	0	0	2	3	0	95
	3	15R	6	0	0	6	0	0	8	10	0	85
	4	20L	12	4	0	3	0	0	25	3	1	60
	5	23R	0	0	0	15	0	0	15	10	0	60
	6	30L	15	0	0	10	0	0	20	5	2	65
	7	35R	15	0	0	10	0	0	45	10	1	40
	8	40L	5	5	0	30	0	0	15	5	3	70
	9	51R	3	0	0	15	0	0	35	0	3	55
	10	53L	5	0	0	50	0	0	25	5	8	50
		Average	7.8	0.9	0	13.9	0	0	19.7	5.4	1.8	67
12	1	6R	8	0	0	15	0	0	75	5	2	20
	2	11L	0	0	0	20	0	0	75	2	2	20
	3	15R	0	0	0	20	0	0	70	3	2	22
	4	20L	0	0	0	20	0	0	5	3	0	93
	5	23R	10	0	0	15	0	0	80	3	1	18
	6	30L	10	0	0	20	0	0	65	4	3	27
	7	35R	12	0	0	10	0	0	45	5	0	45
	8	40L	10	0	0	25	0	0	85	3	0	10
	9	51R	4	0	0	8	0	0	30	1	0	70
	10	53L	15	0	0	20	0	0	50	2	1	40
		Average	6.9	0	0	17.3	0	0	58	3.1	1.1	36.5

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare
13	1	6R	18	0	0	3	0	0	0	8	7	90
	2	11L	5	0	0	3	0	0	0	8	1	93
	3	15R	12	0	0	0	0	0	0	25	3	72
	4	20L	3	0	0	5	0	0	0	0	2	97
	5	23R	2	0	0	1	0	0	0	3	1	97
	6	30L	2	0	0	4	0	0	0	5	10	87
	7	35R	5	0	0	5	0	0	0	8	20	75
	8	40L	15	0	20	0	0	0	0	15	7	65
	9	51R	2	0	0	4	0	0	0	10	5	85
	10	53L	4	0	0	10	0	0	0	2	5	90
		Average	6.8	0	2	3.5	0	0	0	8.4	6.1	85.1
14	1	6R	12	2	0	8	0	0	70	5	2	20
	2	11L	7	4	0	20	0	0	80	10	7	10
	3	15R	30	0	0	23	0	0	85	5	2	5
	4	20L	4	0	0	23	0	0	20	3	2	75
	5	23R	0	0	0	8	0	0	5	1	1	95
	6	30L	10	0	0	18	0	0	20	5	1	70
	7	35R	18	0	0	10	0	0	60	10	2	35
	8	40L	8	3	0	10	0	0	50	5	1	45
	9	51R	8	10	0	15	0	0	35	3	10	45
	10	53L	18	8	0	15	0	0	65	10	4	18
		Average	11.5	2.7	0	15	0	0	49	5.7	3.2	41.8

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare
15	1	6R	8	0	0	3	0	0	5	5	10	80
	2	11L	4	0	0	4	0	0	15	8	5	70
	3	15R	25	0	0	4	0	0	8	8	8	75
	4	20L	5	0	0	8	0	0	3	1	50	45
	5	23R	10	0	0	30	0	0	0	8	3	87
	6	30L	17	0	0	8	0	0	85	7	3	10
	7	35R	20	3	0	25	0	0	15	5	15	50
	8	40L	0	0	0	15	0	0	5	3	10	83
	9	51R	8	0	0	5	0	0	8	3	15	80
	10	53L	4	0	0	10	0	0	3	1	3	92
		Average	10.1	0.3	0	11.2	0	0	14.7	4.9	12.2	67.2
16	1	6R	25	0	0	5	0	0	45	15	2	33
	2	11L	40	0	0	5	0	0	5	8	15	65
	3	15R	25	2	0	4	0	0	15	20	2	70
	4	20L	15	0	0	10	0	0	3	5	3	87
	5	23R	20	0	0	4	0	0	10	20	10	50
	6	30L	10	0	0	8	0	0	2	8	10	87
	7	35R	2	0	0	7	0	0	3	5	10	93
	8	40L	7	0	0	0	0	0	10	2	3	90
	9	51R	4	0	0	20	0	0	5	2	10	87
	10	53L	5	0	0	3	0	0	15	2	3	83
		Average	15.3	0.2	0	6.6	0	0	11.3	8.7	6.8	74.5

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare
17	1	6R	12	0	0	15	0	0	8	5	5	80
	2	11L	18	0	0	10	0	0	10	8	5	75
	3	15R	8	0	0	0	0	0	3	8	5	83
	4	20L	15	0	0	20	0	0	7	3	8	80
	5	23R	2	0	0	18	0	0	7	10	8	73
	6	30L	0	0	0	5	0	0	2	1	40	57
	7	35R	60	0	0	0	0	0	50	25	3	25
	8	40L	12	0	0	3	0	0	7	4	10	83
	9	51R	0	0	0	0	0	0	4	0	15	91
	10	53L	0	0	0	0	0	0	2	0	7	91
		Average	12.7	0	0	7.1	0	0	10	6.4	10.6	73.8
18	1	6R	20	0	0	8	0	0	0	0	0	0
	2	11L	15	0	0	10	0	0	0	0	0	0
	3	15R	12	0	0	7	0	0	0	0	0	0
	4	20L	7	0	0	18	0	0	0	0	0	0
	5	23R	15	0	0	8	0	0	0	0	0	0
	6	30L	50	0	0	12	0	0	0	0	0	0
	7	35R	30	0	0	1	0	0	0	0	0	0
	8	40L	55	0	0	0	0	0	0	0	0	0
	9	51R	4	0	0	4	0	0	0	0	0	0
	10	53L	6	0	0	18	0	0	0	0	0	0
		Average	21.4	0	0	8.6	0	0	0	0	0	0

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare
19	1	8R	3	0	0	5	0	0	0	4	4	90
	2	12L	12	0	0	10	0	0	0	8	1	85
	3	15R	5	0	0	0	0	0	0	4	8	90
	4	25L	0	0	0	2	0	0	0	3	2	97
	5	30R	3	0	0	1	0	0	0	10	30	67
	6	37L	30	2	0	5	0	0	0	10	2	80
	7	48R	4	0	0	4	0	0	0	5	4	90
	8	51L	8	0	0	3	0	0	0	8	10	80
	9	53R	6	1	0	0	0	0	0	5	3	90
	10	66L	8	0	0	0	0	0	0	7	1	92
		Average	7.9	0.3	0	3	0	0	0	6.4	6.5	86.1
20	1	8R	15	0	0	10	0	0	50	8	10	30
	2	12L	15	2	0	15	0	0	45	10	4	35
	3	15R	13	0	0	1	0	0	85	2	2	8
	4	25L	4	0	0	3	0	0	45	8	10	45
	5	30R	17	0	0	0	0	0	55	8	4	30
	6	37L	25	0	0	5	0	0	80	12	2	8
	7	48R	25	3	0	2	0	0	70	2	3	20
	8	51L	10	0	0	4	0	0	15	7	4	83
	9	53R	4	0	0	5	0	0	15	4	3	80
	10	66L	18	0	0	0	0	0	35	7	2	40
		Average	14.6	0.5	0	4.5	0	0	49.5	6.8	4.4	37.9

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare
21	1	8R	6	4	0	8	0	0	70	7	15	12
	2	12L	20	3	0	8	0	0	95	2		3
	3	15R	20	0	0	4	0	0	75	8	8	8
	4	25L	10	0	0	3	0	0	80	4	4	8
	5	30R	8	0	0	4	0	0	70	15	3	12
	6	37L	30	0	0	12	0	0	75	10	1	15
	7	48R	8	0	0	8	0	0	35	5	2	60
	8	51L	10	0	5	3	0	0	30	10	2	60
	9	53R	13	0	0	6	0	0	50	7	2	40
	10	66L	65	0	0	1	0	0	50	20	2	20
		Average	19	0.7	0.5	5.7	0	0	63	8.8	4.3	23.8
22	1	8R	6	0	0	4	0	0	20	10	5	63
	2	12L	20	0	0	4	0	0	8	20	8	65
	3	15R	10	0	0	7	0	0	25	10	5	58
	4	25L	60	0	0	2	0	0	5	60	2	25
	5	30R	12	0	0	8	0	0	18	8	2	73
	6	37L	8	0	0	8	0	0	25	15	5	50
	7	48R	20	0	0	0	0	0	3	10	4	90
	8	51L	60	0	0	0	0	0	20	30		25
	9	53R	15	0	0	10	0	0	1	4	2	90
	10	66L	25	0	0	0	0	0	5	15	3	78
		Average	23.6	0	0	4.3	0	0	13	18.2	4	61.7

Date: June 22 and 25, 2010			Field Team: Pam Blicker and Loren Barber			Conditions: (22nd) Sunny, 70 to 80 °F; (25th) Sunny to partly cloudy, 75 to 80 °F								
Plot No.	**Frame No.**	**Frame location (ft)**	**Perennial Grass**	**Annual Grass**	**Perennial Forb**	**Annual Forb**	**Total Plant cover**	**Shrub**	**Nox. Weeds**	**Compost**	**Litter**	**Rock**	**Bare**	**Total Ground Cover**
1	1	5R	0	4	0	3	7	0	0	83	1	5	10	99
	2	7L	3	8	0	10	21	0	0	50	1	27	15	93
	3	11R	40	35	0	1	76	0	0	85	10	0	2	97
	4	14L	65	5	0	0	70	0	0	85	7	1	2	95
	5	17R	8	25	0	4	37	0	0	77	7	0	15	99
	6	21L	35	25	0	4	64	0	0	88	10	0	2	100
	7	25R	25	0	0	3	28	0	0	60	25	1	10	96
	8	27L	4	18	0	5	27	0	0	75	8	4	10	97
	9	31R	1	30	0	15	46	0	0	60	5	5	15	85
	10	34L	55	2	0	5	62	0	0	45	8	3	30	86
		Average	23.6	15.2	0	5	43.8	0	0	70.8	8.2	4.6	11.1	94.7
2	1	5R	1	0	0	0	1	0	0	0	2	1	96	99
	2	7L	2	0	0	0	2	0	0	0	7	1	90	98
	3	11R	35	0	0	0	35	0	0	0	40	1	55	96
	4	14L	1	1	0	0	2	0	0	0	4	1	95	100
	5	17R	1	5	0	1	7	0	0	0	4	1	94	99
	6	21L	0	8	0	7	15	0	0	0	3	6	90	99
	7	25R	12	1	0	0	13	0	0	0	8	1	85	94
	8	27L	12	35	0	1	48	0	0	0	10	1	85	96
	9	31R	0	7	0	2	9	0	0	0	2	1	97	100
	10	34L	10	0	0	4	14		0	0	2	1	92	95
		Average	7.4	5.7	0	1.5	14.6	0	0	0	8.2	1.5	87.9	97.6

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
3	1	5R	6	0	0	2	8	0	0	50	6	3	35	94
	2	7L	15	3	0	5	23	0	0	90	8	2	0	100
	3	11R	3	5	0	1	9	0	0	75	10	8	5	98
	4	14L	0	3	20	5	28	0	0	65	8	4	10	87
	5	17R	8	3	0	3	14	0	0	75	5	3	15	98
	6	21L	2	20	0	1	23	0	0	50	5	3	40	98
	7	25R	3	20	0	6	29	0	0	5	10	2	75	92
	8	27L	3	15	0	8	26	0	0	35	22	5	35	97
	9	31R	6	50	0	15	71	0	0	3	20	6	55	84
	10	34L	8	25	0	18	51	0	0	3	40	2	40	85
		Average	5.4	14.4	2	6.4	28.2	0	0	45.1	13.4	3.8	31	93.3

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
4	1	5R	60	0	0	1	61	0	0	90	8	0	2	100
	2	7L	45	2	0	0	47	0	0	83	10	1	6	100
	3	11R	50	0	0	1	51	0	0	40	15	2	30	87
	4	14L	20	0	0	0	20	0	0	50	8	3	35	96
	5	17R	10	0	0	4	14	0	0	28	18	2	50	98
	6	21L	0	0	0	2	2	0	0	2	4	55	35	96
	7	25R	12	12	0	8	32	0	0	78	10	2	8	98
	8	27L	0	14	10	0	24	0	0	85	10	2	2	99
	9	31R	2	17	55	0	74	0	0	40	20	5	35	100
	10	34L	25	60	0	0	85	0	0	92	10	1	1	104
		Average	22.4	10.5	6.5	1.6	41	0	0	58.8	11.3	7.3	20.4	97.8

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
5	1	5R	5	0	0	3	8	0	0	30	18	3	45	96
	2	7L	18	0	0	0	18	0	0	70	10	1	20	101
	3	11R	0	1	0	0	1	0	10	35	5	1	50	101
	4	14L	12	0	0	6	18	0	0	65	8	1	23	97
	5	17R	18	0	4	5	27	0	0	40	10	1	45	96
	6	21L	3	5	25	1	34	0	0	75	5	4	15	99
	7	25R	15	4	8	5	32	0	0	70	20	3	7	100
	8	27L	15	0	15	1	31	0	0	35	15	6	35	91
	9	31R	4	5	0	25	34	0	0	8	5	3	65	81
	10	34L	15	0	0	12	27	0	0	2	12	2	70	86
		Average	10.5	1.5	5.2	5.8	23	0	1	43	10.8	2.5	37.5	94.8
6	1	5R	45	0	0	1	46	0	0	85	10	0	3	98
	2	7L	4	0	0	4	8	0	0	45	10	6	35	96
	3	11R	25	0	0	3	28	0	0	80	10	1	10	101
	4	14L	50	0	0	2	52	0	0	75	15	4	5	99
	5	17R	60	0	0	2	62	0	0	82	10	1	1	94
	6	21L	12	0	0	6	18	0	0	55	5	2	30	92
	7	25R	10	15	0	6	31	0	0	60	20	5	15	100
	8	27L	1	5	0	8	14	0	0	50	4	5	35	94
	9	31R	10	5	0	4	19	0	0	4	10	5	70	89
	10	34L	10	0	0	8	18	0	0	1	8	1	85	95
		Average	22.7	2.5	0	4.4	29.6	0	0	53.7	10.2	3	28.9	95.8

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
7	1	5R	30	3	0	3	36	0	0	75	15	5	8	103
	2	7L	40	0	0	5	45	0	0	75	15	0	5	95
	3	11R	25	3	0	1	29	0	0	75	8	1	10	94
	4	14L	65	0	0	3	68	0	0	40	40	0	8	88
	5	17R	6	5	0	45	56	0	0	5	5	5	75	90
	6	21L	30	0	0	3	33	0	0	55	18	6	12	91
	7	25R	40	25	0	0	65	0	0	60	20	5	7	92
	8	27L	0	10	0	1	11	0	0	1	1	5	90	97
	9	31R	0	80	0	4	84	0	0	2	65	2	15	84
	10	34L	0	85	0	5	90	0	0	15	25	0	38	78
		Average	23.6	21.1	0	7	51.7	0	0	40.3	21.2	2.9	26.8	91.2
8	1	5R	0	0	0	4	4	0	0	20	8	15	55	98
	2	7L	0	0	0	0	0	0	0	4	5	2	90	101
	3	11R	12	3	0	0	15	0	0	65	8	8	15	96
	4	14L	15	2	0	1	18	0	0	25	15	8	40	88
	5	17R	1	0	0	1	2	0	0	10	5	15	65	95
	6	21L	35	5	0	3	43	0	0	20	30	12	25	87
	7	25R	60	10	0	0	70	0	0	0	60	8	20	88
	8	27L	0	4	0	4	8	0	0	0	2	10	85	97
	9	31R	35	20	0	2	57	0	0	0	35	30	20	85
	10	34L	35	30	0	8	73	0	0	2	65	8	5	80
		Average	19.3	7.4	0	2.3	29	0	0	14.6	23.3	11.6	42	91.5

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
9	1	5R	5	8	0	0	13	0	0	60	8	12	15	95
	2	7L	20	0	0	0	20	0	0	20	20	12	38	90
	3	11R	25	0	0	5	30	0	0	18	4	20	50	92
	4	14L	0	0	0	1	1	0	0	12	2	10	75	99
	5	17R	65	0	0	0	65	0	0	10	35	12	18	75
	6	21L	15	0	0	1	16	0	0	10	5	35	45	95
	7	25R	15	10	0	1	26	0	0	5	20	50	20	95
	8	27L	4	0	0	0	4	0	0	1	10	50	40	101
	9	31R	20	2	0	2	24	0	0	2	5	40	50	97
	10	34L	30	0	0	15	45	0	0	15	25	25	30	95
		Average	19.9	2	0	2.5	24.4	0	0	15.3	13.4	26.6	38.1	93.4
10	1	5R	15	3	0	0	18	0	0	0	0	0	0	0
	2	7L	20	0	0	0	20	0	0	0	0	0	0	0
	3	11R	12	10	0	4	26	0	0	0	0	0	0	0
	4	14L	4	28	0	5	37	0	0	0	0	0	0	0
	5	17R	1	60	0	5	66	0	0	0	0	0	0	0
	6	21L	12	30	0	0	42	0	0	0	0	0	0	0
	7	25R	8	18	0	0	26	0	0	0	0	0	0	0
	8	27L	4	8	0	1	13	0	0	0	0	0	0	0
	9	31R	0	40	0	0	40	0	0	0	0	0	0	0
	10	34L	10	20	0	0	30	0	0	0	0	0	0	0
		Average	8.6	21.7	0	1.5	31.8	0	0	0	0	0	0	0

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
11	1	6R	20	0	0	1	21	0	0	5	5	5	65	80
	2	11L	0	0	0	8	8	0	0	2	6	4	88	100
	3	15R	10	0	0	10	20	0	0	3	8	6	75	92
	4	20L	10	2	0	10	22	0	0	20	10	8	55	93
	5	23R	5	0	0	15	20	0	0	8	12	4	73	97
	6	30L	20	0	0	12	32	0	0	12	30	3	48	93
	7	35R	35	0	0	15	50	0	0	45	18	7	20	90
	8	40L	5	0	0	18	23	0	0	8	40	8	40	96
	9	51R	4	0	0	4	8	0	0	6	10	8	75	99
	10	53L	20	1	0	8	29	0	0	3	20	3	67	93
		Average	12.9	0.3	0	10.1	23.3	0	0	11.2	15.9	5.6	60.6	93.3
12	1	6R	0	0	0	0	0	0	0	75	8	8	10	101
	2	11L	0	0	0	10	10	0	0	55	8	2	35	100
	3	15R	10	0	0	3	13	0	0	70	10	1	18	99
	4	20L	0	0	0	20	20	0	0	20	12	4	60	96
	5	23R	10	0	0	25	35	0	0	65	18	2	8	93
	6	30L	8	0	0	30	38	0	0	35	40	8	15	98
	7	35R	4	0	0	20	24	0	0	55	8	3	35	101
	8	40L	8	0	0	12	20	0	0	65	10	1	20	96
	9	51R	0	0	0	8	8	0	0	6	12	1	80	99
	10	53L	45	0	0	0	45	0	0	45	10	3	35	93
		Average	8.5	0	0	12.8	21.3	0	0	49.1	13.6	3.3	31.6	97.6

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
13	1	6R	1	0	0	15	16	0	0	0	6	5	85	96
	2	11L	0	0	0	20	20	0	0	0	5	2	90	97
	3	15R	10	0	0	6	16	0	0	0	15	3	80	98
	4	20L	1	0	0	5	6	0	0	0	3	2	95	100
	5	23R	0	0	0	15	15	0	0	0	6	6	85	97
	6	30L	1	0	0	10	11	0	0	0	3	15	80	98
	7	35R	0	0	0	3	3	0	0	0	8	12	80	100
	8	40L	15	0	18	0	33	0	0	0	10	5	75	90
	9	51R	2	0	0	5	7	0	0	0	8	12	80	100
	10	53L	0	0	0	7	7	0	0	0	7	1	90	98
		Average	3	0	1.8	8.6	13.4	0	0	0	7.1	6.3	84	97.4
14	1	6R	8	0	0	3	11	0	0	35	6	15	40	96
	2	11L	8	0	0	8	16	0	0	55	25	3	15	98
	3	15R	40	0	0	6	46	0	0	65	10	7	12	94
	4	20L	1	0	0	20	21	0	0	7	4	4	80	95
	5	23R	2	0	0	8	10	0	0	25	15	3	35	78
	6	30L	15	0	0	8	23	0	0	20	20	3	50	93
	7	35R	2	15	0	8	25	0	0	80	15	1	5	101
	8	40L	8	1	0	1	10	0	0	8	15	4	70	97
	9	51R	10	25	0	1	36	0	0	65	15	3	15	98
	10	53L	20	35	0	20	75	0	0	80	10	5	3	98
		Average	11.4	7.6	0	8.3	27.3	0	0	44	13.5	4.8	32.5	94.8

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
15	1	6R	4	0	0	8	12	0	0	10	12	5	68	95
	2	11L	7	0	0	8	15	0	0	10	8	4	75	97
	3	15R	5	0	0	15	20	0	0	12	8	15	60	95
	4	20L	10	0	0	25	35	0	0	1	2	12	70	85
	5	23R	3	0	0	10	13	0	0	4	20	3	70	97
	6	30L	10	0	0	3	13	0	0	40	20	3	35	98
	7	35R	8	0	0	2	10	0	0	12	20	5	60	97
	8	40L	0	0	0	5	5	0	0	2	6	2	90	100
	9	51R	3	0	0	15	18	0	0	10	15	6	60	91
	10	53L	10	0	0	30	40	0	0	2	3	2	80	87
		Average	6	0	0	12.1	18.1	0	0	10.3	11.4	5.7	66.8	94.2

16	1	6R	5	0	0	2	7	0	0	20	20	5	50	95
	2	11L	5	0	0	4	9	0	0	2	2	50	45	99
	3	15R	45	0	0	1	46	0	0	15	25	5	40	85
	4	20L	8	0	0	4	12	0	0	6	10	5	75	96
	5	23R	15	0	0	1	16	0	0	12	12	8	65	97
	6	30L	10	0	0	0	10	0	0	4	4	12	80	100
	7	35R	0	0	0	5	5	0	0	4	3	10	80	97
	8	40L	6	0	0	5	11	0	0	20	3	8	69	100
	9	51R	0	0	0	0	0	0	0	8	8	10	70	96
	10	53L	6	0	0	0	6	0	0	10	4	8	75	97
		Average	10	0	0	2.2	12.2	0	0	10.1	9.1	12.1	64.9	96.2

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
17	1	6R	12	0	0	1	13	0	0	4	4	4	85	97
	2	11L	18	0	0	0	18	0	0	4	8	5	80	97
	3	15R	8	0	0	2	10	0	0	4	8	4	75	91
	4	20L	4	0	0	2	6	0	0	3	20	8	70	101
	5	23R	6	0	0	3	9	0	0	1	15	5	80	101
	6	30L	0	0	0	0	0	0	0	1	1	45	53	100
	7	35R	70	0	0	0	70	0	0	30	35	3	30	98
	8	40L	5	0	0	0	5	0	0	5	5	5	85	100
	9	51R	0	0	0	0	0	0	0	1	0	10	90	101
	10	53L	0	0	0	0	0	0	0	1	0	10	90	101
		Average	12.3	0	0	0.8	13.1	0	0	5.4	9.6	9.9	73.8	98.7

18	1	6R	7	0	0	50	57	0	0	0	0	0	0	0
	2	11L	10	0	0	1	11	0	0	0	0	0	0	0
	3	15R	2	0	0	5	7	0	0	0	0	0	0	0
	4	20L	7	2	0	10	19	0	0	0	0	0	0	0
	5	23R	8	0	0	2	10	0	0	0	0	0	0	0
	6	30L	40	0	0	1	41	0	0	0	0	0	0	0
	7	35R	8	0	0	0	8	0	0	0	0	0	0	0
	8	40L	30	0	0	0	30	0	0	0	0	0	0	0
	9	51R	1	0	0	1	2	0	0	0	0	0	0	0
	10	53L	3	0	0	0	3	0	0	0	0	0	0	0
		Average	11.6	0.2	0	7	18.8	0	0	0	0	0	0	0

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
19	1	8R	3	0	0	2	5	0	0	0	7	15	75	97
	2	12L	7	0	0	8	15	0	0	0	5	3	88	96
	3	15R	2	0	0	5	7	0	0	0	3	3	94	100
	4	25L	0	0	0	1	1	0	0	0	1	15	84	100
	5	30R	3	0	0	0	3	0	0	0	3	50	45	98
	6	37L	10	0	0	3	13	0	0	0	10	1	84	95
	7	48R	4	0	0	4	8	0	0	0	4	4	85	93
	8	51L	8	0	0	2	10	0	0	0	5	8	85	98
	9	53R	1	0	0	1	2	0	0	0	3	1	95	99
	10	66L	10	0	0	0	10	0	0	0	4	1	88	93
		Average	4.8	0	0	2.6	7.4	0	0	0	4.5	10.1	82.3	96.9
20	1	8R	6	0	0	18	24	0	0	45	18	4	28	95
	2	12L	10	0	0	4	14	0	0	5	15	2	73	95
	3	15R	25	0	0	2	27	0	0	50	20	5	18	93
	4	25L	2	0	0	10	12	0	0	5	4	7	80	96
	5	30R	10	0	0	2	12	0	0	20	10	4	60	94
	6	37L	20	0	0	0	20	0	0	20	20	5	45	90
	7	48R	13	0	0	1	14	0	0	10	12	4	68	94
	8	51L	5	0	0	6	11	0	0	2	4	4	87	97
	9	53R	6	0	0	3	9	0	0	2	3	3	90	98
	10	66L	20	0	0	1	21	0	0	3	8	2	77	90
		Average	11.7	0	0	4.7	16.4	0	0	16.2	11.4	4	62.6	94.2

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
21	1	8R	6	0	0	4	10	0	0	75	4	8	10	97
	2	12L	32	0	0	2	34	0	0	90	5	3	2	100
	3	15R	5	0	0	1	6	0	0	35	5	8	49	97
	4	25L	20	0	0	1	21	0	0	70	8	2	12	92
	5	30R	12	0	0	2	14	0	0	70	10	2	10	92
	6	37L	35	0	0	1	36	0	0	25	11	8	25	69
	7	48R	3	0	0	1	4	0	0	12	6	5	75	98
	8	51L	4	0	0	3	7	0	6	15	12	2	64	99
	9	53R	12	0	0	1	13	0	0	12	5	2	78	97
	10	66L	16	0	0	2	18	0	0	8	12	1	74	95
		Average	14.5	0	0	1.8	16.3	0	0.6	41.2	7.8	4.1	39.9	93.6
22	1	8R	1	0	0	5	6	0	0	8	10	3	78	99
	2	12L	10	0	0	7	17	0	0	4	10	3	80	97
	3	15R	10	0	0	1	11	0	0	4	8	3	80	95
	4	25L	3	0	0	1	4	0	0	2	20	1	77	100
	5	30R	5	0	0	2	7	0	0	4	4	4	87	99
	6	37L	25	0	0	5	30	0	0	15	8	5	70	98
	7	48R	20	0	0	0	20	0	0	3	7	4	80	94
	8	51L	65	0	0	0	65	0	0	10	50	2	25	87
	9	53R	30	0	0	3	33	0	0	4	25	2	65	96
	10	66L	18	0	0	0	18	0	0	2	5	3	85	95
		Average	18.7	0	0	2.4	21.1	0	0	5.6	14.7	3	72.7	96

Date: August 24/25 2010			Field Team: Pam Blicker and Don Jackson			Conditions: Mild sunny weather 70's August 2010								
Plot No.	**Frame No.**	**Frame location (ft)**	**Perennial Grass**	**Annual Grass**	**Perennial Forb**	**Annual Forb**	**Total Plant cover**	**Shrub**	**Nox. Weeds**	**Compost**	**Litter**	**Rock**	**Bare**	**Total Ground Cover**
1	1	5R	7	5	0	0	12	0	0	77	5	2	15	99
	2	7L	5	1	0	0	6	0	0	38	7	55	0	100
	3	11R	35	6	0	0	41	0	0	85	7	2	3	97
	4	14L	35	1	0	1	37	0	0	75	17	0	3	95
	5	17R	1	20	0	0	21	0	0	75	15	2	7	99
	6	21L	50	8	0	0	58	0	0	85	15	0	0	100
	7	25R	10	5	0	5	20	0	0	55	15	2	25	97
	8	27L	3	10	0	2	15	0	0	60	15	5	20	100
	9	31R	1	15	0	5	21	0	0	70	17	3	10	100
	10	34L	35	0	0	5	40	0	0	30	20	5	35	90
		Average	18.2	7.1	0	1.8	27.1	0	0	65	13.3	7.6	11.8	97.7
2	1	5R	0	0	0	0	0	0	0	0	0	3	97	100
	2	7L	0	0	0	0	0	0	0	0	4	1	95	100
	3	11R	30	0	0	0	30	0	0	0	25	3	70	98
	4	14L	1	5	0	0	6	0	0	0	5	1	93	99
	5	17R	0	3	0	0	3	0	0	0	5	1	93	99
	6	21L	0	2	3	2	7	0	0	0	2	3	93	98
	7	25R	30	5	0	1	36	0	0	0	15	3	78	96
	8	27L	17	10	0	5	32	0	0	0	25	1	68	94
	9	31R	5	1	0	0	6	0	0	0	0	3	93	96
	10	34L	10	8	0	5	23	0	0	0	7	2	90	99
		Average	9.3	3.4	0.3	1.3	14.3	0	0	0	8.8	2.1	87	97.9

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
3	1	5R	12	1	0	0	13	0	0	45	20	5	30	100
	2	7L	10	2	0	3	15	0	0	80	5	5	10	100
	3	11R	25	5	0	0	30	0	0	30	15	3	45	93
	4	14L	30	0	0	0	30	0	0	25	10	2	60	97
	5	17R	6	0	0	1	7	0	0	15	5	2	75	97
	6	21L	8	0	0	5	13	0	0	10	10	5	75	100
	7	25R	0	10	0	10	20	0	0	5	10	3	80	98
	8	27L	0	15	0	5	20	0	0	15	25	3	55	98
	9	31R	0	15	0	5	20	0	0	3	30	5	60	98
	10	34L	0	10	0	5	15	0	0	2	25	3	67	97
		Average	9.1	5.8	0	3.4	18.3	0	0	23	15.5	3.6	55.7	97.8
4	1	5R	50	0	0	0	50	0	0	70	20	5	0	95
	2	7L	50	0	0	0	50	0	0	65	30	2	2	99
	3	11R	25	0	0	0	25	0	0	25	20	2	50	97
	4	14L	15	0	0	0	15	0	0	45	10	3	40	98
	5	17R	6	0	0	2	8	0	0	12	5	3	80	100
	6	21L	0	0	0	1	1	0	0	5	3	0	92	100
	7	25R	6	10	0	5	21	0	0	25	20	0	48	93
	8	27L	7	5	6	0	18	0	0	75	20	2	2	99
	9	31R	0	15	60	1	76	0	0	10	15	5	65	95
	10	34L	20	30	0	0	50	0	0	25	50	3	20	98
		Average	17.9	6	6.6	0.9	31.4	0	0	35.7	19.3	2.5	39.9	97.4

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
5	1	5R	1	0	0	0	1	0	0	8	10	5	75	98
	2	7L	10	0	0	0	10	0	0	28	8	2	60	98
	3	11R	1	0	0	2	3	0	20	15	10	2	70	97
	4	14L	6	0	0	10	16	0	0	40	10	0	45	95
	5	17R	28	0	5	1	34	0	0	20	20	2	55	97
	6	21L	6	2	20	0	28	0	0	40	20	5	32	97
	7	25R	5	0	7	0	12	0	0	25	25	5	40	95
	8	27L	6	0	20	0	26	0	2	20	20	5	50	95
	9	31R	4	2	3	15	24	0	0	3	10	4	85	102
	10	34L	0	0	0	8	8	0	0	3	3	2	90	98
		Average	6.7	0.4	5.5	3.6	16.2	0	2.2	20.2	13.6	3.2	60.2	97.2

6	1	5R	15	1	0	5	21	0	0	50	10	5	35	100
	2	7L	10	0	0	4	14	0	0	50	10	5	35	100
	3	11R	25	0	0	1	26	0	0	75	15	2	5	97
	4	14L	25	0	0	1	26	0	0	60	30	2	3	95
	5	17R	45	0	0	5	50	0	0	45	40	5	5	95
	6	21L	10	3	0	2	15	0	0	20	15	3	58	96
	7	25R	12	5	0	10	27	0	0	20	25	10	40	95
	8	27L	0	8	0	10	18	0	0	25	20	5	45	95
	9	31R	7	1	0	0	8	0	0	5	5	5	80	95
	10	34L	15	0	0	4	19	0	5	3	3	2	90	98
		Average	16.4	1.8	0	4.2	22.4	0	0.5	35.3	17.3	4.4	39.6	96.6

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
7	1	5R	13	0	0	0	13	0	0	75	15	5	5	100
	2	7L	25	0	0	1	26	0	0	85	12	0	3	100
	3	11R	20	2	0	0	22	0	0	40	10	5	45	100
	4	14L	40	0	0	0	40	0	0	13	30	3	50	96
	5	17R	4	5	0	3	12	0	0	4	7	7	82	100
	6	21L	30	1	0	0	31	0	0	50	15	10	20	95
	7	25R	55	10	0	0	65	0	0	8	50	5	35	98
	8	27L	5	10	0	5	20	0	0	15	20	8	54	97
	9	31R	0	75	0	0	75	0	0	5	50	5	35	95
	10	34L	0	80	0	0	80	0	0	1	60	2	30	93
		Average	19.2	18.3	0	0.9	38.4	0	0	29.6	26.9	5	35.9	97.4

8	1	5R	1	0	0	5	6	0	0	10	10	10	70	100
	2	7L	3	0	0	0	3	0	0	2	3	5	90	100
	3	11R	20	1	1	1	23	0	0	33	7	5	47	92
	4	14L	20	0	0	1	21	0	0	8	15	15	60	98
	5	17R	1	0	0	4	5	0	0	3	2	40	54	99
	6	21L	12	10	0	7	29	0	0	30	20	25	20	95
	7	25R	50	10	0	0	60	0	0	10	30	10	45	95
	8	27L	4	4	0	1	9	0	0	1	4	15	75	95
	9	31R	10	3	0	8	21	0	0	4	20	35	40	99
	10	34L	40	2	0	5	47	0	0	2	35	15	40	92
		Average	16.1	3	0.1	3.2	22.4	0	0	10.3	14.6	17.5	54.1	96.5

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
9	1	5R	35	0	0	0	35	0	0	20	5	20	50	95
	2	7L	65	0	0	0	65	0	0	25	5	15	45	90
	3	11R	0	0	0	1	1	0	0	15	5	30	50	100
	4	14L	15	0	0	5	20	0	0	1	10	25	60	96
	5	17R	0	0	0	0	0	10	0	1	10	25	65	101
	6	21L	10	3	0	3	16	0	0	25	10	30	30	95
	7	25R	2	0	0	4	6	0	0	5	8	45	41	99
	8	27L	20	0	0	0	20	0	0	1	8	42	43	94
	9	31R	0	0	0	0	0	0	0	1	8	35	56	100
	10	34L	0	0	8	0	8	0	0	1	1	40	58	100
		Average	14.7	0.3	0.8	1.3	17.1	1	0	9.5	7	30.7	49.8	97
10	1	5R	25	0	0	0	25	0	0	98	2	0	0	100
	2	7L	20	0	0	0	20	0	0	90	2	2	5	99
	3	11R	2	5	0	15	22	0	0	82	2	2	10	96
	4	14L	5	3	0	5	13	0	0	90	2	2	5	99
	5	17R	7	15	0	0	22	0	0	95	2	0	3	100
	6	21L	5	25	0	2	32	0	0	95	2	0	3	100
	7	25R	2	40	0	0	42	0	0	95	2	0	3	100
	8	27L	8	20	0	0	28	0	0	92	2	4	3	101
	9	31R	4	15	0	0	19	0	0	95	2	2	0	99
	10	34L	5	20	0	0	25	0	0	90	2	0	3	95
		Average	8.3	14.3	0	2.2	24.8	0	0	92.2	2	1.2	3.5	98.9

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
11	1	6R	6	0	0	1	7	0	0	8	4	3	83	98
	2	11L	0	0	0	8	8	0	0	3	0	25	70	98
	3	15R	6	0	0	15	21	0	0	3	10	0	85	98
	4	20L	6	0	0	10	16	0	0	13	7	3	75	98
	5	23R	1	0	0	10	11	0	0	8	15	3	70	96
	6	30L	7	0	0	6	13	0	0	20	25	5	47	97
	7	35R	26	0	0	8	34	0	0	18	15	0	65	98
	8	40L	7	0	0	12	19	0	0	20	25	8	45	98
	9	51R	2	0	0	3	5	0	0	8	7	3	80	98
	10	53L	15	0	0	15	30	0	0	10	15	5	70	100
		Average	7.6	0	0	8.8	16.4	0	0	11.1	12.3	5.5	69	97.9

12	1	6R	0	0	0	0	0	0	0	30	2	5	63	100
	2	11L	4	0	0	8	12	0	0	15	8	4	72	99
	3	15R	8	4	0	3	15	0	0	50	5	15	26	96
	4	20L	0	0	0	35	35	0	0	5	5	5	80	95
	5	23R	8	0	0	5	13	0	0	65	10	5	20	100
	6	30L	5	0	0	25	30	0	0	45	20	5	30	100
	7	35R	0	0	0	25	25	0	0	12	15	5	65	97
	8	40L	5	0	0	10	15	0	0	75	10	7	7	99
	9	51R	0	0	0	3	3	0	0	30	8	2	58	98
	10	53L	8	6	0	1	15	0	0	40	8	5	40	93
		Average	3.8	1	0	11.5	16.3	0	0	36.7	9.1	5.8	46.1	97.7

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
13	1	6R	0	0	0	5	5	0	0	0	5	5	90	100
	2	11L	0	0	5	8	13	0	0	0	5	5	85	95
	3	15R	5	0	0	3	8	0	0	0	5	3	90	98
	4	20L	7	0	0	5	12	0	0	0	3	2	88	93
	5	23R	0	0	0	8	8	0	0	0	3	2	92	97
	6	30L	0	0	0	8	8	0	0	0	2	5	90	97
	7	35R	0	0	0	3	3	0	0	0	2	5	93	100
	8	40L	10	0	20	0	30	0	0	0	5	5	85	95
	9	51R	0	0	0	10	10	0	0	0	7	5	85	97
	10	53L	0	0	0	5	5	0	0	0	5	3	92	100
		Average	2.2	0	2.5	5.5	10.2	0	0	0	4.2	4	89	97.2
14	1	6R	45	0	0	1	46	0	0	45	15	7	10	77
	2	11L	5	0	0	10	15	0	0	40	25	7	25	97
	3	15R	30	0	0	7	37	0	0	40	15	7	35	97
	4	20L	0	0	0	15	15	0	0	8	7	5	75	95
	5	23R	0	0	0	15	15	0	0	8	10	2	80	100
	6	30L	5	0	0	5	10	0	0	7	12	2	79	100
	7	35R	5	7	0	12	24	0	0	50	35	5	7	97
	8	40L	2	1	0	7	10	0	0	20	15	2	60	97
	9	51R	5	8	0	2	15	0	0	65	15	12	5	97
	10	53L	0	10	0	15	25	0	0	45	12	3	40	100
		Average	9.7	2.6	0	8.9	21.2	0	0	32.8	16.1	5.2	41.6	95.7

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
15	1	6R	5	0	0	1	6	0	0	7	8	7	75	97
	2	11L	5	0	0	5	10	0	0	2	5	3	90	100
	3	15R	6	0	0	8	14	0	0	8	10	10	70	98
	4	20L	10	0	0	15	25	0	0	3	7	10	75	95
	5	23R	0	0	0	12	12	0	0	2	10	5	80	97
	6	30L	6	0	0	8	14	0	0	20	10	8	60	98
	7	35R	8	0	0	13	21	0	0	3	3	10	82	98
	8	40L	0	0	0	5	5	0	0	2	4	8	85	99
	9	51R	1	0	0	1	2	0	0	2	10	8	80	100
	10	53L	0	0	0	1	1	0	0	1	3	2	94	100
		Average	4.1	0	0	6.9	11	0	0	5	7	7.1	79.1	98.2
16	1	6R	7	0	0	7	14	0	0	12	12	5	68	97
	2	11L	15	0	0	5	20	0	0	3	10	15	70	98
	3	15R	15	0	0	0	15	0	0	4	12	5	78	99
	4	20L	10	0	0	0	10	0	0	5	10	5	78	98
	5	23R	18	0	0	1	19	0	0	5	25	5	65	100
	6	30L	4	0	0	5	9	0	0	0	3	5	90	98
	7	35R	0	0	0	10	10	0	0	2	10	15	70	97
	8	40L	15	0	0	3	18	0	0	5	4	5	85	99
	9	51R	0	0	0	0	0	0	0	3	7	30	60	100
	10	53L	0	0	0	0	0	0	0	7	3	10	80	100
		Average	8.4	0	0	3.1	11.5	0	0	4.6	9.6	10	74.4	98.6

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
17	1	6R	10	0	0	1	11	0	0	4	4	5	86	99
	2	11L	15	0	0	1	16	0	0	7	7	5	75	94
	3	15R	5	0	0	8	13	0	0	4	5	5	83	97
	4	20L	5	0	0	5	10	0	0	7	20	15	57	99
	5	23R	10	0	0	3	13	0	0	3	15	10	67	95
	6	30L	0	0	0	0	0	0	0	1	4	70	25	100
	7	35R	55	0	0	0	55	0	0	15	17	8	50	90
	8	40L	1	0	0	0	1	0	0	7	8	8	77	100
	9	51R	0	0	0	1	1	0	0	1	1	15	83	100
	10	53L	0	0	0	0	0	0	0	1	1	10	88	100
		Average	10.1	0	0	1.9	12	0	0	5	8.2	15.1	69.1	97.4
18	1	6R	5	0	0	8	13	0	0	93	0	2	5	100
	2	11L	12	0	0	2	14	0	0	85	0	2	10	97
	3	15R	5	0	0	8	13	0	0	80	0	2	15	97
	4	20L	5	0	0	3	8	0	0	98	0	2	0	100
	5	23R	6	0	0	0	6	0	0	95	0	4	1	100
	6	30L	25	0	0	0	25	0	0	90	0	5	3	98
	7	35R	8	0	0	0	8	0	0	55	5	8	30	98
	8	40L	22	0	0	0	22	0	0	95	0	3	2	100
	9	51R	0	0	0	0	0	0	0	0	50	0	50	100
	10	53L	8	0	0	4	12	0	0	5	45	0	48	98
		Average	9.6	0	0	2.5	12.1	0	0	69.6	10	2.8	16.4	98.8

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
19	1	8R	5	0	0	2	7	0	0	0	5	5	90	100
	2	12L	4	0	0	5	9	0	0	0	3	2	95	100
	3	15R	0	0	0	7	7	0	0	0	4	3	93	100
	4	25L	0	0	0	3	3	0	0	0	1	1	97	99
	5	30R	3	0	0	1	4	0	0	0	3	20	76	99
	6	37L	15	0	0	4	19	0	0	0	15	2	80	97
	7	48R	0	0	0	7	7	0	0	0	4	2	93	99
	8	51L	3	0	0	5	8	0	0	0	5	8	85	98
	9	53R	1	1	0	1	3	0	0	0	5	1	94	100
	10	66L	10	0	0	2	12	0	0	0	8	1	90	99
		Average	4.1	0.1	0	3.7	7.9	0	0	0	5.3	4.5	89.3	99.1
20	1	8R	8	0	0	20	28	0	0	15	10	10	63	98
	2	12L	10	0	0	10	20	0	0	20	10	5	60	95
	3	15R	10	0	0	3	13	0	0	12	8	5	70	95
	4	25L	2	0	0	50	52	0	0	5	3	10	80	98
	5	30R	10	0	0	3	13	0	0	8	12	3	70	93
	6	37L	20	0	0	0	20	0	0	30	20	2	45	97
	7	48R	20	0	0	1	21	0	0	15	20	5	53	93
	8	51L	5	0	0	8	13	0	0	2	5	3	90	100
	9	53R	10	0	0	4	14	0	0	2	5	2	90	99
	10	66L	25	0	0	0	25	0	0	3	20	2	70	95
		Average	12	0	0	9.9	21.9	0	0	11.2	11.3	4.7	69.1	96.3

Plot No.	Frame No.	Frame location (ft)	Perennial Grass	Annual Grass	Perennial Forb	Annual Forb	Total Plant cover	Shrub	Nox. Weeds	Compost	Litter	Rock	Bare	Total Ground Cover
21	1	8R	6	0	0	2	8	0	0	55	8	10	25	98
	2	12L	15	0	0	8	23	0	0	60	10	5	20	95
	3	15R	5	0	0	5	10	0	0	20	15	10	50	95
	4	25L	10	0	0	8	18	0	0	60	15	5	10	90
	5	30R	10	0	0	4	14	0	0	15	15	5	65	100
	6	37L	25	0	0	2	27	0	0	20	40	5	30	95
	7	48R	5	0	0	4	9	0	0	8	10	5	75	98
	8	51L	12	0	10	1	23	0	0	5	15	2	75	97
	9	53R	20	0	0	0	20	0	0	2	5	1	90	98
	10	66L	12	0	0	25	37	0	0	4	15	1	75	95
		Average	12	0	1	5.9	18.9	0	0	24.9	14.8	4.9	51.5	96.1

22	1	8R	3	0	0	10	13	0	0	4	7	5	82	98
	2	12L	4	0	0	8	12	0	0	4	5	5	85	99
	3	15R	6	0	0	4	10	0	0	4	10	2	82	98
	4	25L	25	0	0	1	26	0	0	2	15	2	75	94
	5	30R	8	0	0	8	16	0	0	3	5	2	88	98
	6	37L	12	0	0	12	24	0	0	15	4	5	75	99
	7	48R	15	0	0	10	25	0	0	2	8	2	80	92
	8	51L	55	0	0	0	55	0	0	5	30	2	60	97
	9	53R	12	0	0	15	27	0	0	1	8	2	85	96
	10	66L	12	0	0	1	13	0	0	3	7	2	85	97
		Average	15.2	0	0	6.9	22.1	0	0	4.3	9.9	2.9	79.7	96.8

13. APPENDIX C – EROSION DATA

2009

Plot No.	Surface Litter	Surface Rock Movement	Pedestalling	Flow Patterns	Rills (0.5-6")	Gullies (over 6")	Soil Movement	Total	Rating[1]
1	11	8	9	9	6	0	8	51	Moderate
2	14	14	11	15	6	0	14	74	Critical
3	11	8	9	12	6	0	8	54	Moderate
4	14	11	11	15	6	0	14	71	Critical
5	14	11	11	15	9	0	11	71	Critical
6	11	11	11	12	9	0	11	65	Critical
7	11	11	11	12	9	0	11	65	Critical
8	11	14	11	15	9	0	11	71	Critical
9	11	14	11	15	6	0	11	68	Critical
10	0	0	0	0	0	0	0	0	n/a[3]
11	14	8	11	15	9	0	14	71	Critical
12	14	8	11	15	9	0	14	71	Critical
13	14	8	11	15	9	0	14	71	Critical
14	11	8	11	12	6	0	11	59	Moderate
15	14	11	11	15	6	0	11	68	Critical
16	14	11	11	15	9	0	11	71	Critical
17	14	11	11	15	9	0	11	71	Critical
18	0	0	0	0	0	0	0	0	n/a
19	14	14	14	15	14	9	14	94	Severe
20	14	14	14	15	14	9	14	94	Severe
21	14	14	11	15	14	9	14	91	Severe
22	14	14	14	15	14	9	14	94	Severe

2010

Plot No.	Surface Litter	Surface Rock Movement	Pedestalling	Flow Patterns	Rills (0.5-6")	Gullies (over 6")	Soil Movement	Total[1]	Rating[2]
1	11	8	9	9	6	0	8	51	Moderate
2	14	14	11	15	6	0	14	74	Critical
3	11	8	9	12	6	0	8	54	Moderate
4	14	11	11	15	6	0	14	71	Critical
5	14	11	11	15	9	0	11	71	Critical
6	11	11	11	12	9	0	11	65	Critical
7	11	11	11	12	9	0	11	65	Critical
8	11	14	11	15	9	0	11	71	Critical
9	11	14	11	15	6	0	11	68	Critical
10	0	0	0	0	0	0	0	0	N/A[3]
11	14	8	11	15	9	0	14	71	Critical
12	14	8	11	15	9	0	14	71	Critical
13	14	8	11	15	9	0	14	71	Critical
14	11	8	11	12	6	0	11	59	Moderate
15	14	11	11	15	6	0	11	68	Critical
16	14	11	11	15	9	0	11	71	Critical
17	14	11	11	15	9	0	11	71	Critical
18	0	0	0	0	0	0	0	0	N/A
19	14	14	14	15	14	9	14	94	Severe
20	14	14	14	15	14	9	14	94	Severe
21	14	14	11	15	14	9	14	91	Severe
22	14	14	14	15	14	9	14	94	Severe

[1] Total score of 100 points maximum possible; Erosion condition and total score: low (0-20), slight (21-40), moderate (41-60), critical (61-80), severe (81-100)

[2] Rating system after Clark 1980

[3] N/A = not applicable

Erosion Condition Class Determination Scoring Sheet

SURFACE LITTER	No movement, or if present, less than 2 percent of the unattached litter has been translocated and redeposited against obstacles. 0 or 3	Between 2 and 10 percent of the unattached litter has been translocated and redeposited against obstacles. 6	Between 10 and 25 percent of the unattached litter has been translocated and redepostied against obstacles. 8	Between 25 and 50 percent of the unattached litter has been translocated and redeposited against obstacles. 11	More than 50 percent of the unattached litter has been translocated and redeposited against obstacles. 14
SURFACE ROCK MOVEMENT	No movement, or if present, less than 2 percent of the surface rock fragments show localized concentration. 0 or 2	Between 2 and 10 percent of the surface rock fragments show localized concentration. 5	Between 10 and 25 percent of the surface rock fragments show localized concentration. 8	Between 25 and 50 percent of the surface rock fragments show localized concentration. 11	More than 50 percent of the surface rock fragments show localized concentration. 14
PEDESTALLI NG	Pedestals are mostly less than 0.1 inches (2.5 mm) high and/or less frequent than 2 pedestals per 100 sq. ft. 0 or 3	Pedestals are mostly between 0.1 to 0.3 inches (2.5 to 8 mm) high and/or have a frequency of 2 to 5 pedestals per 100 sq. ft. 6	Pedestals are mostly between 0.3 and 0.6 inches (8 to 15 mm) high, and/or have a frequency of 5 to 7 pedestals per 100 sq. ft. 9	Pedestals are mostly between 0.6 to 1 inch (15 to 25 mm) high, and/or have a frequency of 7 to 10 pedestals per 100 sq. ft. 11	Pedestals are mostly over 1 inch (25 mm) high, and/or have a frequency of over 10 pedestals per 100 sq. ft. 14
FLOW PATTERNS	None, or if present, less than 2 percent of the surface area shows a flow pattern in which water flows over the ground surface for a distance at least 10 linear feet. 0 or 3	Between 2 and 10 percent of the surface area shows a flow pattern in which water flows over the ground surface for a distance of at least 10 linear feet. 6	Between 10 and 25 percent of the surface area shows a flow pattern in which water flows over the ground surface for a distance of at least 10 linear feet. 9	Between 25 and 50 percent of the surface area shows a flow pattern in which water flows over the ground surface for a distance of at least 10 linear feet. 12	Over 50 percent of the surface area shows a flow pattern in which water flows over the ground surface for a distance of at least 10 linear feet. 15
RILLS (0.5 – 6" depth)	Rills, if present, are mostly less than .5 in. (13mm) deep, and generally at infrequent intervals over 10 ft. 0 to 3	Rills are mostly .5 to 1 in. (13mm to 25mm) deep, and generally at infrequent intervals over 10 ft. 6	Rills are mostly 1 to 1.5 in. (25mm to 38mm) deep, and generally at 10 ft. intervals. 9	Rills are mostly 1.5 to 3 in. (38mm to 76mm) deep, and at intervals of 5 to 10 ft. 12	Rills are mostly 3 to 6 in. (76mm to 152mm) deep, and at intervals of less than 5 ft. 14
GULLIES (over 6")	No gullies, or if present, less than 2 percent of the channel bed and walls show active erosion (are not vegetated), gullies make up less than 2 percent of the total area. 0 or 3	Between 2 and 5 percent of the channel bed and walls show active erosion (are not vegetated), or gullies make up between 2 and 5 percent of the total area. 6	Between 5 and 10 percent of the channel bed and walls show active erosion (are not vegetated), or gullies make up between 5 and 10 percent of the total area. 9	Between 10 and 50 percent of the channel bed and walls show active erosion (are not vegetated), or gullies make up between 10 and 50 percent of the total area. 12	Over 50 percent of the channel bed and walls show active erosion (are not vegetated), or gullies make up over 50 percent of the total area. 15
SOIL MOVEMEN T	Depth of deposits around obstacles is between 0 and 0.1 inches (0 to 2.5 mm). 0 or 3	Depth of deposits around obstacles is between 0.1 and 0.2 inches (2.5 to 5mm). 5	Depth of deposits around obstacles 0.2 and 0.4 inches (5 to 10 mm) 8	Depth of deposits around obstacles is between 0.4 and 0.8 inches (10 to 20 mm). 11	Depth of deposits around obstacles is over 0.8 inches (20 mm). 14

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