EVALUATION OF NATIVE GRASS SOD FOR STABILIZATION OF STEEP SLOPES

by

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ABSTRACT

The purpose of this investigation was to evaluate the ability of native grass sod to establish on several different steep slope environments. Specific objectives were to (i) measure plant growth characteristics on slopes with native grass sod treatments compared to other plant establishment methods, (ii) compare runoff, sediment yield, and infiltration rates on slopes with native grass sod to other plant establishment methods for a peak 10 year 24 hour storm event, (iii) model sediment yield on native grass sodded slopes compared to other plant establishment methods using RUSLE version 2.0, and (iv) evaluate the economic cost of using native sod compared to other plant establishment methods.

The sites selected were a highway fill site with a 40 % slope, a ski slope with a 35 % slope, and abandoned mine waste with a 70 % slope. Treatments included native grass sod, redtop sod, broadcast seed, broadcast seed with a straw blanket installed in 2003 and 2001, and broadcast seed with hydromulch.

During the 2003 growing season, mean perennial grass production of native grass sod was significantly greater (14 to 190 fold) than the other treatments on all three sites. Mean basal and canopy cover were significantly greater for native grass sod than the other treatments during both the 2003 and 2004 growing seasons on all three sites. In 2004, mean perennial grass production of native grass sod was significantly greater (7 fold) than the other treatments on the highway fill site. On the mine waste site in 2004, mean perennial grass production of native grass sod was significantly greater (6 fold) than the broadcast seed with the straw blanket installed in 2003.

When a peak 10 year 24 hour precipitation event was applied on the highway fill site, native grass sod and the broadcast seed with the straw blanket treatments had significantly less runoff and sediment loss than the broadcast seed with hydromulch treatment. RUSLE2 estimated sediment loss for native sod (4929 kg/ha/yr) to be four to five times less than the other treatments.

A cost analysis indicated that native sod would cost two to eight times more than the other treatments. However, native sod provided complete and immediate erosion control where the other treatments could not.

INTRODUCTION

Vegetation is a crucial component of erosion control, especially on steep slopes. The intricate root systems provide slope stabilization by binding the soil together. Above ground vegetation may act as a buffer against wind and water erosion. Additionally, vegetation attracts microbial populations that are a key component in nutrient cycling. Their ability to aid in soil aggregation helps to prevent erosion. In steep or sensitive areas it is imperative that vegetation become immediately established in order to stabilize the soil. New technology has allowed native grass sod to become a more feasible method of reclamation that can provide immediate stabilization with live cover.

A long plant establishment time is a major shortcoming of current technologies such as broadcast seeding and hydroseeding. It can take many months for germination and plant establishment to occur. Dense vegetative cover and protection of the soil surface may take two to three growing seasons to develop. This leaves the unvegetated soil subject to accelerated erosion during that interim time. Plugging can improve the speed at which vegetative cover increases, however it is extremely labor intensive and still leaves much of the soil surface unprotected by vegetation for a period of time. Native grass sod is an alternative method of vegetation establishment that may be especially useful in highly disturbed landscapes. Whenever soil is disturbed, it is critical to provide surface cover to minimize raindrop impact energy. Erosion control materials such as sod can absorb and dissipate this energy, thereby preventing detachment of soil particles (Krenitsky et. al. 1998).

Few studies have been conducted on the uses of sod for erosion control, and even fewer studies have been performed on the uses of native sod. Studies that have been done on sod found it extremely effective. However, the sod used in these studies was often comprised of Kentucky bluegrass, a non-native species. Although it is effective, Kentucky bluegrass is not an indigenous species to Montana and may threaten the integrity of the ecosystem by outcompeting native species.

One problem that past researchers have encountered with some native species is that their root system is not conducive to being rolled and the sod may crumble upon handling. However, native grass species that were used as sod in this research project can be easily rolled into large strips up to more than 30 meters long. Another concern of using sod for reclamation is that it can be expensive. Some of the previous studies on sod took place in the 1970's when the sod harvesting equipment had limitations compared to that in use today. Sod was extremely labor intensive to lay because it could only be handled in small squares. However, with today's technological advances, the machinery used to cut, roll, and lay sod are not only quick and easy, but also affordable.

Sodding is one of the most effective means of controlling erosion and preventing sedimentation damage according to the Best Management Practices of the North Carolina Sedimentation Pollution Control Act of 1973.

The purpose of this investigation was to compare native grass sodding methods to other types of plant establishment methods used in land reclamation. Specific objectives were as follows:

- Determine runoff, sediment yield and infiltration rates of native grass sodded slopes compared to other plant establishment methods for a peak 10 year 24 hour storm event.

- Measure plant growth characteristics on native grass sodded slopes compared to other plant establishment methods.
- Model sediment yield on native grass sodded slopes compared to other plant establishment methods using RUSLE version 2.0.
- Evaluate cost of native sodding compared to broadcast seeding with a straw blanket and hydromulch.

LITERATURE REVIEW

Sod and Erosion Control

Sodding is a rapid means of revegetating disturbed soils and stimulating succession. It is a highly effective way to transfer many plant species, associated soil organisms, propagules, nutrients, and organic matter (Whisenant 1999; Munshower 1994; Chambers 1997; Jensen and Sindelar 1979). It is useful in areas of extreme erosion that must be stabilized immediately. The larger the disturbance and the further away from a native seed source, the more important sod becomes (Munshower, 1994).

Sodding is a more reliable approach to stabilize slopes compared to either seeding or mulching methods and requires less maintenance (USEPA 2002). It can be laid during times of the year when seeded grasses are likely to fail. It is a permanent erosion control practice that reduces runoff and can stabilize soils, waterways, and channels (FDEP 2004). It can provide immediate vegetative cover for critical areas, such as steep slopes, that cannot be vegetated by seeding methods. It has been shown that sod can remove up to 99 % of total suspended solids in runoff, whereas permanent seeding such as hydroseeding removes an average of 90 % of total suspended solids (USEPA 2002).

Sodding Equipment

Sodding equipment has drastically improved over the last 30 years allowing sodding to become a more feasible option in reclamation. Transplanting sod allows rapid establishment of plants which is important in the context of land reclamation (Chambers

1997). Ideal seasons for transplanting sod are in fall prior to freeze-up or in early spring before heavy precipitation (Munshower 1994). Dryland sodders, front-end loaders, roll installers, and roll harvesters (Table 1) are the most typical types of sodding equipment

Table 1. Sodding equipment and specifications.

Equipment	Specifications	Power Requirements
Dryland Sodder	Width 4.3 m Length 2.4 m Depth 30 cm	Flywheel 375 to 525 hp (80 to 391 kW)
Articulated front-end loaders	Bucket capacity 18 kl to 32.7 metric tons Width 6.1 m	Flywheel to 690 hp (515 kW) single engine 2 x 635 hp (2 x 474 kW) dual engine
Skid-steer loaders	Bucket Capacity 142 to 1614 l 227 to 1678 kg Width 89 to 213 cm	16 to 72 hp (12 to 55 kW)
Brouwer turf installer	3-point hitch design Turf turns on bearings for easy unrolling Heavy steel frame Installs 61 cm to 76 cm wide rolls of turf	35 to 55 hp with category 2 three point hook-up
Magnum big roll harvester	Width 1.07 m Length 31.09 m	36 hp Yanmar engine and Rexroth hydrostat transmission

used (Brouwer Turf Equipment 2002; Bucyrus Equipment Company 2002). The function of the dryland sodder is to strip the top layer of natural soil and vegetation and place it, intact, over nearby reclamation areas. The dryland sodder is a modified front-end loader bucket. The side walls and back wall are vertical to minimize damage to shrubs and tree seedlings that are stripped along with the soil and sod. The wide, flat bottom of this bucket is lined with plastic to reduce friction. The dryland sodder transfers native topsoil from the mine area to the reclamation area with its structure, profile, and vegetation largely intact. Reclamation is greatly enhanced because the soil horizons are not mixed. Deep cuts are necessary to prevent the sod from breaking apart and to preserve the soil profile. Sodding is practical on critical areas with high erosion potential (Larson 1980).

Articulated front-end loaders are used to remove topsoil and transplant shrubs and trees. They are four-wheel, rubber-tired loading machines with a large bucket on the front. They are available in a wide range of sizes. Front-end loaders are versatile, mobile, and maneuverable. They are easily obtainable for reclamation work. They are limited to slopes less than 20 % and they are only economical for hauling short distances (Larson 1980). Skid-steer loaders are used to dig and move landscaping materials. The small size of skid-steer loaders allows them to maneuver in tight spaces (http://www.bobcat.com/products/ssl/index.html).

The Brouwer turf installer SLH2430 has a 3-point hitch design that fits a standard tractor. The tractor hydraulics allow the operator to clamp and raise the rolls of turf for transport. The turf is easy to unroll without tearing. This model can easily adapt to install either 61 or 76 cm wide rolls of turf.

The Magnum 136A big roll sod harvester has a 36-horsepower Yanmar engine and Rexroth hydrostat transmission with magnum control mounted on a solid frame. The four-wheel steer unit is capable of extremely tight turns or crab steering. The low center of gravity increases stability with excellent flotation to reduce grass damage. Most skid-steer attachments will fit, including the magnum hydraulically operated sod in install/action attachment, which allows for quick and accurate sod installation (Bucyrus Equipment Company 2004).

Site Preparaton and Installation

The U.S. Environmental Protection Agency's webpages on National Pollutant Discharge Elimination System (NPDES) indicate that the type of sod selected should be composed of plants adapted to site conditions (USEPA 2002). Sod composition should reflect environmental conditions as well as the function of the area where the sod will be laid. The sod should be of known genetic origin and be free of noxious weeds, diseases, and insects.

Sod must be laid where the sod roots are in complete contact with the soil surface. The surface should be graded smooth and cleared of all debris greater than 5 cm in diameter. A soil test of pH and nutrients is recommended prior to laying the sod (City of Calgary 2001; USEPA 2002). These tests may be conducted in the field or the lab. If fertilizer is to be used, it should be applied 48 hours before laying the sod. Sod should not be laid on sites without topsoil (City of Calgary 2001).

Freshly cut sod (harvested within 36 hours) with a favorable moisture status should be used in order to insure successful plant establishment (Chambers 1997). It should not be laid on frozen surfaces. During hot summer months the ground should be irrigated before, during, and after laying the sod to ensure successful establishment.

When installing sod on steep or unstable slopes, sod strips should be placed with the long axis perpendicular to the fall of the slope (City of Calgary, 2001; USEPA, 2002).

Case Studies

A study on the use of blue grama (*Bouteloua gracilis*) sod for land revegetation north of Nunn, Colorado (McGinnies and Wilson 1982), found that sod can be used on sites too steep for conventional seeding and on sites where quick cover is needed to prevent erosion. It is also useful in rehabilitating disturbed areas, recreation areas, and for landscaping with native species.

Because blue grama is a bunchgrass, it can not be rolled like other sods.   The blue grama was therefore cut into strips approximately 5 cm deep, 30 cm wide, and 30 to 37 cm long. The transplanting took place on various dates between the months of May and August. Each of the 15 plots received zero to varying amounts of supplemental irrigation.

The results of this experiment indicated that the two most influential factors on blue grama sod establishment were the date of transplanting and amount of irrigation following transplanting. It was concluded that sod should be pre-wet prior to cutting, sodding should be done early in the growing season, and sod should be irrigated as soon as possible after laying.

In another study conducted by Krenisky et. al. (1998), four man-made materials (wood excelsior, jute fabric, coconut fiber blanket, and coconut strand mat) and two natural materials (dry oat straw [*Avena sativa*] and turfgrass sod) were tested for runoff and sediment loss rates on slopes ranging from 8 to 21 % under simulated rainfall. The wood excelsior consisted of a polypropylene netted non-woven mat of elongated wood excelsior fibers.

The materials were evaluated at the University of Maryland Cherry Hill Research and Education Facility in Silver Spring, MD, and at the Fairwood Turf Farm in Glenn Dale, MD. The sod used at these sites had a similar soil texture as the test plots. At Silver Spring the sod used was 100 % 'Falcon' tall fescue (*Festuca arundinacea*). At Glenn Dale, the sod was a mix of tall fescue (25 % 'American', 25 % 'Classic', 25 % 'Georgetown') and 25 % 'Victa' Kentucky bluegrass (*Poa pratensis*). The sod at Silver Spring was irrigated daily at 25 mm for 1 week following installation, and thereafter only received natural rainfall. The Glenn Dale plots were given 50 mm of supplemental rainfall during the week following material installation.

Two simulated rainfall tests of 50 minutes and 138 minutes produced no runoff on one of the sod plots at Silver Spring. Sod reduced runoff rates by 54 to 59 % when compared to all the other erosion control materials. When compared with bare soil, the total amount of runoff was decreased by 61 % for sod, 25 % for straw, and 16 % for jute. There were no significant differences in sediment loss among any of the erosion control materials. It was concluded that of all the erosion control materials tested, only sod, straw and jute would be expected to effectively reduce both runoff and sediment losses.

A shoreline and streambank stabilization project (Hutchinson 1998) on Beaver Creek, located in the southwestern Colorado Rockies, used sedge sod as one of the design criteria for bank stabilization. Located between U.S. Forest Service land and a Colorado

Division of Wildlife (CDOW) reservoir, this area is primarily managed for fishing recreation. A former meandering stream channel was straightened to provide forage for cattle. Because the stream was naturally reverting to a meandering pattern, it was causing severe erosion on the banks. In 1995, the owners of the land restored the creek into a functioning aquatic and riparian ecosystem. One of the criteria for the project was to exclusively use natural materials such as logs, willows, and sedge sod for bank stabilization. Sod used during the project construction was saved or harvested from the newly cut channel and placed on the streambanks. The benefits of this project included a functioning stream and floodplain, improved wildlife habitat, almost no bank erosion, and a thriving fishery.

Staff with the Montana Agricultural Experiment Station developed "dryland sodding", a method that uses native rhizomatous grasses that do not require irrigation during or post-sodding. It is fast, effective, and provides relatively permanent stabilization of roadside erosion. No special site preparations or additional maintenance are required. Natural native vegetative cover also has a higher aesthetic value. A dryland sodding study was conducted near Forsyth, Montana on the use of native sod for the rapid stabilization of semiarid roadsides with high erosion potential (Jensen and Sindelar 1979). Three rhizominous sod species; western wheatgrass (*Agropyron smithii*), Kentucky bluegrass (*Poa pratensis*), and inland saltgrass (*Distichlis stricta*), and two sod thicknesses (3.8 and 7.6 cm) were investigated in the fall of 1971 and the spring of 1972. The sod was cut in 46 cm wide by 46 to 122 cm long strips. Once the sod was placed on the research plots, it was packed firmly with a tractor and then fertilized at a rate of 56 kg/ha each of nitrogen, phosphorus, and potassium.

The results of this experiment indicated Kentucky bluegrass to be the best performing dryland sod species tested. Jensen and Sindelar state that it is usually found in lowland areas with greater soil moisture availability but can also withstand "extremely droughty conditions" (1979). However, according to the USEPA (2004) and the USDA plant database website (2004), Kentucky bluegrass has a poor to fair drought tolerance and requires a minimum of 71 cm of precipitation per year, which would not make it a prime choice for dryland sodding.

Western wheatgrass was very effective at controlling erosion. It is extremely drought and salt tolerant. Because it rarely grows higher than 25-30 cm, it does not need to be mowed frequently. One drawback of the western wheatgrass sod was that it did not have a dense fibrous root mass which required careful handling so that it did not break apart.

Due to some unexpected results, the inland saltgrass did not perform as well as anticipated. Following sodding, crested wheatgrass gradually took the place of inland saltgrass. The saltgrass sod was cut from an old pasture originally seeded to crested wheatgrass, and by cutting and removing the sod, the saltgrass growth was inhibited. This could have resulted from the fact that saltgrass grows better in the warmer growing seasons, whereas crested wheatgrass favors cool seasons. It is unlikely that the crested wheatgrass could be effective in dryland sodding because without the saltgrass sod, the root mass would have been too weak to be handled.

Some rapid developing perennial grasses native to Montana that can be used in a mixture to provide species diversity and specific long-term stand characteristics are western wheatgrass, thickspike wheatgrass, streambank wheatgrass, and buffalo grass. Some slower developing species include prairie sandreed and indian ricegrass.

There are many advantages to dryland sodding. When compared to other methods of erosion control such as concrete or asphalt, dryland sodding costs do not appear excessive. A minimum amount of equipment is needed for dryland sodding. Native sod can be salvaged during highway construction and is most effective when used immediately on areas such as moderate flow drainage areas, steep slopes, and critical use areas. Both spring and fall are recommended as acceptable sodding seasons.

At the time that this article was written, Jensen and Sindelar (1979) remarked that dryland sodding is a slow labor intensive treatment. If a large scale sodding machine can be developed, 'dryland sodding will become a highly desirable rapid soil stabilization treatment.' Various large scale sodding machines have been developed which has made sodding a viable option with minimal labor (http://www.bucyrusmagnum.com).

METHODOLOGY

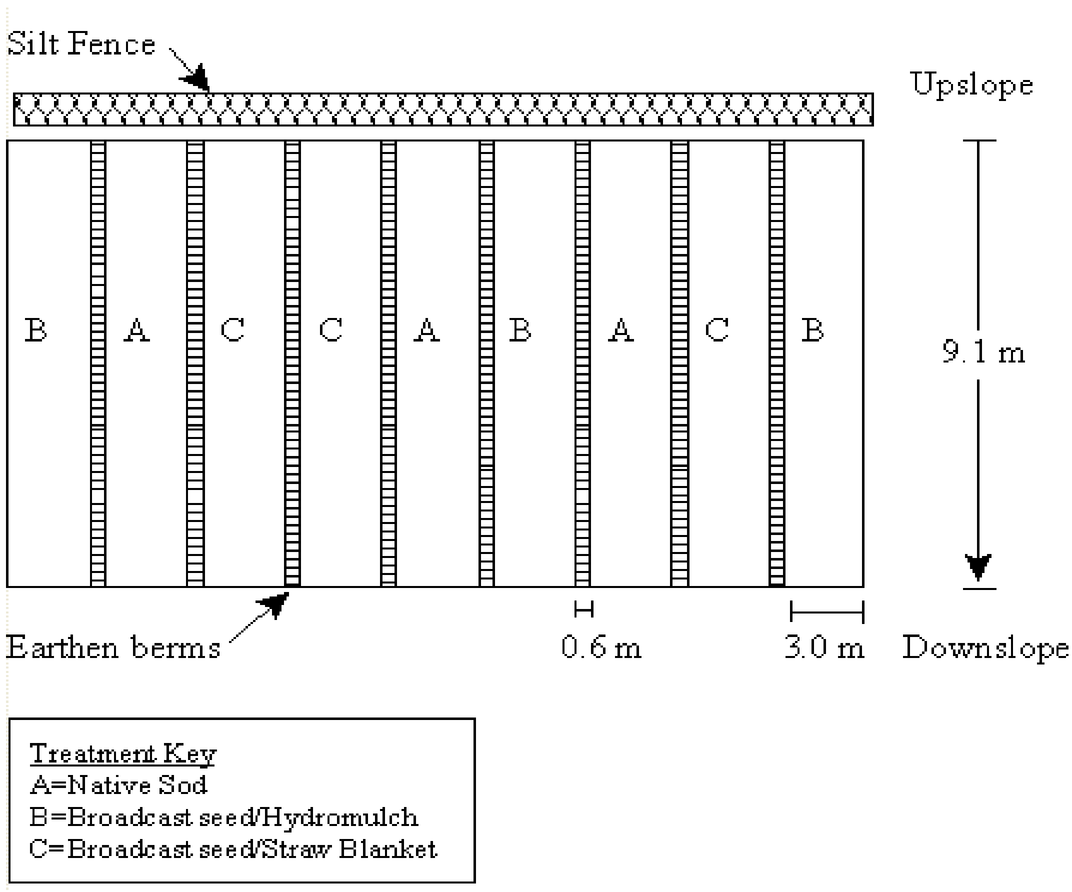
Site Descriptions

Evaluation of sod reclamation techniques was conducted on sloped sites at three different geographic locations in Montana. These sites were chosen because their gradients exceeded 35 % and previous attempts at vegetation establishment had not succeeded. The first site was a newly constructed highway fill on the Norris Highway 21 km west of Bozeman. This site had an elevation of approximately 1460 meters with a 40 % slope and south-facing aspect. The average annual precipitation was approximately 40 to 46 cm per year. The second site was a ski slope at the Yellowstone Club near Big Sky. The elevation of this site was 2195 meters with a 35 % gradient and an east-facing aspect. The average annual precipitation was approximately 91 to 102 cm per year. The third site was on acidic mine waste rock approximately 30 km southwest of Helena in the Helena National Forest. The elevation at this site was approximately 1800 meters with a 70 % slope and an east-facing aspect. The average annual precipitation at this site was approximately 46 to 51 cm per year.

Experimental Design

Highway Fill Site

At the highway fill site, three treatments with three replications, totaling 9 plots (Figure 1) were implemented on a 40% slope in April of 2003. The experimental design was completely randomized. Each plot had a dimension of 3.0 by 9.1 meters. A silt



Treatment	Seedmix percentage	Seedmix weight (kg)	PLS (Pure live seed)	Species
Native Sod	17	Not Applicable	Not Applicable	*Agropyron smithii*
	22			*Agropyron dasystachyum*
	27			*Festuca idahoensis*
	34			*Poa compressa*
Broadcast Seed/ Straw Blanket	4.45	.51	98	*Agropyron trachycaulum*
	22.16	2.33	98	*Agropyron dasystachyum*
	22.64	2.51	96	*Agropyron smithii*
	15.14	1.63	86	*Agropyron spicatum*
BroadcastSeed/ Hydromulch	8.94	.95	97	*Stipa viridula*
	4.54	.49	96	*Poa ampla*
	4.69	.50	93	*Festuca ovina*
	5.23	.56	83	*Rudbeckia fulgida*
	9.25	.97	94	*Cleome serrulata*

Figure 1. Completely random experimental design on a 40 % slope on the Norris Highway road fill and plant species mix. Implemented in April 2003.

fence was constructed at the top of the slope to prevent water and sediment from entering the plots. Plots were laterally bound by 0.6 meter wide earthen berms to prevent any flow of sediment and runoff from adjacent plots. The three treatments were i) native sod, ii) broadcast seeding with a straw blanket, iii) and broadcast seeding with hydromulch. All plots were fertilized at a rate of 12.0 kg/ha 34-0-0 (ammonium nitrate) and 64.8 kg/ha 11-52-0 (monoammonium phosphate) and both seed and fertilizer were hand raked into the soil.

The native sod was obtained from Bitteroot Turf Farm located in Corvallis, MT (BTF 2004). The 2.5 cm thick native sod was pre-wetted and transported to the site on a trailer. It was delivered in rolls that were approximately 0.5 by 3.0 meters. The native sod was rolled out onto the designated plots and stapled into the ground with 15 cm long by 2.5 cm wide staples. Approximately 3 staples per square meter were pounded with a rubber mallet into the underlying substratum.

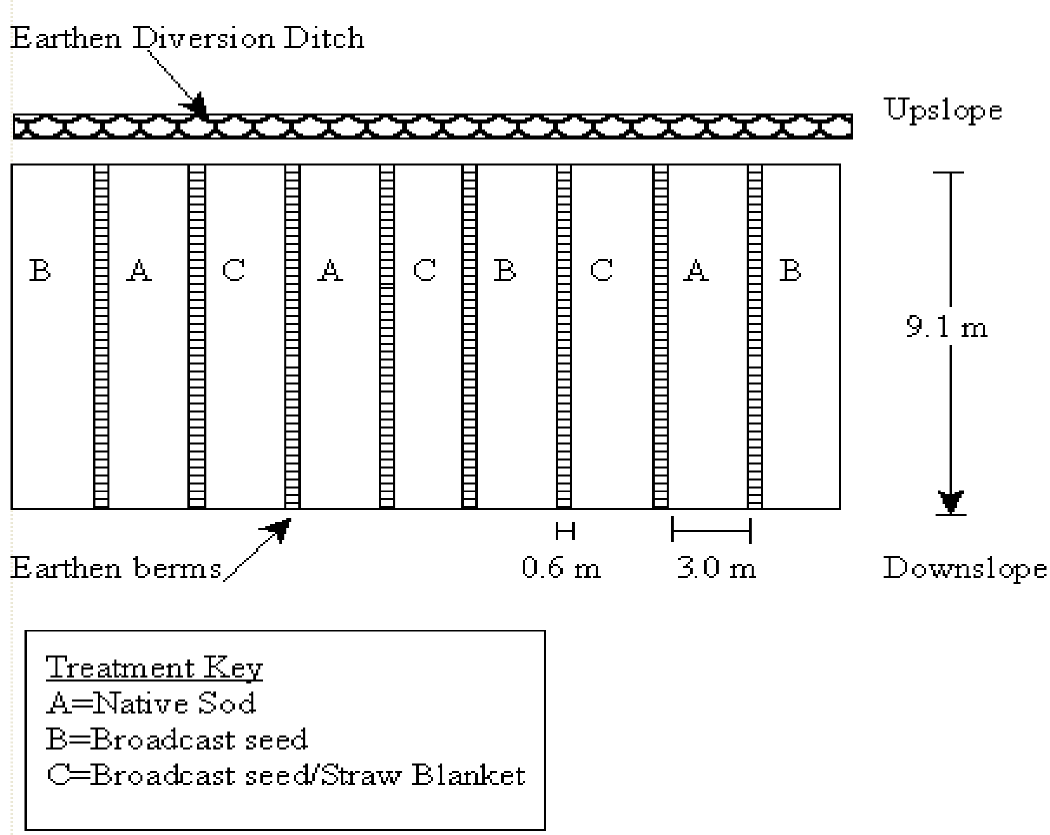
The broadcast seeded plots with the straw blanket were seeded at a rate of 50.6 kg/ha. This rate was selected according to rates used by the Montana Department of Transportation. The SC150BN Double Net Straw-Coconut Blanket was obtained from North American Green in Billings, MT with dimensions 2.0 m by 32.9 m. It consisted of 70 % agricultural straw with 30 % coconut fiber mixture stitched with biodegradable thread between two natural fiber nets. It was 100 % organic and was designed to provide highly effective erosion control for up to 18 months on environmentally sensitive areas (http://www.nagreen.com/products/SC150BN.html). The blanket was cut to fit each plot and was stapled into the ground following the recommended staple patterns. The top edge of the blanket was buried with soil to prevent the wind from lifting it up.

The broadcast seeded plots with hydromulch were seeded at a rate of 50.6 kg/ha. Plots were broadcast seeded by hand and then hydromulched so that an exact rate of seeding could be attained. In addition to the fertilizer mentioned above, the hydromulch consisted of fertilizer, recycled paper fiber mulch, and tackifier mixed with water to form a homogeneous slurry. A hydroseeding machine was used to spray the mixture under pressure to form a uniform application over the soil. This treatment was the typical procedure used by the Highway Department for erosion control. The hydromulch was applied at a rate of 2200 kg/ha plus 1100 kg/ha of commercial dry weight compost.

Ski Slope Site

The completely randomized experimental design at the ski slope site consisted of three treatments with three replications of i) native sod, ii) broadcast seeding with a straw blanket, and iii) broadcast seeding (Figure 2). These treatments were implemented on a 35 % slope on June 18, 2003. The plot dimensions were 3.0 by 9.1 meters. An earthen diversion ditch was installed above the plots to prevent water and sediment from entering the plots. Plots were laterally bound by 0.6 meter wide earthen berms to prevent any flow of sediment and runoff from adjacent plots. All plots were fertilized at a rate of 67.4 kg/ha 16-20-0 (diammonium phosphate) and both seed and fertilizer were hand raked into the soil.

The native sod was obtained from Bitteroot Turf Farm and was delivered in rolls approximately 0.5 by 3.0 meters. The sod was rolled onto the designated plots and



Treatment	Seedmix percentage	Seedmix weight (kg)	PLS (Pure live seed)	Species
Native Sod	17 22 27 34	Not Applicable	Not Applicable	*Agropyron smithii* *Agropyron dasystachyum* *Festuca idahoensis* *Poa compressa*
BroadcastSeed/ Straw Blanket Broadcast Seed	10 55 1.5 22 10 1.5	2.49 12.47 .23 5.22 2.49 .23	99 97 85 90 92 93	*Agropyron trachycaulum* *Bromus marginatus* *Achillea millefolium* *Dactylis glomerata* *Festuca trachyphylla* *Poa compressa*

Figure 2. Completely random experimental design on a 35 % ski slope at the Yellowstone Club and plant species mix. Implemented June 18, 2003.

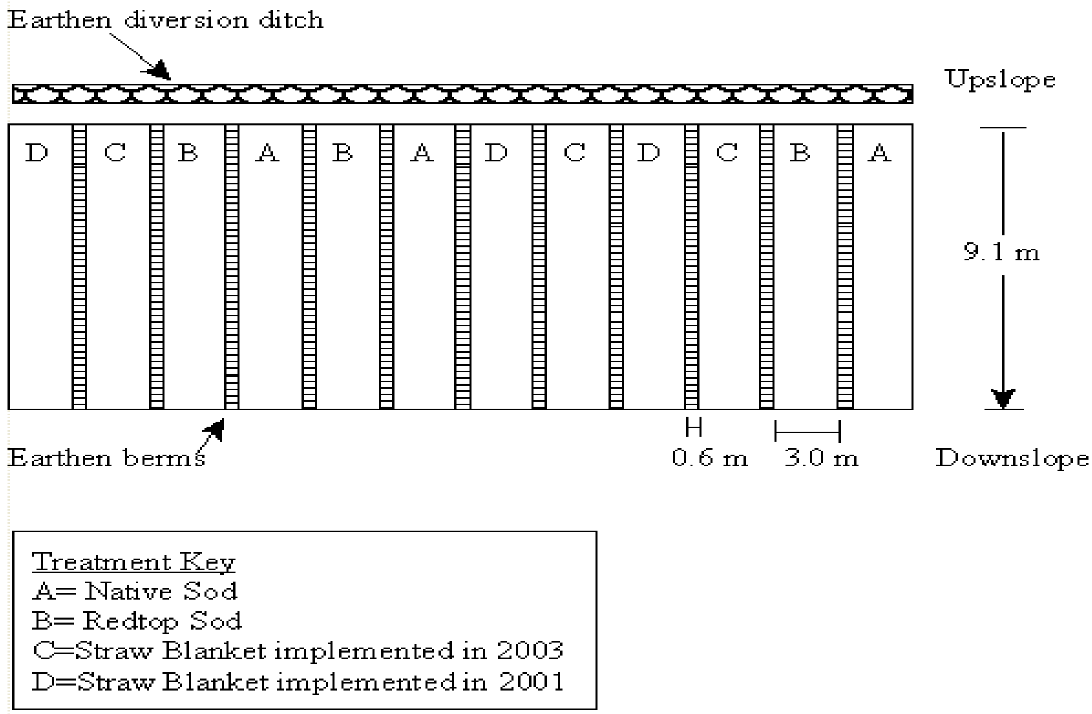
stapled into the soil with15 cm long by 2.5 cm wide staples using a rubber mallet. Approximately 3 staples were placed within every square meter.

The broadcast seeded plots with the straw blanket were seeded at a rate of 34.3 kg/ha. This rate was selected in accordance with that used by the Yellowstone Club for ski slope sites. The straw blanket used was the SC150BN Double Net Straw-Coconut Blanket obtained from North American Green. Its dimensions were 2.0 by 32.9 m. The blanket was cut to fit the plot dimensions and was stapled into the soil. The top edge of the blanket was buried with soil to prevent the wind from lifting it up.

The broadcast seeded plots were seeded at a rate of 34.3 kg/ha. This treatment was the typical measure used by the Yellowstone Club to establish grass at this site.

Mine Waste Site

A completely randomized experimental design including four treatments with three replications was implemented on the mine waste site in early June of 2003 (Figure 3). Treatments included native grass sod, redtop sod, broadcast seeding with a straw blanket installed in 2003, and a straw blanket presumably with broadcast seeding implemented by the Forest Service two years prior in 2001. These treatments were implemented on a 70 % slope on consolidated mine waste in the Helena National Forest. The plot dimensions were 3.0 by 9.1 meters and were separated by 0.6 meter wide earthen berms. Because the top of the site already had a diversion ditch, it was not necessary to install one. All plots were fertilized at a rate of 12.0 kg/ha 34-0-0 (ammonium nitrate) and 64.8 kg/ha 11-52-0 (monoammonium phosphate). Both seed and fertilizer were



Treatment	Seedmix Percentage	Seedmix weight (kg)	PLS (Pure live seed)	Species
Native Sod	17 22 27 34	Not Applicable (NA)	NA	*Agropyron smithii* *Agropyron dasystachyum* *Festuca idahoensis* *Poa compressa*
Redtop Sod	100	NA	NA	*Agrostis stolonifera*
Straw Blanket Installed 2003	4.45 22.16 22.64 15.14 8.94 4.54 4.69 5.23 9.25	.51 2.33 2.51 1.63 .95 .49 .50 .56 .97	98 98 96 86 97 96 93 83 94	*Agropyron tracycaulum* *Agropyron dasystachyum* *Agropyron smithii* *Agropyron spicatum* *Stipa viridula* *Poa ampla* *Festuca ovina* *Rudbeckia fulgida* *Cleome serrulata*
Straw Blanket Installed 2001	Not Known	Not Known	Not Known	NA

Figure 3. Completely random experimental design implemented June 6-7, 2003 on mine waste with a 70 % slope and plant species mix.

hand raked into the mine waste rock material. Both the native and redtop sod were provided by Bitteroot Turf Farm. Due to the topographical constraints of this area, the sod was transported near the site on a trailer, and then was driven in to the site on an all terrain vehicle. Sod rolls were passed along an assembly line of people up to the top of the steep slope. Both native sod and redtop sod were rolled onto their designated plots and were stapled into the substratum with 15 cm long by 2.5 cm wide staples. Three staples were used for approximately one square meter. Staples were pounded into the mine waste rock material using a rubber mallet. Broadcast seeded plots with the straw blanket installed in 2003 were seeded at a rate of 50.6 kg/ha. The SC150BN Double Net Straw-Coconut Blanket was obtained from North American Green. It had dimensions of 2.0 by 32.9 meters and was cut to fit each plot and stapled into the substratum following the recommended staple patterns. The top edge of the blanket was buried with substratum to prevent the wind from lifting it up. The straw blanket that was already present was originally covering the entire test plot area. It was therefore cut to fit the plot size and then was left untouched. No seed or fertilizer was applied to this treatment. This was done to represent measures taken by the Forest Service to attempt to establish plant growth and control erosion on this site.

Data Collection

Plant Cover and Production

Measurements of plant cover (canopy, basal, and ground) and production (above ground biomass) were taken during the peak growing period in July 2003 and 2004.

This

was achieved by placing permanent stakes in the upper left-hand corner and lower right-hand corner of each plot. A measuring tape was used to form a transect across each plot. Plant cover and production were measured on the west side of the transect in 2003 and the east side of the transect in 2004.

Cover (basal, canopy, and ground) was estimated ten times along each transect of each plot using a 20 by 50 cm Daubenmire frame. Cover was estimated according to coverage classes that ranged from one to six (Daubenmire 1959). The range of coverage and midpoint of range were determined as follows in Table 2.

Table 2. Plant coverage classes.

Coverage-Class	Range of Coverage, %	Midpoint of Range, %
1	0-5	2.5
2	5-25	15.0
3	25-50	37.5
4	50-75	62.5
5	75-95	85.0
6	95-100	97.5

Canopy cover is defined by the area of ground covered by the vertical projection of the outermost perimeter of the natural spread of foliage of plants. Basal cover is the area of ground surface occupied by the basal portion of the plants. Ground cover is the cover of plants, litter, rocks, and gravel on a site. Canopy and basal cover were distinguished by growth form (annual and perennial grasses and forbs).

Production was measured by separating the vegetation according to growth form. Five subsamples were clipped within a 20 x 20 cm frame along each transect. Vegetation was clipped as close to the ground as possible. The clippings were then placed in paper bags and were brought back to Montana State University where they were oven-dried at 40 degrees Celsius and weighed (Appendix A).

Soil Characteristics

Composite samples were collected from each project site and analyzed for physiochemical characteristics (Table 3). Composite soil samples were oven dried at 40

Table 3. Soil analytical methods.

Variable	Analytical Technique
Coarse fragment percentage	Sieved 2mm fraction, measured % fragments greater than 2mm. ASTM method 1993.
Particle size distribution	Palmer and Troeh 1995. Hydrometer method.
Saturation %	Grams of water added to saturate 250 g soil. U.S. Salinity Laboratory Staff 1954.
pH	Water saturated paste extract. U.S. Salinity Laboratory Staff 1954.
Electrical Conductivity	Water saturated paste extract. Rhoads 1982.

[/1]Results are presented in Appendix B.

degrees Celsius and were then disaggregated with a mortar and pestle. Soil that passed through a 2 mm sieve was used for all analyses. Soil particles greater than 2 mm in diameter were classified as coarse fragments (Munn et. al. 1987). Physical properties evaluated included saturation percentage, coarse fragment percentage, and particle size distribution (textural class). Chemical properties evaluated included pH and electrical conductivity.

Rainfall Simulator Dimensions and Design

A modified rainfall simulator patterned after the Meeuwig infiltrometer (Meeuwig 1971) was used during the peak growth period of the second field season (July 2004) to apply a 10 year 24 hour peak precipitation event on the highway fill site. This amounted to 4.8 cm of rain over the course of two hours. The four major components of the rainfall simulator include 1) the enclosure; 2) the head assembly; 3) the water delivery system; and 4) the sample collection assembly (Figure 4). The operation of the simulator

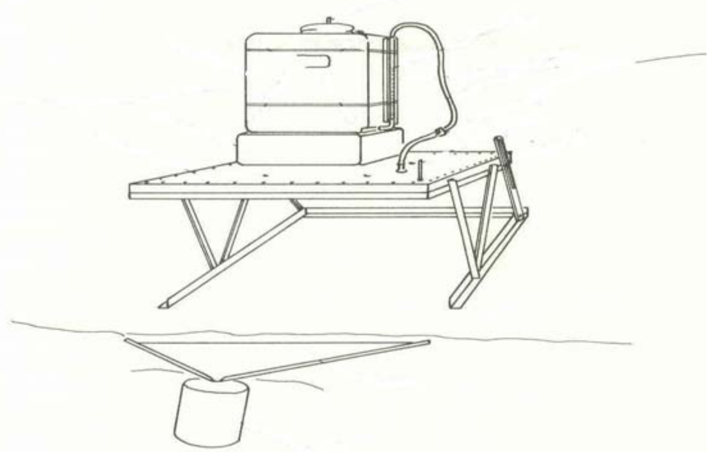


Figure 4. Schematic of rainfall simulator (Meeuwig 1971).

consisted of delivering deionized water from a constant head reservoir to a precision flow meter and then to the simulator head which produced raindrops (Figure 5). The runoff was channeled to a bottle at the base of the collection trough. Measurements of

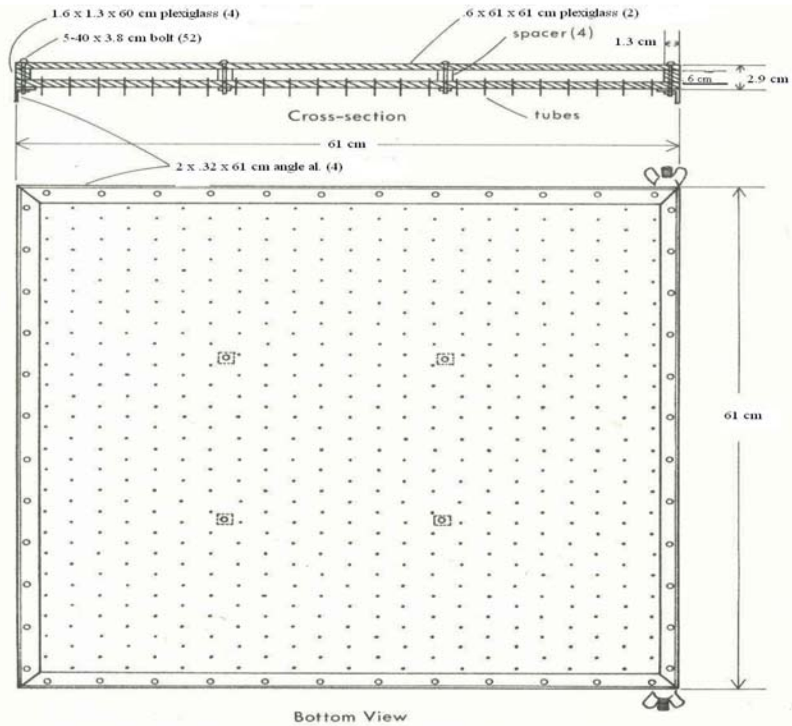


Figure 5. Schematic of rainfall simulator head assembly (Meeuwig 1971).

infiltration, runoff volume, and sediment yield were taken from all plots during each simulation at the highway fill site.

The collection trough consisted of two components welded together, a base and a collector trough (Figure 6). The base was 61 x 61 cm angle aluminum with three sides held together with rivets. The collector trough was constructed with 22 gauge mild steel in the shape of an isosceles triangle. The longest edge of the triangle was 63.5 cm and was attached to the base. Approximately 1.3 cm was bent down 90 degrees so that it could be buried into the ground. The base of the triangle to the top point was 20 cm. The sides of the triangle were bent up 1.3 cm at a 90 degree angle so that runoff could be channeled into the collection bottle. An aluminum support frame was constructed with

Figure 6. Photograph of rainfall simulator and collection trough.

angle iron and a slotted bar so that the water chamber could be adjusted to be level while on a slope.

Sediment Loss, Runoff and Infiltration Measurements

A total of ten rainfall simulation tests were completed at the highway fill site (Appendix C). Each plot including one duplicate receive 4.8 centimeters of rain over the course of 2 hours to simulate a 10 year 24 hour peak precipitation event. The reservoir had a constant head and held about 57 liters of deionized water. It was placed approximately seven meters up-gradient with a hose leading down to the head assembly. The flow was controlled by a brass pin that connected to the flow meter which digitally read the flow in mls/min. The head assembly was filled with water presumably leaving no air bubbles trapped inside. Rain would not fall until the head assembly was full.

Revised Universal Soil Loss Equation (RUSLE2)

The Revised Universal Soil Loss Equation (RUSLE) version 2.0 is a computer model used to estimate an average annual sediment yield from sloped areas using various input values (Toy and Foster 1998). The main factors that RUSLE2 uses to estimate rates of erosion are presented in Table 4. Input values were determined from field data or were obtained from the Natural Resource Conservation Service data base (USDA 2004). Input values from the three treatments at the highway fill site were entered into the latest version of RUSLE (RUSLE2) to calculate sediment loss per year.

Statistical Analysis

Sigma Stat is a computer program that was used to perform a two way analysis of variance on the data collected (Sigma Stat 3.0). The Student-Newman-Keuls test was used for pairwise comparisons of the mean responses among the different treatment groups. A probability level of 0.05 was used to identify mean values that were significantly different. Statistical analysis were performed on raw data and later converted to the appropriate units.

Table 4. RUSLE2 factors and input values used to estimate erosion at the highway fill site.

RUSLE Factor	Input Variable	Native Sod	Broadcast Seed/Straw Blanket	Broacast Seed/Hydro-mulch
Climate (erosivity index or R-value)[1]	City climate database Initial R-value=amount of precipitation and intensity with which it falls.	Precipitation records for Gallatin County, MT, R-value=14[2]		
Soil erodibility (susceptibility to erosion or K-factor)	Soil texture (% sand, silt, clay) Rock cover % Coarse fragment %	loam 49, 31, 20 5 30 (by weight)		
Topography	Slope gradient (%) Slope length, m Slope shape	40 9.1 uniform		
Land use (cover management) Supporting practices	Canopy cover % Ground cover % Surface roughness, cm Mulch or straw blanket Mechanical disturbance Fall height, cm Yield (kg/ha) Contouring Strips and barriers Diversions/terraces Sediment basins Subsurface drains	64 [3] 97 1.8 No No 90 5226 NA[4] NA NA NA NA	7 95 1.8 Yes No 15 475 NA NA NA NA NA	1 4 1.8 No No 30 87 NA NA NA NA NA

[1] R-values are an index based upon rainfall amount, rainfall intensity, temperature, and soil moisture (USDA 2004)
[2]USDA NRCS 2002.
[3]Values obtained from average of 2003 and 2004 field data
[4]Not Applicable

RESULTS AND DISCUSSION

Soil Characteristics

Soil saturation percentages at the highway fill, ski slope, and mine waste sites were 26 %, 27.8 %, and 23 %, respectively, indicating all substrates have a low water holding capacity, yet they were sufficient to support plant growth (Table 5). The ski slope site had a clay loam texture and a resulting higher percent saturation than that of the

Table 5. Soil physiochemical characteristics at each research site.

Site	Saturation %	pH	EC[/1] (ds/m)	Sand %	Silt %	Clay %	Texture class	% Rock by weight
Highway fill	26.0	7.07	1.07	48.54	31.64	19.82	Loam	29.69
Ski slope	27.8	6.16	0.24	39.76	34.00	26.24	Clay loam	32.32
Mine waste	23.0	3.36	0.31	73.8	16.12	10.08	Sandy loam	16.54

[/1] Electrical Conductivity

other sites. The sandy loam texture at the mine waste site had the highest percentage of sand with a corresponding low saturation percentage. A saturation percentage of less than 25 % is a suspect level for land reclamation (Schafer 1979), indicating that the soil may not contain adequate water holding capacity. The mine waste site falls slightly below this level at 23 %. This characteristic may have impeded plant growth on this site. The pH of the soil at the highway fill site was 7.07, while the ski slope was slightly acidic (6.16). This may correspond to the higher precipitation, leaching of bases and the surrounding coniferous vegetation that thrives in slightly acidic conditions. The extremely acidic pH at the mine waste site (3.36) may have impaired plant establishment. Because the substrate at this site consists of mine waste, it is plausible that it also contains heavy metals. At low pH conditions heavy metals become soluble thereby impeding plant growth.

The electrical conductivity at each site was relatively low, implying that salt levels have not impaired plant growth. None of the soil textures determined on any of the sites were found to be limiting. Soil textures that are considered unsuitable for land reclamation include clay, silty clay, silt, sand, and sandy clay. Soils or substrates that contain rock fragments of approximately 25 % by volume or less are considered to be suitable for land reclamation (Munn et. al. 1987). If the rock content is greater than 25 % by volume, certain plant species may have difficulty becoming established. Because the percent rock by volume is equal to approximately half the percent rock by weight, all three sites fell within a suitable range for land reclamation. Rock content may affect nutrient status, seedling emergence, and seed-soil contact (Munn et. al. 1987).

Effects of Treatments on Plant Growth Characteristics on the Highway Fill Site

Production

The mean perennial grass production in 2003 of native sod was 9703 kg/ha (Table 6). This value was 14.6 times greater than the broadcast seeded plots with the

Table 6. Mean plant production during 2003 at the highway fill site.

Native sod	Straw blanket/ broadcast seed	Hydromulch/ broadcast seed
Perennial grass production, kg/ha		
9703 a[/1]	663 b	72 b
Perennial forb production, kg/ha		
0 a	88 b	178 b
Annual forb production, kg/ha		
0 a	636 b	1278 b
Total production, kg/ha		
9703 a	1387 b	1528 b

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[/2]Analysis of variance results are presented in Table 85.

straw blanket (663 kg/ha), and was 134.7 times greater than the broadcast seed with hydromulch treatment (72 kg/ha). These elevated levels of production indicate native sod was a more rapid method of revegetation than the other treatments. There were no native nor weedy annual grasses such as wild oats (*Avena fatua*) or cheatgrass (*Bromus tectorum*) present at this site. Annual grasses are therefore not included on any of the following tables. The broadcast seed with the straw blanket and hydromulch treatments were significantly greater than the native sod for perennial forb and annual forb production. These species included rocky mountain bee plant (*Cleome serrulata*) and yellow prairie coneflower (*Rudbeckia fulgida*). Because the native sod was comprised entirely of grass species, there were no forbs found on these plots. The mean total production of native sod was significantly greater than the broadcast seed with the straw blanket (7 fold) and the broadcast seed with hydromulch (6.4 fold).

In 2004, native sod had significantly greater production (748 kg/ha) than the broadcast seed with the straw blanket (286 kg/ha) and the broadcast seed with the hydromulch (102 kg/ha)(Table 7). This demonstrated that after the second growing season, the native sod was highly successful compared to the other treatments. The hydromulched plots had an increase in production for perennial grass in 2004. It may

Table 7. Mean plant production during 2004 at the highway fill site.

Native sod (live)	Straw blanket/ broadcast seed	Hydromulch/ broadcast seed
Perennial grass production, kg/ha		
748 a[/1]	286 b	102 b
Perennial forb production, kg/ha		
0 a	1609 ab	3162 b
Annual forb production, kg/ha		
0 a	2 a	0 a
Total production, kg/ha		
748 a	1897 a	3264 a

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[/2]Analysis of variance are presented in Table 89.

have taken the seeds that were hydromulched longer to germinate and therefore produced a higher yield the second year. It also could have been that plants were establishing themselves, and therefore had a larger biomass the second year. Perennial forb production had an increase from 2003 to 2004 for the straw blanket and hydromulched plots. In the second year of production, the dominant annual forbs died and allowed perennial forbs to become established. However, it was observed that yellow sweet clover (*Melilotis officinalis*), an introduced species, was predominant on the broadcast seed with the straw blanket and hydromulch plots. Sweet clover was estimated to make up over half the perennial forb production of these treatments. Native sod perennial forb production was zero, indicating this treatment was not easily invaded by the sweet clover. Annual forb production decreased substantially from 2003 to 2004. This is logical because most of the annuals died after the first year. There was no significant difference among all three treatments for annual forbs in 2004. Mean total production was not significantly different among the three treatments.

Two sets of data were collected for the native sod treatment in 2004, live native grass and standing dead grass. The yield of live native grass production was substantially lower in 2004 (748 kg/ha) than it was in 2003 (9703 kg/ha). In 2004, standing dead native grass which emanated from the 2003 growing season was 3468 kg/ha (Appendix A). The large amount of standing dead native grass may be attributed to several factors. In the first year of production, the native sod had been wetted prior to implementation. The plots were fertilized and a series of storms occurred in the following weeks. Together the nutrient pool and ample water provided favorable conditions for native sod to rapidly establish and produce a high amount of production. In 2004, the previous year's biomass and its shade effects may have impeded grass shoots from emerging thereby causing a decrease in production. However, in the years that follow there may be an upward trend in production because the decomposition of the standing dead grass may provide a source of nutrients from which new grass can benefit.

Basal Cover

Basal cover of perennial grass for native sod was significantly greater than the broadcast seed with the straw blanket in 2003 (Table 8). Basal cover of perennial grass

Table 8. Mean basal cover during 2003 at the highway fill site.

Native sod	**Straw blanket/ broadcast seed**	**Hydromulch/ broadcast seed**
Perennial grass basal cover (%)		
95.8 a[/1]	4.2 b	0 c
Perennial forb basal Cover (%)		
0	2.5	2.5
Annual forb basal cover (%)		
0	2.5	2.5
Total basal cover (%)		
95.8 a	9.2 b	5 c

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[/2]Analysis of variance results are presented in Table 86.

for the broadcast seed with the straw blanket was significantly greater than the broadcast seed with hydromulch. The mean basal cover of perennial grass for native sod was 95.8 %, while the other treatments were 4.2 % and 0 % respectively. This may have been due to the live dense cover that native sod provides upon implementation. The straw blanket and hydromulch treatments need time to germinate before they can provide any cover. It could take years to establish a cover like that of native sod. Data for perennial forbs and annual forbs could not be normalized, therefore there is no ANOVA for these growth forms. Mean total basal cover of native sod was significantly greater (10 to 19 fold) than the other treatments.

Perennial grass basal cover of native sod (31.4 %) in the 2004 season was significantly greater than the broadcast seed with the straw blanket (5.8 %) and the hydromulch treatments (2.9 %)(Table 9). Although values for the broadcast seed with the

Table 9. Mean basal cover during 2004 at the highway fill site.

Native sod (live)	**Straw blanket/ broadcast seed**	**Hydromulch/ broadcast seed**
Perennial grass basal cover (%)		
31.4 a[/1]	5.8 b	2.9 b
Perennial forb basal cover (%)		
0 a	6.8 b	6.6 b
Annual forb basal cover (%)		
0 a	2.9 b	2.5 b
Total basal cover (%)		
31.4 a	15.5 a	12 a

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[/2]Analysis of variance results are presented in Table 90.

straw blanket and the broadcast seed with the hydromulch were slightly higher than the previous year, they were not able to provide a dense basal cover like that of native sod.

The basal cover for native sod was three times lower in 2004 than it was in 2003. This may have been due to the presence of standing dead native sod which had a perennial grass basal cover of 96.7 % (Appendix A). Nevertheless, the standing dead native sod provided a dense cover that would ultimately interfere with rainfall impact and inhibit erosion. The annual and perennial forb basal cover of the straw blanket and hydromulch treatments were significantly greater than native sod. This can be attributed to the fact that there were no forbs in the original native sod mix. Additionally, weedy forb species may have had a difficult time establishing on native sod plots due to the dense cover that this treatment provided. Mean total basal cover was not significantly different among the three treatments.

Canopy Cover

Canopy cover of perennial grass for all three treatments was significantly different in 2003 (Table 10). The mean canopy cover of native sod for perennial grass was

Table 10. Mean canopy cover during 2003 at the highway fill site.

Native sod	**Straw blanket/ broadcast seed**	**Hydromulch/ broadcast seed**
Perennial grass canopy cover (%)		
95.8 a[/1]	8.3 b	0 c
Perennial forb canopy cover (%)		
0 a	2.5 b	2.9 b
Annual forb canopy cover (%)		
0 a	5.7 b	9.7 b
Total canopy cover (%)		
95.8 a	16.5 b	12.6 b

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[/2]Analysis of variance results are presented in Table 87.

significantly greater (95.8 %) than the broadcast seed with the straw blanket (8.3 %).

Both the native sod and the broadcast seed with the straw blanket were significantly greater than the broadcast seed with hydromulch (0 %). Canopy cover for native sod was so much greater than the other treatments because its cover was already established prior to implementation. The slow germination period of the other treatments is a severe disadvantage when trying to immediately control erosion. For perennial and annual forbs, the straw blanket and hydromulch mean canopy covers were significantly greater than

native sod. This once more can be attributed to the fact that there were no forbs in the native sod treatment. Additionally, mean total canopy cover was significantly greater for native sod than the other treatments.

The 2004 perennial grass canopy cover for native sod was significantly greater than the broadcast seed with the straw blanket and the broadcast seed with the hydromulch (Table 11). The lag time required for germination of the straw blanket and hydromulch treatments is likely the reason for their low percent canopy cover. The

Table 11. Mean canopy cover during 2004 at the highway fill site.

Native sod (live)	**Straw blanket/ broadcast seeded**	**Hydromulch/ broadcast seed**
Perennial grass canopy cover (%)		
31.4 a[/1]	5.8 b	2.5 b
Perennial forb canopy cover (%)		
3.3 a	8.9 a	9.8 a
Annual forb canopy cover (%)		
0	2.5	0
Total canopy cover (%)		
34.7 a	17.2 b	12.3 b

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.

/2 Analysis of variance results are presented in Table 91.

canopy cover of perennial grass for the straw blanket and hydromulch treatments were not significantly different from one another. The perennial grass canopy cover of native sod in 2004 was considerably lower than that of 2003. This is likely due to the standing dead native grass that had a canopy cover of 96.7 % in 2004 (Appendix A). Although it was dead, it still provided a dense cover that would interfere with raindrop energy impact. There was no significant difference among treatments for perennial forbs. Data for the annual forbs could not be normalized and therefore there is no ANOVA. Mean total canopy cover of native sod was significantly greater than the other treatments. Although the other treatments had comparable production in 2004, the vegetation on these treatments was not uniform and therefore did not provide an even canopy cover like that of native sod. These results demonstrated that greater biomass does not necessarily indicate superior erosion control.

Ground Cover

In 2003 the ground cover for native sod and broadcast seeding with a straw blanket were significantly greater than the hydromulched treatments with means of 97.1 %, 97.1 % and 2.5 % respectively (Table 12). Although the ground cover for the

Table 12. Mean ground cover during 2003 at the highway fill site.

Native sod	**Straw blanket/ broadcast seed**	**Hydromulch/ broadcast aeed**
Ground cover (%)		
97.1 a[/1]	97.1 a	2.5 b

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.

[/2]Analysis of variance results are presented in Table 88.

broadcast seed with the straw blanket was substantial, this type of cover is meant to degrade over time. Alternatively, native sod provides a live ground cover that will continue to grow rather than break down over time.

In 2004 the ground cover of native sod was slightly greater than that of the straw blanket with 96.7 % and 92.2 % respectively (Table 13), but they were not significantly

Table 13. Mean ground cover during 2004 at the highway fill site.

Native sod	**Straw blanket/ broadcast seed**	**Hydromulch/ broadcast seed**
Ground cover (%)		
96.7 a[/1]	92.2 a	5.8 b

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[/2]Analysis of variance results are presented in Table 92.

different from one another. They were significantly greater than the broadcast seed with the hydromulch treatments (5.8 %), however. The mean ground cover of the broadcast seed with hydromulch treatments slightly increased from 2.5 % in 2003 to 5.8 % in 2004. This could have been due to a greater accumulation of leaf litter on these plots.

The dense matting of the native sod and the straw blanket both provided a good ground cover. The advantage of the native sod however, is that the cover is live. It not only provides a barrier between raindrops and bare ground, it also has a fibrous root system that penetrates into the soil which stabilizes it to a greater degree.

Effects of Treatments on Plant Growth Characteristics at the Ski Slope Site

Production

In 2003 the mean perennial grass production for native sod was significantly greater (569 kg/ha) than both the broadcast seed with a straw blanket (72 kg/ha) and the broadcast seeded plots (41 kg/ha)(Table 14). The broadcast seed with the straw blanket

Table 14. Mean plant production during 2003 at the ski slope site.

Native sod	**Straw blanket/ broadcast seed**	**Broadcast seed**
Perennial grass production, kg/ha		
569 a[1]	73 b	41 b
Perennial forb production, kg/ha		
0 a	0 a	50 a
Annual forb production, kg/ha		
0	0	0
Total production, kg/ha		
569 a	73 b	91 b

[1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[2]Analysis of variance results are presented in Table 96.

and the broadcast seed treatments were not significantly different. Because the treatments at this site were implemented later than those on the highway fill site, they did not receive much rainfall throughout the entire summer. This delayed germination of the broadcast seed with the straw blanket and broadcast seeded treatments, thereby reducing the amount of production. Additionally, the ski slope site had the shortest and coolest growing

season of all three sites. Nevertheless, the native sod was able to root into the soil, generating a significantly greater amount of production than the other treatments. The mean total production of native sod was also significantly greater than that of the other treatments.

In 2004 the mean perennial grass production for native sod, broadcast seeding with a straw blanket, and broadcast seeding were 1488 kg/ha, 509 kg/ha, and 662 kg/ha respectively (Table 15). Perennial grass production for native sod was almost three times

Table 15. Mean plant production during 2004 at the ski slope site.

Native sod	Straw blanket/ broadcast seed	Broadcast seed
Perennial grass production, kg/ha		
1488 a [/1]	509 a	662 a
Perennial forb production, kg/ha		
2 a	1 a	13 a
Annual forb production, kg/ha		
0	0	0
Total production, kg/ha		
1490 a	510 a	675 a

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[/2]Analysis of variance results are presented in Table 100.

greater than the straw blanket with broadcast seed and was over twice as great as the broadcast seeded treatment, although these were not statistically different according to the statistical test. There was no difference in perennial forb production for neither 2003 nor 2004. The annual forb production for 2003 and 2004 was zero. The mean total production was not significantly different among the three treatments. This may be attributed to the high variability in the plots. On the broadcast seed with the straw blanket and the broadcast seeded plots, bunch grasses and perennial forbs were scattered randomly across the plots, whereas the native sod plots had relatively even distribution of perennial grass. This may have affected the statistical analysis which indicated there were no significant differences.

The mean perennial grass production for all treatments increased from 2003 to 2004. The mean perennial grass production for native sod was 569 kg/ha in 2003 and 1488 kg/ha in 2004. This is most likely a result of the sod going immediately into senescence in the first season due to drought like conditions. The mean perennial grass production for the broadcast seed with the straw blanket increased from 72 kg/ha to 509 kg/ha, while the mean perennial grass production for broadcast seeding increased from 41 kg/ha to 662 kg/ha. Again the conditions for germination were not ideal the first summer, while the summer of 2004 had extremely high levels of precipitation.

Basal Cover

The mean basal cover for native sod in 2003 for perennial grass was significantly greater than the straw blanket and the broadcast seeded treatments (Table 16). The native sod had an 86.3 % mean basal cover compared to 2.9 % and 2.5 %, respectively. Because native sod is already an established living organism, its basal cover relative to the other treatments was much greater. There was no significant difference among treatments for perennial forbs. Annual forbs had zero percent basal cover for all treatments in 2003.

Table 16. Mean basal cover during 2003 at the ski slope site.

Native sod	Straw blanket/ broadcast seed	Broadcast seed
Perennial grass basal cover (%)		
86.3 a[/1]	2.9 b	2.5 b
Perennial forb basal cover (%)		
0 a	0 a	1.3 a
Annual forb basal cover (%)		
0	0	0
Total basal cover (%)		
86.3 a	2.9 b	3.8 b

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[/2]Analysis of variance results are presented in Table 97.

The mean total basal cover was significantly greater for native sod compared to the other treatments. The dense basal cover of native sod implies its ability to withstand erosional forces.

In 2004 the mean basal cover of perennial grass for native sod was significantly greater than the straw blanket and broadcast seeded treatments (Table 17). However, the mean perennial grass basal cover decreased from 86.3 % in 2003 to 65.5 % in 2004 for native sod. This may have been due to a precipitation event that occurred while installing the plots. The high intensity of rainfall caused the diversion ditch above the plots to fill with water and break, which allowed a huge amount of water and sediment to flow onto one of the native sod plots. It managed to wash about half of the plot downslope. The native sod was retrieved and replaced, but it was covered with sediment which may have

Table 17. Mean basal cover during 2004 at the ski slope site.

Native sod	Straw blanket/ broadcast seed	Broadcast seed
Perennial grass basal cover (%)		
65.5 a[/1]	17.6 b	14.9 b
Perennial forb basal cover (%)		
2.0 a	0.8 a	3.3 a
Annual forb basal cover (%)		
0	0	0
Total basal cover (%)		
67.5 a	18.4 b	18.2 b

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[/2]Analysis of variance results are presented in Table 101.

impeded its ability to provide cover. The mean basal cover of the straw blanket and the broadcast seeded plots increased from 2003 to 2004 to 17.6 % and 14.9 %, respectively. Although these treatments had a year to establish, their percent cover was relatively low. There was no significant difference among treatments for perennial forbs. There was zero percent basal cover for annual forbs for all treatments. The annual forbs may have had difficulty in becoming established due to the rocky substrate. The mean total basal cover of native sod was significantly greater than that of the other treatments.

Canopy Cover

In 2003, the mean canopy cover of perennial grass for native sod was significantly greater (87.1 %) than the broadcast seed with the straw blanket (3.3 %) and the broadcast seeded treatments (2.9 %)(Table 18). The immediate establishment of native sod and its

Table 18. Mean canopy cover during 2003 at the ski slope site.

Native sod	Straw blanket/ Broadcast seed	Broadcast seed
Perennial grass canopy cover (%)		
87.1 a[/1]	3.3 b	2.9 b
Perennial forb canopy cover (%)		
0 a	0 a	1.3 a
Annual forb canopy cover (%)		
0	0	0
Total canopy cover (%)		
87.1 a	3.3 b	4.2 b

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[/2]Analysis of variance results are presented in Table 98.

ability to provide a dense canopy cover compared to the other treatments made it much less susceptible to erosion. The canopy cover of the broadcast seed with the straw blanket and broadcast seeded treatments was not significantly different. This is logical because both of these treatments were seeded identically. It is possible that the straw blanket treatment had slightly more perennial grass canopy cover than the broadcast seeded treatment because the seeds were protected by the straw blanket. There was no significant difference among treatments for perennial forbs. There was zero percent canopy cover for annual forbs. It is possible that the clay loam texture of the soil at this site may have impeded germination. The mean total canopy cover of native sod was significantly greater than the other treatments.

In 2004 the mean canopy cover for perennial grass for native sod was significantly

greater (68.2 %) compared to the broadcast seed with the straw blanket (21.8 %) and the broadcast seeded treatments (19.8 %)(Table 19). The broadcast seed with the straw

Table 19. Mean canopy cover during 2004 at the ski slope site.

Native sod	Straw blanket/ broadcast seed	Broadcast seed
Perennial grass canopy cover (%)		
68.2 a[/1]	21.8 b	19.8 b
Perennial forb canopy cover (%)		
2.0 a	0.8 a	4.1 a
Annual forb canopy cover (%)		
0	0	0
Total canopy cover (%)		
70.2 a	22.6 b	23.9 b

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[/2]Analysis of variance results are presented in Table 102.

blanket and broadcast seeded treatments were not significantly different. The mean canopy cover for native sod decreased from 87.1 % in 2003 to 68.2 % in 2004, while the other two treatments increased. Again this may be attributed to the rainstorm that occurred during implementation of the plots, or possibly the adjustment to its new environment. The sediment that was deposited on top of the native sod plot could have decreased the percent cover in some areas. There was no significant difference among treatments for perennial forbs. Although forbs were not originally present in the native sod, wind or water may have allowed some seeds to become established through areas were the native sod did not survive. Native sod had significantly greater mean total canopy cover compared to the other treatments. When compared with the 2004 total production where there were no significant differences among treatments, it is evident that above ground biomass does not directly correlate with canopy cover. Vegetation that is unevenly distributed may have greater biomass, but may not necessarily have a large percent canopy cover. The high percent canopy cover of native sod will ultimately interfere with raindrop energy impacts thus reducing erosion.

Ground Cover

In 2003, native sod and the straw blanket treatments had significantly greater mean ground cover than the broadcast seeded treatments with 88.8 %, 97.1 %, and 7.4 % respectively (Table 20). This was consistent with the fact that native sod provided not

Table 20. Mean ground cover during 2003 at the ski slope site.

Native Sod	**Straw blanket/ Broadcast Seed**	**Broadcast Seed**
Ground Cover (%)		
88.8 a[/1]	97.1 a	7.4 b

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[/2]Analysis of variance results are presented in Table 99.

only a dense canopy cover, but also a solid ground cover. Additionally, the straw blanket was essentially a ground cover, although it did not necessarily induce an immense amount of plant cover.

In 2004 (Table 21), both native sod and the straw blanket treatments had significantly greater ground cover than the broadcast seeded treatments with means of

Table 21. Mean ground cover during 2004 at the ski slope site.

Native Sod	Straw blanket/ Broadcast Seed	Broadcast Seed
Ground Cover (%)		
92.7 a[/1]	95.8 a	42.2 b

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[/2]Analysis of variance results are presented in Table 103.

92.7 %, 95.8 %, and 42.2 %, respectively. The native sod ground cover increased from 2003 to 2004 due to higher production. However, the straw blanket is intended to degrade over time thereby decreasing the amount of cover it provides. The mean ground cover of the broadcast seeded plots increased substantially from 7.4 % in 2003 to 42.2 % in 2004. This may be credited to increased amounts of leaf litter or other debris that had accumulated over the year.

Effects of Treatments on Plant Growth Characteristics at the Mine Waste Site

Production

In the summer of 2003 the mean perennial grass production for native sod was 1714 kg/ha (Table 22). This value was significantly greater than the redtop sod production (876 kg/ha). This was a surprising result given the fact that redtop is known for its low pH tolerance and its ability to establish on severely disturbed landscapes. It is also widely seeded for erosion control in acid mine waste areas (Munshower 1998). Redtop production was, however, significantly greater than the broadcast seed with the

Table 22. Mean plant production during 2003 at the mine waste site.

Native sod	**Redtop sod**	**Broadcast seed/ Straw blanket installed 2003**	**Broadcast seed/ Straw blanket installed 2001**
Perennial grass production, kg/ha			
1714 a[/1]	876 b	1 c	9 d
Perennial forb production, kg/ha			
0	0	0	21
Annual forb production, kg/ha			
0	0	0	0
Total production, kg/ha			
1714 a	876 b	1 c	30 d

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[/2]Analysis of variance results are presented in Table 104.

straw blanket installed in 2003 (1 kg/ha), and the straw blanket installed in 2001(9 kg/ha). The production of the straw blanket treatment installed in 2003 was significantly less than the straw blanket treatment installed in 2001. This is most likely because the seed that was broadcast with the straw blanket installed in 2001 had approximately two years to become established. Nevertheless, despite the ample time available for germination and growth, there was still minimal production on this treatment. There was zero annual forb production for all treatments. The straw blanket treatment installed in 2001 had 21 kg/ha of perennial forb production, compared to zero production for the other treatments. However, the data could not be normalized and therefore there is no ANOVA table. The low levels of production on this site may be attributed to several factors, including low

amounts of precipitation in the summer following implementation, excessively steep slopes, and acidic conditions. The mean total production for native sod was significantly greater compared to all other treatments.

Perennial grass production decreased from 2003 to 2004 for native sod, redtop sod, and the broadcast seed with the straw blanket installed in 2003 (Table 23). The

Table 23. Mean plant production during 2004 at the mine waste site.

Native sod	**Redtop sod**	**Broadcast seed/ straw blanket installed 2003**	**2001**
Perennial grass production, kg/ha			
631 a [1]	417 ab	0 b	138 ab
Perennial forb production, kg/ha			
0	0	0	0
Annual forb production, kg/ha			
0	0	0	0
Total production, kg/ha			
631 a	417 ab	0 b	138 ab

[1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[2]Analysis of variance results are presented in Table 108.

severity of this site has made plant establishment extremely difficult. The U.S. Forest Service had tried for years to get plant establishment on this site without success. The fact that anything at all survived here is progress. It was obvious that traditional seeding methods did not work in this setting. However, both native and redtop sod were able to penetrate their root systems into this steep acidic environment. Although production for these treatments decreased after one year, the sod treatments were still alive.

The production of the straw blanket treatment installed in 2001 increased from 9 kg/ha to 138 kg/ha from 2003 to 2004. This production resulted from a few bunch grasses that have managed to survive on these plots. There was no significant difference between native sod, redtop sod, and the straw blanket installed in 2001. There was no significant difference between redtop sod, the straw blanket installed in 2003, and the straw blanket installed in 2001. The native sod was significantly greater (631 kg/ha) than the straw blanket installed in 2003 (0 kg/ha). There was zero production in 2004 for perennial and annual forbs. The mean total production indicated that native sod, redtop sod, and the broadcast seed with the straw blanket installed in 2001 were not significantly different.

Basal Cover

In 2003 the mean basal cover of perennial grass was significantly greater for native sod (87.5 %) and redtop sod (90.3 %) than for the straw blanket installed in 2003 (.8 %) and the straw blanket installed in 2001 (2.5 %) (Table 24). Additionally, both native sod and redtop sod had significantly greater mean total basal cover compared to the broadcast seed with the straw blanket treatments. This is logical because both sod treatments inherently have a high percent cover. Because germination was difficult for the other treatments, there was minimal cover. There was no difference among treatments for annual and perennial forbs.

Table 24. Mean basal cover during 2003 at the mine waste site.

Native sod	Redtop sod	Broadcast seed/ straw blanket installed 2003	2001
Perennial grass basal cover (%)			
87.5 a[/1]	90.3 a	0.8 b	2.5 b
Perennial forb basal cover (%)			
0	0	0	0
Annual forb basal cover (%)			
0	0	0	0
Total basal cover (%)			
87.5 a	90.3 a	0.8 b	2.5 b

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[/2]Analysis of variance results are presented in Table 105.

In 2004 both native and redtop sod were the only treatments that were able to survive the harsh conditions at this site. It was first believed that redtop sod would perform better than the native sod due to its low pH tolerance and ability to proliferate on mine sites. However, in 2004 the native sod had a perennial grass basal cover of 30.3 % compared to redtop sod with 20.8 % (Table 25). Perennial grass basal cover and mean total basal cover for both sod treatments were significantly greater than both straw blanket treatments in 2004. The native sod and redtop sod were not significantly different. The decrease in cover for the sod treatments from 2003 to 2004 may be attributed to it slipping downslope and leaving areas devoid of vegetation. These areas were included in the subsampling and may have affected the data. Although these treatments became established the first year, low nutrient levels, low pH, and steep slopes

Table 25. Mean basal cover during 2004 at the mine waste site.

Native sod	Redtop sod	Broadcast seed/ straw blanket installed 2003	2001
Perennial grass basal cover (%)			
30.3 a[/1]	20.8 a	0 b	2.0 b
Perennial forb basal cover (%)			
0	0	0	0
Annual forb basal cover (%)			
0	0	0	0
Total basal cover (%)			
30.3 a	20.8 a	0 b	2.0 b

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[/2]Analysis of variance results are presented in Table 109.

combined to make survival exceptionally difficult. There was zero cover for annual and perennial forbs.

Canopy Cover

The mean canopy cover in 2003 for perennial grass was significantly greater for native sod (87.5 %) and redtop sod (90.3 %) than the straw blanket installed in 2003 (0.8 %) and the straw blanket installed in 2001 (3.33 %)(Table 26). Native sod and redtop sod also had significantly greater mean total canopy cover compared to the other treatments. Again this can be attributed to the intrinsic cover of sod. Aside from the sod, the only living vegetation on this site was a few bunch grasses that may have established with the implementation of the 2001 straw blanket, or possibly seed from nearby bunch grasses.

Table 26. Mean canopy cover during 2003 at the mine waste site.

Native sod	Redtop sod	Broadcast seed/ straw blanket installed 2003	2001
Perennial grass canopy cover (%)			
87.5 a[/1]	90.3 a	0.8 b	3.3 b
Perennial forb canopy cover (%)			
0	0	0	1.3
Annual forb canopy cover (%)			
0	0	0	0
Total canopy cover (%)			
87.5 a	90.3 a	0.8 b	4.6 b

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[/2]Analysis of variance results are presented in Table 106.

There was no significant difference among treatments for annual forbs. Data for perennial forbs could not be normalized and therefore an ANOVA was not performed.

In 2004, the mean perennial grass canopy cover for native sod (28.8 %) and redtop sod (18.8 %) was significantly greater than the broadcast seed with the straw blanket treatment installed in 2003 (0 %) and in 2001 (2.4 %)(Table 27). Total mean canopy cover was also significantly greater for native and redtop sod. The decrease in native and redtop sod canopy cover from 2003 to 2004 may be attributed to bare spots on the plots where the sod slid downslope. The sandy loam texture of the substrate coupled with the 70 % slope made it difficult for anything to remain on this slope. There was no significant difference among treatments for annual forbs in 2004. Data for perennial forb canopy cover could not be normalized and therefore an ANOVA was not performed.

Table 27. Mean canopy cover during 2004 at the mine waste site.

Native sod	**Redtop sod**	**Straw blanket installed 2003**	**Straw blanket installed 2001**
Perennial grass canopy cover (%)			
28.8 a[/1]	18.8 a	0 b	2.4 b
Perennial forb canopy cover (%)			
0	0	0	1.3
Annual forb canopy cover (%)			
0	0	0	0
Total canopy cover (%)			
28.8 a	18.8 a	0 b	3.7 b

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[/2]Analysis of variance results are presented in Table 110.

<u>Ground Cover</u>

In 2003 there was no significant difference among any of the treatments for ground cover (Table 28). Native sod had a ground cover of 87.9 %, redtop sod had a ground cover of 92.0 %, the straw blanket installed in 2003 had a ground cover of 75.8 %,

Table 28. Mean ground cover during 2003 at the mine waste site.

Native sod	**Redtop sod**	**Broadcast seed/ straw blanket installed 2003**	**Broadcast seed/ straw blanket installed 2001**
Ground cover (%)			
87.9 a[/1]	92.0 a	75.8 a	72.2 a

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[/2]Analysis of variance results are presented in Table 107.

and the straw blanket installed in 2001 had a ground cover of 72.2 %. The sod treatments served as live cover as well as a ground cover. The straw blanket treatments provided a solid ground cover, but that did not necessarily translate into a significant amount of live cover.

In 2004 the straw blanket installed in 2001 had significantly less ground cover than the other treatments (Table 29). The ground cover for all treatments was

Table 29. Mean ground cover during 2004 at the mine waste site.

Native sod	**Redtop sod**	**Broadcast seed/ straw blanket installed**	
		2003	**2001**
Ground cover (%)			
55.5 a[/1]	49.1 a	40.0 a	8.2 b

[/1]Means followed by the same letter in the same row are not significantly different, P=0.05.
[/2]Analysis of variance results are presented in Table 111.

substantially lower in 2004 compared to 2003. Again this may be due to the treatments sliding downslope. Additionally, wildlife in the area disturbed the plots by trampling them and caused the straw blanket installed in 2003 to fold over on some plots exposing the bare ground. Despite all the elements, both native and redtop sod had a reasonably good cover the second year where nothing else could survive.

The nature of the mine waste site with such an extremely steep slope made implementing the treatments a difficult task. Posts were pounded in at the top of the slope and ropes were attached and used to hold onto for balance. The soil was continually eroding downslope as work continued on this site. It is difficult to know whether or not the seed and fertilizer that was broadcast on the plots slid down below the plots. Additionally at the mine waste site, the earthen berms constructed between the plots were continually sliding downslope. However, lateral flow on this steep slope was most likely not a concern.

At both the highway fill site and the mine waste site it could be seen that the vegetation below the broadcast seeded plots was the same species that were seeded. There was often more vegetation below the plots than on them, indicating that the seed may have slid down and off the plots and germinated below. Again this points to the merits of the already established sod that is secured with staples and immediately thereafter roots into the substratum thereby evading gravitational displacement.

Runoff, Sediment Loss and Infiltration Characteristics at the Highway Fill Site

For the peak 10 year 24 hour storm that was simulated on the highway fill site, the native sod and broadcast seed with the straw blanket treatments had significantly less runoff compared to the broadcast seed with hydromulch treatment (Figure 7). Percent runoff was defined as the amount of runoff collected divided by the amount of precipitation applied multiplied by 100. Sloped areas treated with native sod had zero percent runoff, the broadcast seed with the straw blanket treatment had a mean of 0.5 % runoff, and broadcast seed with hydromulch plots had a mean of 14.2 % runoff.

The rainfall simulation demonstrated the effectiveness of native sod at controlling runoff compared to the other treatments. Although the broadcast seed with the straw

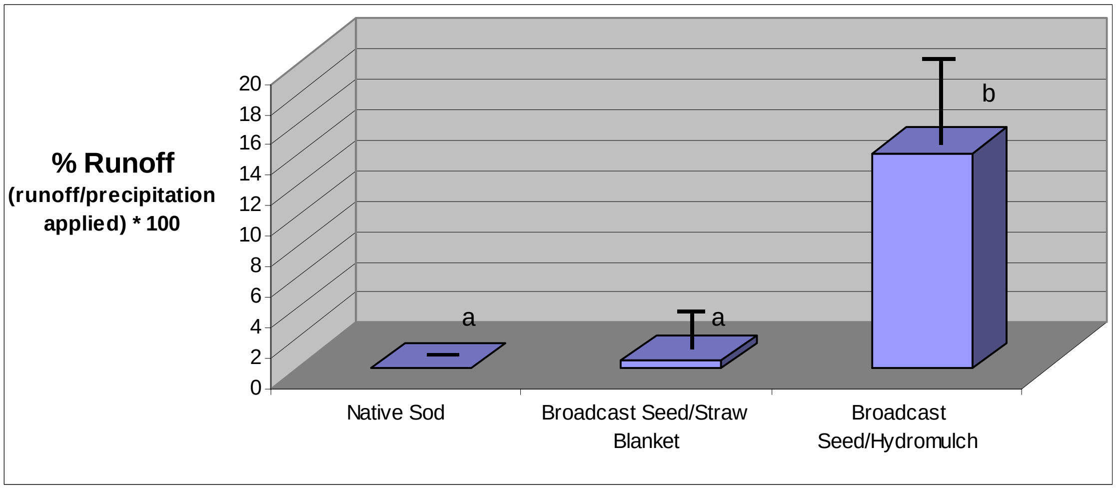


Figure 7. Mean (n=3) and standard error of runoff as a function of treatments on the highway fill site. Bar values capped by the same letter are not significantly different, P=0.05. ANOVA results are presented in Table 94.

blanket provided a good ground cover, this treatment still produced a substantial amount of runoff. The broadcast seed with hydromulch treatment produced 28 times the amount of runoff than the broadcast seed with the straw blanket treatment.

The native sod and broadcast seed with the straw blanket treatments had significantly less sediment loss compared to the broadcast seed with hydromulch treatment, with mean values of 0 kg/ha, 9.29 kg/ha, and 384.51 kg/ha, respectively (Figure 8). Because the broadcast seed with hydromulch treatment had a considerably greater amount of bare ground exposed, the impact of the raindrops that fell on these plots caused the soil particles to detach from the larger masses (Toy 2003), thereby facilitating an increased amount of runoff and sediment loss. The native sod not only provided a live dense cover that interfered with the energy of the raindrop impact, it also stabilized the the soil with its fibrous root system. The broadcast seed with the straw blanket treatment

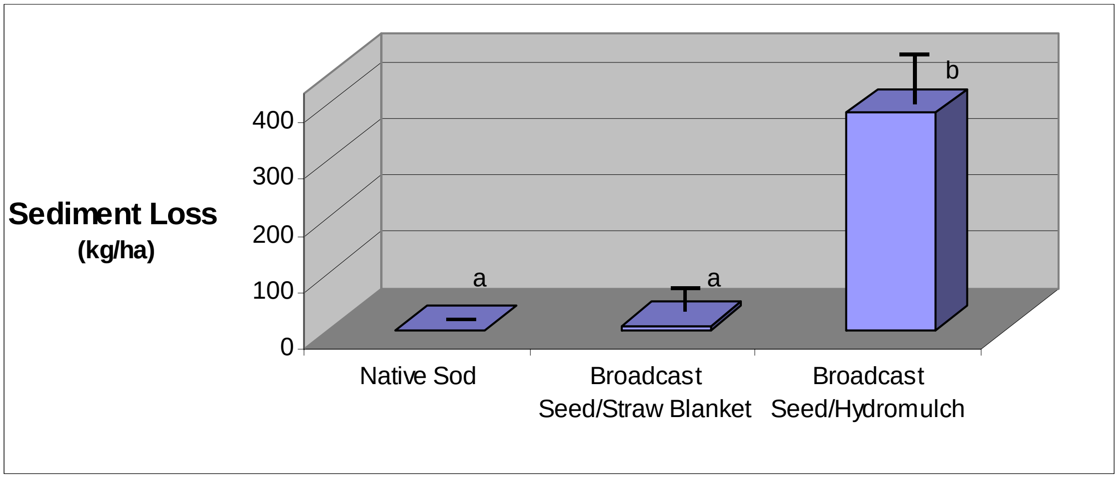


Figure 8. Mean (n=3) and standard error of sediment loss as a function of treatments on the highway fill site. Bar values capped by the same letter are not significantly different, P=0.05. ANOVA results presented in Table 93.

was able to interfere with the raindrop impact, but did not prevent all soil particles from becoming detached, thereby causing erosion and sediment loss.

Infiltration rates further describes the merits of using native sod for erosion control (Figure 9). The rate of water applied in this storm was equal to 1.85 cm/hr. The

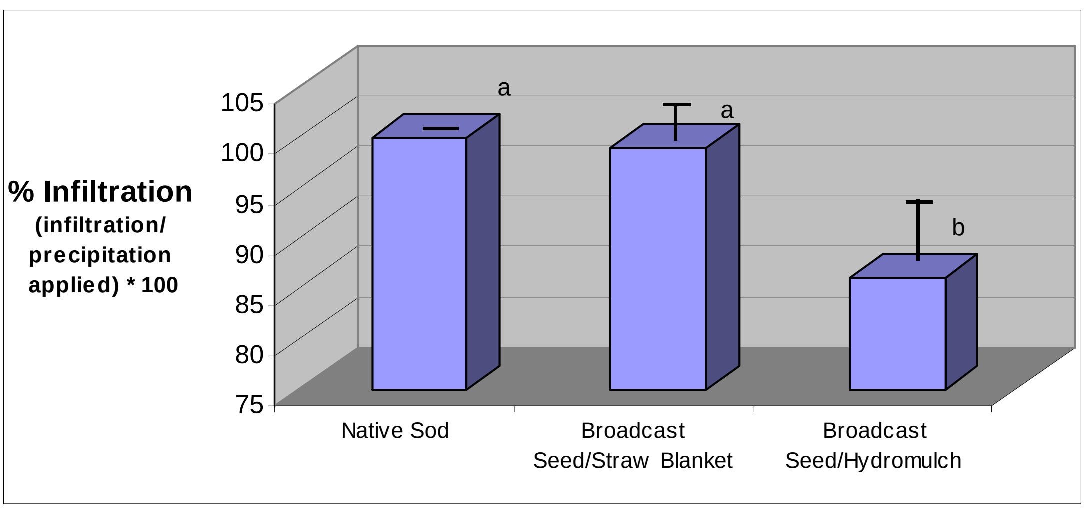


Figure 9. Mean (n=3) and standard error of % infiltration as a function of treatments on the highway fill site. Bar values capped by the same letter are not significantly different, P=0.05. ANOVA results presented in Table 95.

maximum infiltration rate for native sod was never attained because it absorbed all water that was applied during the two hour precipitation event. For the purposes of statistical analysis, an infiltration rate of 1.85 cm/hr was used for the native sod treatment. Both the native sod treatment (1.85 cm/hr) and the broadcast seed with the straw blanket treatment (1.84 cm/hr) had a significantly greater mean infiltration rate compared to the broadcast seed with hydromulch (1.59 cm/hr). The percent infiltration that corresponds to these rates are 100 %, 99 %, and 86 % respectively, as displayed on Figure 9. All of these rates fell within the rapid range of infiltration rates (SCS 1951). This may be due the larger pore size of the loamy textured soil at this site. The considerable amount of vegetation on the native sod plots was able to absorb all of the water. Although there was not as much vegetation on the broadcast seed with the straw blanket plots, the straw blanket may have absorbed the raindrops rather than deflecting them on to the collection trough as happened with the broadcast seed with hydromulch plots. The lack of vegetation on the broadcast seed with hydromulch plots, and greater runoff compared to other treatments, may have been responsible for this treatment having the lowest infiltration rate.

Estimation of Sediment Loss Using the RUSLE2 Model at the Highway Fill Site

RUSLE2 predicts sediment loss in terms of kg/ha/yr (tons/acre/year). The output for the native sod profile predicted 4929 kg/ha/yr (2.2 t/ac/yr)(Table 30)(Figure 10). The RUSLE2 output for the broadcast seed with the straw blanket profile predicted 21,507

Table 30. RUSLE2 predictions of sediment loss for three treatments.[/1]

Sediment Loss		
Native Sod	**Broadcast Seed/Straw Blanket**	**Broadcast Seed/Hydromulch**
t/ac/yr		
2.2	9.6	11.0
kg/ha/yr		
4929	21,507	24,643

[/1]Input variables are presented in Table 4.

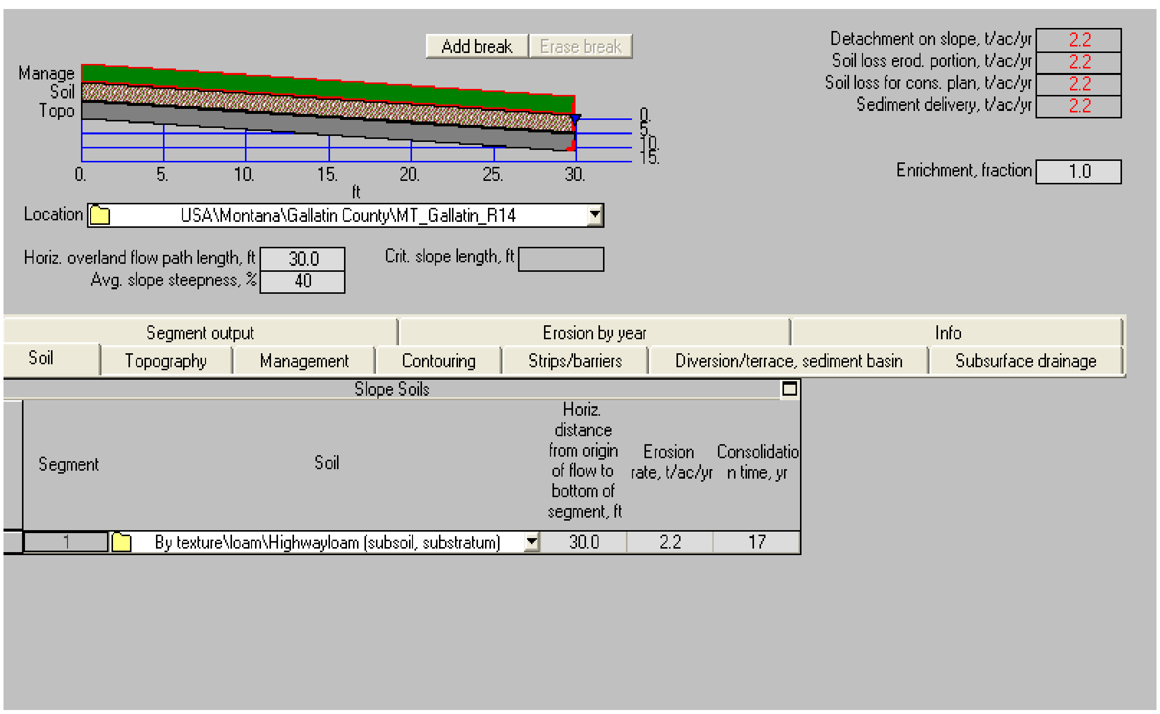


Figure 10. RUSLE2 profile for native sod at the highway fill site

kg/ha/yr (9.6 t/ac/yr)(Figure 11), which is more than four times greater than the prediction for native sod. The RUSLE2 output for the broadcast seed with hydromulch was five times greater than the native sod prediction with 24,643 kg/ha/yr (11 t/ac/yr)(Figure 12).

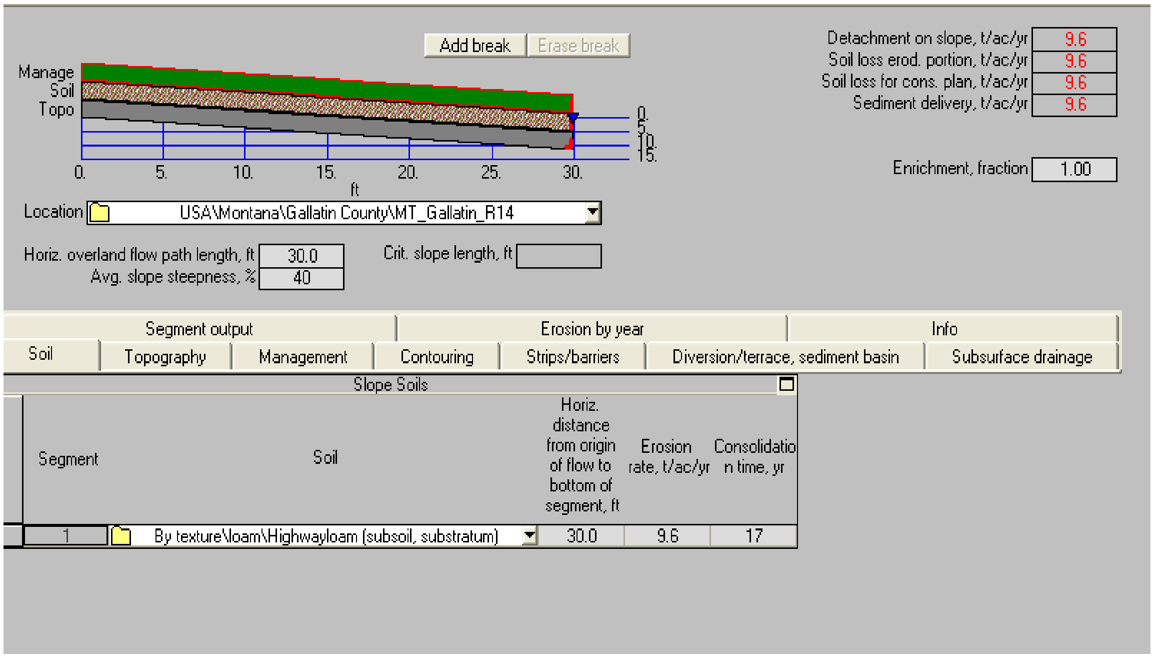


Figure 11. RUSLE2 profile for broadcast seed with the straw blanket at the highway fill site.

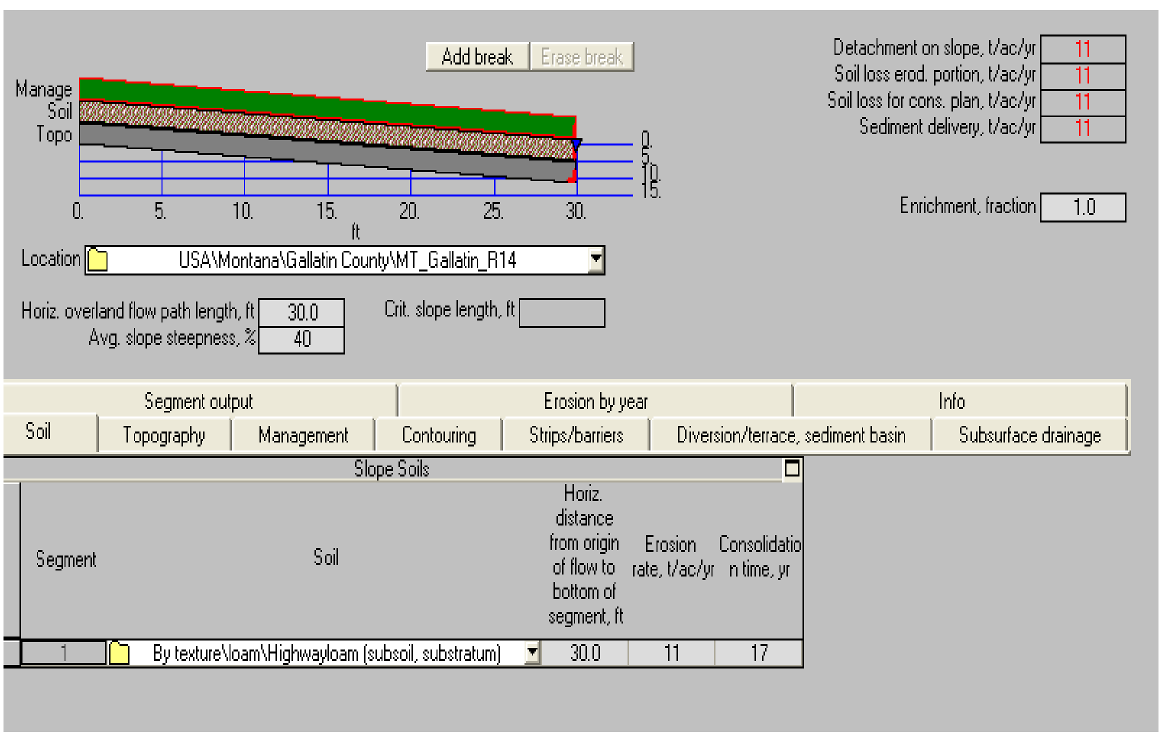


Figure 12. RUSLE2 profile for the broadcast seed with hydromulch at the highway fill site.

The results of native sod for production and cover when modeled in RUSLE2 indicated that it would produce less sediment per year than the other treatments. The RUSLE2 outputs also demonstrated that the broadcast seed with the straw blanket treatment would produce less sediment than the broadcast seed with hydromulch.

Cost Analysis

A cost analysis was performed comparing three treatments on a hypothetical one hectare sloped site and a 100 km mobilization distance (Table 31). The treatments were native sod, broadcast seed with a straw blanket, and broadcast seed with hydromulch. The cost of native grass sod was $3.23/m^2 ($32,300/ ha) plus $1.86/km for delivery ($186/100 km). Water supplies were necessary for irrigation of the native sod upon implementation ($250). Additionally, staples were needed to secure the native sod ($100/ ha). Fertilizer costs were approximately $180/ha, and installation labor costs were $1200. Over a one hectare area, the total cost of implementing native sod was $34,216/ha.

The cost of the SC150BN straw blanket was $1.50/m^2 ($15,000/ha) plus $1.09/km for mobilization. Stakes and staples were necessary to pin the straw blanket down into the soil ($100/ha). The cost of fertilizer was $180/ha and the cost of seed was $189/ha. Application of the seed was $600/ha and the straw blanket was $1000/ha. The total cost of implementing the broadcast seed with the straw blanket was approximately $17,178/ha.

The broadcast seed with hydromulch treatment required $180/ha for fertilizer and

Table 31. Cost analysis as a function of materials, supplies, travel, and installation on a sloped site.

	Unit Cost	Native Sod	Broadcast Seed/ Straw Blanket	Broadcast Seed/ Hydromulch
Materials and supplies				
Native sod	$3.23/m^2	$32,300/ha		
Straw blanket	$1.50/m^2		$15,000/ha	
Stakes, pins, staples	$50	$100/ha	$100/ha	
Fertilizer	$12/ 4.5 kg bag	$180/ha	$180/ha	$180/ha
Seed	$63/11.3 kg bag		$189/ha	$189/ha
Transportation/Mobilization				
Transport of native sod	$1.86/km	$186/100 km		
Transport of straw blanket	$1.09/km		$109/100 km	
Transport of Hydromulch	$.82/km			$82/100 km
Native sod application	$12/hr	$1200/ha		
Straw blanket application	$12/hr		$1000/ ha	
Seeding application	$12/hr		$600/ha	$600/ha
Hydromulch/Compost acquisition and application	$20/hr			$3000/ha
Water supplies	$250	$250		
Total		$34,216	$17,178	$4051

$189/ha for seed. Seeding application was $600/ha. The hydromulch/compost application was $3000/ha plus mobilization costs of $.82/km. Total costs of implementing the broadcast seed with hydromulch were $4051/ha.

Total costs for native sod were almost twice as much as those for the broadcast seeding with the straw blanket. The total cost of the broadcast seeding with the straw blanket was more than four times as much as the broadcast seeding with hydromulch.

These results indicated that the more expensive the treatment, the more successful it was at plant establishment and slope stabilization. Native sod was the most expensive treatment, yet also the most effective as far as production and cover were concerned. Native sod also produced the least amount of runoff and sediment, and had the highest percent infiltration. Although broadcast seeding with either a straw blanket or hydromulch were less costly, these methods will require more maintenance in the future which will inevitably cost more.

One cannot attain complete erosion control with a straw blanket or hydromulch, even after a couple of years. If the broadcast seed with the straw blanket treatment were to be repeated even one additional time, the costs would exceed those of using native sod only once. In this scenario it is apparent that native sod would be a more logical choice. Additionally, the use of native sod may prevent millions of dollars in fines emanating from sediment loading into water resources. However, in areas where it is clear that a less costly treatment such as the broadcast seed with hydromulch will successfully control erosion, it should be used.

The utilization of native grass sod on sensitive areas is warranted where either immediate runoff and erosion control is needed, or the aesthetic appearance of an immediate plant cover is needed. It is also likely that native grass sod will require less weed control management compared to the broadcast seeding method which will have notable exposed soil surface for many years.

SUMMARY AND CONCLUSIONS

Three field sites in Montana were designed to evaluate native grass sod production and cover. Runoff, sediment loss, and infiltration were evaluated on one of the sites. A highway fill site with a 40 % slope gradient was located 10 km west of Four Corners on the Norris Highway. A ski slope site with a 35 % slope gradient was located at the Yellowstone Club near Big Sky. The third site consisted of abandoned mine waste on a 70 % slope gradient located on Forest Service land approximately 30 km southwest of Helena. Erosion was a significant problem at each of these sites. The purpose of this investigation was to compare native grass sod to other plant establishment methods used in land reclamation.

The first objective was to measure plant growth characteristics on native grass sodded slopes compared to broadcast seeding with either a straw blanket or hydromulch. In the first growing season (2003), native grass sod had significantly greater total production and cover compared to the other treatments on the highway fill and ski slope sites. Additionally, native grass sod and redtop sod had significantly greater mean perennial grass production and cover compared to the other treatments on the mine waste site.

In 2004, native sod had significantly greater mean perennial grass production and cover on the highway fill site compared to the other treatments. Total production on the this site was not significantly different among treatments, though total canopy cover was significantly greater for native sod. This implies that a large above ground biomass does not always signify greater cover. On the ski slope site, total basal and canopy cover of native sod were significantly greater than the other treatments. On the mine waste site, total production and cover of native sod were significantly greater than the broadcast seed with the straw blanket installed in 2003. These results demonstrate the effectiveness of using native sod on steep slopes where immediate plant establishment is needed.

The second objective was to determine runoff, sediment yield, and infiltration rates of native grass sodded slopes compared to broadcast seeding with either a straw blanket or hydromulch for a peak 10 year 24 hour storm event on the highway fill site. The native grass sod and the broadcast seed with the straw blanket treatments produced significantly less runoff and sediment yield than the broadcast seed with hydromulch treatment, and had significantly greater infiltration. Due to the dense fibrous root system of native sod, it was able to absorb all of the rainfall that was applied, resulting in 100 % infiltration of applied precipitation. This demonstrates the merit of using native sod on steep slopes where runoff and erosion must be controlled immediately.

The third objective was to model sediment yield on sodded slopes compared to other plant establishment methods using RUSLE version 2. RUSLE2 estimated that slopes treated with native sod would yield four times less sediment than with broadcast seeded slopes equipped with a straw blanket, and would yield five times less sediment than the broadcast seed with hydromulch treatment. Again this reveals the advantages of using native sod where immediate runoff and erosion control are necessary.

The fourth objective was to evaluate costs of implementing native grass sod compared to broadcast seeding with either a straw blanket or hydromulch in a given area. The cost analysis indicated slopes treated with native grass sod would cost twice as much as the broadcast seed with the straw blanket, and would cost approximately eight times as much as the broadcast seed with hydromulch. However, according to the results determined in this study, native sod was the most effective at controlling erosion compared with the other treatments. Native sod is applicable in sensitive areas where immediate erosion control is necessary, or in areas where aesthetics are highly valued. These may include areas where complete plant cover is required by the public or where weed control is desired.

LITERATURE CITED

American Society of Testing Materials. 1993. Standard practice for dry preparation of soil samples for particle-size analysis and determination of soil constants. Method D421-85.

Bitterroot Turf Farm. 2004. 425 Bailey Ln., Corvallis, MT 59828. 1-800-928-6649. <http://www.turfmontana.com>

Bobcat Company. 2004. P.O. Box 6000, West Fargo, ND 58078. <http://www.bobcat.com/products/ssl/index.html>

Brouwer Turf Equipment. 2004. 289 N. Kurzen Rd. Dalton, Ohio 44618 (330) 828-0200 <http://www.brouwerturf.com/index.html>

Bucyrus Equipment Company, Inc. 2004. 209 Main P.O. Box 156. Hillsdale, KS 66036. 1-800-330-0857 <http://www.bucyrusmagnum.com/index.html>

Chambers, J.C. 1997. Restoring alpine ecosystems in the western united states: environmental constraints, disturbance characteristics, and restoration success. pp.172, 173, In Krystyna M. Urbanska, Nigel R. Webb, and Peter J. Edwards [eds.], Restoration Ecology and Sustainable Development. Cambridge University Press, Cambridge. 397 p.

The City of Calgary Wastewater & Drainage Urban Development. 2001. Guidelines for erosion & sediment control, Calgary: February. Erosion Control Standard 4: Sodding p. 80-83, p. 110-113 <http://www.gov.calgary.ab.ca/wwd/manuals/ESCGuidelines2001-02-12.pdf>

Daubenmire, R. 1959. A canopy-coverage method of vegetational analysis. Northwest Science. Vol. 33, No. 1: 43-64

Environmental Laboratory. 1994. US Army Engineer, Waterways Experiment Station, Natural Resources Division (CEWES-EN-S), Vickburg, MS 39180. Riparian zone ecology, restoration and management. Northwestern United States, Billings, MT, June 14-17. Ch. 10 <https://www.denix.osd.mil/denix/Public/ES-Programs/Conservation/Legacy/Riparian/riparian2.html>

Florida Department of Environmental Protection. 2004. Vegetation for erosion control. 6.67:17. *In* Florida erosion and sediment control inspector’s manual. Best Management <Practices.http://www.dep.state.fl.us/water/nonpoint/docs/erosion/chapter6.pdf>

Hossner, L. R. 1988. Reclamation of surface-mined lands volume II. Boca Raton: CRC Press, Inc.

Hutchinson, C.S. 1988. Rehabilitation of beaver creek. Land and Water May/June: 20-21.

Jensen, I.B. and Sindelar, B.W. 1979. Permanent stabilization of semiarid roadsides with grass, legume and shrub seed mixtures and native grass dryland sodding. Vol. 3, Res. Rep. 141, Montana Agricultural Experiment Station, Montana State University, Bozeman.

Krenitsky, E.C., Carroll, M.J., Hill, R.L., and J.M. Krouse. 1988. Runoff and sediment loss from natural and man-made erosion control materials. Crop Science 38: 1042-1046.

Larson, J. E. 1980. Revegetation equipment catalog. Missoula: Forest Service USDA.

McGinnies, W.J. and Wilson, A.M. 1982. Using blue grama sod for range revegetation. J. Range Manage., 35, 259. <http://jrm.library.arizona.edu/data/1982/352/30mcgi.pdf>.

Meeuwig, R.O. 1971. Infiltration and water repellency in granitic soils. U.S. Forest Service Research Paper INT-111.

Mockus, V. 1985 (Rev.). National Engineering Handbook. Section 4: Hydrology. U.S. Dept. of Agric., Soil Cons. Svc.

Munn, L., Harrington, N. and D. R. McGirr. 1987. Reclaiming mine soils and overburden in the western United States. Analytic parameters and procedures. Rock Fragments. Soil Conservation Society of America. Ch. 12:260-270.

Munshower, F. 1998. Grasses and grasslike species for revegetation of disturbed lands in the northern great plains and adjacent areas with comments about some wetland species. Reclamation Research Unit Publ. No. 9805.

Munshower, Frank F. 1994. Practical handbook of disturbed land revegetation. Lewis Publishers, Boca Raton.

N.C. Division of Water Quality. 1997. Basinwide water quality management plan. Appendix V, September. p. A-V-10 <http://h2o.enr.state.nc.us/basinwide/Pasquotank/bmp%20appendix.DOC>

North American Green. 2004. Erosion control has never been more advanced, 14649 Highway 41 North, Evansville, Indiana 47711. 1-800-772-2040 <(http://www.nagreen.com/products/SC150BN.html>

Palmer, R. G. and F. R. Troeh. 1995. Introductory soil science laboratory manual, third edition. Oxford University Press, New York.

Reclamation Research Unit. 1997. ARTS Phase IV Final Report. Anaconda revegetation treatability studies. Phase IV: Monitoring and Evaluation. Volume II: Appendices. Document No.: ASSS-ARTS-IV-FR-073197. Reclamation Research Unit, Montana State Univ., Bozeman, MT. Appendix F.1, pp 4-127,128

Renard, K.G., G.R. Foster, G.A. Weesies, D.K. McCool and D.C. Yoder. 1997. Predicting soil erosion by water: A guide to conservation planning with the Revised Universal Soil Loss Equation (RUSLE), U.S. Department of Agriculture, Agriculture Handbook No. 703, 404pp.

Rhoades, J. D. 1982. Soluble salts. p. 167-179. In: A. L. Page et al. (ed.) Methods of soil analysis: Part 2: Chemical and microbiological properties. Monograph Number 9 (Second Edition). ASA, Madison, WI.

Roe Ecological Services, LLC. 2004. Hydroseeding and erosion control. <http://www.yourwildlife.com/hydroseeding.htm>

Schafer W.M. 1979. Guides for estimating cover-soil quality and mine soil capability for use in coal strip-mine reclamation in the western United States. Reclamation Review 2: 67-74

Sigma Stat Software Program, Jandel Scientific, San Rafael, CA

Soil Conservation Service. 1951. Soil Survey Manual, U.S. Dep. Agric. Agric. Handb. No. 18

Toy, T.J., and G.R. Foster (eds). 1998. Guidelines for the use of the Revised Soil Loss Equation on mined lands, construction sites, and reclaimed lands. Office of Surface Mining, Reclamation, and Enforcement, 149 pp. + software.

Toy, Terry and G.R. Foster. 2003. RUSLE 2.0 for Reclamation Workshop. National Meeting, Billings, Montana. June.

Toy, Terry and G.R. Foster. May 15, 2003. RUSLE2 User Manual for highly disturbed sands: contruction, reclaimed, mined, landfills, military training grounds, and similar lands.

USDA, NRCS. 2002. Field office technical guide. Section 1: Maps. Montana annual precipitation values.

USDA, NRCS. 2004. Revised Universal Soil Loss Equation, version 2 (RUSLE2), Official NRCS RUSLE2 program, Official NRCS database. <http://fargo.nserl.purdue.edu/RUSLE2_dataweb>

USDA, NRCS. 2004. The PLANTS Database, Version 3.5 <http://plants.usda.gov>. National Plant Data Center, Baton Rouge, LA 70874-4490

US EPA National Pollutant Discharge Elimination System (NPDES). 2002. Construction site storm water runoff control. <http://cfpub.epa.gov/npdes/stormwater/menuofbmps/site_31.cfm>

US Environmental Protection Agency. 2004. Turfgrass species and cultivars for the Midwest. <http://www.epa.gov/seahome/lawn/src/grass/midwest2.htm>

U.S. Salinity Laboratory Staff. 1954. pH reading of saturated soil paste. P. 102. In: L.A. Richards (ed.) Diagnosis and improvement of saline and alkali soils. USDA Agricultural Handbook 60. U.S. Government Printing Office, Washington, D.C.

Whisenant, S.G. 1999. Selecting plant materials. Repairing Damaged Wildlands. Cambridge University Press, Cambridge: 128-167.

APPENDICES

APPENDIX A

PRODUCTION AND COVER DATA

Table 32. Highway fill measurements of production in 2003.

Production (grams)

Native Sod

Plot 2								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perrenial grasses	45.65	46.28	28.23	17.82	14.38	30.47	152.36	7618
annual forbs	0	0	0	0	0	0	0	0
perrenial forbs	0	0	0	0	0	0	0	0
Plot 5								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perrenial grasses	42	76.87	24.03	17.43	57.53	43.57	217.86	10893
annual forbs	0	0	0	0	0	0	0	0
perrenial forbs	0	0	0	0	0	0	0	0
Plot 7								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perrenial grasses	58.74	56.56	33.75	35.57	27.32	42.388	211.94	10597
annual forbs	0	0	0	0	0	0	0	0
perrenial forbs	0	0	0	0	0	0	0	0

Broadcast Seed/Straw Blanket

Plot 3								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perrenial grasses	0.92	3.97	2.59	2.61	0.93	2.20	11.02	551
annual forbs	0	0	7.98	12.95	0	4.19	20.93	1046.5
perrenial forbs	0	1.47	0	0	0.65	0.42	2.12	106
Plot 4								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perrenial grasses	2	6	2.53	5.15	0.81	3.30	16.49	824.5
annual forbs	0	0	0	4.44	0	0.89	4.44	222
perrenial forbs	0.48	0	1.37	0	0	0.37	1.85	92.5
Plot 8								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perrenial grasses	1.7	2.72	5.19	1.48	1.15	2.45	12.24	612
annual forbs	0	9.92	0	2.85	0	2.55	12.77	638.5
perrenial forbs	0.44	0	0.33	0.3	0.25	0.26	1.32	66

Table 32. Highway fill measurements of production in 2003-Continued.

	Broadcast Seed/Hydromulch							
Plot 1								
annual grasses	0	0	0	0	0	0	0	0
perennial grass	0	0.55	0	0	0.55	0.22	1.1	55
annual forbs	0	15.54	1.73	0	0	3.45	17.27	863.5
perennial forbs	5.66	1.03	0	0	0	1.34	6.69	334.5
Plot 6								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grass	0.73	0.82	0	0.47	0.37	0.48	2.39	119.5
annual forbs	24.47	0	16.92	3.75	0	9.03	45.14	2257
perennial forbs	0.42	1.12	0	0	0	0.31	1.54	77
Plot 9								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grass	0.23	0.31	0.21	0	0.08	0.17	0.83	41.5
annual forbs	0	0	11.54	2.75	0	2.86	14.29	714.5
perennial forbs	1.31	0	0.61	0.39	0.16	0.49	2.47	123.5

Table 33. Basal cover on the highway fill site in 2003.

Percent Basal Cover (midpoint of range)

Native Sod

Plot 2												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perrenial grass	97.5	97.5	97.5	97.5	97.5	97.5	97.5	85	85	85	93.75	937.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perrenial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 5												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perrenial grass	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perrenial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 7												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perrenial grass	97.5	85	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	96.25	962.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perrenial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Broadcast Seed/Straw Blanket

Plot 3												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perrenial grass	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
perrenial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
Plot 4												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perrenial grass	2.5	2.5	15	2.5	15	2.5	2.5	2.5	2.5	2.5	5	50
annual forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
perrenial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
Plot 8												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perrenial grass	2.5	2.5	15	2.5	15	2.5	2.5	2.5	2.5	2.5	5	50
annual forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
perrenial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25

Table 33. Basal cover on the highway fill site in 2003-Continued.

Broadcast Seed/Hydromulch

Plot 1												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	0	0	0	0	0	0	0	0	0	0	0	0
annual forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25

Plot 6												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	0	0	0	0	0	0	0	0	0	0	0	0
annual forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25

Plot 9												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	0	0	0	0	0	0	0	0	0	0	0	0
annual forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25

Table 34. Canopy cover on the highway fill site in 2003.

Percent Canopy Cover

Native Sod

Plot 2												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	97.5	97.5	97.5	97.5	97.5	97.5	97.5	85	85	85	93.75	937.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 5												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 7												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	97.5	85	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	96.25	962.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Broadcast Seed/Straw Blanket

Plot 3												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	2.5	15	15	2.5	15	15	2.5	2.5	2.5	2.5	7.5	75
annual forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	15	3.75	37.5
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
Plot 4												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	15	15	37.5	15	15	2.5	15	2.5	2.5	2.5	12.25	122.5
annual forbs	2.5	2.5	2.5	2.5	2.5	2.5	15	2.5	2.5	2.5	3.75	37.5
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
Plot 8												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	2.5	2.5	15	2.5	15	2.5	2.5	2.5	2.5	2.5	5	50
annual forbs	2.5	2.5	37.5	2.5	2.5	2.5	37.5	2.5	2.5	2.5	9.5	95
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25

Table 34. Canopy cover on the highway fill site in 2003-Continued.

Broadcast Seed/Hydromulch

Plot 1												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	2.5	62.5	37.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	12	120
perennial forbs	15	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	3.75	37.5

Plot 6												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	37.5	2.5	2.5	15	37.5	2.5	15	15	2.5	2.5	13.25	132.5
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25

Plot 9												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	2.5	2.5	2.5	2.5	15	2.5	2.5	2.5	2.5	2.5	3.75	37.5
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25

Table 35. Ground cover on the highway fill site in 2003.

Percent Ground Cover

Native Sod

Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
Plot 2	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975
Plot 5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975
Plot 7	97.5	85	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	96.25	962.5
	Broadcast Seed/Straw Blanket											
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
Plot 3	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975
Plot 4	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975
Plot 8	85	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	96.25	962.5
	Broadcast Seed/Hydromulch											
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
Plot 1	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
Plot 6	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
Plot 9	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25

Table 36. Measurements of production on the highway fill site in 2004.

	Production (grams)							
Plot 2	Native Sod (live)							
Subsample	1	3	5	7	9	Mean	Total	Mean (kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	3.38	4.36	3.07	1.35	3.46	3.12	15.62	781
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 5								
Subsample	1	3	5	7	9	Mean	Total	Mean (kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	3.53	0.09	1.85	2.95	1.73	2.03	10.15	507.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 7								
Subsample	1	3	5	7	9	Mean	Total	Mean (kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	6	4.27	4.37	2.23	2.21	3.82	19.08	954
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
	Broadcast Seed/Straw Blanket							
Plot 3								
Subsample	1	3	5	7	9	Mean	Total	Mean (kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	1.07	0.62	1.99	0	2.27	1.19	5.95	297.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	1	0	0.14	1	35.7
Plot 4								
Subsample	1	3	5	7	9	Mean	Total	Mean (kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	1.52	0	0.62	1.02	0.88	0.81	4.04	202
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0.33	70.08	22.19	1.02	0.72	18.87	94.34	4717

Table 36. Measurements of production on the highway fill site in 2004-Continued.

Plot 8

Subsample	1	3	5	7	9	Mean	Total	Mean (kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	2.23	1.22	3.19	0	0.55	1.44	7.19	359.5
annual forbs	0	0	0	0.13	0	0.02	0.13	4.64
perennial forbs	0.82	0.04	0.08	0.18	0.36	0.30	1.48	74

Broadcast Seed/Hydromulch

Plot 1

Subsample	1	3	5	7	9	Mean	Total	Mean (kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0	0.21	0	0	0	0.04	0.21	10.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	33.32	6.43	100.44	21.59	0.95	32.55	162.73	8136.5

Plot 6

Subsample	1	3	5	7	9	Mean	Total	Mean (kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	1.23	0	0.65	0.3	0.36	0.51	2.54	127
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	9.62	6.28	0.54	0	0	3.29	16.44	822

Plot 9

Subsample	1	3	5	7	9	Mean	Total	Mean (kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0	1.6	1.58	0	0.21	0.68	3.39	169.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	4.58	1.08	3.81	1.08	0	2.11	10.55	527.5

Native Sod (dead)

Subsample	1	3	5	7	9	Mean	Total	Mean (kg/ha)
Plot 2								
perennial grass	11.1	29.82	18.05	1.25	11.05	14.25	71.27	17817.5
Plot 5								
perennial grass	11.1	21.78	10.92	3.24	14.73	12.35	61.77	3088.5
Plot 7								
perennial grass	23.08	21.58	14.52	8.01	7.84	12.35	75.03	3751.5

Table 37. Basal cover on the highway fill site in 2004.

Percent Basal Cover (midpoint of range)

Native Sod (live)

Plot 2												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	15	37.5	15	62.5	15	37.5	15	2.5	37.5	37.5	27.5	275
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 5												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	37.5	37.5	2.5	2.5	15	15	62.5	62.5	15	15	26.5	265
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 7												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	62.5	15	37.5	37.5	37.5	37.5	37.5	37.5	62.5	37.5	40.25	402.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
	Broadcast Seed/Straw Blanket											
Plot 3												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	15	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	3.75	37.5
annual forbs	2.5	2.5	2.5	2.5	15	2.5	2.5	2.5	2.5	2.5	3.75	37.5
perennial forbs	2.5	2.5	2.5	15	2.5	2.5	2.5	37.5	2.5	2.5	7.25	72.5
Plot 4												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasse	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	15	15	2.5	37.5	2.5	2.5	2.5	2.5	2.5	2.5	8.5	85
annual forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
perennial forbs	2.5	2.5	85	2.5	2.5	2.5	2.5	2.5	2.5	2.5	10.75	107.5
Plot 8												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	15	2.5	2.5	2.5	15	2.5	2.5	2.5	2.5	2.5	5	50
annual forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25

Table 37. Basal cover on the highway fill site in 2004-Continued.

Broadcast Seed/Hydromulch

Plot 1												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
perennial forbs	15	2.5	2.5	62.5	15	2.5	15	2.5	2.5	2.5	12.25	122.5
Plot 6												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
perennial forbs	15	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	3.75	37.5
Plot 9												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	15	2.5	2.5	2.5	2.5	2.5	2.5	3.75	37.5
annual forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
perennial forbs	2.5	2.5	2.5	2.5	2.5	15	2.5	2.5	2.5	2.5	3.75	37.5

Native Sod
(dead)

Plot 2												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
perennial grass	97.5	97.5	97.5	85	97.5	97.5	85	85	97.5	97.5	93.75	937.5
Plot 5												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
perennial grass	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975
Plot 7												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
perennial grass	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975

Table 38. Canopy cover on the highway fill site in 2004.

Percent Canopy Cover

Native Sod (live)

Plot 2												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	15	37.5	15	62.5	15	37.5	15	2.5	37.5	37.5	27.5	275
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	15	2.5	2.5	3.75	37.5
Plot 5												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	37.5	37.5	2.5	2.5	15	15	62.5	62.5	15	15	26.5	265
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
Plot 7												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	62.5	15	37.5	37.5	37.5	37.5	37.5	37.5	62.5	37.5	40.25	402.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	15	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	3.75	37.5

Broadcast Seed/Straw Blanket

Plot 3												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	62.5	2.5	2.5	8.5	85
Plot 4												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	15	15	2.5	37.5	2.5	2.5	2.5	2.5	2.5	2.5	8.5	85
annual forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
perennial forbs	2.5	2.5	97.5	2.5	15	2.5	2.5	2.5	2.5	2.5	13.25	132.5
Plot 8												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	15	2.5	2.5	15	15	2.5	2.5	2.5	2.5	2.5	6.25	62.5
annual forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
perennial forbs	2.5	15	2.5	2.5	2.5	2.5	2.5	15	2.5	2.5	5	50

Table 38. Canopy cover on the highway fill site in 2004-Continued.

Broadcast Seed/Hydromulch

Plot 1												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	37.5	2.5	15	15	15	2.5	15	2.5	2.5	2.5	11	110
Plot 6												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	15	2.5	15	2.5	2.5	2.5	2.5	15	2.5	2.5	6.25	62.5
Plot 9												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	15	15	2.5	2.5	2.5	2.5	2.5	5	50
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	15	2.5	2.5	2.5	15	62.5	2.5	2.5	15	2.5	12.25	122.5

Sod (dead)

Plot 2												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
perennial grass	97.5	97.5	97.5	85	97.5	97.5	85	85	97.5	97.5	93.75	937.5
Plot 5												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
perennial grass	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975
Plot 7												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
perennial grass	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975

Table 39. Ground cover on the highway fill site in 2004.

Percent Ground Cover

Native Sod

Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
Plot 2	97.5	97.5	97.5	97.5	97.5	97.5	97.5	85	85	97.5	95	950
Plot 5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975
Plot 7	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975

Broadcast Seed/Straw Blanket

Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
Plot 3	97.5	97.5	97.5	97.5	97.5	85	97.5	97.5	97.5	97.5	96.25	962.5
Plot 4	97.5	97.5	97.5	97.5	97.5	85	85	85	85	62.5	89	890
Plot 8	97.5	97.5	85	97.5	97.5	85	97.5	85	85	85	91.25	912.5

Broadcast Seed/Hydromulch

Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
Plot 1	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
Plot 6	15	2.5	15	2.5	15	2.5	2.5	2.5	2.5	15	7.5	75
Plot 9	2.5	2.5	15	15	2.5	15	15	2.5	2.5	2.5	7.5	75

Table 40. Measurements of production at the ski slope site in 2004.

Production (grams)

Sod

Plot 2								
Subsample	1	3	5	7	9	Mean	Total	Mean (kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	3.04	2.48	2.4	3.18	3.31	2.88	14.41	720.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 4								
Subsample	1	3	5	7	9	Mean	Total	Mean (kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	1.48	1.27	0.44	0.57	1.37	1.03	5.13	256.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 8								
Subsample	1	3	5	7	9	Mean	Total	Mean (kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	2.3	2.9	4.01	3.01	2.36	2.92	14.58	729
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0

Broadcast Seed/Straw Blanket

Plot 3								
Subsample	1	3	5	7	9	Mean	Total	Mean (kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0	0.18	0.12	0.15	0.91	0.27	1.36	68
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 5								
Subsample	1	3	5	7	9	Mean	Total	Mean (kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0.58	0.41	0.08	0.59	0.16	0.36	1.82	91
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0

Table 40. Measurements of production at the ski slope site in 2004-Continued.

Plot 7								
Subsample	1	3	5	7	9	Mean	Total	Mean (kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0.17	0.27	0.3	0.3	0.12	0.23	1.16	58
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
				Broadcast Seed				
Plot 1								
Subsample	1	3	5	7	9	Mean	Total	Mean (kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0	0	0	0.26	1.47	0.35	1.73	86.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 6								
Subsample	1	3	5	7	9	Mean	Total	Mean (kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0	0.39	0	.66	0.03	0.11	0.42	26.25
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 9								
Subsample	1	3	5	7	9	Mean	Total	Mean (kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0	0	0.2	0	0	0.04	0.2	10
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	2.72	0.27	0.60	2.99	149.50

Table 41. Basal cover on the ski slope site in 2003.

Percent Basal Cover
(midpoint of range)

Native Sod

Plot 2												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 4												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	37.5	37.5	37.5	37.5	37.5	85	85	97.5	97.5	85	63.75	637.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 8												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Broadcast Seed/Straw Blanket

Plot 3												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	15	2.5	2.5	2.5	2.5	2.5	2.5	3.75	37.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 5												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 7												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Table 41. Basal cover on the ski slope site in 2003-Continued.

	Broadcast Seed											
Plot 5												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 9												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 4												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennialforbs	2.5	2.5	2.5	2.5	2.5	2.5	15	2.5	2.5	2.5	3.75	37.5

Table 42. Canopy cover at the ski slope site 2003.

Percent Canopy Cover
(midpoint of range)

Native Sod

Plot 2												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
Plot 4												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	62.5	37.5	37.5	37.5	37.5	85	85	97.5	97.5	85	66.25	662.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 8												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Broadcast Seed/Straw Blanket

Plot 3												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	15	2.5	2.5	2.5	2.5	2.5	2.5	3.75	37.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 5												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	15	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	3.75	37.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 7												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Table 42. Canopy cover at the ski slope site 2003-Continued.

Broadcast Seed

Plot 1												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 6												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	2.5	2.5	15	2.5	2.5	2.5	2.5	3.75	37.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
Plot 9												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perrenial forbs	2.5	2.5	2.5	2.5	2.5	2.5	15	2.5	2.5	2.5	3.75	37.5

Table 43. Ground cover at the ski slope site in 2003.

Percent Ground Cover
(midpoint of range)

Native Sod

Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
Plot 2	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975
Plot 4	62.5	62.5	62.5	37.5	37.5	85	85	97.5	97.5	85	71.25	712.5
Plot 8	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975

Broadcast Seed/Straw Blanket

Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
Plot 3	85	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	96.25	962.5
Plot 5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975
Plot 7	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975

Broadcast Seed

Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
Plot 1	2.5	2.5	2.5	15	15	2.5	2.5	2.5	2.5	37.5	8.5	85
Plot 6	2.5	2.5	2.5	2.5	15	2.5	2.5	15	15	2.5	6.25	62.5
Plot 9	15	2.5	2.5	2.5	2.5	15	15	2.5	2.5	15	7.5	75

Table 44. Measurements of production at the ski slope site in 2004.

	Production (grams) Sod							
Plot 2								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	7.29	2.38	4.47	2.99	1.67	3.76	18.8	940
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 4								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	12.89	2.39	0.73	1.11	5.23	4.47	22.35	1117.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0.1	0	0	0.02	0.1	5
Plot 8								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	27.45	7.09	4.68	3.27	5.61	9.62	48.1	2405
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
	Broadcast Seed/Straw Blanket							
Plot 3								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0.17	1.79	0.49	0.32	0.78	0.71	3.55	177.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0.05	0	0	0	0.01	0.05	2.5
Plot 5								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	6.51	5.97	0.75	3	2.98	3.842	19.21	960.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 7								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0.53	2.52	1.34	1.93	1.48	1.56	7.8	390
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0

Table 44. Measurements of production at the ski slope site in 2004-Continued.

Broadcast Seed

Plot 1								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	3.89	8.48	0.78	1.22	1.5	3.17	15.87	793.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0.39	0	0	0	0.08	0.39	19.5
Plot 6								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0.51	1.32	0.83	4.32	0.15	1.43	7.13	356.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0.03	0.1	0	0.15	0.06	0.28	14
Plot 9								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	2.14	0.71	5.28	0.79	7.77	3.34	16.69	834.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0.08	0	0	0	0.02	0.08	4

Table 45. Basal cover on the ski slope site in 2004.

Percent Basal Cover

Native Sod

Plot 2												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	85	62.5	62.5	37.5	85	62.5	62.5	62.5	37.5	85	64.25	642.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 4												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	62.5	62.5	62.5	62.5	15	37.5	37.5	85	85	62.5	57.25	572.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	2.5	37.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	6	60
Plot 8												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	97.5	97.5	85	97.5	62.5	37.5	62.5	62.5	62.5	85	75	750
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Broadcast Seed/Straw Blanket

Plot 3												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	15	15	15	2.5	2.5	15	2.5	15	15	15	11.25	112.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
Plot 5												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	37.5	15	15	15	15	62.5	15	2.5	15	15	20.75	207.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 7												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	15	15	62.5	2.5	15	15	37.5	15	15	15	20.75	207.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Table 45. Basal cover on the ski slope site in 2004-Continued.

	Broadcast Seed											
Plot 1												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	37.5	15	37.5	2.5	15	37.5	15	15	2.5	15	19.25	192.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
Plot 6												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	2.5	2.5	15	15	2.5	2.5	15	2.5	2.5	15	7.5	75
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	15	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	3.75	37.5
Plot 9												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	15	2.5	15	2.5	62.5	2.5	2.5	37.5	2.5	37.5	18	180
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	15	3.75	37.5

Table 46. Canopy cover on the ski slope site in 2004.

Percent Canopy Cover

Native Sod

Plot 2												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	85	62.5	62.5	37.5	85	85	85	85	37.5	85	71	710
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 4												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	62.5	62.5	62.5	62.5	15	37.5	37.5	85	85	62.5	57.25	572.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	2.5	37.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	6	60
Plot 8												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	97.5	97.5	97.5	97.5	62.5	37.5	62.5	62.5	62.5	85	76.25	762.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Broadcast Seed/Straw Blanket

Plot 3												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	15	15	15	2.5	2.5	15	2.5	15	15	15	11.25	112.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
Plot 5												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	37.5	15	15	15	15	85	15	2.5	15	15	23	230
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 7												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grass	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	15	15	62.5	15	37.5	15	62.5	15	37.5	37.5	31.25	312.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Table 46. Canopy cover on the ski slope site in 2004-Continued.

	Broadcast Seed											
Plot 1												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	37.5	15	37.5	15	15	37.5	37.5	15	15	15	24	240
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
Plot 6												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	15	15	15	2.5	15	15	2.5	2.5	15	10	100
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	37.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	6	60
Plot 9												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	15	2.5	15	15	85	2.5	15	62.5	2.5	37.5	25.25	252.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	15	3.75	37.5

Table 47. Ground cover on the ski slope site in 2004.

Percent Ground Cover

Native Sod

Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
Plot 2	97.5	97.5	85	97.5	97.5	97.5	85	97.5	97.5	97.5	95	950
Plot 4	85	85	85	97.5	62.5	62.5	85	97.5	97.5	97.5	85.5	855
Plot 8	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975

Broadcast
Seed/Straw Blanket

Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
Plot 3	97.5	85	97.5	85	97.5	85	97.5	97.5	97.5	97.5	93.75	937.5
Plot 5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	85	97.5	96.25	962.5
Plot 7	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975

Broadcast Seed

Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
Plot 1	62.5	37.5	62.5	37.5	62.5	62.5	37.5	37.5	62.5	37.5	50	500
Plot 6	37.5	62.5	62.5	37.5	15	15	15	15	15	37.5	31.25	312.5
Plot 9	37.5	37.5	37.5	15	62.5	37.5	37.5	62.5	62.5	62.5	45.25	452.5

Table 48. Production on the mine waste site in 2003.

	Production (g)							
	Native Sod							
Plot 4								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	13.8	9.88	11.21	15.02	13.42	12.67	63.33	3166.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 6								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	2.86	5.09	1.84	4.47	4.23	3.70	18.49	924.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 12								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	5.09	4.69	4.28	2.98	3.99	4.21	21.03	1051.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
	Redtop Sod							
Plot 3								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	4.55	3.43	4.28	2.98	3.99	3.85	19.23	961.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 5								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	3.54	1.23	4.44	3.48	3.88	3.31	16.57	828.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 11								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	3.41	2.67	2.24	5.07	3.35	3.35	16.74	837
annual forbs	0	0	0	0	0	0	0	0

perennial forbs	0	0	0	0	0	0	0	0

Table 48. Production on the mine waste site in 2003-Continued.

	Broadcast Seed/Straw Blanket 2003							
Plot 2								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0	0	0.06	0	0	0.01	0.06	3
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 8								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 10								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
	Straw Blanket 2001							
Plot 1								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0	0.33	0	0	0	0.07	0.33	16.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	1.25	0	0	0.25	1.25	62.5
Plot 7								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0.02	0	0	0	0	0	0.02	1
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 9								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0	0.17	0	0	0	0.03	0.17	8.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0

Table 49. Basal cover on the mine waste site in 2003.

Percent Basal Cover
(midpoint of range)

Native Sod

Plot 4												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	97.5	97.5	62.5	62.5	97.5	37.5	97.5	85	97.5	97.5	83.25	832.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Plot 6												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	97.5	85	85	97.5	37.5	62.5	97.5	85	97.5	85	83	830
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Plot 12												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennal grass	97.5	97.5	97.5	97.5	97.5	97.5	97.5	85	97.5	97.5	96.25	962.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Redtop Sod

Plot 3												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Plot 5												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	97.5	97.5	37.5	97.5	97.5	62.5	85	62.5	97.5	97.5	83.25	832.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Plot 11												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	97.5	85	97.5	97.5	37.5	97.5	97.5	97.5	97.5	97.5	90.25	902.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Table 49. Basal cover at the mine waste site in 2003-Continued.

Broadcast Seed/Straw Blanket 2003

Plot 2												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 8												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	0	0	0	0	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 10												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	0	0	0	0	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
						Straw Blanket 2001						
Plot 1												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 7												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 9												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Table 50. Canopy cover on the mine waste site in 2003.

Percent Canopy Cover
(midpoint of range)

Native Sod

Plot 4												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	97.5	97.5	62.5	62.5	97.5	37.5	97.5	85	97.5	97.5	83.25	832.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Plot 6												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	97.5	85	85	97.5	37.5	62.5	97.5	85	97.5	85	83	830
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Plot 12												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	97.5	97.5	97.5	97.5	97.5	97.5	97.5	85	97.5	97.5	96.25	962.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Redtop Sod

Plot 3												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Plot 5												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	97.5	97.5	37.5	97.5	97.5	62.5	85	62.5	97.5	97.5	83.25	832.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Plot 11												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	97.5	85	97.5	97.5	37.5	97.5	97.5	97.5	97.5	97.5	90.25	902.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Table 50. Canopy cover at the mine waste site in 2003-Continued.

Broadcast Seed/Straw Blanket 2003

Plot 2												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 8												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	0	0	0	0	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 10												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	0	0	0	0	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Straw Blanket 2001

Plot 1												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	2.5	2.5	15	2.5	2.5	2.5	2.5	2.5	2.5	2.5	3.75	37.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 7												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	2.5	15	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	3.75	37.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 9												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	25
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Table 51. Ground cover on the mine waste site in 2003.

Percent Ground Cover (midpoint of range)

Native Sod

Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
Plot 4	97.5	97.5	62.5	62.5	97.5	37.5	97.5	85	97.5	97.5	83.25	832.5
Plot 6	97.5	85	85	97.5	37.5	62.5	97.5	85	97.5	97.5	84.25	842.5
Plot 12	97.5	97.5	97.5	97.5	97.5	97.5	97.5	85	97.5	97.5	96.25	962.5

Redtop Sod

Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
Plot 3	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975
Plot 5	97.5	97.5	62.5	97.5	97.5	62.5	85	62.5	97.5	97.5	85.75	857.5
Plot 11	97.5	85	97.5	97.5	62.5	97.5	97.5	97.5	97.5	97.5	92.75	927.5

Broadcast Seed/Straw Blanket 2003

Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
Plot 2	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975
Plot 8	97.5	97.5	97.5	15	2.5	2.5	2.5	2.5	2.5	2.5	32.25	322.5
Plot 10	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975

Straw Blanket 2001

Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
Plot 1	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	97.5	975
Plot 7	97.5	97.5	37.5	15	15	37.5	2.5	62.5	97.5	97.5	56	560
Plot 9	85	97.5	97.5	85	62.5	37.5	62.5	97.5	2.5	2.5	63	630

Table 52. Production on the mine waste site in 2004.

	Production (g)							
	Native Sod							
Plot 4								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	1.93	0.09	1.58	0.57	4.96	1.83	9.13	456.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 6								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	1.42	1.7	1.98	4.81	0.88	2.16	10.79	539.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 12								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	1.9	4	1.6	3.21	7.24	3.59	17.95	897.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
	Redtop Sod							
Plot 3								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0.38	1.48	0	0.46	2.19	0.90	4.51	225.5
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 5								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	2.05	2.77	4.05	4.89	2.48	3.25	16.24	812
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 11								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0.99	0.5	0	1.32	1.45	0.85	4.26	213
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0

Table 52. Production at the mine waste site in 2004-Continued.

	Broadcast Seed/Straw Blanket 2003							
Plot 2								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 8								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 10								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
	Straw Blanket 2001							
Plot 1								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	1.93	0	5.14	0	1.21	1.66	8.28	414
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 7								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0
Plot 9								
Subsample	1	3	5	7	9	Mean	Total	Mean(kg/ha)
annual grasses	0	0	0	0	0	0	0	0
perennial grasses	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0

Table 53. Basal cover on the mine waste site in 2004.

Percent Basal Cover

Native Sod

Plot 4												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	15	2.5	2.5	37.5	15	85	15	15	2.5	37.5	22.75	227.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 6												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	37.5	37.5	62.5	2.5	15	2.5	85	2.5	2.5	2.5	25	250
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 12												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	62.5	62.5	85	37.5	15	37.5	15	15	62.5	37.5	43	430
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Redtop Sod

Plot 3												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	15	15	2.5	2.5	2.5	2.5	2.5	2.5	37.5	2.5	8.5	85
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 5												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	15	37.5	37.5	37.5	37.5	62.5	37.5	62.5	2.5	62.5	39.25	392.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 11												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	15	15	2.5	2.5	2.5	2.5	37.5	15	37.5	15	14.5	145
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Table 53. Basal cover at the mine waste site in 2004-Continued.

	Broadcast Seed/Straw Blanket 2003											
Plot 2												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	0	0	0	0	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 8												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	0	0	0	0	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 10												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	0	0	0	0	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
	Straw Blanket 2001											
Plot 1												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	2.5	2.5	2.5	2.5	37.5	2.5	2.5	2.5	2.5	2.5	6	60
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 7												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	0	0	0	0	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0
Plot 9												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grasses	0	0	0	0	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Table 54. Canopy cover on the mine waste site in 2004.

Percent Canopy Cover

Native Sod

Plot 4												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grass	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	15	2.5	2.5	37.5	15	85	15	15	2.5	37.5	22.75	227.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Plot 6												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grass	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	15	15	62.5	2.5	15	2.5	85	2.5	2.5	2.5	20.5	205
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Plot 12												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grass	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	62.5	62.5	85	37.5	15	37.5	15	15	62.5	37.5	43	430
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Redtop Sod

Plot 3												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grass	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	37.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	15	15	8.5	85
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Plot 5												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grass	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	15	37.5	37.5	37.5	37.5	62.5	37.5	62.5	15	62.5	40.5	405
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Plot 11												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grasses	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	2.5	15	2.5	2.5	2.5	2.5	15	2.5	15	15	7.5	75
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Table 54. Canopy cover at the mine waste site in 2004-Continued.

Broadcast Seed/Straw Blanket 2003

Plot 2												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grass	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	0	0	0	0	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Plot 8												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grass	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	0	0	0	0	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Plot 10												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grass	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	0	0	0	0	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Straw Blanket 2001

Plot 1												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grass	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	15	2.5	2.5	2.5	37.5	2.5	2.5	2.5	2.5	2.5	7.25	72.5
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Plot 7												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grass	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	0	0	0	0	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	2.5	2.5	2.5	2.5	2.5	2.5	2.5	15	2.5	2.5	3.75	37.5

Plot 9												
Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
annual grass	0	0	0	0	0	0	0	0	0	0	0	0
perennial grass	0	0	0	0	0	0	0	0	0	0	0	0
annual forbs	0	0	0	0	0	0	0	0	0	0	0	0
perennial forbs	0	0	0	0	0	0	0	0	0	0	0	0

Table 55. Ground cover on the mine waste site in 2004.

Percent Ground Cover

Native Sod

Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
Plot 4	62.5	15	2.5	62.5	62.5	85	37.5	85	15	85	51.25	512.5
Plot 6	37.5	62.5	62.5	2.5	37.5	2.5	85	2.5	15	15	32.25	322.5
Plot 12	97.5	97.5	97.5	85	37.5	62.5	85	85	85	97.5	83	830

Redtop Sod

Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
Plot 3	37.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	37.5	37.5	13	130
Plot 5	62.5	62.5	85	62.5	85	85	62.5	97.5	62.5	97.5	76.25	762.5
Plot 11	97.5	85	37.5	37.5	15	97.5	37.5	37.5	37.5	97.5	58	580

Broadcast Seed/Straw Blanket 2003

Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
Plot 2	2.5	2.5	2.5	2.5	2.5	2.5	15	62.5	37.5	62.5	19.25	192.5
Plot 8	85	62.5	85	85	97.5	97.5	37.5	2.5	2.5	2.5	55.75	557.5
Plot 10	85	62.5	85	85	85	37.5	2.5	2.5	2.5	2.5	45	450

Straw Blanket 2001

Subsample	1	2	3	4	5	6	7	8	9	10	Mean	Total
Plot 1	15	15	2.5	2.5	37.5	2.5	2.5	2.5	2.5	2.5	8.5	85
Plot 7	15	37.5	15	2.5	2.5	2.5	2.5	2.5	2.5	2.5	8.5	85
Plot 9	2.5	15	15	15	15	2.5	2.5	2.5	2.5	2.5	7.5	75

APPENDIX B

SOIL PHYSIOCHEMICAL DATA

Table 56. Soil physical and chemical analysis

Highway Fill Site						
Sample	Sand (%)	Silt (%)	Clay (%)	Soil Texture	pH	EC(mmhos/cm)
1	39.76	34	26.24	Loam	7.07	1.07
2	48.54	31.64	19.82	Loam	7.57	1.85
Mean	44.15	32.82	23.03		7.32	1.46
RPD (%)	-19.89	7.19	27.88		-6.83	-53.42
Ski Slope Site						
Sample	Sand (%)	Silt (%)	Clay (%)	Soil Texture	pH	EC(mmhos/cm)
1	56.84	18.08	25.08	Sandy Clay Loam	6.16	0.24
2	41.64	28.36	30	Clay Loam	7.2	0.24
Mean	49.24	23.22	27.54		6.68	0.24
RPD (%)	30.87	-44.27	-17.86		-15.57	0.00
Mine Waste Site						
Sample	Sand (%)	Silt (%)	Clay (%)	Soil Texture	pH	EC(mmhos/cm)
1	73.8	16.12	10.08	Sandy Loam	3.94	0.31
2	66.92	20	13.08	Sandy Loam	3.36	0.3
Mean	70.36	18.06	11.58		3.65	0.305
RPD (%)	9.78	-21.48	-25.91		15.89	3.28

APPENDIX C

RAINFALL SIMULATION DATA

Table 57. Rainfall simulation data for native sod.

Native Sod

30-Aug 12:45 PM		31-Aug 12:35 PM	(Repeat)	3-Sep 10:50 AM		7-Sep 11:10 AM	
	Plot 2		Plot 2		Plot 5		Plot 7
Time (min)	Flowmeter (ml/min)	Time (min)	Flowmeter (ml/min)	Time (min)	Flowmeter (ml/min)	Time (min)	Flowmeter (ml/min)
0	132	0	132	0	132	0	132
5	129	5	141	5	130	10	122
10	118	10	128	10	132	15	135
15	56	15	125	15	125	20	130
18	74	20	130	20	131	25	132
20	132	25	77	25	132	35	129
25	142	30	133	30	132	40	125
27	132	35	132	35	133	45	138
30	90	40	147	40	134	50	132
35	146	45	132	50	126	60	125
40	135	50	126	60	135	70	116
45	104	55	136	70	132	75	132
50	134	60	122	85	125	80	129
55	132	65	147	100	125	90	134
60	151	70	143	110	127	100	132
65	134	80	135	120	135	105	90
70	132	90	139	Mean	130.375	110	132
75	140	95	134			120	133
80	133	100	132			Mean	127.67
85	127	110	132				
90	123	120	132				
95	132	Mean	131.190476				
100	120						
105	153						
110	132						
115	133						
120	132						
Mean	125.85185						

Table 58. Rainfall simulation data for broadcast seed/straw blanket.

Broadcast Seed/Straw Blanket					
31-Aug 3:00 PM		1-Sep 9:30 AM		7-Sep 1:20 PM	
	Plot 3		Plot 4		Plot 8
Time (min)	Flowmeter (ml/min)	Time (min)	Flowmeter (ml/min)	Time (min)	Flowmeter (ml/min)
0	132	0	132	0	132
5	113	5	132	5	130
10	137	10	138	10	129
15	110	15	132	15	131
20	132	20	132	20	108
30	133	25	124	25	129
40	80	30	132	30	132
45	126	35	130	40	116
50	133	40	131	50	128
60	149	50	127	60	142
65	136	60	132	70	137
70	131	65	132	80	133
80	136	70	132	95	136
85	126	80	129	100	133
90	131	90	131	110	144
100	116	100	128	120	133
115	133	105	132	Mean	130.8125
120	132	110	129		
Mean	127	120	135		
		Mean	131.053		

Table 59. Rainfall simulation data for broadcast seed/hydromulch.

Broadcast Seed/Hydromulch					
30-Aug 10:15 AM		3-Sep 1:10 PM		8-Sep 9:05 AM	
	Plot 1		Plot 6		Plot 9
Time (min)	Flowmeter (ml/min)	Time (min)	Flowmeter (ml/min)	Time (min)	Flowmeter (ml/min)
0	132	0	132	0	132
5	132	5	130	5	139
10	132	10	128	10	130
15	122	15	122	15	132
20	122	20	140	20	130
25	131	25	130	25	133
30	130	30	132	30	138
35	131	40	120	35	132
40	115	45	140	40	125
45	115	50	132	45	132
50	132	60	132	50	132
55	125	70	134	55	132
60	132	80	132	60	132
65	130	90	130	70	125
70	133	100	129	80	133
75	48	110	131	90	119
80	132	120	129	95	132
85	130	Mean	130.765	105	132
90	132			115	132
95	132			120	132
105	132			Mean	131.2
110	50				
115	123				
120	128				
Mean	121.708				

Table 60. Runoff volume, sediment loss and infiltration at the highway fill site.

Native Sod

	Runoff Volume (ml)	Flask weight empty (g)	Flask weight after drying (g)	Sediment (g)	Sediment (kg/ha)	Infiltration Rate (cm/hr)
Plot 2	0			0	0	1.85
Duplicate	0			0	0	1.85
Plot 5	0			0	0	1.85
Plot 7	0			0	0	1.85
Mean	0			0	0	1.85
Total	0			0	0	

Broadcast Seed/Straw Blanket

	Runoff Volume (ml)	Flask weight empty (g)	Flask weight after drying (g)	Sediment (g)	Sediment (kg/ha)	Infiltration Rate (cm/hr)
Plot 3	4	58.9	59.23	0.33	10.57	1.85
Plot 4	2	54.68	54.89	0.21	6.73	1.85
Plot 8	168	331.75	332.08	0.33	10.57	1.82
Mean	58			0.29	9.29	1.84
Total	174			0.87	27.86	

Broadcast
Seed/Hydromulch

	Runoff Volume (ml)	Flask weight empty (g)	Flask weight after drying (g)	Sediment (g)	Sediment (kg/ha)	Infiltration Rate (cm/hr)
Plot 1	917	405.58	413.29	7.71	246.91	1.70
Plot 6	2610	498.48	508.33	9.85	315.44	1.43
		407.93	414.61	6.68	213.93	
Plot 9	1400	338.2	349.98	11.78	377.25	1.62
Mean	1642			12.01	384.00	1.59
Total	4927			36.02	1153.53	

APPENDIX D

PRODUCTION AND COVER DATA TABLES

Table 61. Plant production during 2003 at the highway fill site.

Replication	Native Sod	Straw Blanket Broadcast Seeded	Hydromulch Broadcast Seeded
	Perennial Grass Production, kg/ha		
1	7618 [/1]	551	55
2	10893	825	120
3	10597	612	42
Mean	9703 a[/2]	663 b	72 b
	Annual Grass Production, kg/ha		
1	0	0	0
2	0	0	0
3	0	0	0
Mean	0	0	0
	Perennial Forb Production, kg/ha		
1	0	106	334.5
2	0	92.5	77
3	0	66	123.5
Mean	0 a	88.18 b	178.25 b
	Annual Forb Production, kg/ha		
1	0	1046.5	863.5
2	0	222	2257
3	0	638.5	714.5
Mean	0 a	635.75 b	1278.25 b

[/1] Mean of 5 measurements.
[/2]Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 62. Plant production during 2004 at the highway fill site.

Replication	Native Sod	Straw Blanket Broadcast Seeded	Hydromulch Broadcast Seeded
	Perennial Grass Production, kg/ha		
1	781 [/1]	298	11
2	508	202	127
3	954	360	170
Mean	748 a[/2]	286 c	102 c
	Annual Grass Production, kg/ha		
1	0	0	0
2	0	0	0
3	0	0	0
Mean	0	0	0
	Perennial Forb Production, kg/ha		
1	0	36	8137
2	0	4717	822
3	0	74	528
Mean	0 a	1609 ab	3162 b
	Annual Forb Production, kg/ha		
1	0	0	0
2	0	0	0
3	0	5	0
Mean	0 a	2 a	0 a

[/1] Mean of 5 measurements.
[/2]Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 63. Basal cover during 2003 at the highway fill site.

Replication	Native Sod	Straw Blanket Broadcast Seeded	Hydromulch Broadcast Seeded
	Perennial Grass Basal Cover (%)		
1	93.75[/1]	2.50	0
2	97.50	5.00	0
3	96.25	5.00	0
Mean	95.83 a[/2]	4.17 b	0 c
	Annual Grass Basal Cover (%)		
1	0	0	0
2	0	0	0
3	0	0	0
Mean	0	0	0
	Perennial Forb Basal Cover (%)		
1	0	2.50	2.50
2	0	2.50	2.50
3	0	2.50	2.50
Mean	0	2.50	2.50
	Annual Forb Basal Cover (%)		
1	0	2.50	2.50
2	0	2.50	2.50
3	0	2.50	2.50
Mean	0	2.50	2.50

[/1] Mean of 10 measurements. Values representative of the midpoint of range.
[/2]Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 64. Basal cover during 2004 at the highway fill site.

Replication	Native Sod	Straw Blanket Broadcast Seeded	Hydromulch Broadcast Seeded
	Perennial Grass Basal Cover (%)		
1	27.50[/1]	3.75	2.50
2	26.50	8.50	2.50
3	40.25	5.00	3.75
Mean	31.42 a[/2]	5.75 c	2.92 c
	Annual Grass Basal Cover (%)		
1	0	0	0
2	0	0	0
3	0	0	0
Mean	0	0	0
	Perennial Forb Basal Cover (%)		
1	0	7.25	12.25
2	0	10.75	3.75
3	0	2.50	3.75
Mean	0 a	6.83 b	6.58 b
	Annual Forb Basal Cover (%)		
1	0	3.75	2.50
2	0	2.50	2.50
3	0	2.50	2.50
Mean	0 a	2.92 b	2.50 b

[/1] Mean of 10 measurements. Values representative of the midpoint of range.
[/2]Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 65. Canopy cover during 2003 at the highway fill site.

Replication	Native Sod	Straw Blanket Broadcast Seeded	Hydromulch Broadcast Seeded
	Perennial Grass Canopy Cover (%)		
1	93.75[/1]	7.50	0
2	97.50	12.25	0
3	96.25	5.00	0
Mean	95.80 a[/2]	8.25 b	0 c
	Annual Grass Canopy Cover (%)		
1	0	0	0
2	0	0	0
3	0	0	0
Mean	0	0	0
	Perennial Forb Canopy Cover (%)		
1	0	2.5	3.75
2	0	2.5	2.5
3	0	2.5	2.5
Mean	0 a	2.5 b	2.92 b
	Annual Forb Canopy Cover (%)		
1	0	3.75	12.0
2	0	3.75	13.25
3	0	9.5	3.75
Mean	0 a	5.67 b	9.67 b

[/1] Mean of 10 measurements. Values representative of the midpoint of range.
[/2]Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 66. Canopy cover during 2004 at the highway fill site.

Replication	Native Sod	Straw Blanket Broadcast Seeded	Hydromulch Broadcast Seeded
	Perennial Grass Canopy Cover (%)		
1	27.50[/1]	2.50	2.50
2	26.50	8.50	2.50
3	40.25	6.25	2.50
Mean	31.42 a[/2]	5.75 c	2.50 c
	Annual Grass Canopy Cover (%)		
1	0	0	0
2	0	0	0
3	0	0	0
Mean	0	0	0
	Perennial Forb Canopy Cover (%)		
1	3.75	8.5	11
2	2.5	13.25	6.25
3	3.75	5	12.25
Mean	3.33 a	8.92 a	9.83 a
	Annual Forb Canopy Cover (%)		
1	0	2.5	0
2	0	2.5	0
3	0	2.5	0
Mean	0	2.5	0

[/1] Mean of 10 measurements. Values representative of the midpoint of range.
[/2] Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 67. Ground cover during 2003 at the highway fill site.

Replication	**Native Sod**	**Straw blanket/ Broadcast Seed**	**Hydromulch/ Broadcast Seed**
	Ground Cover (%)		
1	97.50[/1]	97.50	2.50
2	97.50	97.50	2.50
3	96.25	96.25	2.50
Mean	97.08 a[/2]	97.08 a	2.50 b

[/1] Mean of 10 measurements. Values representative of the midpoint of range.
[/2]Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 68. Ground cover during 2004 at the highway fill site.

Replication	**Native Sod**	**Straw blanket/ Broadcast Seed**	**Hydromulch/ Broadcast Seed**
	Ground Cover (%)		
1	95.00[/1]	96.25	2.50
2	97.50	89.00	7.50
3	97.50	91.25	7.50
Mean	96.70 a[/2]	92.17 a	5.80 b

[/1] Mean of 10 measurements. Values representative of the midpoint of range.
[/2]Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 69. Plant production during 2003 at the ski slope site.

Replication	Native Sod	Straw Blanket/ Broadcast Seed	Broadcast Seed
	Perennial Grass Production, kg/ha		
1	721[/1]	68	87
2	257	91	26
3	729	58	10
Mean	569 a[/2]	73 b	41 b
	Annual Grass Production, kg/ha		
1	0	0	0
2	0	0	0
3	0	0	0
Mean	0	0	0
	Perennial Forb Production, kg/ha		
1	0	0	0
2	0	0	0
3	0	0	150
Mean	0 a	0 a	50 a
	Annual Forb Production, kg/ha		
1	0	0	0
2	0	0	0
3	0	0	0
Mean	0	0	0

[/1] Mean of 5 measurements.
[/2]Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 70. Plant production during 2004 at the ski slope site.

Replication	Native Sod	Straw Blanket/ Broadcast Seed	Broadcast Seed
	Perennial Grass Production, kg/ha		
1	940[1]	178	794
2	1118	961	357
3	2405	390	835
Mean	1488 a [2]	509 a	662 a
	Annual Grass Production, kg/ha		
1	0	0	0
2	0	0	0
3	0	0	0
Mean	0	0	0
	Perennial Forb Production, kg/ha		
1	0	2.5	19.5
2	5	0	14
3	0	0	4
Mean	1.7 a	.8 a	12.5 a
	Annual Forb Production, kg/ha		
1	0	0	0
2	0	0	0
3	0	0	0
Mean	0	0	0

[1] Mean of 5 measurements.
[2]Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 71. Basal cover during 2003 at the ski slope site.

Replication	Native Sod	Straw Blanket/ Broadcast Seed	Broadcast Seed
	Perennial Grass Basal Cover (%)		
1	97.50[/1]	3.75	2.50
2	63.75	2.50	2.50
3	97.50	2.50	2.50
Mean	86.25 a[/2]	2.92 b	2.50 b
	Annual Grass Basal Cover (%)		
1	0	0	0
2	0	0	0
3	0	0	0
Mean	0	0	0
	Perennial Forb Basal Cover (%)		
1	0	0	0
2	0	0	0
3	0	0	3.75
Mean	0 a	0 a	1.25 a
	Annual Forb Basal Cover (%)		
1	0	0	0
2	0	0	0
3	0	0	0
Mean	0	0	0

[/1] Mean of 10 measurements. Values representative of the midpoint of range.
[/2]Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 72. Basal cover during 2004 at the ski slope site.

Replication	Native Sod	Straw Blanket/ Broadcast Seed	Broadcast Seed
	Perennial Grass Basal Cover (%)		
1	64.25[/1]	11.25	19.25
2	57.25	20.75	7.5
3	75	20.75	18
Mean	65.5 a[/2]	17.58 b	14.92 b
	Annual Grass Basal Cover (%)		
1	0	0	0
2	0	0	0
3	0	0	0
Mean	0	0	0
	Perennial Forb Basal Cover (%)		
1	0	2.5	2.5
2	6	0	3.75
3	0	0	3.75
Mean	2.00 a	.83 a	3.33 a
	Annual Forb Basal Cover (%)		
1	0	0	0
2	0	0	0
3	0	0	0
Mean	0	0	0

[/1] Mean of 10 measurements. Values representative of the midpoint of range.
[/2]Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 73. Canopy cover during 2003 at the ski slope site.

Replication	Native Sod	Straw Blanket/ Broadcast Seed	Broadcast Seed
	Perennial Grass Canopy Cover (%)		
1	97.50[/1]	3.75	2.50
2	66.25	3.75	3.75
3	97.50	2.50	2.50
Mean	87.08 a[/2]	3.33 b	2.92 b
	Annual Grass Canopy Cover (%)		
1	0	0	0
2	0	0	0
3	0	0	0
Mean	0	0	0
	Perennial Forb Canopy Cover (%)		
1	0	0	0
2	0	0	0
3	0	0	3.75
Mean	0 a	0 a	1.25 a
	Annual Forb Canopy Cover (%)		
1	0	0	0
2	0	0	0
3	0	0	0
Mean	0	0	0

[/1] Mean of 10 measurements. Values representative of the midpoint of range.
[/2] Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 74. Canopy cover during 2004 at the ski slope site.

Replication	Native Sod	Straw Blanket/ Broadcast Seed	Broadcast Seed
	Perennial Grass Canopy Cover (%)		
1	71[/1]	11.25	24
2	57.25	23	10
3	76.25	31.25	25.25
Mean	68.17 a[/2]	21.8 b	19.75 b
	Annual Grass Canopy Cover (%)		
1	0	0	0
2	0	0	0
3	0	0	0
Mean	0	0	0
	Perennial Forb Canopy Cover (%)		
1	0	2.50	2.5
2	6.0	0	6.0
3	0	0	3.75
Mean	2.0 a	0.83 a	4.08 a
	Annual Forb Canopy Cover (%)		
1	0	0	0
2	0	0	0
3	0	0	0
Mean	0	0	0

[/1] Mean of 10 measurements. Values representative of the midpoint of range.
[/2] Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 75. Ground cover during 2003 at the ski slope site.

Replication	**Native Sod**	**Straw blanket/ Broadcast Seed**	**Broadcast Seed**
	Ground Cover (%)		
1	97.5[/1]	96.25	8.5
2	71.25	97.5	6.25
3	97.5	97.5	7.5
Mean	88.75 a[/2]	97.08 a	7.42 b

[/1] Mean of 10 measurements. Values representative of the midpoint of range.
[/2]Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 76. Ground cover during 2004 at the ski slope site.

Replication	**Native Sod**	**Straw blanket/ Broadcast Seed**	**Broadcast Seed**
	Ground Cover (%)		
1	95[/1]	93.75	50
2	85.5	96.25	31.25
3	97.5	97.5	45.25
Mean	92.67 a[/2]	95.83 a	42.17 b

[/1] Mean of 10 measurements. Values representative of the midpoint of range.
[/2]Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 77. Plant production during 2003 at the mine waste site.

Replication	Native Sod	Redtop Sod	Straw Blanket Installed 2003	Straw Blanket Installed 2001
	Perennial Grass Production, kg/ha			
1	3167[1]	962	3	17
2	925	829	0	1
3	1052	837	0	9
Mean	1714 a[2]	876 b	1 c	9 d
	Annual Grass Production, kg/ha			
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
Mean	0	0	0	0
	Perennial Forb Production, kg/ha			
1	0	0	0	62.5
2	0	0	0	0
3	0	0	0	0
Mean	0	0	0	20.8
	Annual Forb Production, kg/ha			
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
Mean	0	0	0	0

/1 Mean of 5 measurements.
/2 Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 78. Plant production during 2004 at the mine waste site.

Replication	**Native Sod**	**Redtop Sod**	**Straw Blanket Installed 2003**	**2001**
	Perennial Grass Production, kg/ha			
1	456.5[1]	225.5	0	414
2	539.5	812	0	0
3	897.5	213	0	0
Mean	631.2 a [2]	416.8 ab	0 b	138 ab
	Annual Grass Production, kg/ha			
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
Mean	0	0	0	0
	Perennial Forb Production, kg/ha			
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
Mean	0	0	0	0
	Annual Forb Production, kg/ha			
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
Mean	0	0	0	0

/1 Mean of 5 measurements.
/2 Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 79. Basal cover during 2003 at the mine waste site.

Replication	**Native Sod**	**Redtop Sod**	**Straw Blanket Installed 2003**	**2001**
	Perennial Grass Basal Cover (%)			
1	83.25[/1]	97.5	2.5	2.5
2	83.0	83.25	0	2.5
3	96.25	90.25	0	2.5
Mean	87.5 a[/2]	90.33 a	.83 b	2.5 b
	Annual Grass Basal Cover (%)			
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
Mean	0	0	0	0
	Perennial Forb Basal Cover (%)			
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
Mean	0	0	0	0
	Annual Forb Basal Cover (%)			
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
Mean	0	0	0	0

[/1] Mean of 10 measurements. Values representative of the midpoint of range.
[/2] Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 80. Basal cover during 2004 at the mine waste site.

Replication	Native Sod	Redtop Sod	Straw Blanket Installed 2003	Straw Blanket Installed 2001
	Perennial Grass Basal Cover (%)			
1	22.75[/1]	8.50	0	6.00
2	25.00	39.25	0	0
3	43.00	14.50	0	0
Mean	30.25 a[/2]	20.75 a	0 b	2.00 b
	Annual Grass Basal Cover (%)			
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
Mean	0	0	0	0
	Perennial Forb Basal Cover (%)			
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
Mean	0	0	0	0
	Annual Forb Basal Cover (%)			
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
Mean	0	0	0	0

[/1] Mean of 10 measurements. Values representative of the midpoint of range.
[/2]Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 81. Canopy cover during 2003 at the mine waste site.

Replication	Native Sod	Redtop Sod	Straw Blanket Installed 2003	2001
	Perennial Grass Canopy Cover (%)			
1	83.25[/1]	97.25	2.50	3.75
2	83.00	83.25	0	3.75
3	96.25	90.25	0	2.50
Mean	87.50 a[/2]	90.25 a	.83 b	3.33 b
	Annual Grass Canopy Cover (%)			
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
Mean	0	0	0	0
	Perennial Forb Canopy Cover (%)			
1	0	0	0	3.75
2	0	0	0	0
3	0	0	0	0
Mean	0	0	0	1.25
	Annual Forb Canopy Cover (%)			
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
Mean	0	0	0	0

[/1] Mean of 10 measurements. Values representative of the midpoint of range.
[/2]Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 82. Canopy cover during 2004 at the mine waste site.

Replication	Native Sod	Redtop Sod	Straw Blanket Installed 2003	2001
	Perennial Grass Canopy Cover (%)			
1	22.75[/1]	8.5	0	7.25
2	20.5	40.5	0	0
3	43	7.5	0	0
Mean	28.75 a[/2]	18.83 a	0 b	2.42 b
	Annual Grass Canopy Cover (%)			
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
Mean	0	0	0	0
	Perennial Forb Canopy Cover (%)			
1	0	0	0	0
2	0	0	0	3.75
3	0	0	0	0
Mean	0	0	0	1.25
	Annual Forb Canopy Cover (%)			
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
Mean	0	0	0	0

[/1] Mean of 10 measurements. Values representative of the midpoint of range.
[/2]Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 83. Ground cover during 2003 at the mine waste site.

Replication	**Native Sod**	**Redtop Sod**	**Straw Blanket Installed** 2003	2001
	Ground Cover (%)			
1	83.25[/2]	97.5	97.5	97.5
2	84.25	85.75	32.25	56.0
3	96.25	92.75	97.5	63.0
Mean	87.92 a[/3]	92.0 a	75.75 a	72.17 a

[/1] Mean of 10 measurements. Values representative of the midpoint of range.
[/2]Means followed by the same letter in the same row are not significantly different, P=0.05.

Table 84. Ground cover during 2004 at the mine waste site.

Replication	**Native Sod**	**Redtop Sod**	**Straw Blanket Installed** 2003	2001
	Ground Cover (%)			
1	51.25[/1]	13	19.25	8.5
2	32.25	76.25	55.75	8.5
3	83	58	45	7.5
Mean	55.5 a[/2]	49.08 a	40.0 a	8.17 b

[/1] Mean of 10 measurements. Values representative of the midpoint of range.
[/2]Means followed by the same letter in the same row are not significantly different, P=0.05.

APPENDIX E

STATISTICAL DATA ANALYSIS

Table 85. Highway fill production (g) sigma stat data table for 2003.

REPS	TRTS	Perennial Grass Production	Perennial Forb Production	Annual Forb Production	Mean Total
1	1	30.47	0.00	0.00	30.47
1	2	2.20	0.65	2.05	6.81
1	3	0.22	1.16	1.86	5.01
2	1	43.57	0.00	0.00	43.57
2	2	3.29	0.61	0.94	4.56
2	3	0.48	0.56	3.01	9.81
3	1	42.39	0.00	0.00	42.39
3	2	2.45	0.51	1.60	5.26
3	3	0.17	0.70	1.69	3.52

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Highway Fill Production 2003

General Linear Model (No Interactions)

Dependent Variable: Perennial Grass Production

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	40.102	20.051	1.222	0.385
TRTS	2	2797.169	1398.584	85.261	<0.001
Residual	4	65.614	16.404		
Total	8	2902.885	362.861		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.385).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0686
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	**Mean**
1.000	10.965
2.000	15.783
3.000	15.001

Std Err of LS Mean = 2.338

Least square means for TRTS :

Group	**Mean**
1.000	38.811
2.000	2.650
3.000	0.288

Std Err of LS Mean = 2.338

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **REPS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
2.000 vs. 1.000	4.817	3	2.060	0.399	No
2.000 vs. 3.000	0.782	2	0.334	0.825	Do Not Test
3.000 vs. 1.000	4.035	2	1.726	0.290	Do Not Test

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	38.523	3	16.474	<0.001	Yes
1.000 vs. 2.000	36.161	2	15.464	<0.001	Yes
2.000 vs. 3.000	2.362	2	1.010	0.515	No

A result of "Do Not Test" occurs for a comparison when no significant difference is found between two means that enclose that comparison. For example, if you had four means sorted in order, and found no difference between means 4 vs. 2, then you would not test 4 vs. 3 and 3 vs. 2, but still test 4 vs. 1 and 3 vs. 1 (4 vs. 3 and 3 vs. 2 are enclosed by 4 vs. 2: 4 3 2 1). Note that not testing the enclosed means is a procedural rule, and a result of Do Not Test should be treated as if there is no significant difference between the means, even though one may appear to exist.

Two Way Analysis of Variance

Data source: Data 1 in Highway Fill Production 2003

General Linear Model (No Interactions)

Dependent Variable: Perennial Forb Production-square root transform

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	0.0853	0.0427	1.408	0.344
TRTS	2	1.043	0.521	17.208	0.011
Residual	4	0.121	0.0303		
Total	8	1.249	0.156		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.344).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.011). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0832
Power of performed test with alpha = 0.0500: for TRTS : 0.919

Least square means for REPS :

Group	**Mean**
1.000	0.603
2.000	0.388
3.000	0.406

Std Err of LS Mean = 0.101

Least square means for TRTS :

Group	**Mean**
1.000	0.000
2.000	0.591
3.000	0.805

Std Err of LS Mean = 0.101

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
3.000 vs. 1.000	0.805	3	8.008	0.011	Yes
3.000 vs. 2.000	0.214	2	2.127	0.207	No
2.000 vs. 1.000	0.591	2	5.881	0.014	Yes

Two Way Analysis of Variance

Data source: Data 1 in Highway Fill Production 2003

General Linear Model (No Interactions)

Dependent Variable: Annual Forb Production-square root transform

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	0.0905	0.0452	0.117	0.893
TRTS	2	7.540	3.770	9.737	0.029
Residual	4	1.549	0.387		
Total	8	9.179	1.147		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.893).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.029). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 0.700

Least square means for REPS :

Group	**Mean**
1.000	1.301
2.000	1.316
3.000	1.096

Std Err of LS Mean = 0.359

Least square means for TRTS :

Group	**Mean**
1.000	1.110E-016
2.000	1.529
3.000	2.185

Std Err of LS Mean = 0.359

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
3.000 vs. 1.000	2.185	3	6.081	0.027	Yes
3.000 vs. 2.000	0.656	2	1.825	0.267	No
2.000 vs. 1.000	1.529	2	4.256	0.040	Yes

Two Way Analysis of Variance

Data source: Highway Fill Total Production 2003

General Linear Model (No Interactions)

Dependent Variable: Mean Total

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	DF	SS	MS	F	P
REPS	2	41.068	20.534	0.931	0.466
TRTS	2	2176.068	1088.034	49.332	0.002
Residual	4	88.222	22.055		
Total	8	2305.357	288.170		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.466).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.002). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	Mean	SEM
1.000	14.097	2.711
2.000	19.313	2.711
3.000	17.057	2.711

Least square means for TRTS :

Group	Mean	SEM
1.000	38.810	2.711
2.000	5.543	2.711
3.000	6.113	2.711

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: TRTS

Comparison	Diff of Means	p	q	P	P<0.050
1.000 vs. 2.000	33.267	3	12.269	0.002	Yes
1.000 vs. 3.000	32.697	2	12.059	0.001	Yes
3.000 vs. 2.000	0.570	2	0.210	0.889	No

Table 86. Highway fill basal cover (%) Sigma Stat table for 2003.

REPS	TRTS	Basal perennial grass	Mean total basal cover
1	1	93.75	93.70
1	2	2.50	7.50
1	3	0.00	5.00
2	1	97.50	97.50
2	2	5.00	10.00
2	3	0.00	5.00
3	1	96.25	96.25
3	2	5.00	10.00
3	3	0.00	5.00

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Highway Fill Cover 2003

General Linear Model (No Interactions)

Dependent Variable: Basal Perennial Grass

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	7.292	3.646	3.500	0.132
TRTS	2	17604.167	8802.083	8450.000	<0.001
Residual	4	4.167	1.042		
Total	8	17615.625	2201.953		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.132).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.261
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	**Mean**
1.000	32.083
2.000	34.167
3.000	33.750

Std Err of LS Mean = 0.589

Least square means for TRTS :

Group	**Mean**
1.000	95.833
2.000	4.167
3.000	0.000

Std Err of LS Mean = 0.589

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	95.833	3	162.635	<0.001	Yes
1.000 vs. 2.000	91.667	2	155.563	<0.001	Yes
2.000 vs. 3.000	4.167	2	7.071	0.008	Yes

Two Way Analysis of Variance

Data source: Data 1 in Highway Fill Cover

General Linear Model (No Interactions)

Dependent Variable: Mean total basal cover

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	7.292	3.646	3.500	0.132
TRTS	2	15779.167	7889.583	7574.000	<0.001
Residual	4	4.167	1.042		
Total	8	15790.625	1973.828		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.132).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.261
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	**Mean**
1.000	35.417
2.000	37.500
3.000	37.083

Std Err of LS Mean = 0.589

Least square means for TRTS :

Group	**Mean**
1.000	95.833
2.000	9.167
3.000	5.000

Std Err of LS Mean = 0.589

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	90.833	3	154.149	<0.001	Yes
1.000 vs. 2.000	86.667	2	147.078	<0.001	Yes
2.000 vs. 3.000	4.167	2	7.071	0.008	Yes

Table 87. Highway fill canopy cover (%) Sigma Stat table for 2003.

REPS	TRTS	Canopy perennial grass	Canopy annual forbs-sq rt	Canopy perennial forbs	Mean total canopy cover
1	1	93.75	0.00	0.00	93.75
1	2	7.50	1.94	2.50	13.75
1	3	0.00	3.46	3.75	18.25
2	1	97.50	0.00	0.00	97.50
2	2	12.25	1.94	2.50	18.50
2	3	0.00	3.64	2.50	18.25
3	1	96.25	0.00	0.00	96.25
3	2	5.00	3.08	2.50	17.00
3	3	0.00	1.94	2.50	8.75

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Highway fill cover 2003

General Linear Model (No Interactions)

Dependent Variable: Perennial Grass Canopy Cover

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	16.056	8.028	1.749	0.285
TRTS	2	16922.931	8461.465	1843.345	<0.001
Residual	4	18.361	4.590		
Total	8	16957.347	2119.668		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.285).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.111
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	Mean
1.000	33.750
2.000	36.583
3.000	33.750

Std Err of LS Mean = 1.237

Least square means for TRTS :

Group	Mean
1.000	95.833
2.000	8.250
3.000	0.000

Std Err of LS Mean = 1.237

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	Diff of Means	p	q	P	P<0.050
1.000 vs. 3.000	95.833	3	77.474	<0.001	Yes
1.000 vs. 2.000	87.583	2	70.805	<0.001	Yes
2.000 vs. 3.000	8.250	2	6.670	0.009	Yes

Two Way Analysis of Variance

Data source: Data 1 in Highway fill cover 2003

General Linear Model (No Interactions)

Dependent Variable: Annual Forb Canopy Cover-square root transform

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	0.0542	0.0271	0.0421	0.959
TRTS	2	14.940	7.470	11.597	0.022
Residual	4	2.576	0.644		
Total	8	17.570	2.196		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.959).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.022). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 0.780

Least square means for REPS :

Group	**Mean**
1.000	1.800
2.000	1.859
3.000	1.673

Std Err of LS Mean = 0.463

Least square means for TRTS :

Group	**Mean**
1.000	-1.110E-016
2.000	2.318
3.000	3.014

Std Err of LS Mean = 0.463

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
3.000 vs. 1.000	3.014	3	6.504	0.022	Yes
3.000 vs. 2.000	0.695	2	1.500	0.349	No
2.000 vs. 1.000	2.318	2	5.003	0.024	Yes

Two Way Analysis of Variance

Data source: Data 1 in Highway fill cover 2003

General Linear Model (No Interactions)

Dependent Variable: Perennial Forb Canopy Cover

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	0.347	0.174	1.000	0.444
TRTS	2	14.931	7.465	43.000	0.002
Residual	4	0.694	0.174		
Total	8	15.972	1.997		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.444).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.002). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 0.999

Least square means for REPS :

Group	**Mean**
1.000	2.083
2.000	1.667
3.000	1.667

Std Err of LS Mean = 0.241

Least square means for TRTS :

Group	**Mean**
1.000	-2.220E-016
2.000	2.500
3.000	2.917

Std Err of LS Mean = 0.241

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
3.000 vs. 1.000	2.917	3	12.124	0.002	Yes
3.000 vs. 2.000	0.417	2	1.732	0.288	No
2.000 vs. 1.000	2.500	2	10.392	0.002	Yes

Two Way Analysis of Variance

Data source: Data 1 in Highway Fill 2003

General Linear Model (No Interactions)

Dependent Variable: Mean total canopy cover

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	26.264	13.132	0.991	0.447
TRTS	2	12829.347	6414.674	484.253	<0.001
Residual	4	52.986	13.247		
Total	8	12908.597	1613.575		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.447).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	**Mean**	**SEM**
1.000	41.917	2.101
2.000	44.750	2.101
3.000	40.667	2.101

Least square means for TRTS :

Group	Mean	SEM
1.000	95.833	2.101
2.000	16.417	2.101
3.000	15.083	2.101

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	Diff of Means	p	q	P	P<0.050
1.000 vs. 3.000	80.750	3	38.428	<0.001	Yes
1.000 vs. 2.000	79.417	2	37.794	<0.001	Yes
2.000 vs. 3.000	1.333	2	0.635	0.677	No

Table 88. Highway fill ground cover (%) Sigma Stat table for 2003.

REPS	TRTS	Ground Cover
1	1	97.50
1	2	97.50
1	3	2.50
2	1	97.50
2	2	97.50
2	3	2.50
3	1	96.25
3	2	96.25
3	3	2.50

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Highway fill cover 2003

General Linear Model (No Interactions)

Dependent Variable: Ground Cover

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	1.389	0.694	4.000	0.111
TRTS	2	17892.014	8946.007	51529.000	<0.001
Residual	4	0.694	0.174		
Total	8	17894.097	2236.762		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.111).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.304
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	**Mean**
1.000	65.833
2.000	65.833
3.000	65.000

Std Err of LS Mean = 0.241

Least square means for TRTS :

Group	**Mean**
1.000	97.083
2.000	97.083
3.000	2.500

Std Err of LS Mean = 0.241

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **REPS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	0.833	3	3.464	0.143	No
1.000 vs. 2.000	0.000	2	0.000	1.000	Do Not Test
2.000 vs. 3.000	0.833	2	3.464	0.071	Do Not Test

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	94.583	3	393.176	<0.001	Yes
1.000 vs. 2.000	0.000	2	0.000	1.000	No
2.000 vs. 3.000	94.583	2	393.176	<0.001	Yes

A result of "Do Not Test" occurs for a comparison when no significant difference is found between two means that enclose that comparison. For example, if you had four means sorted in order, and found no difference between means 4 vs. 2, then you would not test 4 vs. 3 and 3 vs. 2, but still test 4 vs. 1 and 3 vs. 1 (4 vs. 3 and 3 vs. 2 are enclosed by 4 vs. 2: 4 3 2 1). Note that not testing the enclosed means is a procedural rule, and a result of Do Not Test should be treated as if there is no significant difference between the means, even though one may appear to exist.

Table 89. Highway fill production (g) Sigma Stat table for 2004

REPS	TRTS	Perennial Grass Production	Perennial Forb Production-rank	Annual Forb Production	Mean Total Production
1	1	3.12	2.00	0.00	3.12
1	2	1.19	4.00	0.00	1.33
1	3	0.04	9.00	0.00	32.59
2	1	2.03	2.00	0.00	2.03
2	2	0.81	8.00	0.00	19.68
2	3	0.51	7.00	0.00	3.80
3	1	3.82	2.00	0.00	3.82
3	2	1.44	5.00	0.02	1.75
3	3	0.68	6.00	0.00	2.79

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Highway fill production 2004

General Linear Model (No Interactions)

Dependent Variable: Perennial Grass Production

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	1.132	0.566	2.495	0.198
TRTS	2	10.604	5.302	23.364	0.006
Residual	4	0.908	0.227		
Total	8	12.644	1.581		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.198).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.006). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.174
Power of performed test with alpha = 0.0500: for TRTS : 0.975

Least square means for REPS :

Group	**Mean**
1.000	1.452
2.000	1.115
3.000	1.977

Std Err of LS Mean = 0.275

Least square means for TRTS :

Group	**Mean**
1.000	2.990
2.000	1.145
3.000	0.409

Std Err of LS Mean = 0.275

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	2.581	3	9.383	0.006	Yes
1.000 vs. 2.000	1.845	2	6.707	0.009	Yes
2.000 vs. 3.000	0.736	2	2.676	0.132	No

Two Way Analysis of Variance

Data source: Data 1 in Highway fill production 2004

General Linear Model (No Interactions)

Dependent Variable: Perennial Forb Production-ranked

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	2.667	1.333	0.500	0.640
TRTS	2	44.667	22.333	8.375	0.037
Residual	4	10.667	2.667		
Total	8	58.000	7.250		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.640).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.037). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 0.627

Least square means for REPS :

Group	**Mean**
1.000	5.000
2.000	5.667
3.000	4.333

Std Err of LS Mean = 0.943

Least square means for TRTS :

Group	**Mean**
1.000	2.000
2.000	5.667
3.000	7.333

Std Err of LS Mean = 0.943

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
3.000 vs. 1.000	5.333	3	5.657	0.035	Yes
3.000 vs. 2.000	1.667	2	1.768	0.280	No
2.000 vs. 1.000	3.667	2	3.889	0.052	No

Two Way Analysis of Variance

Data source: Data 1 in Highway fill production 2004

General Linear Model (No Interactions)

Dependent Variable: Annual Forb Production

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	0.0000766	0.0000383	1.000	0.444
TRTS	2	0.0000766	0.0000383	1.000	0.444
Residual	4	0.000153	0.0000383		
Total	8	0.000307	0.0000383		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.444).

The difference in the mean values among the different levels of TRTS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in REPS. There is not a statistically significant difference (P = 0.444).

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 0.0514

Least square means for REPS :

Group	**Mean**
1.000	0.000
2.000	0.000
3.000	0.00619

Std Err of LS Mean = 0.00357

Least square means for TRTS :

Group	**Mean**
1.000	4.337E-019
2.000	0.00619
3.000	0.000

Std Err of LS Mean = 0.00357

Two Way Analysis of Variance

Data source: Total Highway Production 2004

General Linear Model (No Interactions)

Dependent Variable: Mean Total Production

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	138.881	69.440	0.424	0.681
TRTS	2	152.453	76.226	0.466	0.658
Residual	4	654.850	163.713		
Total	8	946.184	118.273		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.681).

The difference in the mean values among the different levels of TRTS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in REPS. There is not a statistically significant difference (P = 0.658).

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 0.0514

Least square means for REPS :

Group	**Mean**
1.000	12.348
2.000	8.503
3.000	2.787

Std Err of LS Mean = 7.387

Least square means for TRTS :

Group	Mean
1.000	2.991
2.000	7.587
3.000	13.060

Std Err of LS Mean = 7.387

Table 90. Highway fill basal cover (%) Sigma Stat table for 2004

REPS	TRTS	Basal Perennial Grass	Basal Annual Forbs	Basal Perennial Forbs-sq rt	Mean total basal cover
1	1	27.50	0.00	0.00	27.5
1	2	3.75	3.75	2.69	14.75
1	3	2.50	2.50	3.50	17.25
2	1	26.50	0.00	0.00	26.5
2	2	8.50	2.50	3.28	21.75
2	3	2.50	2.50	1.94	8.75
3	1	97.50	0.00	0.00	40.25
3	2	5.00	2.50	1.58	10
3	3	3.75	2.50	1.94	10

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Highway fill cover 2004

General Linear Model (No Interactions)

Dependent Variable: Basal Perennial Grass

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	42.097	21.049	0.950	0.460
TRTS	2	1479.056	739.528	33.383	0.003
Residual	4	88.611	22.153		
Total	8	1609.764	201.220		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.460).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.003). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 0.996

Least square means for REPS :

Group	**Mean**
1.000	11.250
2.000	12.500
3.000	16.333

Std Err of LS Mean = 2.717

Least square means for TRTS :

Group	**Mean**
1.000	31.417
2.000	5.750
3.000	2.917

Std Err of LS Mean = 2.717

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	28.500	3	10.488	0.004	Yes
1.000 vs. 2.000	25.667	2	9.445	0.003	Yes
2.000 vs. 3.000	2.833	2	1.043	0.502	No

Two Way Analysis of Variance

Data source: Data 1 in Highway fill cover 2004

General Linear Model (No Interactions)

Dependent Variable: Basal Annual Forbs

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	0.347	0.174	1.000	0.444
TRTS	2	14.931	7.465	43.000	0.002
Residual	4	0.694	0.174		
Total	8	15.972	1.997		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.444).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.002). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 0.999

Least square means for REPS :

Group	**Mean**
1.000	2.083
2.000	1.667
3.000	1.667

Std Err of LS Mean = 0.241

Least square means for TRTS :

Group	**Mean**
1.000	-1.110E-016
2.000	2.917
3.000	2.500

Std Err of LS Mean = 0.241

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
2.000 vs. 1.000	2.917	3	12.124	0.002	Yes
2.000 vs. 3.000	0.417	2	1.732	0.288	No
3.000 vs. 1.000	2.500	2	10.392	0.002	Yes

Two Way Analysis of Variance

Data source: Data 1 in Highway fill cover 2004

General Linear Model (No Interactions)

Dependent Variable: Basal Perennial Forbs-square root

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	1.221	0.611	1.289	0.370
TRTS	2	12.381	6.191	13.066	0.018
Residual	4	1.895	0.474		
Total	8	15.498	1.937		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.370).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.018). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0738
Power of performed test with alpha = 0.0500: for TRTS : 0.829

Least square means for REPS :

Group	**Mean**
1.000	2.064
2.000	1.738
3.000	1.173

Std Err of LS Mean = 0.397

Least square means for TRTS :

Group	**Mean**
1.000	-2.220E-016
2.000	2.517
3.000	2.458

Std Err of LS Mean = 0.397

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
2.000 vs. 1.000	2.517	3	6.335	0.024	Yes
2.000 vs. 3.000	0.0598	2	0.151	0.921	No
3.000 vs. 1.000	2.458	2	6.184	0.012	Yes

Two Way Analysis of Variance

Data source: Data 1 in Highway fill cover 2004

General Linear Model (No Interactions)

Dependent Variable: Mean total basal cover

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	DF	SS	MS	F	P
REPS	2	1.931	0.965	0.0170	0.983
TRTS	2	642.597	321.299	5.646	0.068
Residual	4	227.611	56.903		
Total	8	872.139	109.017		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.983).

The difference in the mean values among the different levels of TRTS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in REPS. There is not a statistically significant difference (P = 0.068).

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 0.440

Least square means for REPS :

Group	Mean	SEM
1.000	19.833	4.355
2.000	19.000	4.355
3.000	20.083	4.355

Least square means for TRTS :

Group	Mean	SEM
1.000	31.417	4.355
2.000	15.500	4.355
3.000	12.000	4.355

Table 91. Highway fill canopy cover (%) Sigma Stat table for 2004.

REPS	TRTS	Canopy perennial grass	Canopy perennial forbs	Mean total canopy cover
1	1	27.50	3.75	31.25
1	2	2.50	8.50	13.5
1	3	2.50	11.00	13.5
2	1	26.50	2.50	29
2	2	8.50	12.25	24.5
2	3	2.50	6.25	8.75
3	1	40.25	3.75	44
3	2	6.25	5.00	13.75
3	3	5.00	12.25	17.25

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Highway fill cover 2004

General Linear Model (No Interactions)

Dependent Variable: Canopy Perennial Grass

Normality Test: Passed ($P > 0.050$)

Equal Variance Test: Passed ($P = 1.000$)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	64.667	32.333	1.715	0.290
TRTS	2	1453.292	726.646	38.540	0.002
Residual	4	75.417	18.854		
Total	8	1593.375	199.172		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference ($P = 0.290$).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference ($P = 0.002$). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.108
Power of performed test with alpha = 0.0500: for TRTS : 0.999

Least square means for REPS :

Group	**Mean**
1.000	10.833
2.000	12.500
3.000	17.167

Std Err of LS Mean = 2.507

Least square means for TRTS :

Group	**Mean**
1.000	31.417
2.000	5.750
3.000	3.333

Std Err of LS Mean = 2.507

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	28.083	3	11.202	0.003	Yes
1.000 vs. 2.000	25.667	2	10.238	0.002	Yes
2.000 vs. 3.000	2.417	2	0.964	0.533	No

Two Way Analysis of Variance

Data source: Data 1 in Highway fill cover 2004

General Linear Model (No Interactions)

Dependent Variable: Canopy Perennial Forbs

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	0.847	0.424	0.0311	0.970
TRTS	2	74.264	37.132	2.724	0.179
Residual	4	54.528	13.632		
Total	8	129.639	16.205		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.970).

The difference in the mean values among the different levels of TRTS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in REPS. There is not a statistically significant difference (P = 0.179).

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 0.194

Least square means for REPS :

Group	**Mean**
1.000	7.750
2.000	7.333
3.000	7.000

Std Err of LS Mean = 2.132

Least square means for TRTS :

Group	**Mean**
1.000	3.333
2.000	8.917
3.000	9.833

Std Err of LS Mean = 2.132

Two Way Analysis of Variance

Data source: Data 1 in Highway fill cover 2004

General Linear Model (No Interactions)

Dependent Variable: Mean total canopy cover

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	51.014	25.507	0.523	0.628
TRTS	2	788.764	394.382	8.089	0.039
Residual	4	195.028	48.757		
Total	8	1034.806	129.351		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.628).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.039). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 0.609

Least square means for REPS :

Group	**Mean**	**SEM**
1.000	19.417	4.031
2.000	20.750	4.031
3.000	25.000	4.031

Least square means for TRTS :

Group	**Mean**	**SEM**
1.000	34.750	4.031
2.000	17.250	4.031
3.000	13.167	4.031

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	21.583	3	5.354	0.041	Yes
1.000 vs. 2.000	17.500	2	4.341	0.037	Yes
2.000 vs. 3.000	4.083	2	1.013	0.514	No

Table 92. Highway fill ground cover Sigma Stat table for 2004.

REPS	TRTS	Ground Cover
1	1	95.00
1	2	96.25
1	3	2.50
2	1	97.50
2	2	89.00
2	3	7.50
3	1	97.50
3	2	91.25
3	3	7.50

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Highway fill cover 2004

General Linear Model (No Interactions)

Dependent Variable: Ground Cover

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	1.264	0.632	0.0537	0.948
TRTS	2	15724.389	7862.194	667.545	<0.001
Residual	4	47.111	11.778		
Total	8	15772.764	1971.595		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.948).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	**Mean**	**SEM**
1.000	64.583	1.981
2.000	64.667	1.981
3.000	65.417	1.981

Least square means for TRTS :

Group	**Mean**	**SEM**
1.000	96.667	1.981
2.000	92.167	1.981
3.000	5.833	1.981

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	90.833	3	45.843	<0.001	Yes
1.000 vs. 2.000	4.500	2	2.271	0.184	No
2.000 vs. 3.000	86.333	2	43.572	<0.001	Yes

Table 93. Highway fill sediment loss Sigma Stat table.

REPS	TRTS	Sediment (kg/ha)
1	1	0.00
1	2	10.57
1	3	246.91
2	1	0.00
2	2	6.73
2	3	529.37
3	1	0.00
3	2	10.57
3	3	377.25

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 Highway fill sediment 2004

General Linear Model (No Interactions)

Dependent Variable: Sediment Loss

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	12955.653	6477.826	0.959	0.457
TRTS	2	288727.898	144363.949	21.368	0.007
Residual	4	27024.684	6756.171		
Total	8	328708.234	41088.529		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.457).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.007). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 0.963

Least square means for REPS :

Group	**Mean**	**SEM**
1.000	85.826	47.456
2.000	178.698	47.456
3.000	129.273	47.456

Least square means for TRTS :

Group	Mean	SEM
1.000	0.000	47.456
2.000	9.287	47.456
3.000	384.511	47.456

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	Diff of Means	p	q	P	P<0.050
3.000 vs. 1.000	384.511	3	8.103	0.010	Yes
3.000 vs. 2.000	375.224	2	7.907	0.005	Yes
2.000 vs. 1.000	9.287	2	0.196	0.897	No

Table 94. Highway fill runoff volume Sigma Stat table.

REPS	TRTS	Runoff Volume (ml)
1	1	0
1	2	4
1	3	917
2	1	0
2	2	2
2	3	2610
3	1	0
3	2	168
3	3	1400

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 Highway fill runoff 2004

General Linear Model (No Interactions)

Dependent Variable: Runoff Volume

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	485336.222	242668.111	0.921	0.469
TRTS	2	5210734.889	2605367.444	9.887	0.028
Residual	4	1054028.444	263507.111		
Total	8	6750099.556	843762.444		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.469).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.028). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 0.707

Least square means for REPS :

Group	Mean	SEM
1.000	307.000	296.371
2.000	870.667	296.371
3.000	522.667	296.371

Least square means for TRTS :

Group	Mean	SEM
1.000	0.000	296.371
2.000	58.000	296.371
3.000	1642.333	296.371

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	Diff of Means	p	q	P	P<0.050
3.000 vs. 1.000	1642.333	3	5.541	0.037	Yes
3.000 vs. 2.000	1584.333	2	5.346	0.020	Yes
2.000 vs. 1.000	58.000	2	0.196	0.897	No

Table 95. Highway fill infiltration Sigma Stat table.

REPS	TRTS	Infiltration (cm/hr)
1	1	1.85
1	2	1.85
1	3	1.70
2	1	1.85
2	2	1.85
2	3	1.43
3	1	1.85
3	2	1.82
3	3	1.62

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Highway Fill Infiltration Rate

Dependent Variable: Infiltration Rate (cm/hr)

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	0.0123	0.00614	0.918	0.470
TRTS	2	0.137	0.0685	10.239	0.027
Residual	4	0.0268	0.00669		
Total	8	0.176	0.0220		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.470).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.027). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 0.724

Least square means for REPS :

Group	**Mean**
1.000	1.800
2.000	1.710
3.000	1.763

Std Err of LS Mean = 0.0472

Least square means for TRTS :

Group	Mean
1.000	1.850
2.000	1.840
3.000	1.583

Std Err of LS Mean = 0.0472

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **REPS**

Comparison	Diff of Means	p	q	P	P<0.050
1.000 vs. 2.000	0.0900	3	1.905	0.445	No
1.000 vs. 3.000	0.0367	2	0.776	0.612	Do Not Test
3.000 vs. 2.000	0.0533	2	1.129	0.470	Do Not Test

Comparisons for factor: **TRTS**

Comparison	Diff of Means	p	q	P	P<0.050
1.000 vs. 3.000	0.267	3	5.645	0.035	Yes
1.000 vs. 2.000	0.01000	2	0.212	0.888	No
2.000 vs. 3.000	0.257	2	5.433	0.019	Yes

A result of "Do Not Test" occurs for a comparison when no significant difference is found between two means that enclose that comparison. For example, if you had four means sorted in order, and found no difference between means 4 vs. 2, then you would not test 4 vs. 3 and 3 vs. 2, but still test 4 vs. 1 and 3 vs. 1 (4 vs. 3 and 3 vs. 2 are enclosed by 4 vs. 2: 4 3 2 1). Note that not testing the enclosed means is a procedural rule, and a result of Do Not Test should be treated as if there is no significant difference between the means, even though one may appear to exist.

Table 96. Ski slope production (g) Sigma Stat table 2003.

REPS	TRTS	Perennial Grass Production	Perennial Forb Production	Mean total production
1	1	2.88	0.00	2.88
1	2	0.27	0.00	0.27
1	3	0.35	0.00	0.35
2	1	1.03	0.00	1.03
2	2	0.36	0.00	0.36
2	3	0.11	0.00	0.11
3	1	2.92	0.00	2.92
3	2	0.23	0.00	0.23
3	3	0.04	0.60	0.64

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Ski Slope Production 2003

General Linear Model (No Interactions)

Dependent Variable: Perennial Grass Production

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	0.776	0.388	0.955	0.458
TRTS	2	8.414	4.207	10.358	0.026
Residual	4	1.625	0.406		
Total	8	10.814	1.352		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.458).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.026). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 0.729

Least square means for REPS :

Group	**Mean**
1.000	1.167
2.000	0.498
3.000	1.063

Std Err of LS Mean = 0.368

Least square means for TRTS :

Group	**Mean**
1.000	2.275
2.000	0.289
3.000	0.164

Std Err of LS Mean = 0.368

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	2.111	3	5.737	0.033	Yes
1.000 vs. 2.000	1.985	2	5.396	0.019	Yes
2.000 vs. 3.000	0.126	2	0.342	0.821	No

Two Way Analysis of Variance

Data source: Data 1 in Ski Slope Production 2003

General Linear Model (No Interactions)

Dependent Variable: Perennial Forb Production

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	0.0795	0.0397	1.000	0.444
TRTS	2	0.0795	0.0397	1.000	0.444
Residual	4	0.159	0.0397		
Total	8	0.318	0.0397		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.444).

The difference in the mean values among the different levels of TRTS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in REPS. There is not a statistically significant difference (P = 0.444).

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 0.0514

Least square means for REPS :

Group	**Mean**
1.000	0.000
2.000	0.000
3.000	0.199

Std Err of LS Mean = 0.115

Least square means for TRTS :

Group	Mean
1.000	0.000
2.000	0.000
3.000	0.199

Std Err of LS Mean = 0.115

Two Way Analysis of Variance

Data source: Data 1 in Ski slope production 2003

General Linear Model (No Interactions)

Dependent Variable: Mean total production

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	1.039	0.519	1.431	0.340
TRTS	2	7.601	3.801	10.470	0.026
Residual	4	1.452	0.363		
Total	8	10.092	1.262		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.340).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.026). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0850
Power of performed test with alpha = 0.0500: for TRTS : 0.734

Least square means for REPS :

Group	**Mean**
1.000	1.167
2.000	0.498
3.000	1.262

Std Err of LS Mean = 0.348

Least square means for TRTS :

Group	**Mean**
1.000	2.275
2.000	0.289
3.000	0.363

Std Err of LS Mean = 0.348

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 2.000	1.985	3	5.707	0.034	Yes
1.000 vs. 3.000	1.912	2	5.496	0.018	Yes
3.000 vs. 2.000	0.0737	2	0.212	0.888	No

Table 97. Ski slope basal cover (%) Sigma Stat table 2003.

REPS	TRTS	Basal Perennial Grass	Basal Perennial Forbs	Mean total basal cover
1	1	97.50	0	97.50
1	2	3.75	0	3.75
1	3	2.50	0	2.50
2	1	63.75	0	63.75
2	2	2.50	0	2.50
2	3	2.50	0	2.50
3	1	97.50	0	97.50
3	2	2.50	0	2.50
3	3	2.50	3.75	6.25

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Ski Slope Cover 2003

General Linear Model (No Interactions)

Dependent Variable: Basal Perennial Grass

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	262.847	131.424	1.057	0.428
TRTS	2	13958.681	6979.340	56.107	0.001
Residual	4	497.569	124.392		
Total	8	14719.097	1839.887		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.428).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0558
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	**Mean**	**SEM**
1.000	34.583	6.439
2.000	22.917	6.439
3.000	34.167	6.439

Least square means for TRTS :

Group	Mean	SEM
1.000	86.250	6.439
2.000	2.917	6.439
3.000	2.500	6.439

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **REPS**

Comparison	Diff of Means	p	q	P	P<0.050
1.000 vs. 2.000	11.667	3	1.812	0.475	No
1.000 vs. 3.000	0.417	2	0.0647	0.966	Do Not Test
3.000 vs. 2.000	11.250	2	1.747	0.285	Do Not Test

Comparisons for factor: **TRTS**

Comparison	Diff of Means	p	q	P	P<0.050
1.000 vs. 3.000	83.750	3	13.006	0.002	Yes
1.000 vs. 2.000	83.333	2	12.941	0.001	Yes
2.000 vs. 3.000	0.417	2	0.0647	0.966	No

A result of "Do Not Test" occurs for a comparison when no significant difference is found between two means that enclose that comparison. For example, if you had four means sorted in order, and found no difference between means 4 vs. 2, then you would not test 4 vs. 3 and 3 vs. 2, but still test 4 vs. 1 and 3 vs. 1 (4 vs. 3 and 3 vs. 2 are enclosed by 4 vs. 2: 4 3 2 1). Note that not testing the enclosed means is a procedural rule, and a result of Do Not Test should be treated as if there is no significant difference between the means, even though one may appear to exist.

Two Way Analysis of Variance

Data source: Data 1 in Ski Slope Cover 2003

General Linear Model (No Interactions)

Dependent Variable: Basal Perennial Forbs

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	3.125	1.562	1.000	0.444
TRTS	2	3.125	1.562	1.000	0.444
Residual	4	6.250	1.563		
Total	8	12.500	1.563		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.444).

The difference in the mean values among the different levels of TRTS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in REPS. There is not a statistically significant difference (P = 0.444).

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 0.0514

Least square means for REPS :

Group	**Mean**
1.000	0.000
2.000	0.000
3.000	1.250

Std Err of LS Mean = 0.722

Least square means for TRTS :

Group	Mean
1.000	0.000
2.000	0.000
3.000	1.250

Std Err of LS Mean = 0.722

Two Way Analysis of Variance

Data source: Data 1 in Ski slope cover 2003

General Linear Model (No Interactions)

Dependent Variable: Mean total basal cover

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	293.056	146.528	1.229	0.384
TRTS	2	13751.389	6875.694	57.690	0.001
Residual	4	476.736	119.184		
Total	8	14521.181	1815.148		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.384).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0691
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	**Mean**	**SEM**
1.000	34.583	6.303
2.000	22.917	6.303
3.000	35.417	6.303

Least square means for TRTS :

Group	**Mean**	**SEM**
1.000	86.250	6.303
2.000	2.917	6.303
3.000	3.750	6.303

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 2.000	83.333	3	13.221	0.002	Yes
1.000 vs. 3.000	82.500	2	13.089	<0.001	Yes
3.000 vs. 2.000	0.833	2	0.132	0.930	No

Table 98. Ski slope canopy cover (%) Sigma Stat table 2003.

REPS	TRTS	Canopy perennial grass	Canopy perennial forbs	Mean total canopy cover
1	1	97.50	0	100.00
1	2	3.75	0	3.75
1	3	2.50	0	2.50
2	1	66.25	0	66.25
2	2	3.75	0	3.75
2	3	3.75	0	6.25
3	1	97.50	0	97.50
3	2	2.50	0	2.50
3	3	2.50	3.75	6.25

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Ski Slope Cover 2003

General Linear Model (No Interactions)

Dependent Variable: Canopy Perennial Grass

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	192.014	96.007	0.833	0.498
TRTS	2	14098.264	7049.132	61.149	0.001
Residual	4	461.111	115.278		
Total	8	14751.389	1843.924		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.498).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	**Mean**
1.000	34.583
2.000	24.583
3.000	34.167

Std Err of LS Mean = 6.199

Least square means for TRTS :

Group	Mean
1.000	87.083
2.000	3.333
3.000	2.917

Std Err of LS Mean = 6.199

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **REPS**

Comparison	Diff of Means	p	q	P	P<0.050
1.000 vs. 2.000	10.000	3	1.613	0.543	No
1.000 vs. 3.000	0.417	2	0.0672	0.965	Do Not Test
3.000 vs. 2.000	9.583	2	1.546	0.336	Do Not Test

Comparisons for factor: **TRTS**

Comparison	Diff of Means	p	q	P	P<0.050
1.000 vs. 3.000	84.167	3	13.578	0.002	Yes
1.000 vs. 2.000	83.750	2	13.511	<0.001	Yes
2.000 vs. 3.000	0.417	2	0.0672	0.965	No

A result of "Do Not Test" occurs for a comparison when no significant difference is found between two means that enclose that comparison. For example, if you had four means sorted in order, and found no difference between means 4 vs. 2, then you would not test 4 vs. 3 and 3 vs. 2, but still test 4 vs. 1 and 3 vs. 1 (4 vs. 3 and 3 vs. 2 are enclosed by 4 vs. 2: 4 3 2 1). Note that not testing the enclosed means is a procedural rule, and a result of Do Not Test should be treated as if there is no significant difference between the means, even though one may appear to exist.

Two Way Analysis of Variance

Data source: Data 1 in Ski Slope Cover 2003

General Linear Model (No Interactions)

Dependent Variable: Canopy Perennial Forbs

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	3.125	1.562	1.000	0.444
TRTS	2	3.125	1.562	1.000	0.444
Residual	4	6.250	1.563		
Total	8	12.500	1.563		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.444).

The difference in the mean values among the different levels of TRTS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in REPS. There is not a statistically significant difference (P = 0.444).

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 0.0514

Least square means for REPS :

Group	**Mean**
1.000	0.000
2.000	0.000
3.000	1.250

Std Err of LS Mean = 0.722

Least square means for TRTS :

Group	**Mean**
1.000	0.000
2.000	0.000
3.000	1.250

Std Err of LS Mean = 0.722

Two Way Analysis of Variance

Data source: Data 1 in Ski slope cover 2003

General Linear Model (No Interactions)

Dependent Variable: Mean total canopy cover

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	DF	SS	MS	F	P
REPS	2	200.000	100.000	0.773	0.520
TRTS	2	14032.292	7016.146	54.209	0.001
Residual	4	517.708	129.427		
Total	8	14750.000	1843.750		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.520).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	Mean	SEM
1.000	35.417	6.568
2.000	25.417	6.568
3.000	35.417	6.568

Least square means for TRTS :

Group	Mean	SEM
1.000	87.917	6.568
2.000	3.333	6.568
3.000	5.000	6.568

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	Diff of Means	p	q	P	P<0.050
1.000 vs. 2.000	84.583	3	12.878	0.002	Yes
1.000 vs. 3.000	82.917	2	12.624	0.001	Yes
3.000 vs. 2.000	1.667	2	0.254	0.866	No

Table 99. Ski slope ground cover (%) Sigma Stat table for 2003

REPS	TRTS	Ground Cover
1	1	97.5
1	2	96.25
1	3	8.5
2	1	71.25
2	2	97.5
2	3	6.25
3	1	97.5
3	2	97.5
3	3	7.5

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Ski Slope Cover 2003

General Linear Model (No Interactions)

Dependent Variable: Ground Cover

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	166.542	83.271	1.124	0.410
TRTS	2	14724.667	7362.333	99.351	<0.001
Residual	4	296.417	74.104		
Total	8	15187.625	1898.453		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.410).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0609
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	**Mean**	**SEM**
1.000	67.417	4.970
2.000	58.333	4.970
3.000	67.500	4.970

Least square means for TRTS :

Group	**Mean**	**SEM**
1.000	88.750	4.970
2.000	97.083	4.970
3.000	7.417	4.970

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **REPS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
3.000 vs. 2.000	9.167	3	1.844	0.465	No
3.000 vs. 1.000	0.0833	2	0.0168	0.991	Do Not Test
1.000 vs. 2.000	9.083	2	1.828	0.266	Do Not Test

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
2.000 vs. 3.000	89.667	3	18.041	<0.001	Yes
2.000 vs. 1.000	8.333	2	1.677	0.302	No
1.000 vs. 3.000	81.333	2	16.365	<0.001	Yes

A result of "Do Not Test" occurs for a comparison when no significant difference is found between two means that enclose that comparison. For example, if you had four means sorted in order, and found no difference between means 4 vs. 2, then you would not test 4 vs. 3 and 3 vs. 2, but still test 4 vs. 1 and 3 vs. 1 (4 vs. 3 and 3 vs. 2 are enclosed by 4 vs. 2: 4 3 2 1). Note that not testing the enclosed means is a procedural rule, and a result of Do Not Test should be treated as if there is no significant difference between the means, even though one may appear to exist.

Table 100. Ski slope production (g) sigma stat table 2004.

REPS	TRTS	Perennial grass production	Perennial forb production	Mean total production
1	1	3.76	0.00	3.76
1	2	0.71	0.01	0.72
1	3	3.17	0.08	3.25
2	1	4.47	0.02	4.49
2	2	3.84	0.00	3.84
2	3	1.43	0.06	1.48
3	1	9.62	0.00	9.62
3	2	1.56	0.00	1.56
3	3	3.34	0.02	3.35

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Ski Slope Production 2004

General Linear Model (No Interactions)

Dependent Variable: Perennial Grass Production

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	8.276	4.138	0.841	0.495
TRTS	2	26.596	13.298	2.704	0.181
Residual	4	19.672	4.918		
Total	8	54.544	6.818		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.495).

The difference in the mean values among the different levels of TRTS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in REPS. There is not a statistically significant difference (P = 0.181).

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 0.192

Least square means for REPS :

Group	**Mean**
1.000	2.548
2.000	3.246
3.000	4.839

Std Err of LS Mean = 1.280

Least square means for TRTS :

Group	**Mean**
1.000	5.950
2.000	2.037
3.000	2.646

Std Err of LS Mean = 1.280

Two Way Analysis of Variance

Data source: Data 1 in Ski Slope Production 2004

General Linear Model (No Interactions)

Dependent Variable: Perennial Forb Production

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	0.000992	0.000496	1.506	0.325
TRTS	2	0.00407	0.00203	6.174	0.060
Residual	4	0.00132	0.000329		
Total	8	0.00638	0.000797		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.325).

The difference in the mean values among the different levels of TRTS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in REPS. There is not a statistically significant difference (P = 0.060).

Power of performed test with alpha = 0.0500: for REPS : 0.0910
Power of performed test with alpha = 0.0500: for TRTS : 0.480

Least square means for REPS :

Group	**Mean**
1.000	0.0293
2.000	0.0253
3.000	0.00533

Std Err of LS Mean = 0.0105

Least square means for TRTS :

Group	Mean
1.000	0.00667
2.000	0.00333
3.000	0.0500

Std Err of LS Mean = 0.0105

Two Way Analysis of Variance

Data source: Data 1 in Ski slope production 2004

General Linear Model (No Interactions)

Dependent Variable: Mean total production

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	8.098	4.049	0.821	0.503
TRTS	2	26.396	13.198	2.675	0.183
Residual	4	19.735	4.934		
Total	8	54.229	6.779		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.503).

The difference in the mean values among the different levels of TRTS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in REPS. There is not a statistically significant difference (P = 0.183).

Power of performed test with alpha = 0.0500: for REPS : 0.0514
Power of performed test with alpha = 0.0500: for TRTS : 0.189

Least square means for REPS :

Group	**Mean**
1.000	2.577
2.000	3.271
3.000	4.845

Std Err of LS Mean = 1.282

Least square means for TRTS :

Group	**Mean**
1.000	5.957
2.000	2.041
3.000	2.696

Std Err of LS Mean = 1.282

Table 101. Ski slope basal cover (%) sigma stat table 2004.

REPS	TRTS	Basal perennial grass	Basal perennial forbs	Mean total basal cover
1	1	64.25	0.00	64.25
1	2	11.25	2.50	13.75
1	3	19.25	2.50	21.75
2	1	57.25	6.00	57.25
2	2	20.75	0.00	20.75
2	3	7.50	3.75	11.25
3	1	75.00	0.00	75.00
3	2	20.75	0.00	20.75
3	3	18.00	3.75	21.75

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Ski Slope Cover 2004

General Linear Model (No Interactions)

Dependent Variable: Basal Perennial Grass

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	138.292	69.146	1.676	0.296
TRTS	2	4861.792	2430.896	58.916	0.001
Residual	4	165.042	41.260		
Total	8	5165.125	645.641		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.296).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.105
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	**Mean**	**SEM**
1.000	31.583	3.709
2.000	28.500	3.709
3.000	37.917	3.709

Least square means for TRTS :

Group	**Mean**	**SEM**
1.000	65.500	3.709
2.000	17.583	3.709
3.000	14.917	3.709

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	50.583	3	13.640	0.002	Yes
1.000 vs. 2.000	47.917	2	12.921	0.001	Yes
2.000 vs. 3.000	2.667	2	0.719	0.638	No

Two Way Analysis of Variance

Data source: Data 1 in Ski Slope Cover 2004

General Linear Model (No Interactions)

Dependent Variable: Basal Perennial Forbs

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	4.042	2.021	1.565	0.315
TRTS	2	2.167	1.083	0.839	0.496
Residual	4	5.167	1.292		
Total	8	11.375	1.422		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.315).

The difference in the mean values among the different levels of TRTS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in REPS. There is not a statistically significant difference (P = 0.496).

Power of performed test with alpha = 0.0500: for REPS : 0.0957
Power of performed test with alpha = 0.0500: for TRTS : 0.0514

Least square means for REPS :

Group	**Mean**
1.000	2.500
2.000	4.083
3.000	2.917

Std Err of LS Mean = 0.656

Least square means for TRTS :

Group	Mean
1.000	3.667
2.000	2.500
3.000	3.333

Std Err of LS Mean = 0.656

Two Way Analysis of Variance

Data source: Data 1 in Ski slope cover 2004

General Linear Model (No Interactions)

Dependent Variable: Mean total basal cover

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	135.931	67.965	2.089	0.239
TRTS	2	4449.431	2224.715	68.394	<0.001
Residual	4	130.111	32.528		
Total	8	4715.472	589.434		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.239).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.139
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	**Mean**	**SEM**
1.000	33.250	3.293
2.000	29.750	3.293
3.000	39.167	3.293

Least square means for TRTS :

Group	**Mean**	**SEM**
1.000	65.500	3.293
2.000	18.417	3.293
3.000	18.250	3.293

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	47.250	3	14.349	0.001	Yes
1.000 vs. 2.000	47.083	2	14.299	<0.001	Yes
2.000 vs. 3.000	0.167	2	0.0506	0.973	No

Table 102. Ski slope canopy cover (%) sigma stat table 2004.

REPS	TRTS	Canopy Perennial grass	Canopy perennial forbs	Mean total canopy cover
1	1	71.00	0.00	71.00
1	2	11.25	2.50	13.75
1	3	24.00	2.50	24.00
2	1	57.25	6.00	63.25
2	2	23.00	0.00	23.00
2	3	10.00	6.00	16.00
3	1	76.25	0.00	76.25
3	2	31.25	0.00	31.25
3	3	25.25	3.75	29.00

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Ski Slope Cover 2004

General Linear Model (No Interactions)

Dependent Variable: Canopy Perennial Grass

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	307.167	153.583	2.662	0.184
TRTS	2	4495.292	2247.646	38.955	0.002
Residual	4	230.792	57.698		
Total	8	5033.250	629.156		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.184).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.002). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.188
Power of performed test with alpha = 0.0500: for TRTS : 0.999

Least square means for REPS :

Group	**Mean**
1.000	35.417
2.000	30.083
3.000	44.250

Std Err of LS Mean = 4.386

Least square means for TRTS :

Group	**Mean**
1.000	68.167
2.000	21.833
3.000	19.750

Std Err of LS Mean = 4.386

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	48.417	3	11.040	0.003	Yes
1.000 vs. 2.000	46.333	2	10.565	0.002	Yes
2.000 vs. 3.000	2.083	2	0.475	0.754	No

Two Way Analysis of Variance

Data source: Data 1 in Ski Slope Cover 2004

General Linear Model (No Interactions)

Dependent Variable: Canopy Perennial Forbs

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	9.292	4.646	3.597	0.128
TRTS	2	4.042	2.021	1.565	0.315
Residual	4	5.167	1.292		
Total	8	18.500	2.313		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.128).

The difference in the mean values among the different levels of TRTS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in REPS. There is not a statistically significant difference (P = 0.315).

Power of performed test with alpha = 0.0500: for REPS : 0.270
Power of performed test with alpha = 0.0500: for TRTS : 0.0957

Least square means for REPS :

Group	**Mean**
1.000	2.500
2.000	4.833
3.000	2.917

Std Err of LS Mean = 0.656

Least square means for TRTS :

Group	**Mean**
1.000	3.667
2.000	2.500
3.000	4.083

Std Err of LS Mean = 0.656

Two Way Analysis of Variance

Data source: Data 1 in Ski slope cover 2004

General Linear Model (No Interactions)

Dependent Variable: Mean total canopy cover

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	220.597	110.299	4.233	0.103
TRTS	2	4481.056	2240.528	85.979	<0.001
Residual	4	104.236	26.059		
Total	8	4805.889	600.736		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.103).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.324
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	**Mean**	**SEM**
1.000	36.250	2.947
2.000	34.083	2.947
3.000	45.500	2.947

Least square means for TRTS :

Group	Mean	SEM
1.000	70.167	2.947
2.000	22.667	2.947
3.000	23.000	2.947

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	Diff of Means	p	q	P	P<0.050
1.000 vs. 2.000	47.500	3	16.117	<0.001	Yes
1.000 vs. 3.000	47.167	2	16.004	<0.001	Yes
3.000 vs. 2.000	0.333	2	0.113	0.940	No

Table 103. Ski slope ground cover (%) Sigma Stat table for 2004.

REPS	TRTS	Ground Cover
1	1	95.00
1	2	93.75
1	3	50.00
2	1	85.50
2	2	96.25
2	3	31.25
3	1	97.50
3	2	97.50
3	3	45.25

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Ski Slope Cover 2004

General Linear Model (No Interactions)

Dependent Variable: Ground Cover

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	156.431	78.215	2.584	0.190
TRTS	2	5440.389	2720.194	89.872	<0.001
Residual	4	121.069	30.267		
Total	8	5717.889	714.736		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.190).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.182
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	**Mean**	**SEM**
1.000	79.583	3.176
2.000	71.000	3.176
3.000	80.083	3.176

Least square means for TRTS :

Group	Mean	SEM
1.000	92.667	3.176
2.000	95.833	3.176
3.000	42.167	3.176

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	Diff of Means	p	q	P	P<0.050
2.000 vs. 3.000	53.667	3	16.896	<0.001	Yes
2.000 vs. 1.000	3.167	2	0.997	0.520	No
1.000 vs. 3.000	50.500	2	15.899	<0.001	Yes

Table 104. Mine waste production (g) Sigma Stat table for 2003.

REPS	TRTS	Perennial grass production-ranked	Mean total production-ranked
1	1	12.00	12.00
1	2	10.00	10.00
1	3	4.00	4.00
1	4	6.00	6.00
2	1	9.00	9.00
2	2	7.00	7.00
2	3	1.50	1.50
2	4	3.00	3.00
3	1	11.00	11.00
3	2	8.00	8.00
3	3	1.50	1.50
3	4	5.00	5.00

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Mine Waste Production 2003

General Linear Model (No Interactions)

Dependent Variable: Perennial Grass Production-ranked

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	16.625	8.313	32.351	<0.001
TRTS	3	124.333	41.444	161.297	<0.001
Residual	6	1.542	0.257		
Total	11	142.500	12.955		

The difference in the mean values among the different levels of REPS is greater than would be expected by chance after allowing for effects of differences in TRTS. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 1.000
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	**Mean**
1.000	8.000
2.000	5.125
3.000	6.375

Std Err of LS Mean = 0.253

Least square means for TRTS :

Group	**Mean**
1.000	10.667
2.000	8.333
3.000	2.333
4.000	4.667

Std Err of LS Mean = 0.293

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **REPS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 2.000	2.875	3	11.344	<0.001	Yes
1.000 vs. 3.000	1.625	2	6.412	0.004	Yes
3.000 vs. 2.000	1.250	2	4.932	0.013	Yes

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	8.333	4	28.475	<0.001	Yes
1.000 vs. 4.000	6.000	3	20.502	<0.001	Yes
1.000 vs. 2.000	2.333	2	7.973	0.002	Yes
2.000 vs. 3.000	6.000	3	20.502	<0.001	Yes
2.000 vs. 4.000	3.667	2	12.529	<0.001	Yes
4.000 vs. 3.000	2.333	2	7.973	0.002	Yes

Two Way Analysis of Variance

Data source: Data 1 in Mine waste production 2003

General Linear Model (No Interactions)

Dependent Variable: Mean total production ranked

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	16.625	8.313	32.351	<0.001
TRTS	3	124.333	41.444	161.297	<0.001
Residual	6	1.542	0.257		
Total	11	142.500	12.955		

The difference in the mean values among the different levels of REPS is greater than would be expected by chance after allowing for effects of differences in TRTS. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 1.000
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	**Mean**
1.000	8.000
2.000	5.125
3.000	6.375

Std Err of LS Mean = 0.253

Least square means for TRTS :

Group	**Mean**
1.000	10.667
2.000	8.333
3.000	2.333
4.000	4.667

Std Err of LS Mean = 0.293

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **REPS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 2.000	2.875	3	11.344	<0.001	Yes
1.000 vs. 3.000	1.625	2	6.412	0.004	Yes
3.000 vs. 2.000	1.250	2	4.932	0.013	Yes

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	8.333	4	28.475	<0.001	Yes
1.000 vs. 4.000	6.000	3	20.502	<0.001	Yes
1.000 vs. 2.000	2.333	2	7.973	0.002	Yes
2.000 vs. 3.000	6.000	3	20.502	<0.001	Yes
2.000 vs. 4.000	3.667	2	12.529	<0.001	Yes
4.000 vs. 3.000	2.333	2	7.973	0.002	Yes

Table 105. Mine waste basal cover (%) Sigma Stat table 2003

REPS	TRTS	Basal perennial grass	Mean total basal cover
1	1	83.25	83.25
1	2	97.50	97.50
1	3	2.50	2.50
1	4	2.50	2.50
2	1	83.00	83.00
2	2	83.25	83.25
2	3	0.00	0.00
2	4	2.50	2.50
3	1	96.25	96.25
3	2	90.25	90.25
3	3	0.00	0.00
3	4	2.50	2.50

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Mine Waste Cover 2003

General Linear Model (No Interactions)

Dependent Variable: Basal Perennial Grass

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	59.135	29.568	1.099	0.392
TRTS	3	22853.896	7617.965	283.112	<0.001
Residual	6	161.448	26.908		
Total	11	23074.479	2097.680		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.392).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0595
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	**Mean**
1.000	46.438
2.000	42.188
3.000	47.250

Std Err of LS Mean = 2.594

Least square means for TRTS :

Group	Mean	SEM
1.000	87.500	2.995
2.000	90.333	2.995
3.000	0.833	2.995
4.000	2.500	2.995

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	Diff of Means	p	q	P	P<0.050
2.000 vs. 3.000	89.500	4	29.884	<0.001	Yes
2.000 vs. 4.000	87.833	3	29.328	<0.001	Yes
2.000 vs. 1.000	2.833	2	0.946	0.529	No
1.000 vs. 3.000	86.667	3	28.938	<0.001	Yes
1.000 vs. 4.000	85.000	2	28.382	<0.001	Yes
4.000 vs. 3.000	1.667	2	0.557	0.708	No

Two Way Analysis of Variance

Data source: Data 1 in Mine waste cover 2003

General Linear Model (No Interactions)

Dependent Variable: Mean total basal cover

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	59.135	29.568	1.099	0.392
TRTS	3	22853.896	7617.965	283.112	<0.001
Residual	6	161.448	26.908		
Total	11	23074.479	2097.680		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.392).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0595
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	**Mean**
1.000	46.438
2.000	42.188
3.000	47.250

Std Err of LS Mean = 2.594

Least square means for TRTS :

Group	Mean	SEM
1.000	87.500	2.995
2.000	90.333	2.995
3.000	0.833	2.995
4.000	2.500	2.995

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	Diff of Means	p	q	P	P<0.050
2.000 vs. 3.000	89.500	4	29.884	<0.001	Yes
2.000 vs. 4.000	87.833	3	29.328	<0.001	Yes
2.000 vs. 1.000	2.833	2	0.946	0.529	No
1.000 vs. 3.000	86.667	3	28.938	<0.001	Yes
1.000 vs. 4.000	85.000	2	28.382	<0.001	Yes
4.000 vs. 3.000	1.667	2	0.557	0.708	No

Table 106. Mine waste canopy cover (%) Sigma Stat table 2003

REPS	TRTS	Canopy Perennial Grass	Mean total canopy cover
1	1	83.25	83.25
1	2	97.25	97.25
1	3	2.50	2.50
1	4	3.75	7.50
2	1	83.00	83.00
2	2	83.25	83.25
2	3	0	0
2	4	3.75	3.75
3	1	96.25	96.25
3	2	90.25	90.25
3	3	0	0
3	4	2.50	2.50

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Mine Waste Cover 2003

General Linear Model (No Interactions)

Dependent Variable: Canopy Perennial Grass

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	53.885	26.943	0.985	0.427
TRTS	3	22619.099	7539.700	275.510	<0.001
Residual	6	164.198	27.366		
Total	11	22837.182	2076.107		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.427).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0502
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	**Mean**	**SEM**
1.000	46.688	2.616
2.000	42.500	2.616
3.000	47.250	2.616

Least square means for TRTS :

Group	**Mean**
1.000	87.500
2.000	90.250
3.000	0.833
4.000	3.333

Std Err of LS Mean = 3.020

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
2.000 vs. 3.000	89.417	4	29.605	<0.001	Yes
2.000 vs. 4.000	86.917	3	28.778	<0.001	Yes
2.000 vs. 1.000	2.750	2	0.911	0.544	No
1.000 vs. 3.000	86.667	3	28.695	<0.001	Yes
1.000 vs. 4.000	84.167	2	27.867	<0.001	Yes
4.000 vs. 3.000	2.500	2	0.828	0.580	No

Two Way Analysis of Variance

Data source: Data 1 in Mine waste cover 2003

General Linear Model (No Interactions)

Dependent Variable: Mean total canopy cover

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	65.292	32.646	1.185	0.368
TRTS	3	22306.521	7435.507	269.905	<0.001
Residual	6	165.292	27.549		
Total	11	22537.104	2048.828		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.368).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = <0.001). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0677
Power of performed test with alpha = 0.0500: for TRTS : 1.000

Least square means for REPS :

Group	**Mean**
1.000	47.625
2.000	42.500
3.000	47.250

Std Err of LS Mean = 2.624

Least square means for TRTS :

Group	**Mean**
1.000	87.500
2.000	90.250
3.000	0.833
4.000	4.583

Std Err of LS Mean = 3.030

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
2.000 vs. 3.000	89.417	4	29.507	<0.001	Yes
2.000 vs. 4.000	85.667	3	28.270	<0.001	Yes
2.000 vs. 1.000	2.750	2	0.907	0.545	No
1.000 vs. 3.000	86.667	3	28.600	<0.001	Yes
1.000 vs. 4.000	82.917	2	27.362	<0.001	Yes
4.000 vs. 3.000	3.750	2	1.237	0.415	No

Table 107. Mine waste ground cover (%) Sigma Stat table 2003

REPS	TRTS	Ground Cover
1	1	83.25
1	2	97.25
1	3	97.50
1	4	97.50
2	1	84.25
2	2	85.75
2	3	32.25
2	4	56.00
3	1	96.25
3	2	92.75
3	3	97.50
3	4	63.00

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Mine Waste Cover 2003

General Linear Model (No Interactions)

Dependent Variable: Ground Cover

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	1901.823	950.911	2.719	0.144
TRTS	3	812.271	270.757	0.774	0.549
Residual	6	2098.260	349.710		
Total	11	4812.354	437.487		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.144).

The difference in the mean values among the different levels of TRTS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in REPS. There is not a statistically significant difference (P = 0.549).

Power of performed test with alpha = 0.0500: for REPS : 0.232
Power of performed test with alpha = 0.0500: for TRTS : 0.0505

Least square means for REPS :

Group	**Mean**	**SEM**
1.000	93.938	9.350
2.000	64.563	9.350
3.000	87.375	9.350

Least square means for TRTS :

Group	**Mean**	**SEM**
1.000	87.917	10.797
2.000	92.000	10.797
3.000	75.750	10.797
4.000	72.167	10.797

Table 108. Mine waste production (g) Sigma Stat table 2004.

1-REPS	2-TRTS	Perennial Grass Production-sq rt	Mean total production-sq rt
1	1	1.35	1.35
1	2	0.95	0.95
1	3	0.00	0.00
1	4	1.29	1.29
2	1	1.47	1.47
2	2	1.80	1.80
2	3	0.00	0.00
2	4	0.00	0.00
3	1	1.89	1.89
3	2	0.92	0.92
3	3	0.00	0.00
3	4	0.00	0.00

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Mine Waste Production 2004

General Linear Model (No Interactions)

Dependent Variable: Perennial Grass Production-sq rt

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	0.0749	0.0375	0.133	0.878
TRTS	3	4.661	1.554	5.507	0.037
Residual	6	1.693	0.282		
Total	11	6.428	0.584		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.878).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.037). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0502
Power of performed test with alpha = 0.0500: for TRTS : 0.596

Least square means for REPS :

Group	**Mean**
1.000	0.897
2.000	0.818
3.000	0.704

Std Err of LS Mean = 0.266

Least square means for TRTS :

Group	**Mean**
1.000	1.572
2.000	1.225
3.000	1.110E-016
4.000	0.429

Std Err of LS Mean = 0.307

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	1.572	4	5.125	0.042	Yes
1.000 vs. 4.000	1.143	3	3.726	0.086	No
1.000 vs. 2.000	0.347	2	1.131	0.455	Do Not Test
2.000 vs. 3.000	1.225	3	3.995	0.068	No
2.000 vs. 4.000	0.796	2	2.596	0.116	Do Not Test
4.000 vs. 3.000	0.429	2	1.399	0.361	Do Not Test

A result of "Do Not Test" occurs for a comparison when no significant difference is found between two means that enclose that comparison. For example, if you had four means sorted in order, and found no difference between means 4 vs. 2, then you would not test 4 vs. 3 and 3 vs. 2, but still test 4 vs. 1 and 3 vs. 1 (4 vs. 3 and 3 vs. 2 are enclosed by 4 vs. 2: 4 3 2 1). Note that not testing the enclosed means is a procedural rule, and a result of Do Not Test should be treated as if there is no significant difference between the means, even though one may appear to exist.

Two Way Analysis of Variance

Data source: Data 1 in Mine waste production 2004

General Linear Model (No Interactions)

Dependent Variable: Mean total production-square root

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	0.0749	0.0375	0.133	0.878
TRTS	3	4.661	1.554	5.507	0.037
Residual	6	1.693	0.282		
Total	11	6.428	0.584		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.878).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.037). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0502
Power of performed test with alpha = 0.0500: for TRTS : 0.596

Least square means for REPS :

Group	**Mean**
1.000	0.897
2.000	0.818
3.000	0.704

Std Err of LS Mean = 0.266

Least square means for TRTS :

Group	**Mean**
1.000	1.572
2.000	1.225
3.000	1.110E-016
4.000	0.429

Std Err of LS Mean = 0.307

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	1.572	4	5.125	0.042	Yes
1.000 vs. 4.000	1.143	3	3.726	0.086	No
1.000 vs. 2.000	0.347	2	1.131	0.455	Do Not Test
2.000 vs. 3.000	1.225	3	3.995	0.068	No
2.000 vs. 4.000	0.796	2	2.596	0.116	Do Not Test
4.000 vs. 3.000	0.429	2	1.399	0.361	Do Not Test

A result of "Do Not Test" occurs for a comparison when no significant difference is found between two means that enclose that comparison. For example, if you had four means sorted in order, and found no difference between means 4 vs. 2, then you would not test 4 vs. 3 and 3 vs. 2, but still test 4 vs. 1 and 3 vs. 1 (4 vs. 3 and 3 vs. 2 are enclosed by 4 vs. 2: 4 3 2 1). Note that not testing the enclosed means is a procedural rule, and a result of Do Not Test should be treated as if there is no significant difference between the means, even though one may appear to exist.

Table 109. Mine waste basal cover (%) Sigma Stat table 2004.

REPS	TRTS	Basal perennial grass-sq rt	Mean total basal cover-sq rt
1	1	4.77	4.77
1	2	2.92	2.92
1	3	0.00	0.00
1	4	2.45	2.45
2	1	5.00	5.00
2	2	6.26	6.26
2	3	0.00	0.00
2	4	0.00	0.00
3	1	6.56	6.56
3	2	3.81	3.81
3	3	0.00	0.00
3	4	0.00	0.00

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Mine Waste Cover 2004

General Linear Model (No Interactions)

Dependent Variable: Basal Perennial Grass-square root

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	0.178	0.0892	0.0456	0.956
TRTS	3	63.006	21.002	10.742	0.008
Residual	6	11.731	1.955		
Total	11	74.916	6.811		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.956).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.008). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0502
Power of performed test with alpha = 0.0500: for TRTS : 0.913

Least square means for REPS :

Group	**Mean**
1.000	2.534
2.000	2.816
3.000	2.591

Std Err of LS Mean = 0.699

Least square means for TRTS :

Group	**Mean**
1.000	5.442
2.000	4.329
3.000	1.110E-016
4.000	0.816

Std Err of LS Mean = 0.807

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	5.442	4	6.742	0.012	Yes
1.000 vs. 4.000	4.626	3	5.730	0.016	Yes
1.000 vs. 2.000	1.113	2	1.379	0.367	No
2.000 vs. 3.000	4.329	3	5.363	0.021	Yes
2.000 vs. 4.000	3.513	2	4.352	0.022	Yes
4.000 vs. 3.000	0.816	2	1.011	0.502	No

Two Way Analysis of Variance

Data source: Data 1 in Mine waste cover 2004

General Linear Model (No Interactions)

Dependent Variable: Mean total basal cover-sqrt

Normality Test: Passed ($P > 0.050$)

Equal Variance Test: Passed ($P = 1.000$)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	0.178	0.0892	0.0456	0.956
TRTS	3	63.006	21.002	10.742	0.008
Residual	6	11.731	1.955		
Total	11	74.916	6.811		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference ($P = 0.956$).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference ($P = 0.008$). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0502
Power of performed test with alpha = 0.0500: for TRTS : 0.913

Least square means for REPS :

Group	**Mean**
1.000	2.534
2.000	2.816
3.000	2.591

Std Err of LS Mean = 0.699

Least square means for TRTS :

Group	**Mean**
1.000	5.442
2.000	4.329
3.000	1.110E-016
4.000	0.816

Std Err of LS Mean = 0.807

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	5.442	4	6.742	0.012	Yes
1.000 vs. 4.000	4.626	3	5.730	0.016	Yes
1.000 vs. 2.000	1.113	2	1.379	0.367	No
2.000 vs. 3.000	4.329	3	5.363	0.021	Yes
2.000 vs. 4.000	3.513	2	4.352	0.022	Yes
4.000 vs. 3.000	0.816	2	1.011	0.502	No

Table 110. Mine waste canopy cover (%) Sigma Stat table 2004.

REPS	TRTS	Canopy perennial grass-sq rt	Mean total canopy cover-sq rt
1	1	4.77	4.77
1	2	2.92	2.92
1	3	0.00	0.00
1	4	2.69	2.69
2	1	4.53	4.53
2	2	6.36	6.36
2	3	0.00	0.00
2	4	0.00	1.94
3	1	6.56	6.56
3	2	2.74	2.74
3	3	0.00	0.00
3	4	0.00	0.00

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Mine Waste Cover 2004

General Linear Model (No Interactions)

Dependent Variable: Canopy Perennial Grass-square root

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	0.332	0.166	0.0650	0.938
TRTS	3	56.499	18.833	7.378	0.019
Residual	6	15.315	2.553		
Total	11	72.146	6.559		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.938).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.019). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0502
Power of performed test with alpha = 0.0500: for TRTS : 0.756

Least square means for REPS :

Group	**Mean**
1.000	2.594
2.000	2.723
3.000	2.324

Std Err of LS Mean = 0.799

Least square means for TRTS :

Group	Mean
1.000	5.285
2.000	4.006
3.000	-2.220E-016
4.000	0.898

Std Err of LS Mean = 0.922

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	Diff of Means	p	q	P	P<0.050
1.000 vs. 3.000	5.285	4	5.729	0.026	Yes
1.000 vs. 4.000	4.387	3	4.756	0.035	Yes
1.000 vs. 2.000	1.279	2	1.386	0.365	No
2.000 vs. 3.000	4.006	3	4.343	0.050	Yes
2.000 vs. 4.000	3.108	2	3.370	0.055	No
4.000 vs. 3.000	0.898	2	0.973	0.517	No

Two Way Analysis of Variance

Data source: Data 1 in Mine waste cover 2004

General Linear Model (No Interactions)

Dependent Variable: Mean total canopy cover-square root

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	1.638	0.819	0.377	0.701
TRTS	3	51.048	17.016	7.833	0.017
Residual	6	13.033	2.172		
Total	11	65.719	5.974		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.701).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.017). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0502
Power of performed test with alpha = 0.0500: for TRTS : 0.786

Least square means for REPS :

Group	**Mean**
1.000	2.594
2.000	3.207
3.000	2.324

Std Err of LS Mean = 0.737

Least square means for TRTS :

Group	**Mean**
1.000	5.285
2.000	4.006
3.000	2.220E-016
4.000	1.543

Std Err of LS Mean = 0.851

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
1.000 vs. 3.000	5.285	4	6.211	0.018	Yes
1.000 vs. 4.000	3.742	3	4.397	0.048	Yes
1.000 vs. 2.000	1.279	2	1.503	0.329	No
2.000 vs. 3.000	4.006	3	4.708	0.037	Yes
2.000 vs. 4.000	2.463	2	2.894	0.087	No
4.000 vs. 3.000	1.543	2	1.813	0.247	No

Table 111. Mine waste ground cover (%) Sigma Stat table 2004.

REPS	TRTS	Ground Cover-reciprocal
1	1	0.02
1	2	0.08
1	3	0.05
1	4	0.12
2	1	0.03
2	2	0.01
2	3	0.02
2	4	0.12
3	1	0.01
3	2	0.02
3	3	0.02
3	4	0.13

The ANOVA for each data set listed above are presented in sequence in the following pages.

Two Way Analysis of Variance

Data source: Data 1 in Mine Waste Cover 2004

General Linear Model (No Interactions)

Dependent Variable: Ground Cover-reciprocal

Normality Test: Passed (P > 0.050)

Equal Variance Test: Passed (P = 1.000)

Source of Variation	**DF**	**SS**	**MS**	**F**	**P**
REPS	2	0.00860	0.00430	0.581	0.588
TRTS	3	0.270	0.0899	12.141	0.006
Residual	6	0.0444	0.00741		
Total	11	0.323	0.0294		

The difference in the mean values among the different levels of REPS is not great enough to exclude the possibility that the difference is just due to random sampling variability after allowing for the effects of differences in TRTS. There is not a statistically significant difference (P = 0.588).

The difference in the mean values among the different levels of TRTS is greater than would be expected by chance after allowing for effects of differences in REPS. There is a statistically significant difference (P = 0.006). To isolate which group(s) differ from the others use a multiple comparison procedure.

Power of performed test with alpha = 0.0500: for REPS : 0.0502
Power of performed test with alpha = 0.0500: for TRTS : 0.945

Least square means for REPS :

Group	**Mean**
1.000	0.175
2.000	0.218
3.000	0.239

Std Err of LS Mean = 0.0430

Least square means for TRTS :

Group	**Mean**
1.000	0.0387
2.000	0.0919
3.000	0.400
4.000	0.313

Std Err of LS Mean = 0.0497

All Pairwise Multiple Comparison Procedures (Student-Newman-Keuls Method) :

Comparisons for factor: **TRTS**

Comparison	**Diff of Means**	**p**	**q**	**P**	**P<0.050**
3.000 vs. 1.000	0.361	4	7.271	0.009	Yes
3.000 vs. 2.000	0.308	3	6.200	0.011	Yes
3.000 vs. 4.000	0.0874	2	1.758	0.260	No
4.000 vs. 1.000	0.274	3	5.514	0.019	Yes
4.000 vs. 2.000	0.221	2	4.442	0.020	Yes
2.000 vs. 1.000	0.0532	2	1.071	0.478	No