MEYERS AIRPORT TEST PLOTS REPORT

May 2008

INTRODUCTION

This report describes the monitoring activity and results for the Meyers Airport South Test Plots (Meyers Airport plots). The Meyers Airport plots are located off of Highway 89/50 just west of the south end of the South Lake Tahoe Airport runway, in Meyers, California (Figure 1). There are north and south restoration areas at the Meyers Airport site. This report focuses on eighteen south test plots.

Figure 1. Satellite image showing the location of the Meyers Airport plots in relation to Lake Tahoe and the City of South Lake Tahoe.

The Meyers Airport South test plots were constructed in 2004. Eighteen plots were installed with three replications of six different treatments. There are three different treatment categories: full treatment (12 plots), surface treatment (3 plots), and no treatment (3 plots). Full treatment plots are characterized by a combination of soil loosening and the addition of organic amendments, organic fertilizer, native seeds, and pine needle or woodchip mulch. Surface treatment plots were treated with Caltrans Erosion Control Type D (EC Type D) hydroseed treatment. No treatment plots were initially treated with EC Type D, but subsequently disturbed in such a manner that the original treatment was no longer viable.

Full treatment test plots are designed to study the erosion control effectiveness of compost versus woodchips as soil amendments and ripping versus tilling as soil loosening techniques. In addition, the performance of each full treatment variation was also compared to surface treatment and no treatment plots.

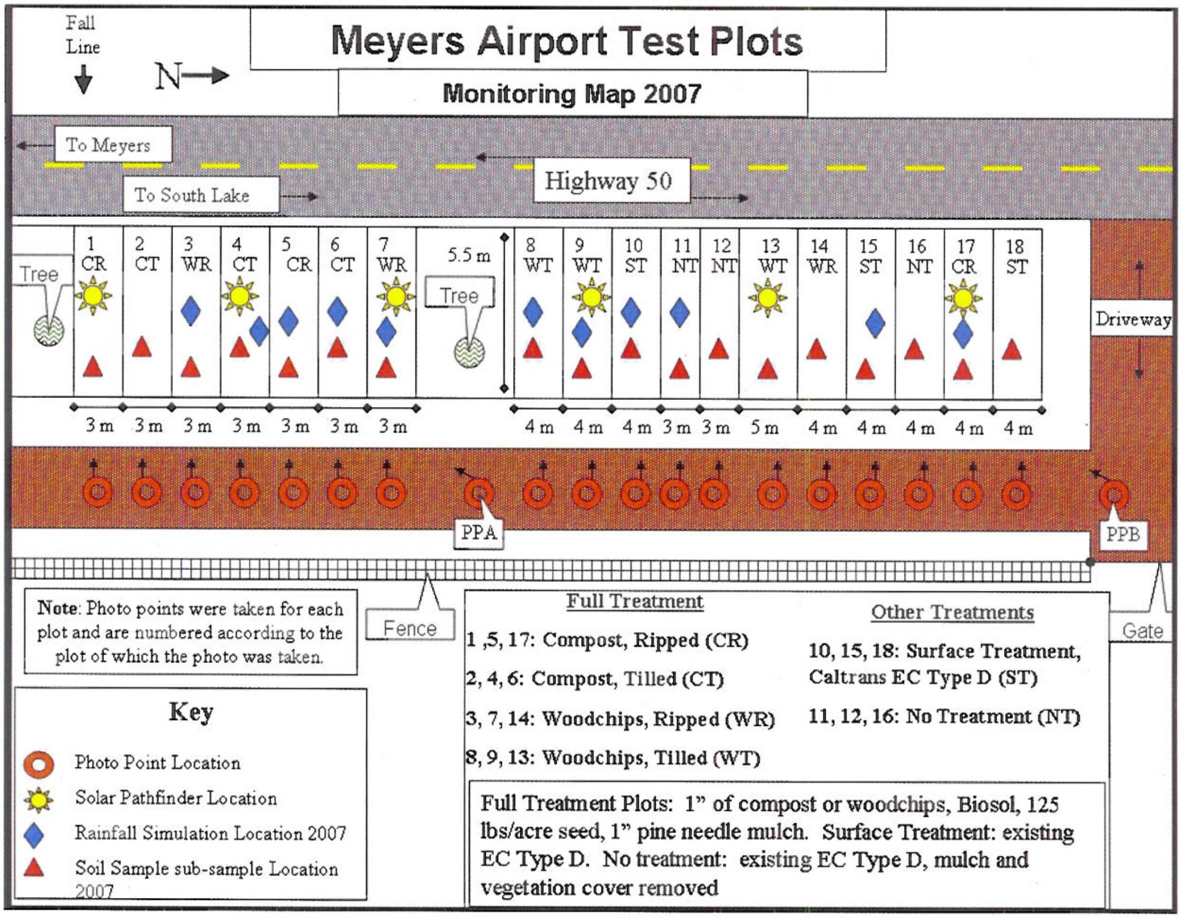

Figure 2. Test plot treatment and monitoring map of Meyers Airport showing photo point, rainfall, Solar Pathfinder, and soil sample locations.

PURPOSE

Test plots were monitored to determine whether a difference exists between the erosion control performance of fully treated soils, with ripping or tilling as soil loosening techniques, compost or woodchips as amendment types, and surface treatment only or no treatment at all. The following measurements are used to determine which plots have the greatest capacity for erosion control: infiltration rate, sediment yield, soil density, soil shear strength, nutrient levels, foliar cover by plants, and ground cover by mulch. Treatment recommendations will be made based on the monitoring results.

SITE DESCRIPTION

The Meyers Airport plots are situated on an east facing, 24 degree slope at about 6,270 feet above mean sea level (AMSL). They are beside Highway 89/50 on granitic parent material with soil classified as Jabu sandy loam with between 82-86% sand content. These plots have very little canopy cover and receive full sun from sunrise until mid-afternoon. Surrounding vegetation consists of Jeffrey pine (Pinus jeffreyi), bitterbrush (Purshia tridentata), Wyoming sagebrush (Artemisia tridentata v. wyomingensis) and native bunchgrasses. The range of solar exposures in August for all plots is 72-99%.

MATERIALS AND METHODS

Treatments

The treatments at Meyers Airport were completed in 2004. There are three replicates of six different treatments that were randomly positioned along the slope (Table 1, Figure 2, Figure 3, and Figure 4). Each plot measures 13 feet (4 m) long by 23 feet (7m) high.

Table 1. Meyers Airport test plot treatments. All amendments were added at a rate of 1 inch.

Plot Numbers	Plot Names	Amendment	Soil Loosening	Native Seed	Woodchip or Pine Needle Mulch
1, 5, 17	Compost Rip	Compost	Ripping	X	x
2, 4, 6	Compost Till	Compost	Tilling	X	x
3, 7, 19	Compost Rip	Woodchips	Ripping	X	x
8, 9, 13	Woodchips Till	Woodchips	Tilled	X	x
10, 15, 18	Surface Treatment	None	None	X	x
11, 12, 16	No Treatment	None	None		

Figure 3. Meyers Airport test plots during treatment in 2004.

Figure 4. Meyers Airport test plots two seasons after treatment, 2006.

Plots 2, 4, 6, 8, 9, and 13 were tilled to a depth of 12 inches (30 cm). Plots 1, 5, 17, 3, 7, and 14 were ripped to 12 inches (30 cm). Compost or woodchip amendments were added to the tilled and ripped plots. Approximately 714 lbs/acre (800 kg/ha) of nitrogen equivalent, which was approximately one inch of compost or one inch of woodchips, was incorporated into the soil. The compost is composed of 25% fine humus that passed through a 3/8 inch (1 cm) screen, and 75% coarse overs that ranged between 3/8 inch and 3 inches (8 cm) in size. Biosol was then raked into the top 1.5 inches (3.8 cm) of soil and native seed was lightly raked into the top ½ inch (1.3 cm) of soil at a rate of 125 lbs/acre (140 kg/ha). The seed mix composition is presented in Table 2. One inch (2.5 cm) of pine needle or woodchip mulch was applied to the surface. Plots 10, 15, and 18 (surface treatment plots) were treated with the Caltrans Erosion Control Type D hydroseed treatment prior to 2004. These plots received no further treatment. Plots 11, 12, 16 (no treatment plots) were treated with EC Type D prior to 2004, but were scraped bare in 2004 to represent pre-treatment disturbed conditions at the test plots site. Irrigation was applied in 2004, but not in subsequent years.

Table 2. Seed mix composition for tilling plots, ripping plots, and Caltrans control plots.

Common Name	Scientific Name
Mountain brome	*Bromus carinatus*
Blue wild rye	*Elymus glaucus*
Squirreltail	*Elymus elymoides*
Idaho fescue	*Festuca idahoensis*
Yarrow	*Achillea millefolium*
Spanish lotus	*Lotus purshianus*
Brewer's lupine	*Lupinus breweri*
Gray's lupine	*Lupinus grayii*
Sulfur buckwheat	*Eriogonum umbellatum*

Monitoring

Monitoring data is available for the Meyers Airport plots from 2005 and 2006. When available, historical data will be presented with the 2007 monitoring data for comparison. The following measurements are used to determine which plots have the greatest capacity for erosion control: infiltration rate, sediment yield, soil density, soil shear strength, nutrient levels, foliar cover by plants, and ground cover by mulch.

All monitoring was conducted in metric units, while treatment applications were calculated in English units. In the text, both metric and English units are given.

Cover

Cover, as measured with the cover point method, was recorded at all plots in both 2006 and 2007.[1] The cover pointer consists of a metal rod with a laser pointer mounted 3.3 feet (1 meter) above the ground. After the rod is leveled, the button on the laser pointer is depressed and two cover measurements are recorded (Figure 5 and Figure 6):

1) first cover hit, represents the first object intercepted starting from a height of 3.3 feet (1 meter) above the ground
2) ground cover hit

[1] Hogan, Michael. Luther Pass Monitoring Report: Plant and Soil Cover Monitoring for Evaluating Sediment Source Control Success in the Lake Tahoe Basin. 2003. South Lake Tahoe, CA, Lahontan Regional Water Quality Control Board.

The first cover hit measures the foliar cover by plants (leaves and stems). It does not measure the part of the plant actually rooted in the ground. The ground cover hit measures whatever is lying on the ground or rooted in the ground (i.e. litter/mulch, bare ground, basal (or rooted) plant cover, rock and woody debris).

Figure 5. Cover pointer in use along transects.

Figure 6. Cover pointer rod with first cover hit and ground cover hit by the laser pointer. The laser pointer hits are circled in red. The first cover hit is a native grass and the ground cover hit is pine needle mulch.

Total ground cover comprises all cover other than bare ground. Plant cover both on the ground and foliar was recorded by species and then organized into cover groups based on four categories: lifeform (herbaceous/woody), perennial/annual, native/alien (2007 only), and seeded/volunteer (2007 only). Perennial herbaceous species include seeded grasses, native grasses and forbs, and any non-native perennial species. Annual herbaceous species include native annuals such as prairie smoke (*Gayophytum diffusum*) and invasive species such as Russian thistle (*Salsola tragus*).

Woody species include any tree or shrub species of interest, either native or introduced. Each species was then classified based on whether it was native to the Tahoe area, and whether it was seeded during treatment. Data is also presented on the amount of cover by species. An ocular estimate of cover at each plot was also recorded and includes species not hit using cover point sampling. The species list, as well as the ocular estimates of cover by species is presented in Appendix A.

Soil and Site Physical Conditions

Soil Density

The penetrometer depth to resistance (DTR) is often used as an index of soil density since a denser soil is less likely to allow infiltration. Rainfall simulations conducted on roadcuts in Oregon found increased infiltration rates in soils with penetrometer depths to refusal (DTRs) greater than 4 inches (10 cm).[2]

In 2006 and 2007, soil density and soil moisture were measured along the same transects as the cover point data for all of the plots. A cone penetrometer was used to measure soil density. The cone penetrometer with a ½ inch diameter tip was pushed straight down into the soil until a maximum pressure of 350 pounds per square inch (2,411 kPa) was reached (Figure 7 and Figure 8). The depth at which that pressure was reached was recorded as the depth to refusal (DTR). These depth measurements were used as an index for soil density and infiltration capacity.

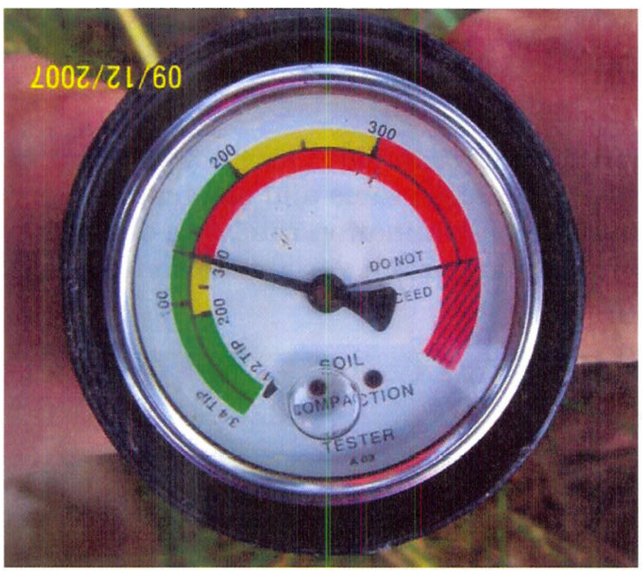

Figure 7. Cone penetrometer dial, showing pressure applied in pounds per square inch.

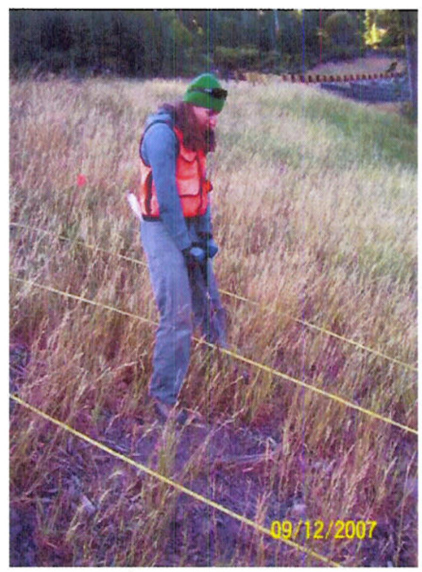

Figure 8. Conducting cone penetrometer readings along transects.

Soil Moisture

A hydrometer was used to measure volumetric soil moisture content adjacent to the penetrometer readings at a depth of 4.7 inches (12 cm) (Figure 9).

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[2] Grismer, M. Simulated Rainfall Evaluation at SunRiver and Mt Bachelor Highways, Oregon. Unpublished.

Soil Strength

High soil strength may be related to soils resistance to mass slope failure under high moisture conditions. Soil strength can be attributed to one or all of these soil characteristics: internal structure of the soil, woody material in the soil, dense plant roots in the soil, or soil compaction. It is important to know how each soil derives its strength to determine whether its strength will be beneficial in preventing erosion. In laboratory tests, the density of plant roots has been shown to increase soil strength.[3]

In 2007, soil strength was tested along cover point transects in the same manner as soil density and soil moisture. A hand-held shear vane with 1.5 inch (3.8 cm) long blades was pushed into the soil to a depth of 3 inches (7.6 cm) and turned until the soil could no longer resist the force exerted by the blades and the soil structure fractured or deformed (Figure 10). This force was then recorded as the "shear stress" in kilopascals (kPa). Forty kPa is the maximum force the shear vane can measure. Any values above 40 kPa are recorded as 40 kPa and noted as such. This method of determining shear strength has been used regularly in agricultural soils and various laboratory tests.[4] This method of testing soil shear strength has not been applied to many forest soils.

Solar exposure

Solar radiation measurements were taken at each plot using a Solar Pathfinder (Figure 11). Since solar input affects evaporation rates and soil temperature, which may affect time of seed germination, germination rate, rate of plant growth and soil microbial activity, it is an important variable to consider when monitoring plant growth and soil development.

Figure 9. Conducting soil moisture readings along transects.

Figure 10. Soil shear strength tester in use.

Figure 11. Solar pathfinder in use.

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[3] Tengbeh, G.T. 1993. The Effect of Grass Roots on Shear Strength Variations with Moisture Content. *Soil Technology*. Vol. 6. pp. 287-295.

[4] Ibid, pp. 287-295.

Soil Nutrient Analysis

In 2006 and 2007, soil sub-samples were taken from beneath the mulch layer to a depth of 12 inches (30 cm) for each of the six treatment types (Figure 2 and Figure 12). The native site was sampled in 2007, the year it was established. Three soil sub-samples were taken from each location. These samples were collected from the top 12 inches (30 cm) of the mineral soil beneath the mulch layer. These sub-samples were combined and sieved to remove any material larger than 0.08 inches (2 mm) in diameter, and then sent to A&L Laboratories (Modesto, CA) for S3C total Kjeldahl nitrogen (TKN) and organic matter analysis. A surface treatment sample and a full treatment sample were also analyzed for particle size distribution.

Figure 12. Soil sub-sample collection.

Rainfall Simulation

In 2006 and 2007, rainfall simulation was conducted for each treatment type (Figure 2). In 2007, rainfall simulation was also performed at the native reference site. The rainfall simulator "rains" on a square plot from a height of 3.3 feet (1 meter) (Figure 13 and Figure 14). The rate of rainfall is controlled, and runoff is collected from a trough at the bottom of a 6.5 square foot (0.6 m^2) frame that is pounded into the ground. The volume of water collected is measured and the volume of infiltration is calculated by subtracting the volume of runoff from the total volume of water applied to the plot. The average steady state infiltration rate is presented in the report. If runoff was not observed during the first 30 minutes, the simulation was stopped. The collected runoff samples are then analyzed for the amount of sediment, which is presented as the average steady state sediment yield.

Figure 13. Rainfall simulator and frame.

Figure 14. Rainfall simulator and two frames. The same system was used at Meyers Airport.

The cone penetrometer was used to record the DTR in the area of the runoff frames before rainfall simulations. The 2006 DTR pre-rainfall values were taken at a maximum pressure of 250 psi (1,724 kPa) and the 2007 DTR values that were taken at 350 psi (2,413 kPa), the current standard. Soil moisture was also measured in each runoff frame prior to conducting the rainfall simulations. After rainfall simulation, at least three holes were dug with a trowel to determine the depth to wetting front, which shows how deeply the water infiltrated within the soil. In 2007, at least 9 holes were dug to measure the depth to wetting front.

Different rainfall rates were applied to different plots depending on their propensity to runoff. The initial rainfall rate applied to the test plots was 2.8 to 3.0 inches/hour (70 - 75 mm/hour). If runoff was not observed, the rainfall rate was increased to 4.7 inches/hour (120 mm/hour) until runoff was observed or all the water was infiltrated. The rainfall rate of 2.8 inches per hour is more than twice the intensity of the 20 year, 1 hour "design storm" for the local area.

Statistical Analysis

An analysis of variance test (ANOVA), which compares average values between two or more different groups, was used to resolve differences between penetrometer DTR, plant cover, and mulch cover values by treatment type, amendment type, and soil loosening method. If a difference was detected using the ANOVA test, the Mann-Whitney test was used to further investigate differences between two sub-groups or sample sets within the larger group. The

Mann-Whitney test is a non-parametric test that can be applied to data sets with non-normal distributions. Non-normal distributions are common within small data sets. At the Meyers Airport test plots, some of the sample sets only have three replications (n=3) making these very small data sets. The term "significance" was used only to refer to results that had a p-value of less than 0.1.

RESULTS AND DISCUSSION

Rainfall

The average sediment yield at the treated plots was 1.8 times lower than the average sediment yield at the untreated plots (Figure 15 and Figure 16). The two-year average sediment yield for the full treatment plots was 103 lbs/acre/in (45 kg/ha/cm). The average sediment yield for the surface treatment plots was 108 lbs/acre/in (48 kg/ha/cm), while the no treatment plots produced 196 lbs/acre/in (86 kg/ha/cm).

The average sediment yield at the plots with soil loosening was 1.5 times lower than the average sediment yield at the plots without soil loosening (Figure 15 and Figure 16. The two-year average sediment yield at the plots with soil loosening was 103 lbs/acre/in (45 kg/ha/cm), compared to the plots without soil loosening, which was 152 lbs/acre/in (67 kg/ha/cm).

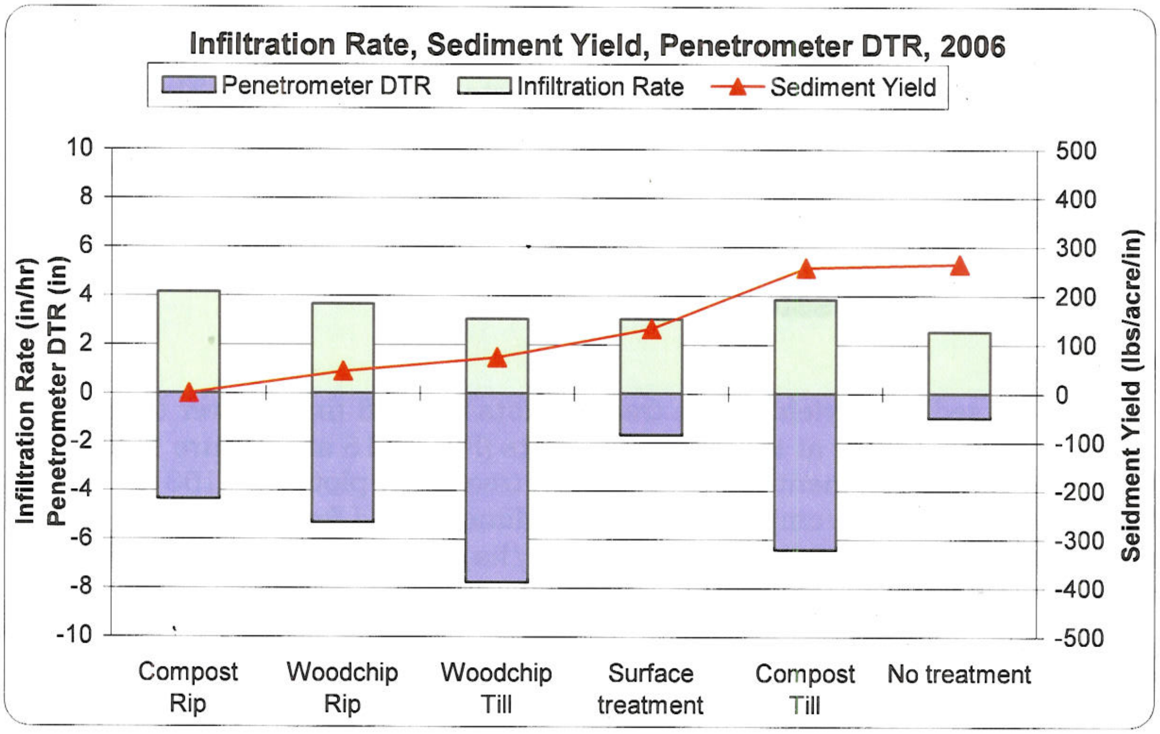

Figure 15. Infiltration rate, Sediment yield, and Penetrometer DTR, 2006. The compost rip plots did not produce any sediment and had the highest infiltration rate. Penetrometer DTR was measured pre-rainfall just outside the collection frame.

The average sediment yield at ripped plots was 13 times lower than the average sediment yield at tilled plots and similar to the average sediment yield at the native plot (Figure 15 and Figure 16). The compost rip plots did not produce any sediment in 2006 or 2007. The average sediment yield for all the ripped plots was 15 lbs/acre/in (7 kg/ha/cm), while the average sediment yield for the tilled plots was 190 lbs/acre/in (84 kg/ha/cm). The sediment produced at the ripped plots was similar to the sediment production at the native reference plot, which produced 8 lbs/acre/in (4 kg/ha/cm) of sediment.

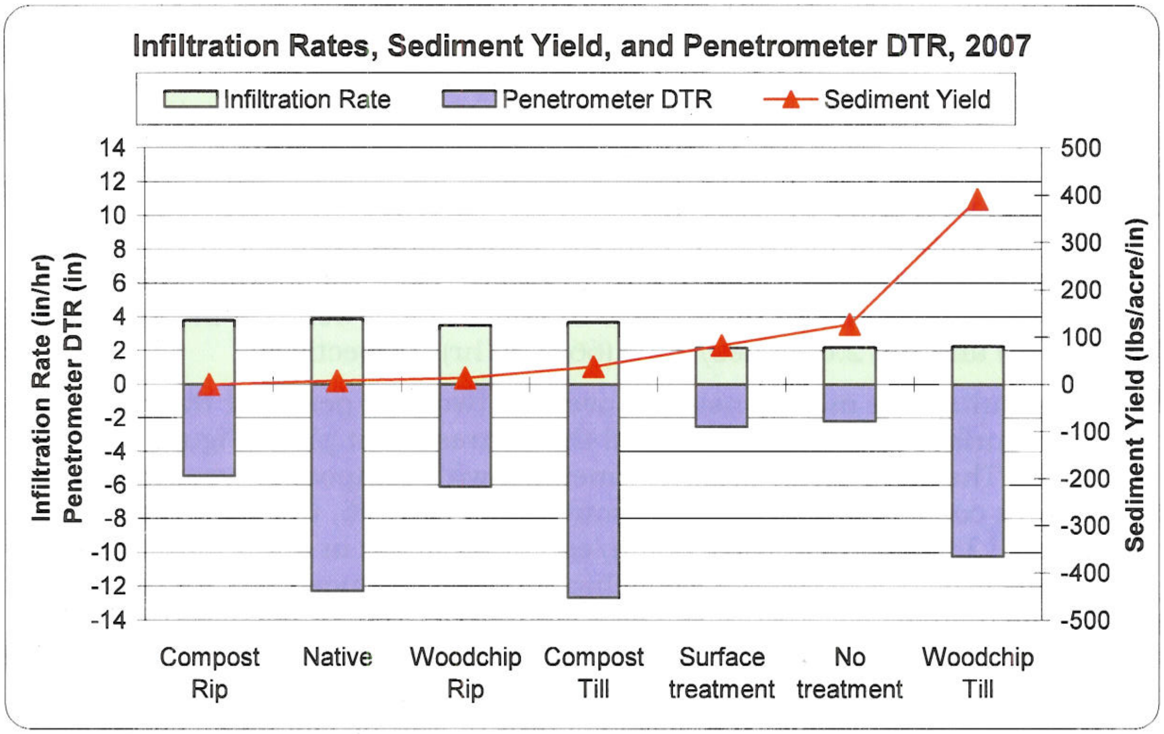

Figure 16. Infiltration Rate, Sediment Yield, and Penetrometer DTR, 2007. For the second year in a row, the compost rip plots did not produce any sediment and exhibited the highest infiltration rate. Penetrometer DTR was measured pre-rainfall just outside the collection frame.

The average sediment yield at the compost plots was 1.8 times lower than the average sediment yield at the woodchip plots (Figure 15 and Figure 16). In 2006 and 2007, the average sediment yield for the compost plots was 74 lbs/acre/in (33 kg/ha/cm), while the sediment yield at the woodchip plots was 131 lbs/acre/in (58 kg/ha/cm). In 2006, the compost till plots had unusually high sediment yields, while in 2007, the same phenomenon was observed at the woodchip till plots. The trend that compost plots have lower sediment yields needs to be further examined to determine whether the unusually high sediment yields at the compost and woodchip till plots were unusual.

The average infiltration rate at the full treatment plots was 1.5 times higher than the average infiltration rate at the no treatment plots, and 1.3 times higher than the average infiltration rates at the surface treatment plots (Figure 15 and Figure 16). The average infiltration rate at the full treatment plots was 3.5 inches/hour (89 mm/hr), while the infiltration rate for the no treatment plot was 2.4 inches/hour (61 mm/hr) and the surface treatment plot was 2.6 inches/hour (66 mm/hr).

The average infiltration rate at the plots with soil loosening was 1.4 times higher than the average infiltration rate at the plots without soil loosening

(Figure 15 and Figure 16). The two-year average infiltration rate at the plots with soil loosening was 3.5 inches/hour (89 mm/hr), compared to the plots without soil loosening, which was 1.4 inches/hour (36 mm/hr).

The average infiltration rate at the compost rip and native plots was 1.6 times higher than the average infiltration rate at the no treatment and surface treatment plots (Figure 15 and Figure 16). The average infiltration rates for the compost rip plots and native plot was 4.0 inches/hour (102 mm/hr) and 3.9 inches/hour (99 mm/hr), respectively. In comparison, the infiltration rate for the no treatment plots and the surface treatment plots were 2.4 inches/hour (61 mm/hr) and the 2.6 inches/hour (66 mm/hr), respectively.

Rainfall results were most consistent over the two year period at the ripped plots, the surface treatment plots, and the no treatment plots (Figure 15 and Figure 16). The tilled plots, whether amended with compost or woodchips, did not perform consistently in rainfall simulations. In 2006, the compost till plots produced 513 lbs/acre/in (226 kg/ha/cm) of sediment in one simulation and none in the other. In 2007, the woodchip till plots produced 751 lbs/acre/in (331 kg/ha/cm) of sediment in the first simulation and 34 lbs/acre/in (15 kg/ha/cm) of sediment in the second simulation. In both cases, the high sediment yield produced in only one frame was unusual since the other frame produced little to no runoff. It is possible that there was soil disturbance within the frame, either caused by an animal, or due to improper frame installation. These variations could also be the result of uneven tilling or poorly distributed amendments.

Soil Density

Plots with full treatment had significantly higher average DTRs than plots with surface treatment and plots with no treatment. Plots with full treatment had average DTRs that were approximately 3.7 times higher than the average DTRs at plots with surface treatment and approximately 5.2 times higher than average DTRs at the plots with no treatment (Figure 18 and Table 3). The average three year DTR at the full treatment plots was 8 inches (20 cm), while the average DTR at the surface treatment plot was 2 inches (5 cm), and the DTR at the no treatment plot was 1.5 inches (4 cm).

Plots with soil loosening (tilling or ripping) had significantly deeper average DTRs than the plots without soil loosening (no treatment and surface treatment). The soil loosening average DTRs were more than 4 times deeper than at plots without soil loosening (Table 3, Figure 17, and Figure 18). The average penetrometer depth to refusal (DTR) for plots without soil loosening was only 1.7 inches (4.3 cm), while the average DTR for plots with soil loosening was 7 inches (18 cm).

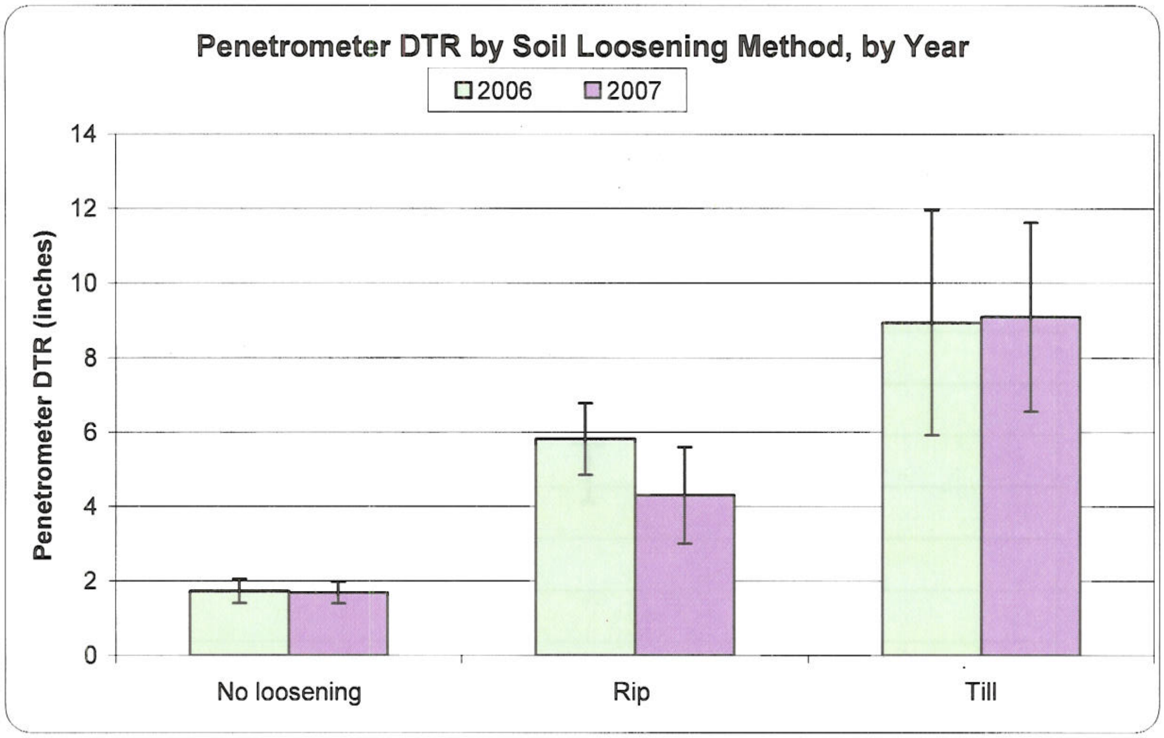

Figure 17. Penetrometer DTR by Soil Loosening Method, by Year. According the Mann-Whitney statistical test, tilling DTRs were significantly higher than ripping DTRs. Both soil loosening methods had significantly higher DTRs than the treatment methods that did not include soil loosening. The error bars represent one standard deviation above and below the mean.

The tilled plots had significantly deeper average DTRs than the ripped plots. The average DTRs at the tilled plots were more than 1.8 times deeper than the average DTRs at the ripped plots (Table 3). The tilled plots had an average DTR of 9 inches (23 cm), while the ripped plots had an average of 5 inches (13 cm).

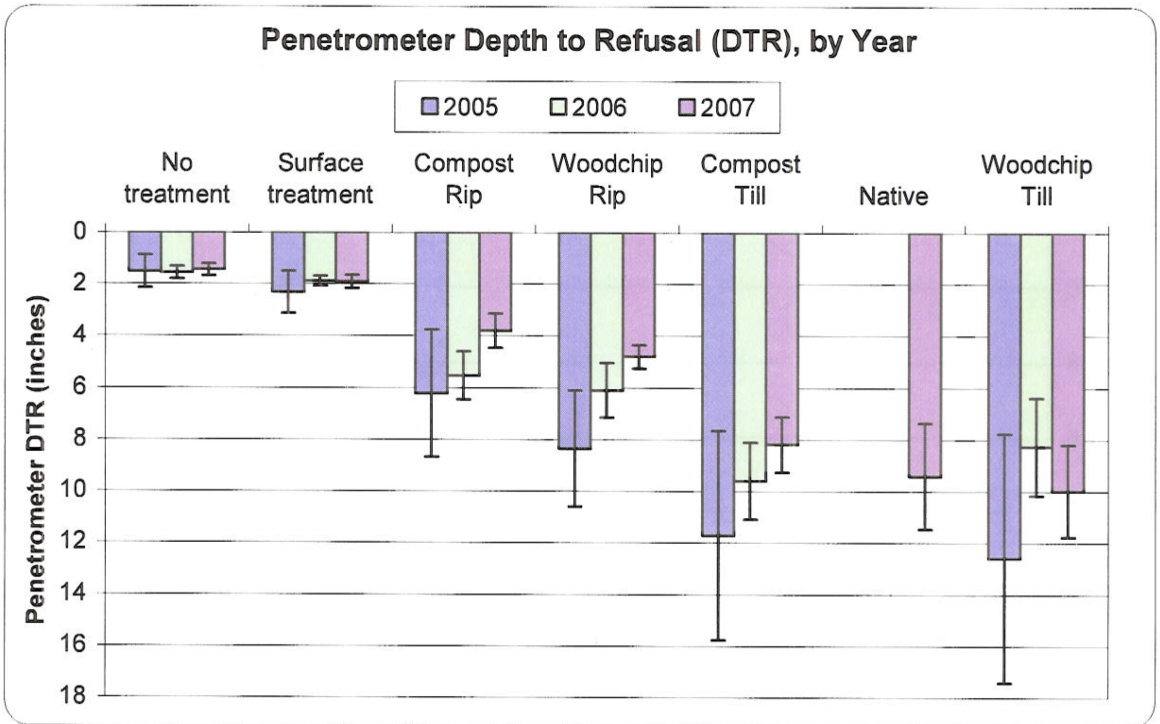

Figure 18. Penetrometer Depth to Refusal (DTR), by Year, as measured along transects, and sorted by average depth for 2007. The no treatment and surface treatment plots, without soil loosening, have the shallowest depths to refusal while the tilled plots have the deepest depths to refusal. The error bars represent one standard deviation above and below the mean.

Table 3. Mann-Whitney results for penetrometer DTR.

Y –variable	Test	Years	Statistic
DTR	Full treatment > Surface treatment	2006 2007	$U_{(12,3)} = 36$, $p < 0.01$ $U_{(12,3)} = 36$, $p < 0.01$
DTR	Full treatment > No treatment	2006 2007	$U_{(12,3)} = 36$, $p < 0.01$ $U_{(12,3)} = 36$, $p < 0.01$
DTR	Soil loosening > No soil loosening	2006 2007	$U_{(12,6)} = 72$, $p<0.01$ $U_{(12,6)} = 72$, $p<0.01$
DTR	Tilling > Ripping	2006 2007	$U_{(6,6)} = 30$, $p < 0.1$ $U_{(6,6)} = 30$, $p < 0.01$

Cover

Mulch Cover

The average mulch cover at plots with soil loosening was significantly higher than at plots without soil loosening (Table 4 and Figure 19). The average mulch cover at plots with soil loosening was 1.4 times higher, 90%, than at the plots without soil loosening, 65%.

The average mulch cover at ripped plots was significantly higher than the average mulch cover at tilled plots and at plots without soil loosening (Table 4 and Figure 19). The average mulch cover at ripped plots was 1.1 times higher than at tilled plots and 1.5 times higher than at plots without soil loosening (no treatment and surface treatment). The mean cover by mulch at ripped plots was 95%, compared to 84% cover at tilled plots and 65% cover at plots without soil loosening. High mulch cover is often associated with sediment reduction.[5] The higher mulch cover most likely contributed to the low sediment yields measured at the ripped plots (Figure 15 and Figure 16).

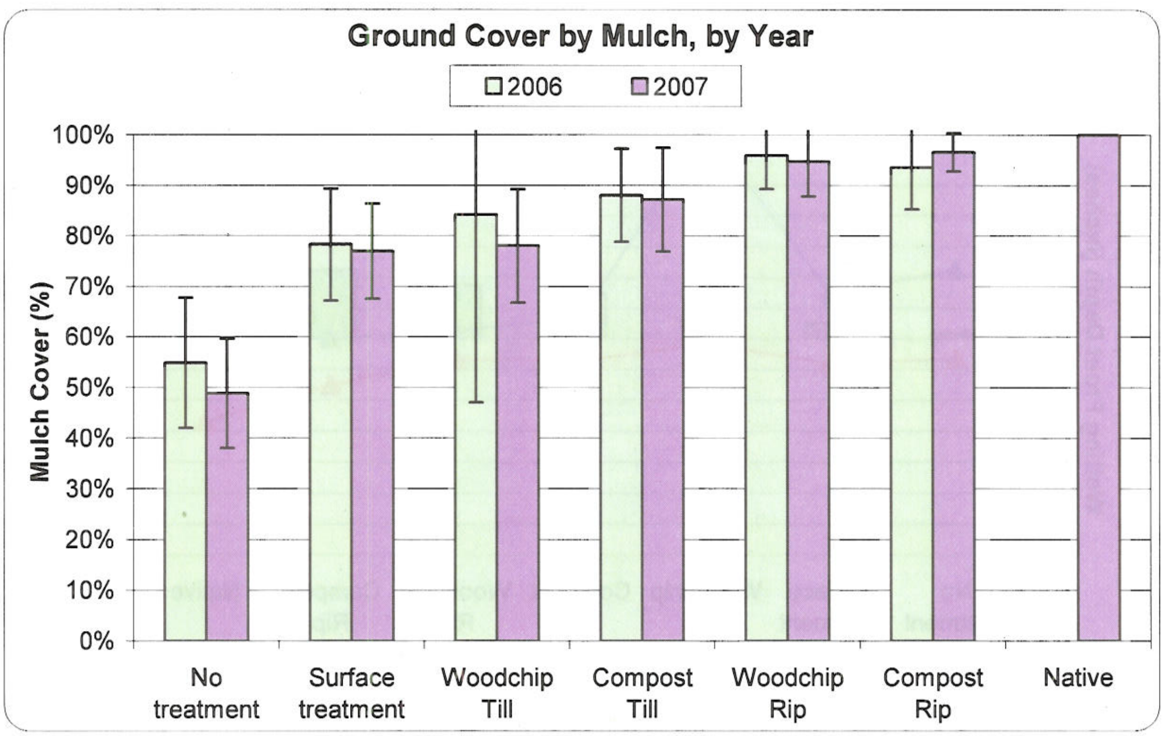

Figure 19. Ground Cover by Mulch, by Year. According to the Mann-Whitney results, ripped plots had the highest proportion of mulch when compared to tilled plots and plots without treatment or with surface treatment. The error bars represent one standard deviation above and below the mean.

[5] Grismer, ME, Hogan, MP. 2004. Evaluation of revegetation/mulch erosion control using simulated rainfall in the Lake Tahoe basin: 1. Method Assessment. *Land Degrad. & Develop.* 13:573-578.

Mulch Depth

In 2007, the deepest mulch (greater than 1.5 inches or 4 cm) was present at the plots with the lowest sediment yields (less than 83 lbs/acre/in or 37 kg/ha/cm) and deepest wetting depths (greater than 0.7 inches or 2 cm): the native plot and the ripped plots (Figure 20).

The native plot had the deepest mulch depth, 6 inches (15 cm) as measured along transects, while the ripped plots had depths between 1.7 and 2.2 inches (4.3 to 5.6 cm). All the other plots had mulch depths less than 1.5 inches (3.8 cm). The depth of mulch, as well as mulch cover, may be important factors in both reducing sediment yield from a slope and allowing water to infiltrate into the soil. It is possible that mulch allows lateral movement of the water through the mulch layer, thereby slowing the downward movement of water and allowing water to infiltrate slowly into the soil.

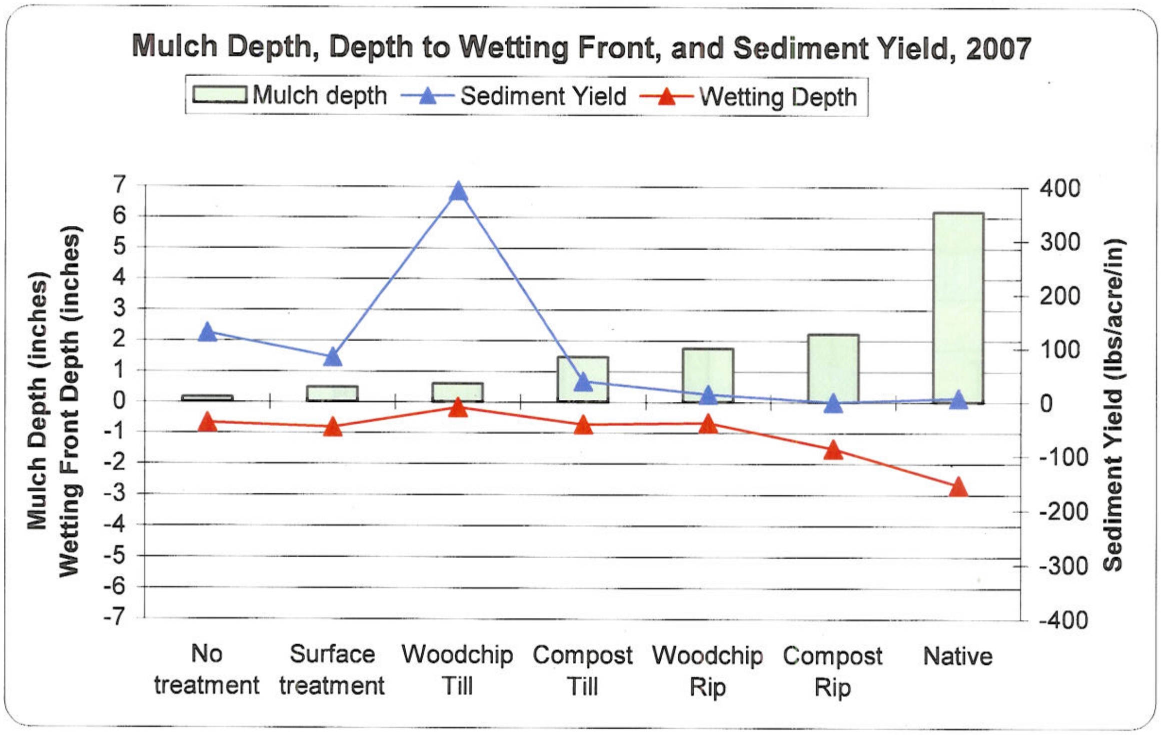

Figure 20. Mulch Depth, Depth to Wetting Front, and Sediment Yield, 2007. The plots with deeper mulch depths (native and ripped plots) allowed water to penetrate deeper, as shown by the soil depth to wetting. They also produced very little to no sediment.

Bare Soil

The plots with soil loosening had significantly lower average cover by bare soil than plots without soil loosening. The average percent of bare soil was 2.5 times lower at the plots with soil loosening (8%) when compared to the plots without soil loosening (19%, Table 4 and Figure 21).

The ripped plots had significantly lower average cover by bare soil in 2006 and 2007 when compared to the tilled plots and the plots without soil loosening (no treatment and surface treatment). Bare soil at the ripped plots was 3.3 times less than bare soil at the tilled plots and 6.3 times less than bare soil at the plots without soil loosening (Table 4 and Figure 21). The average percentage of bare soil at ripped plots was 3%, compared to 10% at tilled plots, and 19% at plots without treatment or surface treatment. The low proportion of bare soil most likely contributed to the lower sediment yields measured at ripped plots (Figure 15 and Figure 16).

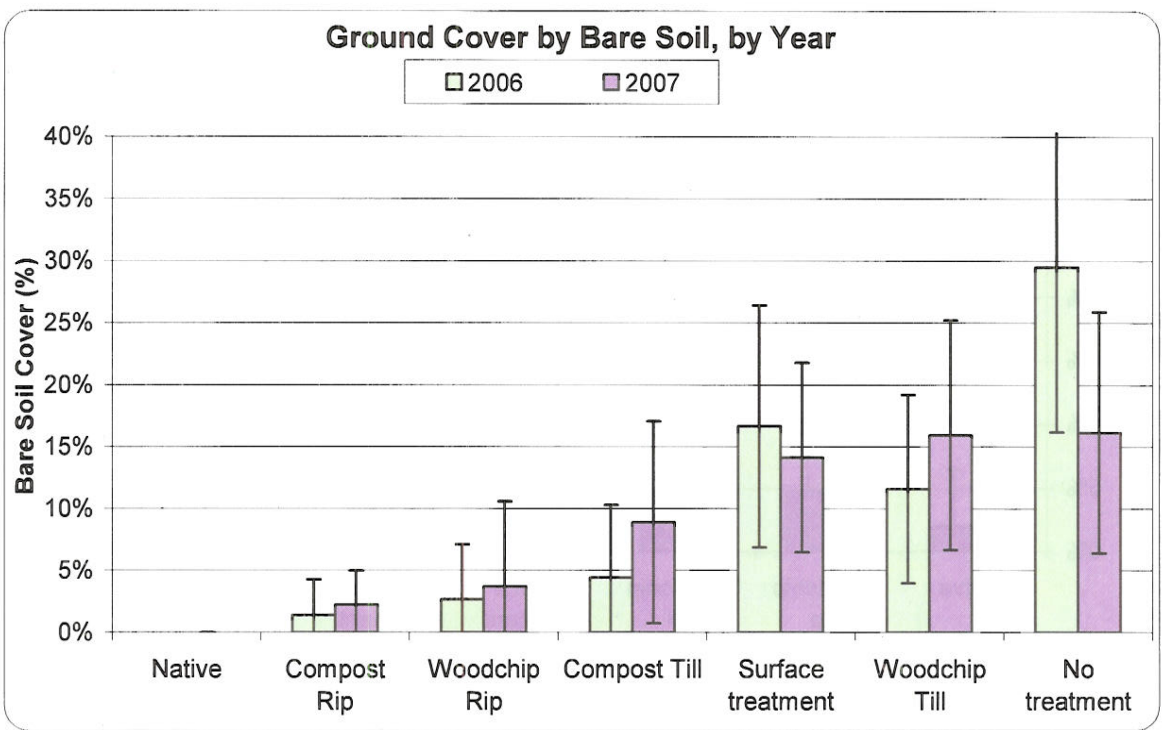

Figure 21. Ground Cover by Bare Soil, by Year. According to the Mann-Whitney test, the compost plots had the lowest proportion of bare soil in 2006 and 2007. The data is sorted by 2007 bare cover. The error bars represent one standard deviation above and below the mean.

Foliar Plant Cover

In 2006 and 2007, plots amended with compost exhibited significantly higher average foliar cover by plants than plots amended with woodchips (Table 4 and Figure 22). The average foliar plant cover was 3.4 times higher at the compost plots compared to woodchips plots. The average foliar cover for compost plots was 17%, while the cover for woodchips plots and no amendment plots was 5% and 8%, respectively.

Plots with compost had significantly higher foliar cover than plots without treatment or with surface treatment in 2006, but not in 2007 (Table 4). In 2007, no treatment plots and plots with surface treatment had significantly higher foliar plant cover than plots with woodchips; however, this was not the case in 2006 (Table 4).

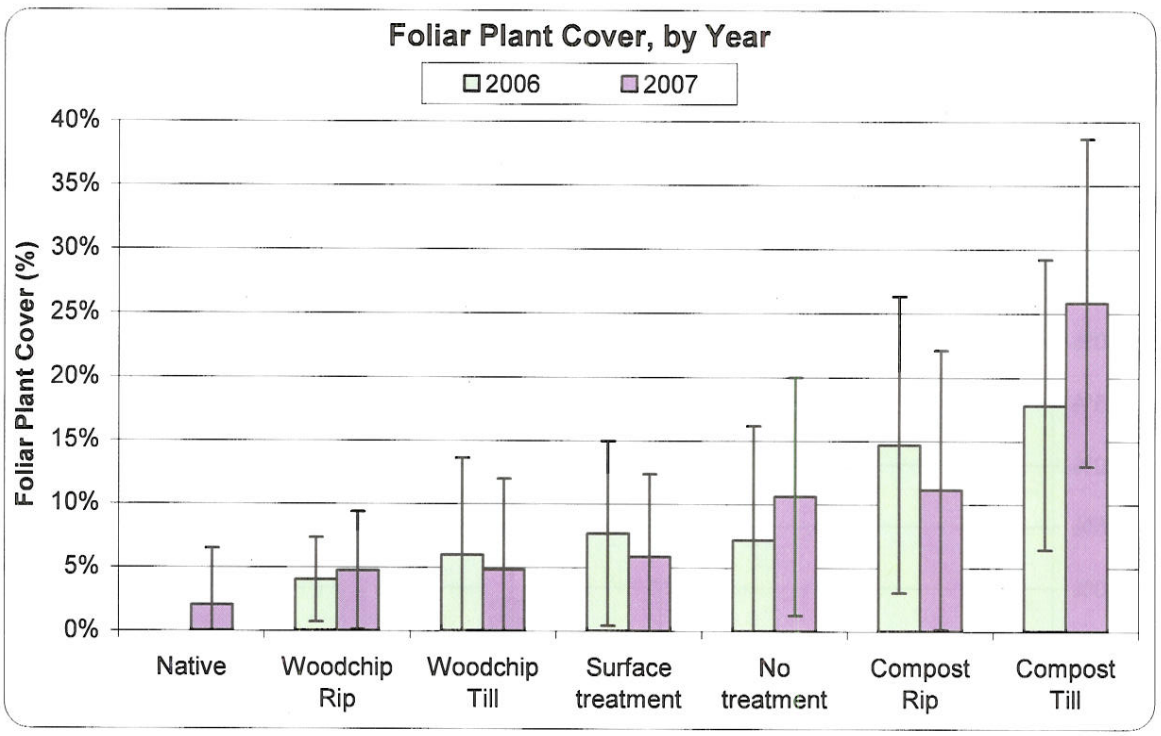

Figure 22. Foliar Plant Cover, by Year. According to the Mann-Whitney results, the plots amended with compost had the highest foliar plant cover when compared to plots with the woodchips (2006 and 2007) and to surface treatment and no treatment plots (in 2006 only). The error bars represent one standard deviation above and below the mean.

Cover Composition

In 2006, perennial native plants dominated at most treatment sites, while in 2007, alien plants dominated at most treatment sites (Figure 23, Figure 24, Figure 25, and Figure 26).

In 2006, the average percent of total plant cover by perennial species on compost plots was significantly higher than for plots without amendments (no treatment or surface treatment, Table 4). Compost plots had 1.6 times higher average proportion of perennial plant cover than plots without amendments (no treatment or surface treatment). Compost plots had 72% percent cover by perennial species while no treatment and surface treatment plots had 45% at cover by perennial plants (Figure 23). This pattern did not extend into 2007. The proportion of cover by perennial species was significantly higher on plots with surface treatment and no treatment than on plots with compost (Table 4). No treatment and surface treatment plots had 52% percent cover by perennial species, while compost plots had 25% percent perennial species cover (Figure 24). Diverse cover by native perennial plants with deep, extensive root systems contributes to soil strength and a healthy plant ecosystem.

In 2006, the average percent of total plant cover by perennial species on full treatment plots amended with compost was significantly higher than for no treatment plots (Table 4). The percent of perennial cover for compost plots was 1.9 times higher than from no treatment plots. The percent of perennial cover for compost plots was 72%, compared to 37% for no treatment plots.

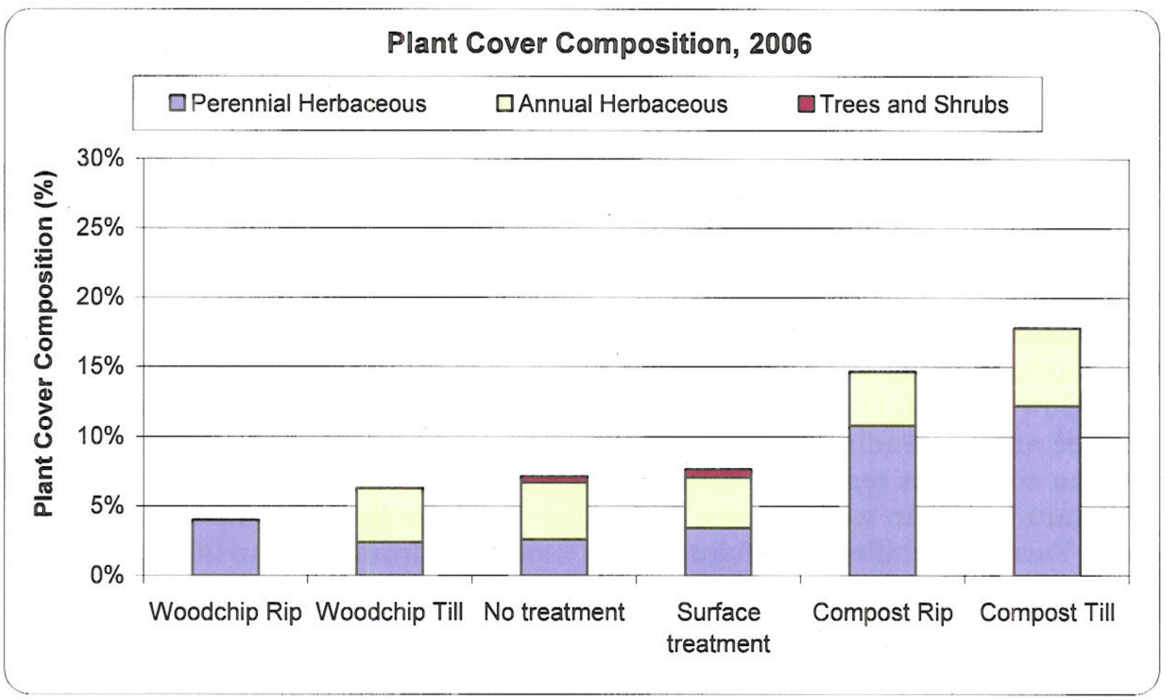

Figure 23. Plant Cover Composition, 2006. Plots with compost had the highest proportion of perennial species.

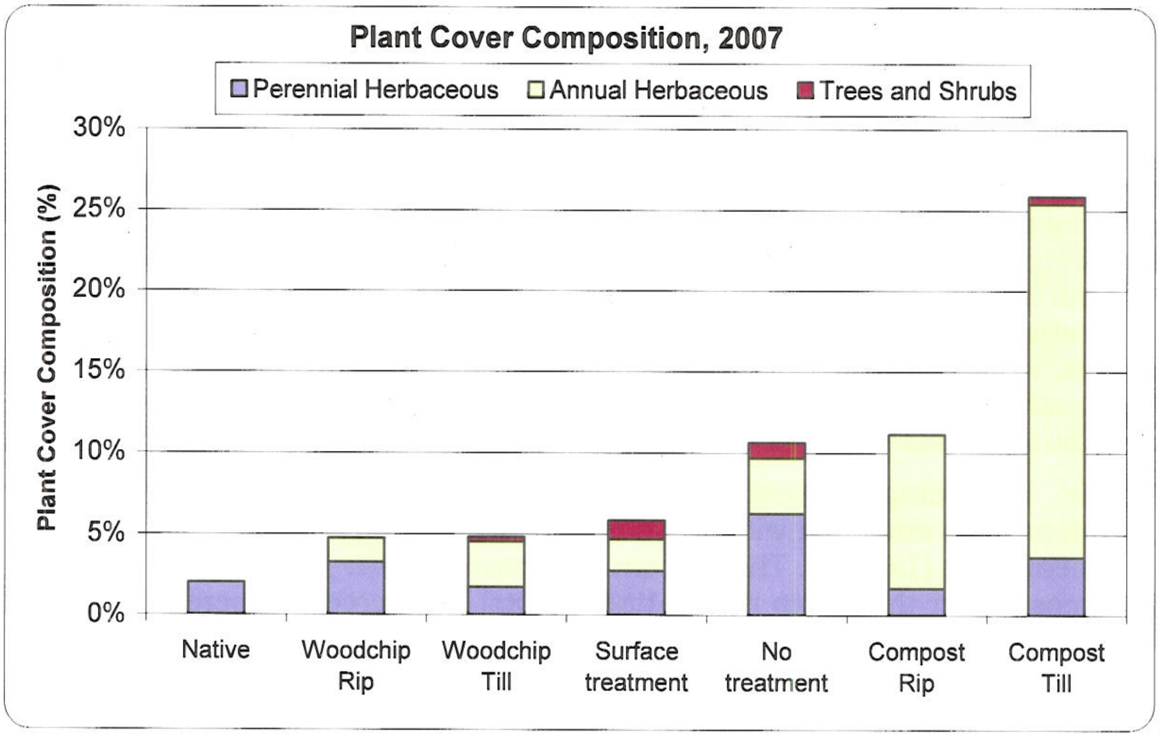

Figure 24. Plant Cover Composition, 2007. Plots without treatment or with surface treatment had the highest proportion of cover by perennial species.

In 2006, mountain brome was the dominant seeded grass, while in 2007, mountain brome was present in small quantities and squirreltail was the dominant seeded grass (Figure 25 and Figure 26). In 2006, annual precipitation was above the normal 30 inches received in the Tahoe-Truckee area during a water year (October 1 – September 30). In 2007, precipitation was below normal. Other studies of plant cover composition within the Tahoe-Truckee area, including the Caltrans Truckee Bypass test plots and the Tahoma soil boxes test site exhibited the same pattern: a higher proportion of mountain brome in wetter years and a higher proportion of squirreltail in drier years. Yarrow (Achillea millefolium) also increased from 2006 to 2007, but is unknown whether this is related to the difference between the water years.

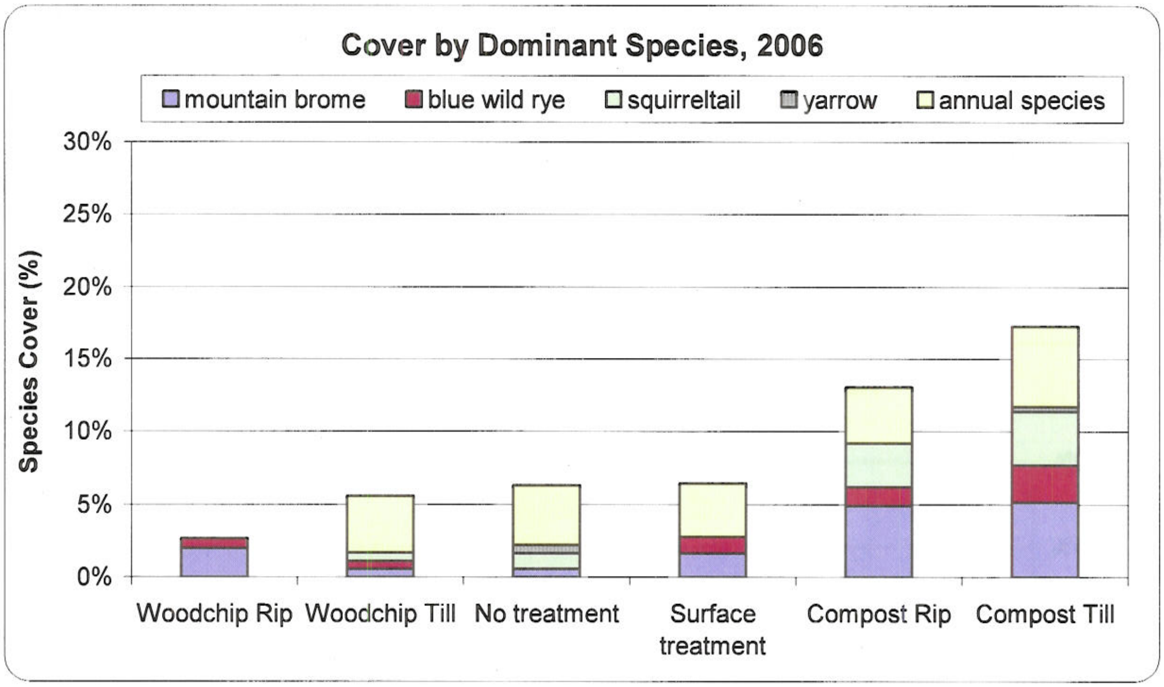

Figure 25. Cover by Dominant Species, 2006. Mountain brome is the most widely distributed species. Other perennial species were present in small quantities, but are not presented here. Therefore, 100% of cover is not represented.

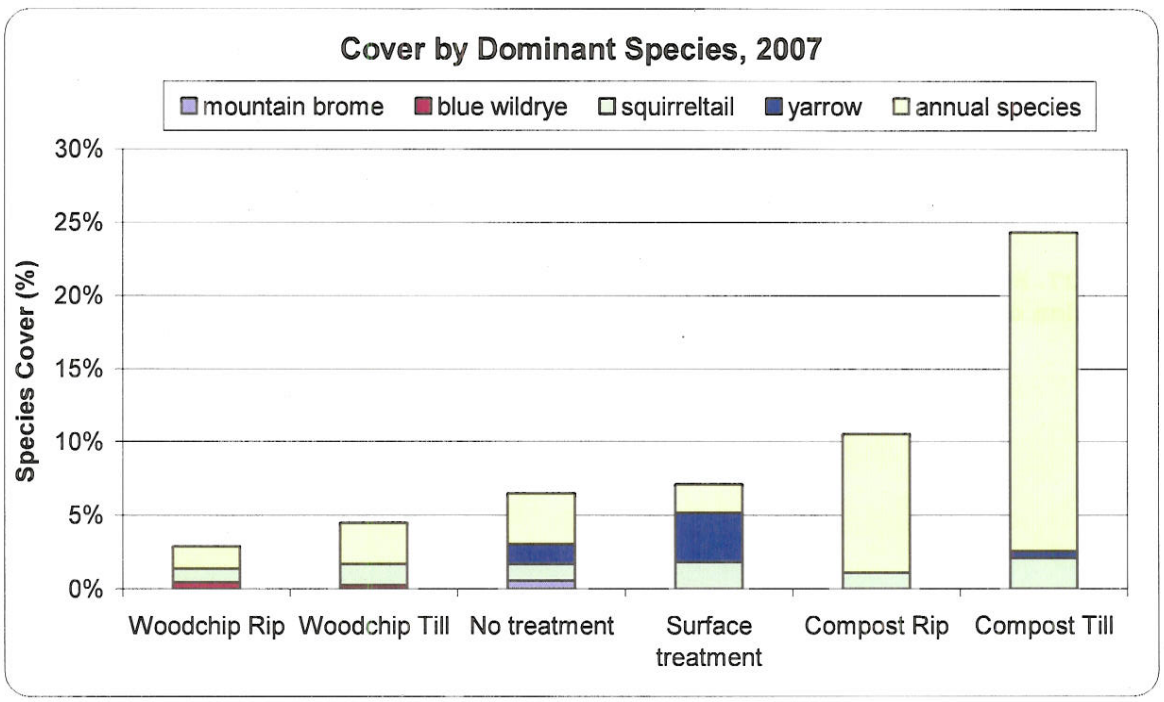

Figure 26. Cover by Dominant Species, 2007. Squirreltail is the most widely distributed perennial species in 2007. Other perennial species were present in small quantities but are not presented here. Therefore, 100% of cover is not represented.

In 2007, the average alien species composition at compost plots was significantly higher than at surface treatment and no treatment plots. The average percent of alien species at compost plots, 78%, was 1.9 times higher than the average percent of alien species at surface treatment and no treatment plots, 42% (Table 4, Figure 27, Figure 28, and Figure 29). Since higher cover by alien species was not observed (ocularly) at compost plots in 2006, further study is necessary to determine whether alien species will persist on these plots.

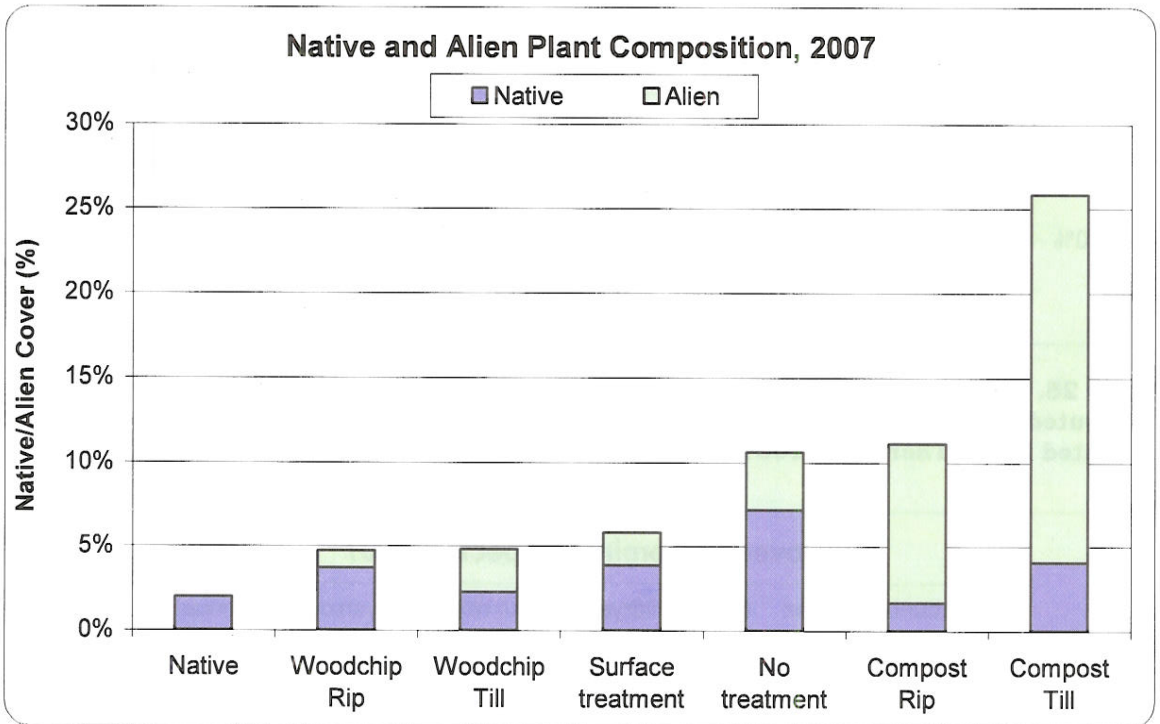

Figure 27. Native and Alien Plant Composition, 2007. Plots with compost have a higher proportion of cover by alien species when compared to test plots without amendments.

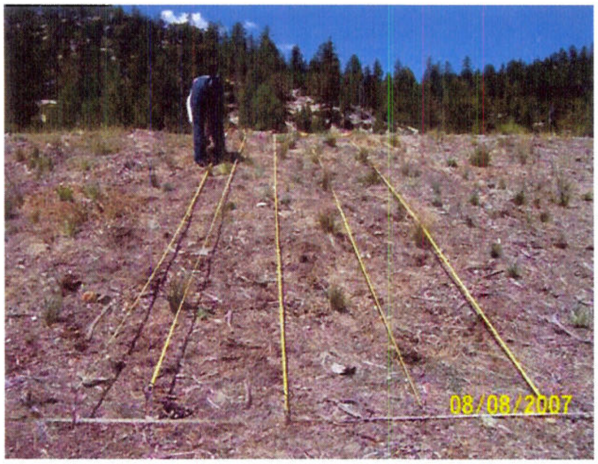

Figure 28. Photo of woodchip rip plot with transects, 2007. This plot had comparatively low overall cover, but a high percentage of native, perennial plants (green bunch grasses).

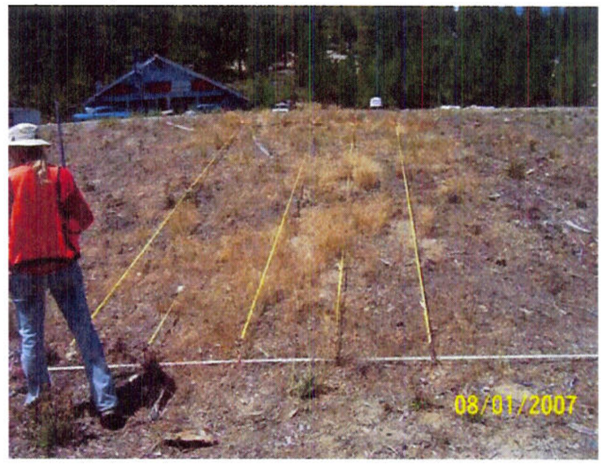

Figure 29. Photo of compost till plot with transects, 2007. This plot had comparatively high overall cover, but the majority of cover was by alien, annual species (brown diffuse grasses).

It is important to note that some of the annual species found at the Meyers Airport plots were alien species and a few are considered invasive by the California Invasive Plant Council (Appendix A).[6] It is often difficult to minimize the number of annual plants close to roadsides and it is important to further study the levels of these invasive plants over time and whether certain treatments increase or reduce the proportion of these species.

Table 4. Mann-Whitney results for cover.

Y –variable	Test	Year	Statistic
% Mulch Cover	Soil Loosening > No Soil Loosening	2006 2007	$U_{(12,6)} = 70, p < 0.01$ $U_{(12,6)} = 68, p < 0.01$
% Mulch Cover	Ripped > Tiilled	2006 2007	$U_{(6,6)} = 30, p < 0.01$ $U_{(6,6)} = 30, p < 0.01$
% Mulch Cover	Ripped > No Soil Loosening	2006 2007	$U_{(6,6)} = 30, p < 0.01$ $U_{(6,6)} = 30, p < 0.01$
% Bare Cover	Soil Loosening > No Soil Loosening	2006 2007	$U_{(12,6)} = 69, p < 0.01$ $U_{(12,6)} = 55.5, p < 0.1$
% Bare Cover	Ripped < Tilled	2006 2007	$U_{(6,6)} = 32.5, p < 0.05$ $U_{(6,6)} = 33, p < 0.05$
% Bare Cover	Ripped < No Soil Loosening	2006 2007	$U_{(6,6)} = 36, p < 0.01$ $U_{(6,6)} = 33, p < 0.05$
% Foliar Plant Cover	Compost > Woodchips	2006 2007	$U_{(6,6)} = 36, p < 0.01$ $U_{(6,6)} = 28.5, p < 0.1$
% Foliar Plant Cover	Compost > No amendment (no treatment or surface treatment)	2006	$U_{(6,6)}=36, p < 0.01$
% Foliar Plant Cover	No amendment (no treatment or surface treatment) > Woodchips	2007	$U_{(6,6)}=28.5, p < 0.1$

[6] http://portal.cal-ipc.org/weedlist

Y –variable	Test	Year	Statistic
% Perennial Plant Cover of Foliar Plant Cover	Compost > No amendment (no treatment or surface treatment)	2006	$U_{(6,6)}=30$, $p < 0.1$
% Perennial Plant Cover of Foliar Plant Cover	Compost > No treatment	2006	$U_{(6,3)} = 18$, $p < 0.05$
% Perennial Plant Cover of Foliar Plant Cover	No amendment (no treatment or surface treatment > Compost	2007	$U_{(6,6)} =30$, $p <0.1$
% Alien Species	Compost > No amendment (no treatment or surface treatment)	2007	$U_{(6,6)}=30.5$, $p < 0.05$

Soil Nutrients

Neither organic matter, nor TKN reached native reference levels at any of the test plots (Figure 30). TKN at the native site was 1,448 ppm and the organic matter content was 4%. In 2007, TKN at the compost plots was 1.4 times higher than TKN at the woodchip plots and 1.6 times higher than TKN at the surface treatment plots. Organic matter was about 1.2 times higher than at the woodchip plots. At compost plots, TKN was 1,125 ppm and the organic matter content was 1.9%.

Although both organic matter and TKN increased between 2006 and 2007 for each treatment type sampled, compost plots exhibited the largest increase in TKN, 220% (Figure 30). In comparison, organic matter and TKN at no treatment and surface treatment plots showed a small increase. If nutrient levels at compost plots continue to increase over time, it is possible that the nutrient levels will reach native levels.

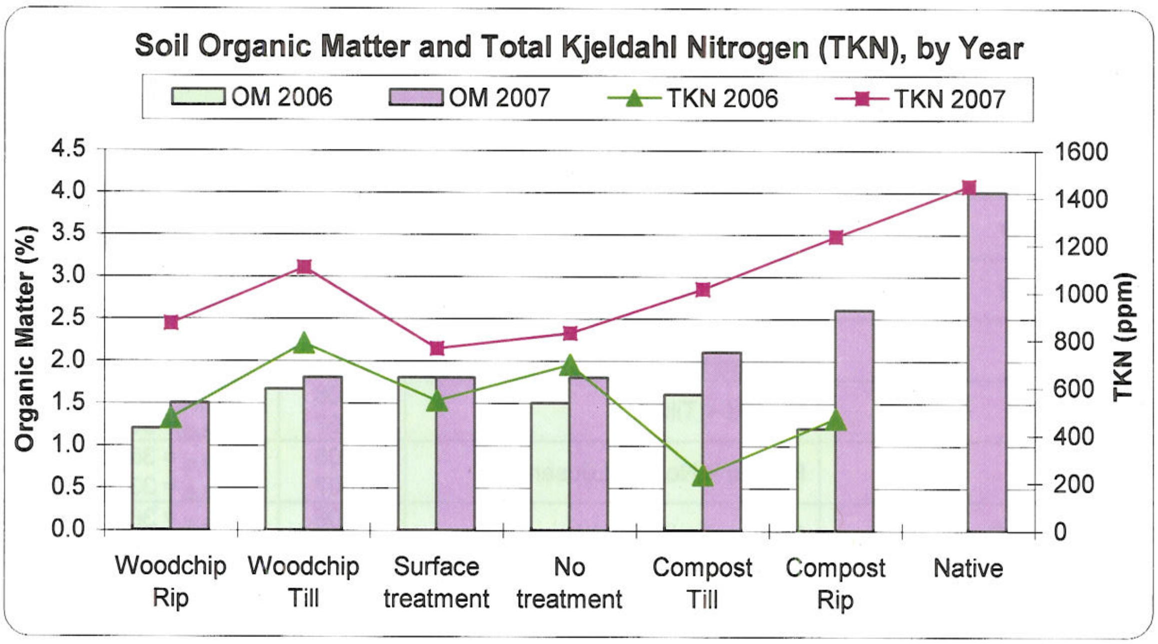

Figure 30. Soil Organic Matter (OM) and Total Kjeldahl Nitrogen (TKN), by Year. Organic matter and TKN increased between 2006 and 2007. In 2007, compost plots had the highest organic matter and TKN of the treatment plots. Graph sorted by organic matter.

The average TKN for the compost plots in 2007 was 1,125 ppm, while the average TKN at woodchip plots was 985 ppm and plots without treatment or with a surface treatment, 795 ppm. Organic matter content did not vary as much between treatments. Compost plots had slightly higher organic matter than woodchips plots. Organic matter content at compost plots and woodchip plots was 1.9% and 1.6%, respectively. Plots without treatment or with surface treatment had an organic matter content average of 1.7%. Although the same amount of nitrogen was applied in compost and woodchip test plots with soil loosening, nitrogen in the compost may release faster. This would lead to higher TKN levels observed at the compost plots.

Soil Shear Strength

Shear strength at most treatment plots was similar to that at the native plot, but shear strength at woodchip till plots exceeded shear strength at native plot by 1.5 times (Figure 31). The average shear strength for the woodchip till plots was 31 kPa, while the range for the other treatment plots was 19 – 22 kPa. The native site shear strength was 21 kPa. It may be that the woody material in woodchip till plots provides resistance to the shear vane.

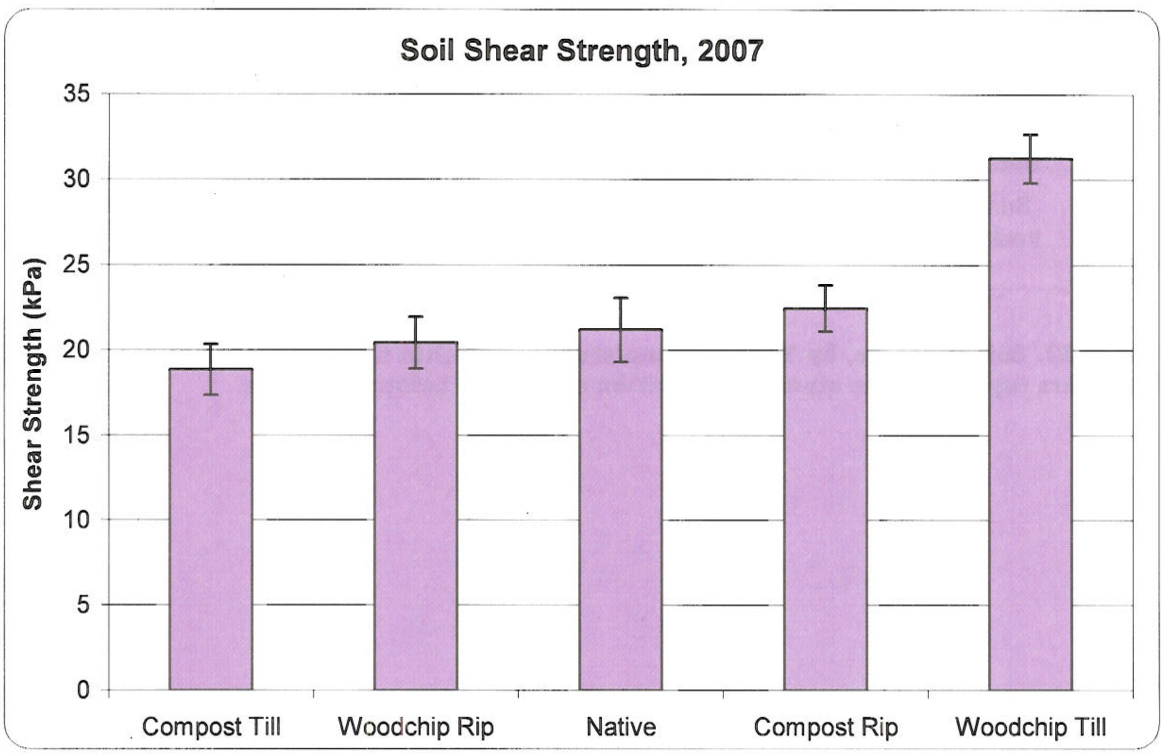

Figure 31. Soil Shear Strength, 2007. Woodchip till plots had the highest shear strength. The other treatment plots had shear strengths similar to that of the native site. The error bars represent one standard deviation above and below the mean.

Soil Moisture

Soil moisture was between 4% and 7% over a three year period (Figure 32) for all sites, which has been observed as a normal soil moisture level in soils with high solar exposure. Soil moisture affects biological activity in the soil. This activity is maximized at certain moisture levels with considerable decreases in biological activity above or below those levels.[7, 8]

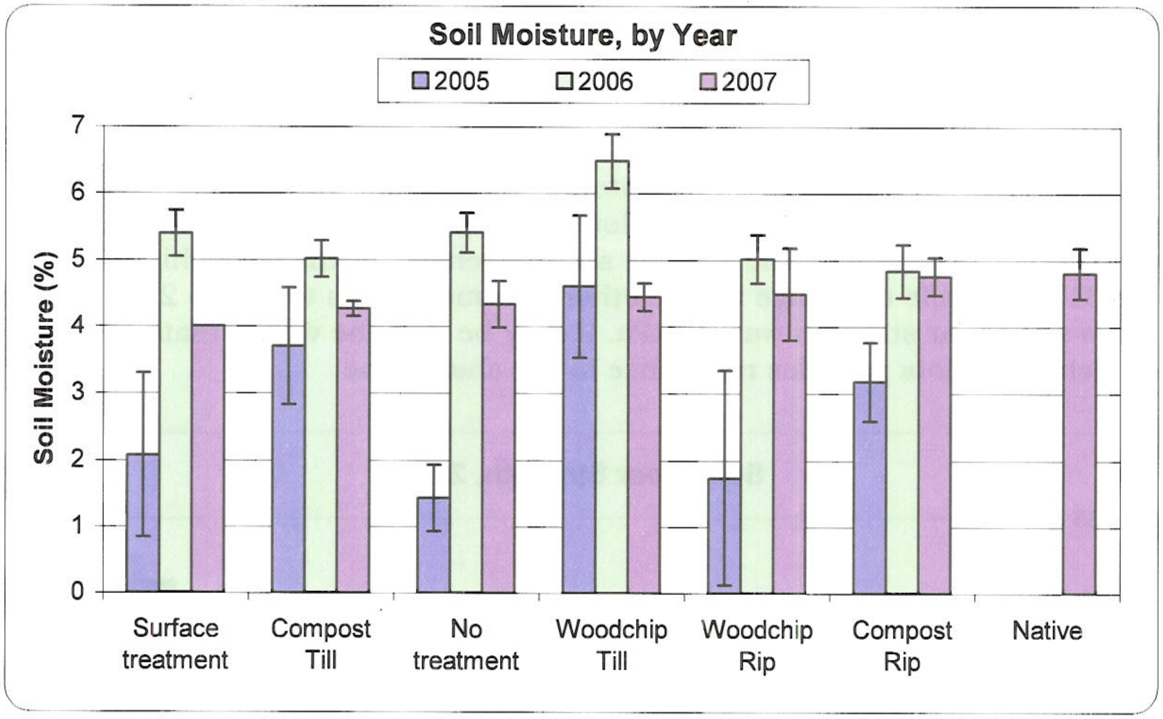

Figure 32. Soil Moisture, by Year. Soil moisture was within the normal range for all plots. Error bars represent one standard deviation about and below the mean.

[7] Paul E. A. and F.E. Clark. 1989. Soil Microbiology and Biochemistry. San Diego: Academic Press

[8] Allen, M.F. 1992. Mycorrhizal Functioning. NY: Chapman and Hall.

CONCLUSIONS

Infiltration

- Sediment yield at treated plots was 1.8 times lower than the sediment yield at untreated plots (Figure 15 and Figure 16).
- Sediment yield at plots with soil loosening was 1.5 times lower than sediment yield at plots without soil loosening (Figure 15 and Figure 16).
- Ripped plots exhibited sediment yields that were 13 times lower than sediment yields at tilled plots and similar to the sediment yields at the native plot (Figure 15 and Figure 16).
- Compost plots exhibited sediment yields that were 1.8 times lower than the sediment yields at woodchip plots (Figure 15 and Figure 16).
- Full treatment plots exhibited infiltration rates that were 1.5 times higher than infiltration rates at no treatment plots, and 1.3 times higher than infiltration rates at surface treatment plots (Figure 15 and Figure 16).
- Compost rip plots and native plots exhibited infiltration rates that were 1.6 times higher than infiltration rates at no treatment and surface treatment plots (Figure 15 and Figure 16).
- Rainfall results were most consistent over the two year period at ripped plots, surface treatment plots, and no treatment plots (Figure 15 and Figure 16).

Soil Density

- Plots with full treatment had DTRs that were 3.7 times higher than DTRs at plots with surface treatment plot, and 5.2 times higher than DTRs at plots with no treatment (Figure 18 and Table 3).
- Plots with soil loosening (tilling or ripping) had significantly deeper DTRs than plots without soil loosening (no treatment and surface treatment). The DTRs at plots with soil loosening were more than 4 times deeper than plots without soil loosening (Table 3, Figure 17, and Figure 18).
- Tilled plots had significantly deeper DTRs than ripped plots. The DTRs at tilled plots were more than 1.8 times deeper than DTRs at ripped plots (Table 3).

Mulch Cover

- Average mulch cover at plots with soil loosening was significantly higher than at plots without soil loosening (Table 4 and Figure 19). Average mulch cover at plots with soil loosening was 1.4 times higher, 90%, than at plots without soil loosening, 65%.

- Mulch cover at ripped plots was significantly higher than mulch cover at tilled plots and at plots without soil loosening (Table 4 and Figure 19). Mulch cover at ripped plots was 1.1 times higher than at tilled plots and 1.5 times higher than at plots without soil loosening (no treatment and surface treatment).

Mulch Depth

- In 2007, the deepest mulch (greater than 1.5 inches or 4 cm) was present at plots with the lowest sediment yields (less than 83 lbs/acre/in or 37 kg/ha/cm) and the deepest wetting depths (greater than 0.7 inches or 2 cm): the native plot and ripped plots (Figure 20).

Bare Soil

- Ripped plots had significantly lower cover by bare soil in 2006 and 2007 when compared to tilled plots and plots without soil loosening (no treatment and surface treatment). The average percent of bare soil was 2.5 times lower at plots with soil loosening (8%) when compared to plots without soil loosening (19%) (Table 4 and Figure 21).
- Bare soil at ripped plots was 3.3 times less than bare soil at tilled plots and 6.3 times less than bare soil at plots without soil loosening (Table 4 and Figure 21).

Plant Cover and Composition

- In 2006 and 2007, plots amended with compost exhibited significantly higher foliar cover by plants than plots amended with woodchips (Table 4 and Figure 22). Foliar plant cover was 3.4 times higher at compost plots compared to woodchips plots
- In 2006, perennial native plants dominated at most treatment sites, while in 2007, alien plants dominated at most treatment sites (Figure 23, Figure 24, Figure 25, and Figure 26).
- In 2006, the percent of total plant cover by perennial species on compost plots was significantly higher than for plots with no treatment or surface treatment (Table 4). Compost plots had 1.9 times higher proportion of perennial plant cover than plots with no treatment or surface treatment.
- In 2006, mountain brome was the dominant seeded grass, while in 2007, mountain brome was present in small quantities and squirreltail was the dominant seeded grass (Figure 25 and Figure 26).
- In 2007, the alien species composition at compost plots was significantly higher than at surface treatment and no treatment plots. The percent of

alien species at compost plots, 78%, was 1.9 times higher than the percent of alien species at surface treatment and no treatment plots, 42% (Table 4, Figure 27, Figure 28, and Figure 29).

Soil Nutrients

- Neither organic matter nor TKN reached native reference levels at any of test plots (Figure 30).
- In 2007, TKN at the compost plots was 1.4 to 1.6 times higher than other treatment plots and organic matter was about 1.2 times higher than at full treatment plots (Figure 30).
- Although both organic matter and TKN increased between 2006 and 2007 for each treatment type sampled, compost plots exhibited the largest increase in TKN, 220% (Figure 30).

Shear Strength

- Shear strength at most treatment plots was similar to the native plot, but shear strength at woodchip till plots exceeded shear strength at the native plot by 1.5 times (Figure 31).

RECOMMENDATIONS

These recommendations pertain to east-facing sites with: approximately 24 degree slopes, granitic parent material, approximate elevations of 6,270 feet (1,911 m), and solar exposures ranging from 72-99%.

Tilling or Ripping: 12 inches (30.5 cm)

Amendment: 4 inches (10 cm) of compost (25% fines and 75% coarse)

Biosol: 2,000 lbs/ac (2,241 kg/ha)

Seed: 125 lbs/ac (140 kg/ha) seed with the following composition:

30% squirreltail
40% blue wildrye
20% mountain brome
10% native forbs and shrubs

Mulch: pine needles, 2 inches (5 cm), applied to 99%

Full treatment versus No Treatment

Full treatment, which includes soil loosening, organic soil amendment application, organic fertilizer addition, native seed application at 125 lbs/acre (140 kg/ha), and pine needle mulch (greater than 1 inch or 2.5 cm deep) application, is recommended for the following reasons. When compared to no treatment plots, full treatment plots exhibited:

- sediment yields that were 1.8 times lower
- infiltration rates that were 1.5 times higher at full treatment versus surface treatment plots
- penetrometer DTRs that were significantly deeper, as much as 5.2 times
- significantly higher proportion of perennial plant cover at full treatment plots with compost when compared to the no treatment plots (2006). Full treatment plots with compost had 1.9 times higher proportion of plant cover than no treatment plots.

Full treatment versus Surface Treatment

Full treatment, which includes soil loosening, organic soil amendment application, organic fertilizer addition at 2,000 lbs/acre (2,241 kg/ha), native seed application at 125 lbs/acre (140 kg/ha), and pine needle mulch (greater than 1 inch or 2.5 cm deep) application, is recommended for the following reasons. When compared to surface treatment plots, full treatment plots exhibited:

- similar sediment yields
- infiltration rates that were 1.3 times higher
- penetrometer DTRs that were significantly deeper, by 3.7 times

Soil Loosening versus No Soil Loosening

Soil loosening is recommended, rather than no soil loosening, for the following reasons. Plots with soil loosening exhibited:

- sediment yields that were 1.5 times lower than at plots without soil loosening
- infiltration rates that were 1.4 times higher than infiltration rates at plots without soil loosening
- DTRs that were more than 4 times deeper than DTRs at plots without soil loosening (Table 3, Figure 17, and Figure 18)
- significantly higher mulch cover than plots without soil loosening. Mulch cover at plots with soil loosening was 90%, 1.4 times higher, than at plots without soil loosening where the cover was 65%.
- significantly lower cover by bare soil than plots without soil loosening. The percent of bare soil was 2.5 times lower at plots with soil loosening (8%) when compared to plots without soil loosening (19%).

Soil Loosening Method (Tilling versus Ripping)

It is difficult to draw conclusions about the two soil loosening methods because of the affect of surface mulch cover and the difference in tilling depths between tilled and ripped plots.

- Tilled plots had significantly deeper DTRs than ripped plots. The DTRs at tilled plots were more than 1.8 times deeper than the DTRs at ripped plots.
- Sediment yields at ripped plots were 13 times lower than sediment yields at tilled plots and similar to sediment yields at the native plot (Figure 15 and Figure 16).
- Bare soil at ripped plots was 3.3 times less than bare soil at tilled plots and 6.3 times less than bare soil at plots without soil loosening (Table 4 and Figure 21).
- Mulch cover at ripped plots was significantly higher than mulch cover at tilled plots (Table 4 and Figure 19). Mulch cover at ripped plots was 1.1 times higher than at tilled plots.

Amendment Types (Compost versus Woodchips)

Compost, applied to 4 inches (10 cm), is recommended over woodchips for the following reasons. Compost plots exhibited:

- sediment yields that were 1.8 times lower than sediment yields at woodchip plots (Figure 15 and Figure 16)
- penetrometer DTRs that were not statistically different from woodchip plots
- significantly higher foliar cover by plants than plots amended with woodchips (Table 4 and Figure 22). Foliar plant cover was 3.4 times higher at compost plots compared to woodchip plots.
- TKN concentrations that were at least 1.4 times higher than at woodchip plots (2007)
- the largest increase in TKN between 2006 and 2007, 220% (Figure 30)

Biosol

Biosol application at 2,000 lbs/acre (2,241 kg/ha) is recommended for the following reasons:

- This level has been shown to return soil nutrients to near native levels when appropriate and sufficient amendments are added in other studies. Soil nutrients did not reach native levels with this application because insufficient organic amendments were applied.

Seed

Native seed is recommended at the tested rate, 125 lbs/acre (140 kg/ha). Suggested species composition is:

40% squirreltail
20% blue wildrye
30% mountain brome
10% native forbs and shrubs

For the following reasons:

- Squirreltail was the most drought resistant species and was dominant in 2007 and present in 2006; therefore, it should dominate the seed mix.
- Blue wild rye did not dominate at the plots and should remain only in small quantities.
- Mountain brome should not compose a majority of the seed mix, as it did not respond well to low water conditions, but will proliferate in higher water years.
- A variety of native forbs and shrubs will maintain species diversity.

Mulch

Mulch application is recommended at 2 inches (5 cm) for the following reasons:

- In 2007, the deepest mulch (greater than 1.5 inches or 4 cm) was present at plots with the lowest sediment yields (less than 83 lbs/acre/in or 37 kg/ha/cm) and deepest wetting depths (greater than 0.7 inches or 2 cm): the native plot and ripped plots (Figure 20).
- Mulch application of 1 inch (2.5 cm) resulted in high bare cover at some plots (compost till and woodchip till).

Appendix A

Species list for the Meyers Airport, 2006. Highlighted species are dominant.

KEY

C = Compost W = Woodchips
R = Ripped T = Tilled
CC = Caltrans control B = Bare

Lifeform	Family	Scientific name	Common name	Annual/ Perennial	Native/ Alien	Invasive/ Noxious	In seed mix?	Plot 1 CR	Plot 5 CR	Plot 17 CR	Plot 2 CT	Plot 4 CT	Plot 6 CT	Plot 3 WR	Plot 7 WR	Plot 14 WR	Plot 8 WT	Plot 9 WT	Plot 13 WT	Plot 10 CC	Plot 15 CC	Plot 18 CC	Plot 11 B	Plot 12 B	Plot 16 B
Forb	Asteraceae	Ambrosia acanthicarpa	annual burweed	Annual	Native						X			X			X	X	X	X		X	X	X	X
Forb	Chenopodiaceae	Chenopodium albens	goosefoot	Annual	Alien						X														
Forb	Onagraceae	Gayophytum humile	Dwarf Groundsmoke	Annual	Native			X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Forb	Asteraceae	Lactuca serriola	devil's lettuce	Annual	Alien	Invasive				X	X					X			X		X				X
Forb	Fabaceae	Melilotus sp.	sweet clover	Annual	Alien			X	X	X		X	X					X							X
Forb	Chenopodiaceae	Salsola tragus	Russian thistle	Annual	Alien	Noxious		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Forb	Brassicaceae	Sisymbrium altissimum	tumble mustard	Annual	Alien				X	X	X	X	X	X		X	X	X	X						
Forb	Asteraceae	Tragapogon dubius	false salsify	Annual	Alien					X						X			X	X	X	X			X
Forb	Scrophulariaceae	Verbascum thapsis	mullen	Annual	Native	Invasive						X													
Forb	Brassicaceae	Lepidium campestre	English pepperweed	Annual	Alien				X	X	X	X	X												
Forb	Asteraceae	Achillea millefolium	yarrow	Perennial	Native		X			X	X		X	X		X	X	X				X			
Forb	Lilliaceae	Allium sp.	onion	Perennial	Native										X										
Forb	Asteraceae	Antennaria rosea	pussy toes	Perennial	Native							X	X	X											
Forb	Asteraceae	Aster integrifolius	entire-leaved aster	Perennial	Native																				
Forb	Fabaceae	Astragalus sp.	locoweed	Perennial	Native												X								
Forb	Polygonaceae	Eriogonum nudum	nude buckwheat	Perennial	Native																				X
Forb	Polygonaceae	Eriogonum umbellatum	sulfur flower	Perennial	Native		X			X							X			X	X	X	X	X	X
Forb	Onagraceae	Gayophytum diffusum	prarie smoke	Perennial	Native						X	X		X		X	X		X		X	X	X	X	X
Forb	Asteraceae	Grindelia nana	Idaho gumweed	Perennial	Native																X				
Forb	Fabaceae	Lathyrus latifolius	everlasting pea	Perennial	Alien												X								
Forb	Fabaceae	Lotus purshianus	Spanish lotus	Perennial	Native		X					X				X	X	X	X		X	X		X	X
Forb	Fabaceae	Lupinus brewerii	Brewer's lupine	Perennial	Native		X	X	X	X	X	X	X	X	X	X	X	X	X					X	
Forb	Fabaceae	Lupinus grayii	Gray's lupine	Perennial	Native		X							X											
Forb	Scrophulariaceae	Penstemon	Penstemon	Perennial	Native					X															
Forb	Hydrophyllaceae	Phacelia hastata	silverleaf phacelia	Perennial	Native						X			X		X		X	X		X			X	X
Forb	Fabaceae	Trifolium pratense	red clover	Perennial	Alien											X			X						

Lifeform	Family	Scientific name	Common name	Annual/ Perennial	Native/ Alien	Invasive/ Noxious	In seed mix?	Plot 1 CR	Plot 5 CR	Plot 17 CR	Plot 2 CT	Plot 4 CT	Plot 6 CT	Plot 3 WR	Plot 7 WR	Plot 14 WR	Plot 8 WT	Plot 9 WT	Plot 13 WT	Plot 10 CC	Plot 15 CC	Plot 18 CC	Plot 11 B	Plot 12 B	Plot 16 B
Graminoid	Poaceae	Bromus tectorum	cheatgrass	Annual	Alien			X	X	X	X	X	X	X	X	X	X	X	X				X	X	
Graminoid	Poaceae	Festuca octoflora	slender fescue	Annual	Native														X	X	X	X	X	X	
Graminoid	Poaceae	Agropyron intermedium	intermediate wheatgrass	Perennial	Alien																				
Graminoid	Poaceae	Bromus carinatus	mountain brome	Perennial	Native		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Graminoid	Poaceae	Elymus elymoides	squirreltail grass	Perennial	Native		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Graminoid	Poaceae	Elymus glaucus	blue wildrye	Perennial	Native		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Graminoid	Poaceae	Festuca idahoensis	Idahoe fescue	Perennial	Native		X	X	X		X			X	X		X	X						X	
Graminoid	Poaceae	Poa pratenseis	Kentucky bluegrass	Perennial	Native					X	X				X										
Shrub	Asteraceae	Artemisia tridentata	sagebrush	Perennial	Native			X			X							X		X	X		X		
Shrub	Rhamnaceae	Ceanothus velutinus	Tobacco brush	Perennial	Native														X						
Shrub	Rosaceae	Purshia tridentata	bitterbrush	Perennial	Native																X			X	X
Tree	Pinaceae	Abies concolor	white fir	Perennial	Native												X	X			X		X	X	X
Tree	Pinaceae	Pinus jefferyi	Jeffrey pine	Perennial	Native																X				

Species list for the Meyers Airport with Ocular Estimates of Cover, 2007. Highlighted species are dominant.

Lifeform	Family	Scientific name	Common name	Annual/ Perennial	Native/ Alien	Noxious	In seed mix?	% in seed mix	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9	Plot 10	Plot 11	Plot 12	Plot 13	Plot 14	Plot 15	Plot 16	Plot 17	Plot 18
Forb	Asteraceae	Achillea millefolium	yarrow	Perennial	Native		x	5.0%		T	T		T	T			T			T		T	T	<5	T	T
Forb	Asteraceae	Ambrosia acanthicarpa	annual burweed	Annual	Native				T	T	<5	T	T			T	<5	T	<5	<5	<5	T	T		T	T
Forb	Asteraceae	Aster integrifolius	entire-leaved aster	Perennial	Native																			T		
Forb	Fabaceae	Astragalus canadensis	short toothed milkvetch	Perennial	Native											T	T									
Forb	Chenopodiaceae	Bassia hyssopifolia	five horn bassia	Annual	Alien	Invasive							T										T			T
Forb	Asteraceae	Chaenactis douglasii	Douglas pincushion	Annual	Native																			T		
Forb	Chenopodiaceae	Chenopodium album	goosefoot	Annual	Alien				T	T	T	T												T		T
Forb	Boraginaceae	Cryptantha ambigua	Wilke's cryptantha	Annual	Native																				T	T
Forb	Brassicaceae	Descurainia sophia	herb sophia	Annual	Alien				T			<5	T	T										T	T	T
Forb	Polygonaceae	Eriogonum umbellatum	sulfur flower	Perennial	Native					T	T				T	T		T	T	T	T	T	T	T	T	<5
Forb	Polygonaceae	Eriogonum nudum	nude buckwheat	Perennial	Native		x	2.5%																		
Forb	Onagraceae	Gayophytum diffusum	prairie smoke	Perennial	Native				T	T	T	T		T		T		T	T	T	T	T	T	T	T	T
Forb	Onagraceae	Gayophytum humile	dwarf groundsmoke	Annual	Native				T			T	T		T	T	T	T	T	T	T	T	T	T		
Forb	Asteraceae	Grindelia nana	Idaho gumweed	Perennial	Native															<5			T	T		
Forb	Asteraceae	Lactuca serriola	devil's lettuce	Annual	Alien					T	T		T			T	T	T	T	T	T	T	T	T	T	T
Forb	Brassicaceae	Lepidium campestre	English pepperweed	Annual	Alien					T								T								
Forb	Brassicaceae	Lepidium perfoliatum	shield cress	Annual	Native																					T
Forb	Polemoniaceae	Linanthus harknessii	Harken's linanthus	Annual	Native				T																	
Forb	Fabaceae	Lotus purshianus	Spanish lotus	Perennial	Native		x	7.5%															T	T		
Forb	Fabaceae	Lupinus breweri	Brewer's lupine	Perennial	Native		x	5.0%	T	T	T	T	T	T	T	T	T			T	T	T	T			
Forb	Fabaceae	Lupinus grayii	Gray's lupine	Perennial	Native		x	5.0%	T		T										T					
Forb	Fabaceae	Medicago sativa	alfalfa	Annual	Alien								T													
Forb	Fabaceae	Melilotus alba	sweet clover	Annual	Alien												T			T	T					
Forb	Scrophulariaceae	Penstemon rydbergii	Rydberg's penstemon	Perennial	Native		x	5.0%																		
Forb	Hydrophyllaceae	Phacelia hastata	silverleaf phacelia	Perennial	Native					T	T						T			T	T	T	T	T		
Forb	Polygonaceae	Polygonum douglasii	Douglas knotweed	Annual	Native														T			T				
Forb	Chenopodiaceae	Salsola tragus	Russian thistle	Annual	Alien	Invasive/ Noxious			T	T	T	T	T	T	T	T	<5	5	T	T	T	<5	<5	T	T	T
Forb	Brassicaceae	Sisymbrium altissimum	tumble mustard	Annual	Alien				T	<5	T	<5	T	<5	T	T	T		T		T	T			T	T
Forb	Asteraceae	Tragopogon dubius	false salsify	Annual	Alien													T		T	T	T	T	T	T	T
Graminoid	Poaceae	Achnatherum occidentale	western needlegrass	Perennial	Native		x	7.5%																T		

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Graminoid	Poaceae	Agropyron intermedium /Elytrigia intermedia ssp. intermedia	intermediate wheatgrass	Perennial	Alien											T							T			T
Graminoid	Poaceae	Bromus carinatus	mountain brome	Perennial	Native		x	25.0%															T	T		T
Graminoid	Poaceae	Bromus tectorum	cheatgrass	Annual	Alien				T	T	T				T	T	T	T	T	<5	T	T	T	T - 5	10	T
Graminoid	Poaceae	Deschampsia elongata	elongated hairgrass	Perennial	Native		x	5.0%																		
Graminoid	Poaceae	Elymus elymoides	squirrel's tail grass	Perennial	Native		x	25.0%	<5	<5	5	<5	<5	<5	<5	5	<5	5	5-10	5	5-10	10	5	5	25	<5
Graminoid	Poaceae	Elymus glaucus	blue wildrye	Perennial	Native					T	T				T					T	<5	<5	<5	5	5	5
Graminoid	Poaceae	Festuca idahoensis	Idahoe fescue	Perennial	Native										T		T	T	T	<5	T		T			<5
Shrub	Asteraceae	Artemisia tridentata	sagebrush	Perennial	Native		x	2.5%	T	T	T					5-10	T	T	<5	T	T		T			
Shrub	Asteraceae	Chrysothamnus nauseosus	rubber rabbitbrush	Perennial	Native		x	2.5%																		
Shrub	Rosaceae	Purshia tridentata	bitterbrush	Perennial	Native		x	2.5%								T				T			T	<5		
Tree	Pinaceae	Abies concolor	white fir	Perennial	Native											T			T	T			T	T		
Tree	Pinaceae	Pinus jeffreyi	Jeffrey pine	Perennial	Native																		T			

T = trace amounts of cover