Silver Dollar Growth Media Demonstration Plots
Final Report

Nick Zilka, Idaho Department of Environmental Quality
John Lawson, Idaho Department of Environmental Quality
Steven McGeehan, University of Idaho
January 2008

TABLE OF CONTENTS

SUMMARY

The IDEQ initiated a study to identify alternative approaches for reclamation and revegetation of waste rock piles in the Coeur d'Alene Mining District. A series of demonstration plots was installed during October 2002 at the Silver Dollar Mine site, located near Osburn, Idaho. The plots were evaluated for revegetation success, nutrient runoff, and soil stabilization during the first four field seasons with the results summarized in annual reports (McGeehan et al., 2003, 2004, 2005, and 2006). This report summarizes plot evaluations conducted during the fifth field season, April – September 2007, and also serves as the final report for the five-year project. A discussion of specific findings may be found in the following text. A summary of findings includes:

- Each treatment was successful in establishing plant cover during Year 1 and sustaining plant growth throughout the five-year study.
- Significant improvements in soil fertility parameters and physical properties were observed in each plot.
- Plant cover varied considerably among the treatments, ranging from 30% to 77% during Year 1; however, by Year 3, most plots exhibited at least 70% cover and this was maintained through Year 5.
- Plant density also varied considerably, ranging from 145 to 327 plants/m^2. Density increased significantly in most cases between Years 2 and 3, tended to peak in Year 4, and often declined in Year 5.
- The species distribution within most plots changed over time:
    - Wheatgrass dominated many plots during Years 1 and 2 but a more equal distribution between wheatgrass, bromes, fescues, and bluegrass was observed during Years 3-5.
    - The remaining plots exhibited a greater balance between grasses and forbs; these plots exhibited increases in yarrow, white clover, and cicer milkvetch over time.
- The incidence of invasive weeds was significant on several plots; the most frequently encountered species included black medic, yellow sweet clover, and knapweed.
- The fertility status of the amendment had a strong impact on species distribution and unseeded vegetation:
    - High fertility amendments promoted a grass dominated/low forb profile with a low incidence of unseeded vegetation.
    - Low fertility amendments promoted a more diverse grass-forb mixture with a higher incidence of unseeded vegetation.
- Available soil nitrogen levels ranged from <20 to >2500 lb/ac during Year 1 of the study and decreased to below 50 lb/ac in all plots by Year 5.
- Nitrogen and phosphorus concentrations in the surface runoff were initially very high in several plots but decreased significantly by Year 5; however, P concentrations exceeded EPA criteria for surface water quality in several early samplings.

METHODS

Site Description

The Silver Dollar Mine site is located west of Osburn, Idaho (47^{o} 30.22' N; 115^{o} 59.39' W). The site is dominated by a waste rock pile produced during mine development and sorted from the ore during the mining process (Figure 1). Milling and smelting activities took place off-site so heavy metal concentrations are a minor issue (relative to low fertility) for plant growth. The waste rock pile rests on a north-facing slope at an elevation of about 2500 feet. Average total monthly precipitation ranges from 1.5 inches in July to 4.5 inches in November, with a total annual precipitation of 38 inches. Average monthly temperatures are 32.9/21.3 ^{o}F (max/min) in January and 78.6/47.2 ^{o}F in August.

Figure 1. Waste rock pile at the Silver Dollar Mine site prior to start of project (date: May 2002).

Site Preparation/Plot Installation

The site was regraded using a Cat D5 Dozer and ten plots (20' X 100') were installed with a berm (3' X 2') separating each plot (Figure 2A). Nelson Construction of Boise, ID completed all earth-moving activities. The western- and eastern-most plots were reserved for controls; the remaining plots were assigned to participants on a random basis. Project participants were solicited and selected by IDEQ (Table 1).

Table 1. Silver Dollar demonstration project participants.

Plot	Treatment	Affiliation	Plot	Treatment	Affiliation
A	Control (topsoil)	IDEQ	F	Glacier Gold Compost	Glacier Gold, LLC
B	Biosolid + Woodash I	Coeur d'Alene Wastewater Treatment Plant	G	Biosol	Rocky Mountain Bio Products
C	Potlatch Log Yard Waste	Potlatch Corp. St. Maries, ID	H	Glacier Gold Log Yard Waste	Glacier Gold, LLC
D	Kiwi Power	Quattro Environmental, Inc.	I	Biosolid + Woodash II	Coeur d'Alene Wastewater Treatment Plant
E	Eko Compost	Eko Compost	J	Control (fertilizer)	IDEQ

Installation of the plots began September 25, 2002 and concluded October 23, 2002 (Figure 2B). A complete description of amendment materials, rates, and installation methods is included in the Individual Plot section of this report. Each plot was seeded, either by hand or by hydroseeding, using a standardized seed mix (Table 2). Following plot installation, the lower access road was closed using an earthen berm and a barbed wire fence was installed around the perimeter of the site. None of the participants conducted additional work, modification, or maintenance on their plots following the initial installation work was completed. However, Nick Zilka (IDEQ) reseeded Plot C (St. Maries Log Yard Waste) in August 2003. This was necessary due to a complete failure of germination and growth on this plot during Year 1. In addition, the plots were periodically spot-treated with herbicide by Zilka and McGeehan to control knapweed.

Figure 2. Site of demonstration plots (A) following site preparation (date: September 2002) and (B) following addition of amendments (date: October 2002).

Table 2. Seed mix used on the Silver Dollar Demonstration Plots.

Common Name	Scientific Name	Amount/Acre	Pct by wt.	Min. pct.
Slender wheatgrass	*Elymus trachycaulus* ssp. *Trachycaulus* var. Revenue	14 lbs	22.3	21.9
Idaho fescue	*Festuca idahoensis* var. Joseph	8 lbs. 7 oz	13.4	13.2
Sheep fescue	*Festuca ovina* var. Covar	7 lbs	11.1	10.9
Mountain brome	*Bromus marginatus* var. Bromar	7 lbs. 11 oz	12.2	12.0
Meadow brome	*Bromus biebersteinii* var. Paddock	8 lbs. 7 oz	13.4	13.2
White Yarrow	*Achillea millefolium*	11 oz	1.1	1.1
Blue flax	*Linum lewisii* var. Appar	4 lbs. 3 oz	6.7	6.6
Rocky Mountain penstemon	*Penstemon strictus*	1 lb. 6 oz	2.2	2.2
White dutch clover	*Trifolium repens* L.	8 oz	0.8	0.8
Canada bluegrass	*Poa compressa*	11 oz	1.1	1.1
Big bluegrass	*Poa ampla* var. Sherman	1 lb. 7 oz	2.3	2.3
Canby bluegrass	*Poa canbyi* var. Canbar	1 lb. 6 oz	2.2	2.2
Cicer milkvetch	*Astragalus cicer*	7 lbs.	11.1	10.9
Fireweed	*Epilobium angustifolia*	1 oz	0.1	0.1
Weed seed				0.5 (Max)
Inert and other crop				1.5 (Max)

Vegetation Assessment

Steven McGeehan (UI) inspected the plots on a monthly basis during each field season, beginning in April and concluding in August. The early season assessments (April, May, and June) visually estimated plant coverage and overall condition of the plot. In addition, a qualitative assessment of leaf color was made as this can provide clues to nutrient sufficiency/deficiency and plant stress due to diseases and pests. Uniformity of coverage was also noted for each plot. Detailed field notes and montly plot assessments are included in the Individual Plots section of this report.

Quantitative determination of revegetation success was conducted each July using Bureau of Land Management standard methods (Elzinga et al., 1998). Percent coverage was measured using a cover-point optical projection scope[1]. This instrument projects an extremely fine point from which the observer can precisely determine a hit or miss of vegetation. The cover-point scope eliminates much of the bias associated with the conventional line-transect method. In this study, 100 points were recorded at 1-m intervals along a randomly located transect within each plot. Each point identified an individual plant, rock, bare soil, or litter.

Plant density (plants/m^2) was also determined for each plot within one week of the coverage measurements. Density was evaluated at two sampling areas per plot, 10 m in from the bottom and top of the plot. The exact location of the sampling area was randomly selected - the observer faced away from the plot and tossed a 1-m^2 PVC hoop over their head into the plot. Each individual plant within the hoop was tallied and identified, including plants that were not a component of the original seed mix. The mean value of the replicate density assessments is reported in the following figures and tables. All plant identifications were made by Jill Blake (Consulting Botanist) at the time of the coverage and density measurements.

Assessment of Erosion, Runoff, and Soil Properties

Erosion traps, consisting of a 10' X 20' pit, were installed at the toe of each plot (Figure 3). The traps were covered with landscape fabric to allow water infiltration while collecting eroded soil. Erosion was visually estimated on a monthly basis by examining the solid material accumulated in the traps. The presence and approximate size of rills within each plot was also noted. Runoff flumes were also installed at the bottom of each plot (Figure 3). The flumes were constructed using PVC rain gutters (4" X 2.5" X 10') fitted with a perforated leaf guard and covered with landscape fabric. The ends of the flume were capped and one end was fitted with a drain hose leading to a 4-L plastic bottle (Figure 3). Each flume was placed into a trench dug at the bottom of the plot (1-2' above the erosion trap). The flumes were situated in the trench such that the tops were continuous with the soil surface and slope of each plot.

Surface runoff was collected monthly, coinciding with a significant rain event, and analyzed for ammonia-N, nitrate-N, and orthophosphate using EPA Methods 350.1, 353.2, and 365.2, respectively (EPA 1982, 1883). Pre-project control soil surface samples were collected and analyzed prior to regrading the site; these results were reported in the Project Workplan (Johnson, 2002). Duplicate soil samples were also collected from the control plots following regrading but prior to addition of plot amendments; these results are reported as the Unamended Control in the following figures and tables. At the end of the Year 1, 3, and 5 field seasons, a composite (3x) soil sample was collected from the 0-10 cm depth of each plot. The complete schedule of plot assessment activities is summarized in Table 3. Soil fertility parameters (ammonia-N, nitrate-N, available P and K, pH, and EC) and physical properties (percent sand, silt, clay, coarse fragments, and textural class) were determined using standard

[1] ESCO Associates. Cover-point optical projection device, Operation Manual – Models 4 and 5.

methods (Miller et al., 1997). Organic matter content was determined by colorimetry (Sims and Haby, 1971). Total recoverable metals were determined using EPA Method 3050B/6010 (EPA, 1986A). All laboratory work was conducted at the University of Idaho Analytical Sciences Laboratory. Standard quality assurance/quality control protocols were followed for all analytical work (ASL, 2003).

Cost Evaluation

Information for the cost evaluation was received from the vendors, subcontractors working at the site, and vendor invoices. This invoice was collected and compiled by Kathy Lombardi and Carl Johnson (SAIC) and submitted to Nick Zilka (IDEQ) via a Technical Memorandum dated February 5, 2004. Technical Memorandum included both 'actual' and 'normalized' costs, the latter reflecting adjustments to allow a more equitable comparison of alternative costs.

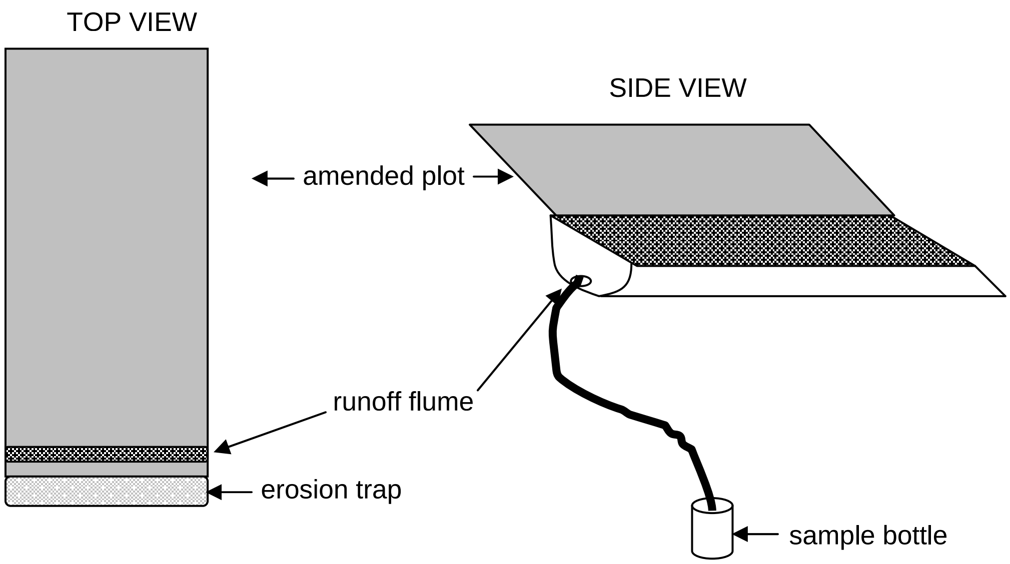


Figure 3. Schematic design of runoff flume and erosion trap (not to scale).

Table 3. Annual schedule for plot assessment activities.

	2003	2004	2005	2006	2007
Monthly Plot Assessment	X	X	X	X	X
Erosion Assessment	X	X	X	X	X
Coverage Assessment	X	X	X	X	X
Density Assessment	X	X	X	X	X
Runoff Assessment	X		X		X

RESULTS

Soil and Amendment Properties and Surface Runoff

Following site preparation but prior to amendment application, the site surface material was a mixture of waste rock and fine material. The unamended control (Table 4 and Figure 4) exhibits properties endemic to the Silver Dollar site: an alkaline, sandy growth media with a high percentage of coarse (> 2 mm) fragments and low native fertility. The alkaline pH is typical of soils derived from the dolomitic and calcareous quartizite parent materials present in the Wallace Formation, which is penetrated by the Silver Dollar workings.

Texture analysis indicated a very cobbley sandy loam with 58% coarse fragments (Table 4). The electrical conductivity (EC) of the unamended control was 0.35 dS/m, which is well below the critical level at which salinity can limit performance of agronomic crops (typically 2-4 dS/m). The highest EC values were observed on the Biosolids and Potlatch Log Yard Waste Plots (Table 4). This is due to the addition of woodash or urea fertilizer, respectively. Despite these higher EC values, none of these plots exhibited any indication of a salinity problem.

The total recoverable metals profile of the amended soils did not differ appreciably from the unamended control (Table 5). The primary differences observed were elevated levels of Ca, K, and Na in the Biosolid/Wood Ash plots, no doubt due to the presence of alkaline earth oxides in wood ash. Elevated total phosphorus concentrations were exhibited by the Biosolids, Potlatch Log Yard Waste, Eko Compost, and Glacier Gold Compost plots. Given that the milling and smelting activities are known to have taken place off-site, the lack of elevated metal concentrations is not surprising. Thus, the chemical and physical data summarized in Tables 4 and 5 clearly indicate that low soil fertility is the primary factor limiting sustainable plant growth at this site, with a secondary factor being low water holding capacity.

Most of the amendments decreased the plot pH relative to the initial value of 8.3 (Figure 4A). The pH of the amended plots ranged from 6.3 to 8.3 with the 1:1 woodash/biosolid mixture exhibiting the highest pH. Overall, the pH was relatively consistent among the amended plots throughout the study period. The organic matter content varied from ~1% in the controls and liquid-based amendments to 15-34% in the solid-based amendments (Figure 4B).
Each of the plot treatments significantly increased the available P and K content, with the extent of increase being strongly dependent on the nature of the amendment (Figures 4C,D). Available P values ranged from <2 to >600 ug/g while available K ranged from 80 to 1000 ug/g. To put these numbers into perspective, available P and K levels in excess of 8 and 100 ug/g, respectively, are considered sufficient for non-irrigated legume and legume-grass pastures in northern Idaho (Mahler, 2005). Thus, each of the amended plots contained adequate to excessive P and K relative to typical plant requirements. The ammonia-N level in the unamended soil-waste rock was 1.8 ug/g while the amended plots exhibited concentrations ranging from <1 to >600 ug/g (Figure 4E). Similarly, nitrate-N was initially low and varied significantly among the amended plots, ranging from <2 to >60 ug/g (Figure 4F).

Erosion was minimal to non-existent during the study. A minor amount (< 5 kg) of sediment was observed in the traps of the Kiwi Power, Eko Compost and Glacier Gold Compost plots during Year 1 and rills (3-5” wide X 1-3” deep) were present in bottom half of these plots. In addition, large rills (8-12” X 4-6” were present on upper-half of the Control Fertilizer plot. This plot was designed with sporadic berms, which trapped the eroded sediment within the plot and no sediment was found in the trap at the bottom of the plot. No additional evidence of erosion was observed during Years 2-5.

Table 4. Electrical conductivity and particle size distribution for the unamended control and each amended demonstration plot.

	Electrical Conductivity (dS/m)	Particle Size Sand (%)	Clay (%)	Silt (%)	U.S.D.A Texture	Coarse Fragments (% >2mm)
Control (unamended)	0.35	66	16	18	Sandy Loam	58
Control (topsoil)	0.24	46.4	9.6	44.0	Loam	59
Biosolid + Woodash I	3.8	72.4	7.6	20.0	Sandy Loam	35
Potlatch Log Yard Waste + Urea Fertilizer	3.4	52.4	7.6	40.0	Sandy Loam	38
Kiwi Power	0.78	70.4	11.6	18.0	Sandy Loam	57
Eko Compost	1.3	56.4	7.6	36.0	Sandy Loam	34
Glacier Gold Compost	0.31	66.4	9.6	24.0	Sandy Loam	51
Biosol	1.6	60.4	15.6	24.0	Sandy Loam	57
Glacier Gold Log Yard Waste	0.54	64.4	9.6	26.0	Sandy Loam	33
Biosolid + Woodash II	2.2	62.4	5.6	32.0	Sandy Loam	19
Control (fertilizer)	0.80	66.4	13.6	20.0	Sandy Loam	68

As would be expected, runoff nitrogen and phosphorus concentrations closely reflected the available nutrient contents of each amendment (compare Figure 5 to Figures 4C,E,F). Both controls exhibited low runoff concentrations of ammonium-N, nitrate-N, and orthophosphate as did the Biosol and Glacier Gold Log Yard Waste Plots. Intermediate runoff concentrations were observed in the Kiwi Power, Eko Compost, and Glacier Gold Compost plots. The highest runoff ammonia- and nitrate-N concentrations (5.3 and 34 mg/L, respectively) were observed in the Potlatch Log Yard Waste (Figures 5A,B). This is undoubtedly due to the very high rate of urea fertilizer (10% v/v) mixed into the log yard waste by the vendor. Significant N runoff was also observed in the Eko Compost and Biosolids + Woodash II plots. Despite having very high available N (~2500 lb/ac), runoff ammonia- and nitrate-N concentrations were low in the Biosolids + Woodash I plot.

A wide range of runoff orthophosphate concentrations were observed which, like the nitrogen results, correlated with the available nutrient content of the amendment (Figures 4C and 5C). The highest runoff P values were observed in the Eko Compost, Glacier Gold Compost, and Biosolid II plots, where concentrations ranged from 1 to as high as 3 mg/L for the much of the study. Although critical levels for phosphorus in surface runoff from agricultural fields have not been established, the USEPA recommends a limit of 0.05 mg/L total phosphorus in streams that enter lakes and 0.1 mg/L total phosphorus in flowing streams (EPA, 1986B). Regulatory criteria for ammonia and nitrate have not been promulgated by the USEPA, due in part to the fact that surface waters are typically considered ‘P-limiting’ with respect to eutrophication. Despite the lack of formal regulations, both nitrogen and phosphorus continue to be recognized as important nonpoint pollutants of surface waters (Carpenter et al., 1998) and should be carefully managed in revegetation projects utilizing biosolids, composts, and other high nutrient materials.

Available soil nitrogen levels ranged from <20 to >2500 lb/ac during Year 1 of the study and decreased significantly between 2003 and 2005 (Figure 6). The greatest decline in available N was observed in plots with the highest initial levels, including the Biosolids, Potlatch Log Yard Waste, and Eko Compost plots. Potential fates of available N include leaching, plant uptake, and volatilization. It is clear that a significant fraction of available N was lost via surface runoff and this was most significant in the biosolids and urea-amended log yard waste, particularly during the first year (Figures 5A,B). The high available N associated with these plots also supported very heavy vegetative growth, primarily of perennial grasses which exhibit high uptake rates and N sequestration (Sullivan et al., 1997; Miller et al., 2001). However, given the magnitude of declines observed, it is likely that ammonia volatilization played the most significant role in decreased available N. Large and rapid loss of N is commonly observed in surface-applied biosolids with volatilization rates exceeding 50% of total N (Robinson et al., 2002; Robinson and Roper, 2003, Mendoza et al., 2006). This mechanism was further enhanced by the high pH levels of the demonstration plots, particularly in the wood ash amended biosolids. Although volatilization represents a major loss of available N, it also greatly decreases the risk of nitrogen leaching from nutrient rich amendments used in revegetation projects.

Table 5. Total recoverable metals[1] for the unamended control and each amended demonstration plot.

		As	Ba	Be	Ca	Cd	Co	Cr	Cu	Fe	K	Mg	Mn	Mo	Na	Ni	P	Pb	S	Zn
		ug/g																		
	Control (unamended)	59	220	<0.38	20000	0.08	15	13	81	20000	1400	7500	1400	<3.8	<150	16	370	100	1400	170
Plot A	Control (topsoil)	16	240	1.1	5500	<0.75	13	54	25	27000	3900	8500	830	<3.8	<150	32	850	19	540	91
Plot B	Biosolid + Woodash I	34	850	0.70	59000	2.8	11	58	130	16000	7100	10000	2200	<3.8	1800	45	15000	34	2300	470
Plot C	Potlatch Log Yard Waste	12	310	0.44	15000	<0.75	11	71	33	22000	3700	4200	930	<3.8	420	43	1100	22	630	110
Plot D	Kiwi Power	46	230	0.63	36000	<0.75	18	35	140	29000	1700	15000	2400	4.6	<150	32	440	26	1600	74
Plot E	Eko Compost	22	260	0.43	23000	0.75	13	63	110	22000	3300	7000	1400	4.6	64	41	3600	37	2900	190
Plot F	Glacier Gold Compost	33	400	0.49	20000	<0.75	8.8	74	130	17000	2200	6600	1500	<3.8	<150	41	2700	29	1600	110
Plot G	Biosol	47	480	0.63	24000	<0.75	12	66	96	23000	2300	8400	2000	<3.8	<150	39	460	80	1800	150
Plot H	Glacier Gold Log Yard Waste	23	240	0.49	16000	<0.75	7.3	62	35	16000	2500	8100	1100	<3.8	<150	36	760	16	900	78
Plot I	Biosolid + Woodash II	36	940	0.67	74000	3.3	11	140	110	19000	11000	10000	2900	<3.8	2900	83	12000	34	2000	530
Plot J	Control (fertilizer)	62	350	0.64	21000	3.7	11	46	86	22000	2200	8200	1300	<3.8	690	31	490	99	2000	920

[1] EPA Method 3050

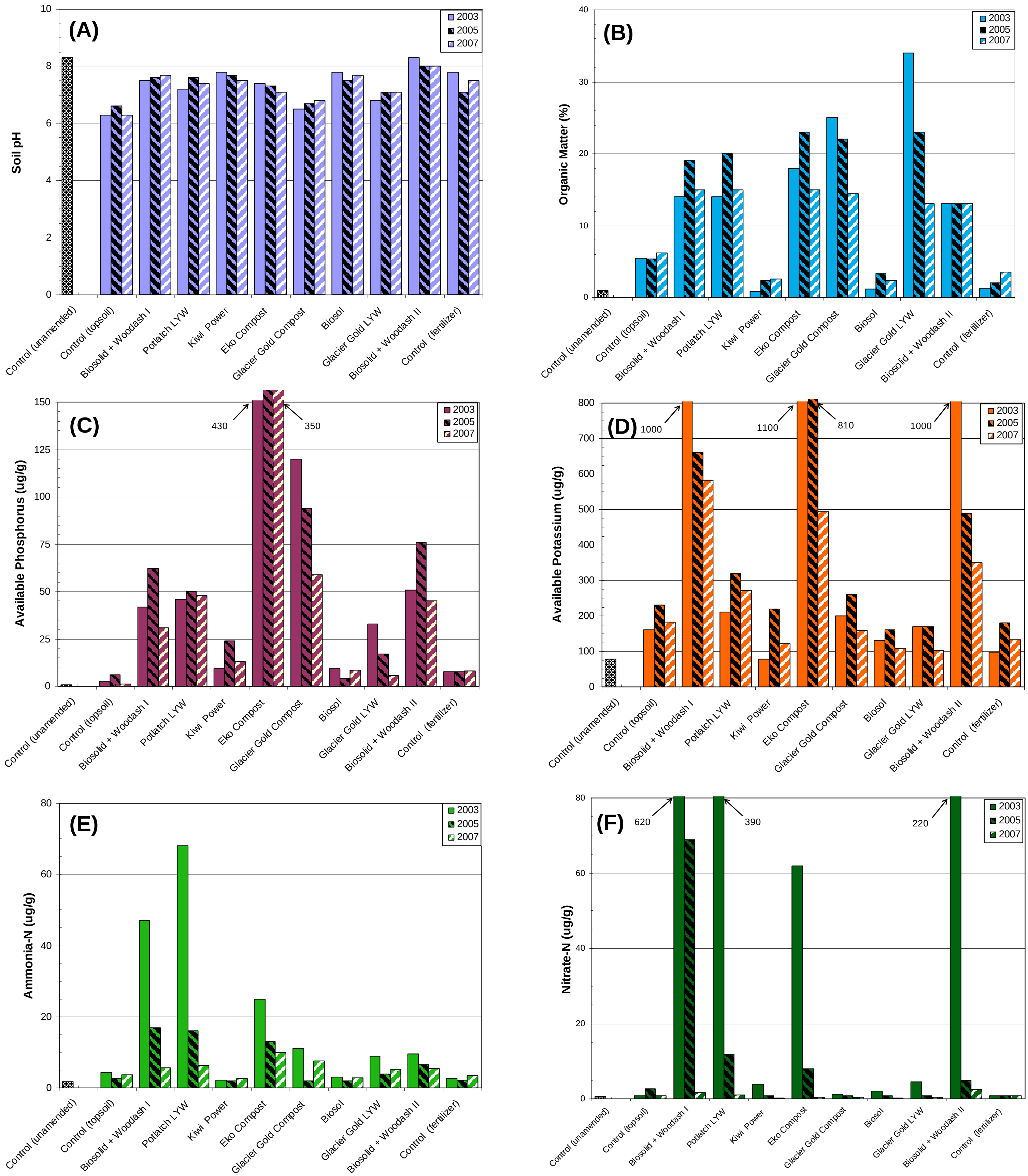


Figure 4. Soil parameters in 2003, 2005, and 2007: (A) soil pH, (B) organic matter, (C) available potassium, (D) available phosphorus, (E) ammonia-N, and (F) nitrate-N.

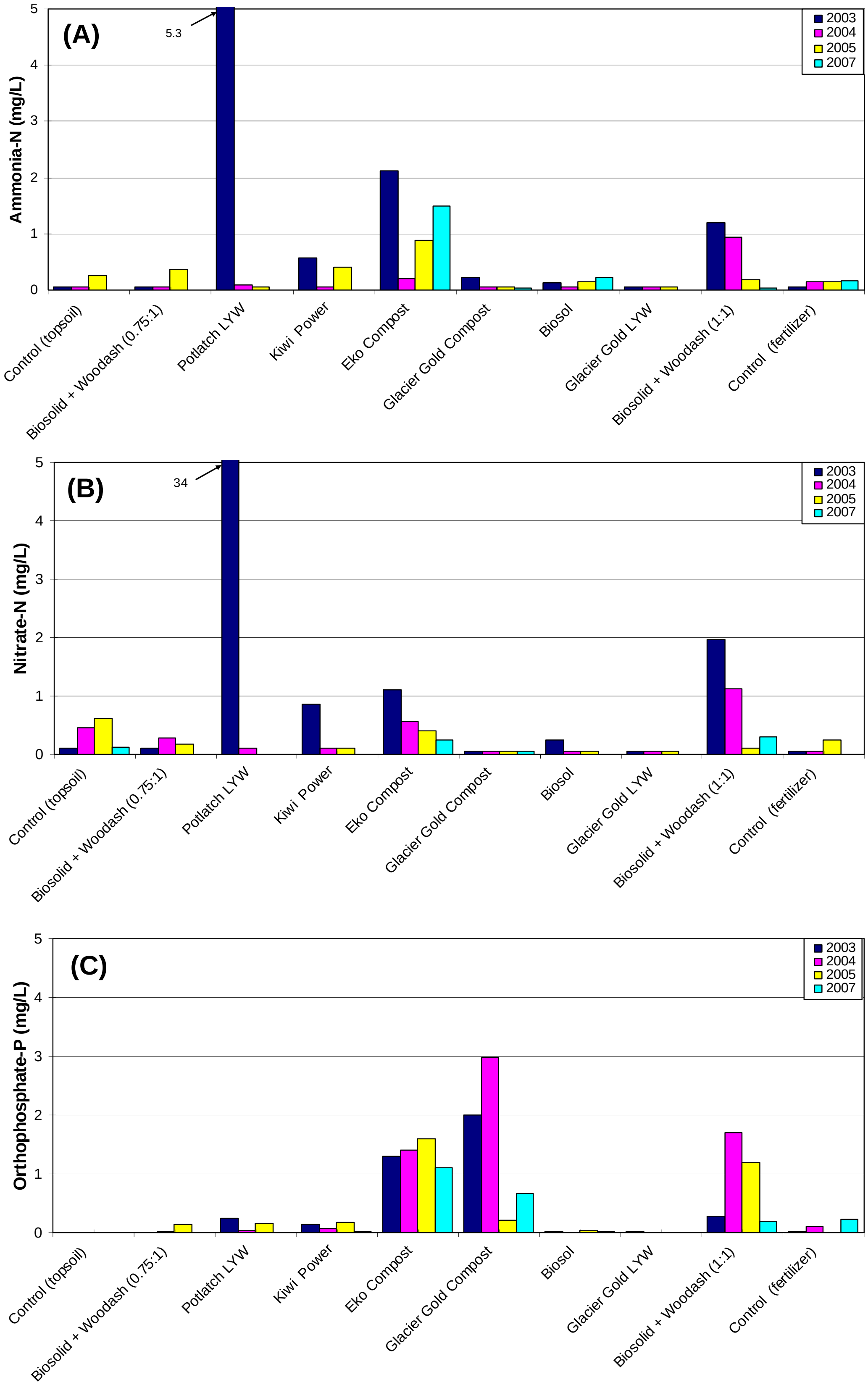


Figure 5. Mean seasonal runoff concentrations of (A) ammonia-N, (B) nitrate-N, and (C) orthophosphate-P in 2003, 2004, 2005, and 2007. Data represent three-month averages (April, May, June) for each year.

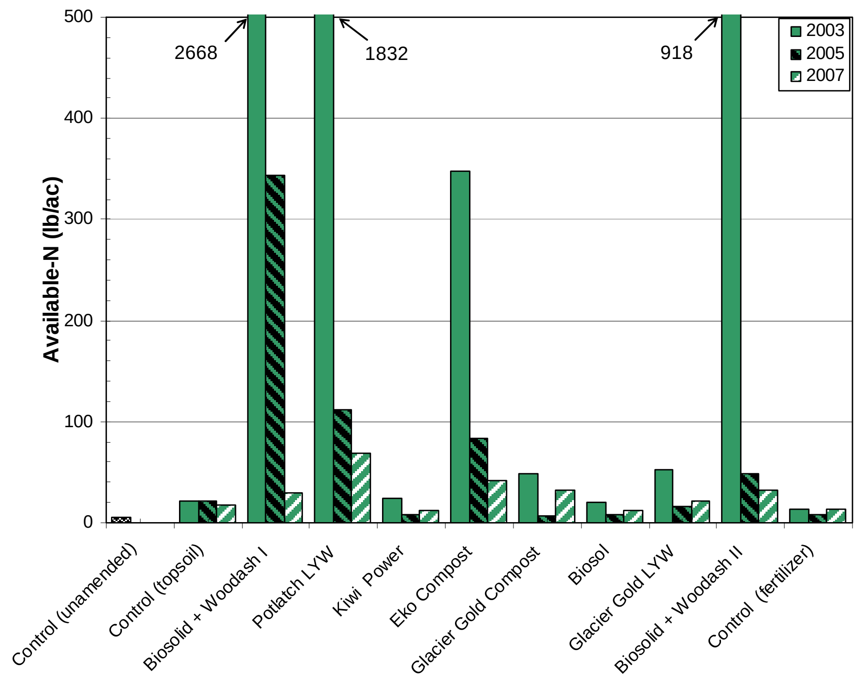


Figure 6. Available soil N in 2003, 2005, and 2007.

The addition of the various amendments had differing impacts on the soil profile of each plot (Table 6). It should be noted that a true pedogenic soil profile takes hundreds to thousands of years to form. Thus, it is somewhat of a stretch to describe the profile of each plot using standard soils terminology. None-the-less, the amendments did alter the surface properties of each plot in ways that will have lasting impacts on the sustainability of a plant cover. For example, the addition of roughly 20 yd^3 of biosolids, compost, or log yard waste resulted in an overburden depth of 4-6 in. This overburden tended to be dark in color with a very friable (easily crumbled) texture. Such characteristics are associated with highly productive and fertile topsoil and, hence, these plots supported very good plant growth resulting in the presence of profuse fine roots in the overburden. Since the organic materials were spread but not incorporated, there was an abrupt boundary between the overburden and underlying waste rock, with very few roots penetrating this boundary. Also, the physical condition of the overburden improved over the course of the 5 year study. For example, the biosolids were very sticky and tended to smear when the Dozer attempted to spread this material. However, as this material dried and weathered for several years, the result was a very light material with physical properties that are ideal for plant growth. Likewise, the log yard waste and composts underwent both physical and biological weathering, resulting in a very friable material with excellent tilth and other desirable physical properties.

In contrast, the Kiwi Power, Biosol, and Fertilizer Control did not receive large quantities of organic amendments. Consequently, these plots exhibited a thin organic surface layer developed from decaying plant debris. Despite the lack of a thick, organic overburden, these plots still supported good plant growth as evidenced by the moderate root presence. It is likely that these plots will continue to build organic matter content over time and slowly develop desirable properties like water holding capacity, nutrient cycling, and physical tilth.

Table 6. Soil profile descriptions taken at the end of the 5 year study period.

Amendment	Overburden Depth (in)	Color	Texture	Structure	Roots	Notes
Control (unamended)	0	10 YR 6/3 pale brown	cobbley sandy loam	none	none	
Control (topsoil)	3	10 YR 3/3 dark brown	cobbley sandy loam	none	profuse fine	abrupt boundary covering light grey waste rock; few roots penetrating waste rock
Biosolid + Woodash I	4-5	7.5 YR 3/0 very dark grey	organic	none	profuse fine	overburden very soft and friable; slightly moist; abrupt boundary covering light grey waste rock: few roots penetrating waste rock
Potlatch Log Yard Waste	4-6	10 YR 3/3 dark brown	organic	none	profuse fine	overburden very soft and friable; slightly moist; abrupt boundary covering light grey waste rock: few roots penetrating waste rock
Kiwi Power	0	10 YR 3/3 dark brown	cobbley sandy loam	none	moderate fine	presence of thin organic surface layer (<0.5 in) consisting of slightly decomposed roots, moss, and organic debris; roots penetrating waste rock to a depth of 1-2"
Eko Compost	4	10 YR 3/2 dark greyish brown	organic	none	profuse fine	overburden very soft and friable; slightly moist; abrupt boundary covering light grey waste rock: few roots penetrating waste rock
Glacier Gold Compost	2	10 YR 4/3 brown	organic	none	profuse fine	overburden very soft and friable; slightly moist; abrupt boundary covering light grey waste rock: few roots penetrating waste rock
Biosol	0	10 YR 6/3 pale brown	cobbley sandy loam	none	moderate fine	presence of thin organic surface layer (<0.5 in) consisting of slightly decomposed roots, moss, and organic debris; roots penetrating waste rock to a depth of 1-2"
Glacier Gold Log Yard Waste	4	10 YR 3/3 dark brown	organic	none	profuse fine	overburden very soft and friable; slightly moist; abrupt boundary covering light grey waste rock: few roots penetrating waste rock
Biosolid + Woodash II	4-6	10 YR 3/1 very dark grey	organic	none	profuse fine	overburden very soft and friable; slightly moist; abrupt boundary covering light grey waste rock: few roots penetrating waste rock
Control (fertilizer)	0	10 YR 6/3 pale brown	cobbley sandy loam	none	moderate fine	presence of thin organic surface layer (<0.5 in) consisting of slightly decomposed roots, moss, and organic debris; roots penetrating waste rock to a depth of 1-2"

Vegetation Assessment
Figures 7 and 8 provide a comparison of plant coverage and plant density across all plots. Each plot has five data bars corresponding to coverage or density results for 2003, 2004, 2005, 2006, and 2007. More detailed assessment information, including the distribution of plant species, is included in the Individual Plot section of this report.

Plant Coverage
Plant coverage describes the probability of finding any plant, or a particular species, at a given point along a transect line. Coverage is expressed as a value between 0% and 100%, representing the percentage of sampling points where a plant was observed during sampling.

Each treatment was successful in promoting a self-sustaining plant cover during Year 1 and maintaining plant growth throughout the five-year study. The extent of coverage varied considerably among the treatments, ranging from 30% in the Biosol plot to 77% in the Eko Compost and Biosolids II plots (2003 data). Plant coverage increased significantly between Years 1 and 2 (Figure 7). These increases can be attributed to increased grass growth in the Biosolids, Eko Compost, and Biosol plots and increases in forb growth in the Kiwi Power, Glacier Gold Compost, and Glacier Gold Log Yard Waste plots. Slender wheatgrass and brome species were the most extensive grasses observed during Years 1 and 2 while yarrow and white dutch clover were the most frequently observed forbs. Unseeded vegetation, primarily black medic and hares foot clover, accounted for the increase in coverage observed in both control plots.

In general, the total plant coverage did not change significantly in the Silver Dollar plots from Year 3 to Year 5 (Figure 7). The majority (9 of 10 plots) maintained plant coverage in the 75 - 90% range. Three plots – Kiwi Power, Glacier Gold Compost, and Control-Fertilizer – did exhibit increased coverage and this change was due to an increase in unseeded vegetation in each case. The proportion of grasses relative to forbs was also consistent between 2005 and 2007. That is, the frequency with which of grasses were encountered remained relatively constant within a given plot. Several plots – Biosolids, Potlatch Log Yard Waste, and Eko Compost – continued to be dominated by grasses with wheatgrass, bromes, and fescues comprising at least 75% of the total plant cover. At this point, it is important to make the distinction between relatively constant total grass coverage vs. changes in the distribution of individual grass species. The coverage data of the Individual Plots (e.g. Figures 10-1A, 10-1B, 10-1C, …, 10-1J) clearly show significant changes in species distribution (i.e. the relative contents of wheatgrass vs. brome vs. fescue) occurring between 2005 and 2007.

Forb coverage was variable between Year 3 to Year 5 (Figure 7). However, in three plots (Kiwi Power, Glacier Gold Compost, and Control Fertilizer), total forb coverage declined slightly. As mentioned above, this decline was accompanied by an increase in unseeded vegetation. Substantial increases in cicer milkvetch were observed in the Glacier Gold Compost and Glacier Gold Log Yard Waste plots. Significant decreases in yarrow were observed in the Kiwi Power, Eko Compost, and Glacier Gold Compost plots. These changes can be examined in detail in the Individual Plot coverage results (e.g. Figures 10-1A, 10-1B, 10-1C, …, 10-1J).

It should be noted that the large forb coverage reported for the Glacier Gold Log Yard Waste plot in 2004 (Figure 7) was primarily due to the growth of clover. This observation was erroneously reported as white clover in 2004 but was later confirmed to be sweet clover. The significant increase in unseeded vegetation for this plot in 2005 and 2006 reflects the correct

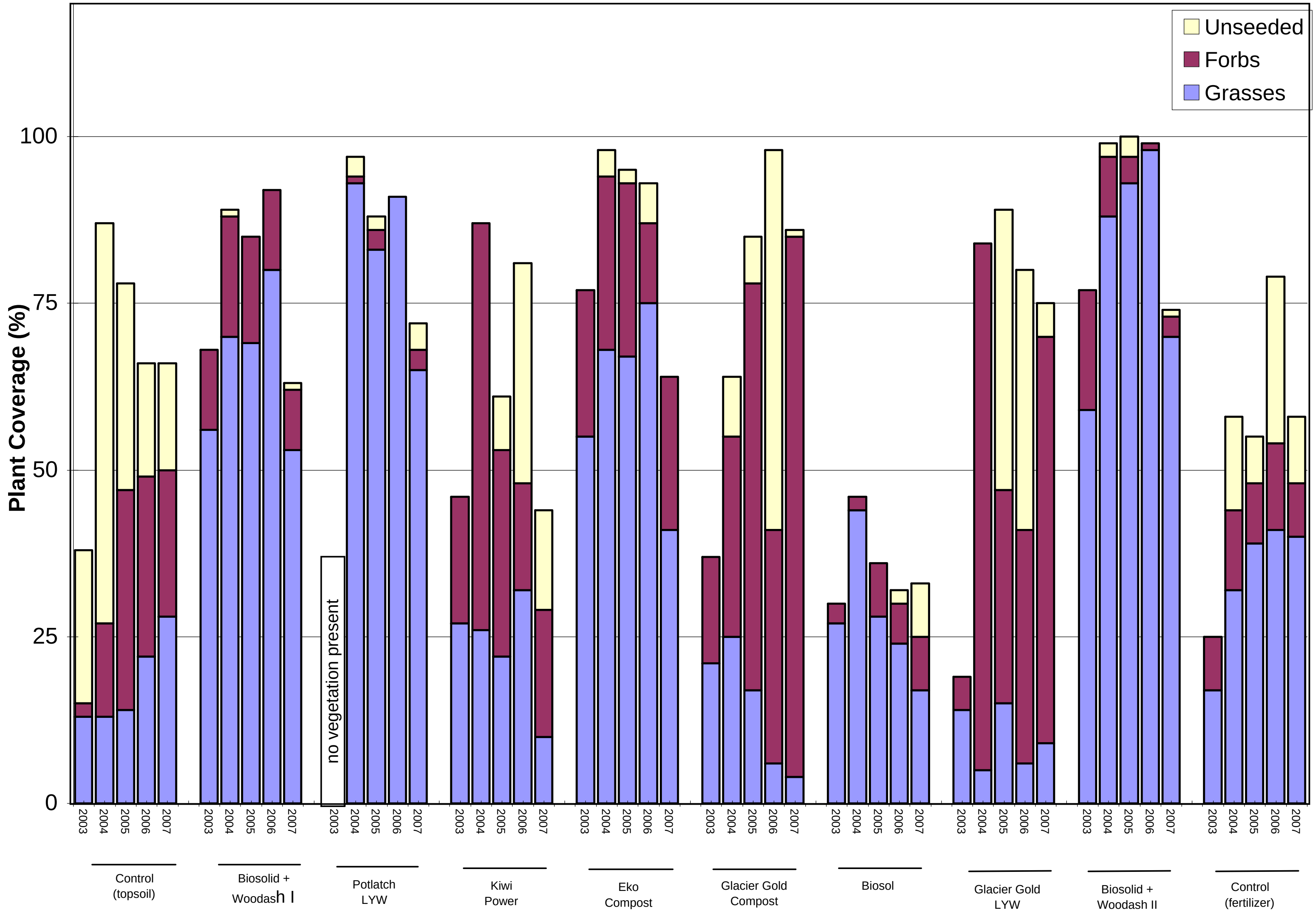


Figure 7. Plant coverage in each of the demonstration plots from 2003 to 2007.

classification of these plants as sweet clover. As Figure 7 indicates, sweet clover (plotted as unseeded vegetation) almost completely disappears in 2007, apparently being displaced by cicer milkvetch.

Plant Density

Density describes the number of individual plants observed within a specified area. A one square meter sampling area is frequently used for rangeland and vegetation restoration studies involving non-woody species. Two randomly-placed density measurements were conducted per plot and the mean of these measurements summarized in Figure 8. More detailed density data, including a listing of each species encountered, can be found in the Individual Plots section of this report.

Plant density varied considerably among the plots, ranging from 145 to 327 plants/m^2 in the Glacier Gold Compost and Biosol plots, respectively (2003 data). Plant density increased significantly between Years 2 and 3, tended to peak in Year 4, and often declined in Year 5 (Figure 8). This is in contrast to the coverage measurements which, as discussed above, increased in most plots between Years 1 and 2 and remained relatively constant in Years 3-5. The increased density was due to greater numbers of grass species (primarily Brome sp.) in the Potlatch and Eko plots. The Glacier Gold Compost, Glacier Gold Log Yard Waste, and Kiwi Power plots exhibited significant increases in unseeded vegetation, largely due to the spread of sweet clover and black medic (Table 3).

An important, and potentially misleading, aspect of the density data are the relatively low densities exhibited by both Biosolid plots as well as the Potlatch Log Yard Waste and Eko Compost plots, particularly in 2003 and 2004. While these treatments exhibit some of the lowest density values in Figure 8, these plots are not exhibiting poor performance. To the contrary, these plots exhibit very large and thriving vegetation relative to the same species growing on the other plots. As pointed out earlier, this exceptional growth is in response to high available nitrogen. It is likely that the sheer size of the vegetation is a limiting factor for density in these high fertility plots. This observation is further supported by evaluating the density data for the Topsoil Control, Kiwi Power, Biosol, and Glacier Gold plots. These plots appear to be sparsely vegetated relative to the Biosolid, Potlatch, and Eko Compost plots (see photos in the Individual Plots section of this report). This is consistent with the lower fertility growth media added to these plots. A closer examination indicates that each of these low fertility amendments is supporting large numbers of small plants (note: in some cases, the vegetation is exhibiting signs of nutrient deficiency (i.e. stunting, chlorosis, reddish leaves)). Thus, in terms of sheer numbers of plants per unit area; these plots exhibit relatively high plant densities (Figure 8). In most cases, an inverse relationship exists between plant coverage and plant density within a given plot. These observations clearly indicate that neither coverage nor density data alone can completely portray the overall quality and performance of a given plot.

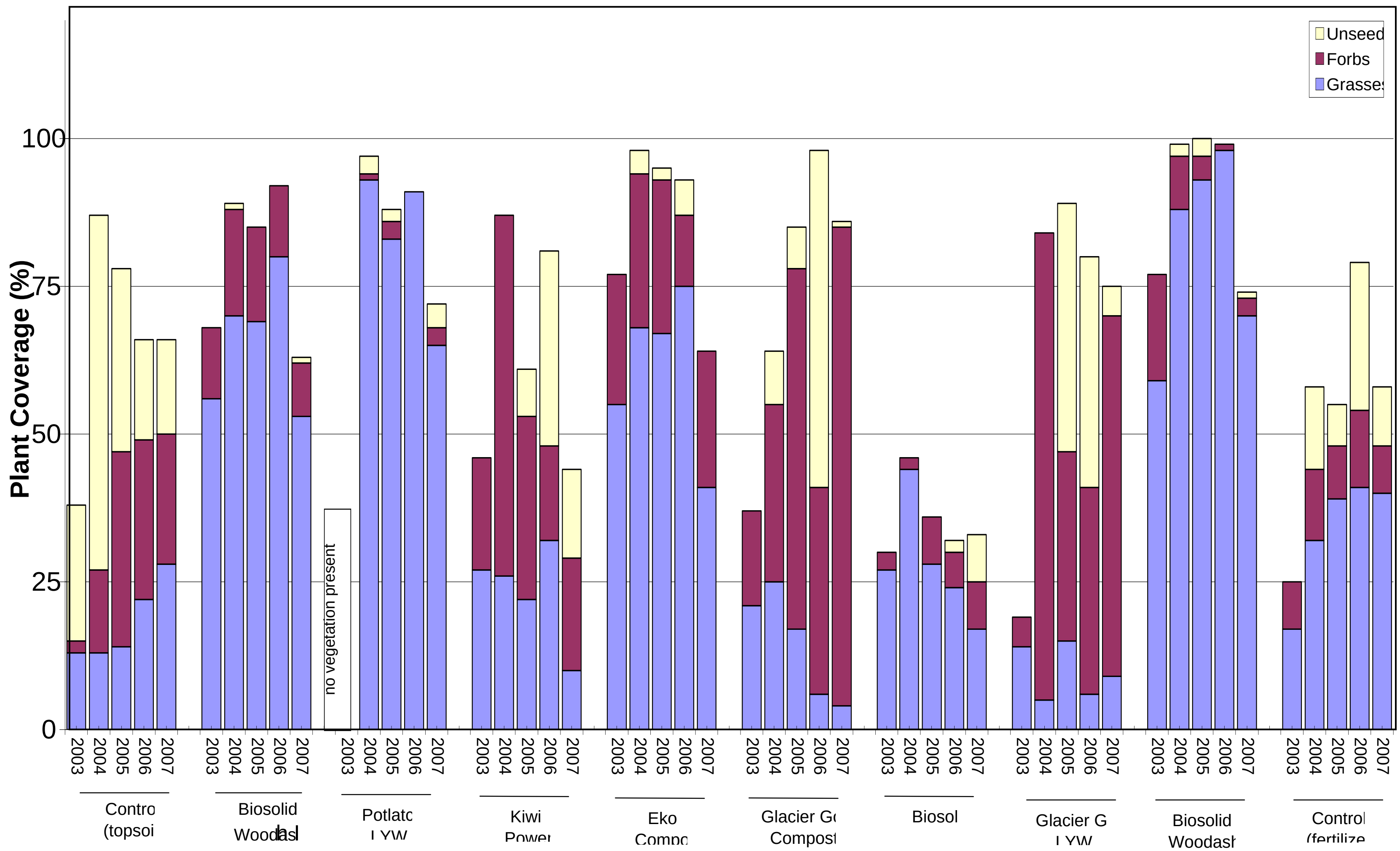


Figure 8. Plant density in each of the demonstration plots from 2003 to 2007.

Changes in Species Distribution
An additional trend is apparent when comparing the year-to-year data – the species distribution within the plots changed over time. This can be clearly seen in the coverage and density graphs for the Individual Plots where data are broken down by species (e.g. Figures 10-1A, 10-1B, 10-1C, …, 10-1J). While the total coverage and density of grasses in many plots did not change significantly from Year 3 to Year 5, marked changes in individual species did take place. For example, wheatgrass was clearly the dominant grass in the Biosolids amendments in 2003 (Year 1). However, the 2004-2007 (Years 2-5) data showed a more equal distribution between wheatgrass, bromes, and fescues (Individual Plots, Figure 10-2B). This general trend of declining wheatgrass with concurrent increases in bromes and fescues was evident in most of the grass-dominated (higher fertility) plots. It is unclear whether the gradual decline in wheatgrass is a natural successional characteristic or a response of this species to a decrease in available N.

The lower fertility plots tended to exhibit greater plant diversity throughout the study period but significant species changes were evident as well. Yarrow tended to increase steadily in most of the plots through Years 1, 2, and 3. White clover was common on several of the lower fertility plots in Year 1 but was rarely encountered during Years 2-5. In contrast, cicer milkvetch was not observed during Years 1 and 2 but increased significantly during the final three years of the study. Both yarrow and cicer milkvetch produce many profuse seed heads, which suggests the presence of these species is likely to increase in the future.

Impact of Surface Residue
Another consistent trend among the high fertility (grass dominated) plots was the gradual build up of surface residue. As described above, these plots exhibited very high plot coverages, which led to large quantities of plant debris carrying over to the succeeding year. By the fifth year of the study, a thick surface layer of organic material had developed, consisting of undecomposed residue overlying partially to fully decomposed organic matter. It is likely that development of this surface layer has and will continue to impact plot performance in several ways (both positive and negative):

1. Reduced surface evaporation and higher available soil moisture throughout the summer months.
2. Increased nutrient retention and enhanced nutrient cycling (including nitrogen, phosphorus, and most micronutrients) due to incorporated humic components.
3. More rapid warming of soil surface during the spring due to dark colored surface horizon.
4. Decreased plant coverage and more patchy growth due to pockets of excessively thick mulch.

Most of the impacts, while difficult to quantify, are positive in nature. However, the vegetation assessments clearly show a decline in coverage in the Biosolids, Potlatch Log Yard Waste, and Eko Compost plots and this is due almost entirely to decreased grass growth (Figure 7). For example, coverage on the Biosolids I and Eko Compost plots decreased from roughly 92% in 2006 to 63% in 2007. Field observations on each of these plots confirmed sporadic clumps of decomposing residue in areas with little or no grass growth. In contrast, the lower fertility plots, such as Kiwi Power, Biosol, Glacier Gold Log Yard Waste, and the Fertilizer Control, did not exhibit heavy grass growth and, hence, did not build up the thick surface residue. Thus, these plots did not experience suppressed plant growth due to thick mulch. Finally, it should be noted that, although coverage did decrease in the high fertility plots, it still exceeds that observed in the lower fertility plots (Figure 7). Furthermore, the high fertility plots maintained excellent plant vigor, plant size, and leaf color throughout the study suggesting that the negative impacts of surface residue were relatively insignificant in overall plot performance.

Unseeded Vegetation
Significant increases in both the coverage and density of unseeded vegetation were observed in several of the plots during the study period. As Figures 7 and 8 show, the Topsoil Control plot exhibited a high incidence of weeds beginning in Year 1 and throughout the study. For example, this plot contained 60% unseeded species and the weed density increased from 186 to 280 plants/m^2 between 2004 and 2005. The majority of this increase was due to the establishment and growth of hare's foot clover. However, as Table 3 indicates, the frequency of hare's foot declined during Years 4 and 5, with a significant increase in black medic and knapweed.

In contrast, Kiwi Power, Glacier Gold Compost, and Glacier Gold Log Yard Waste did not exhibit substantial increases in weeds until Year 3 (Figure 7, Table 3) with 25 to 50% of the total plant coverage occupied by unseeded species (Figure 7). These large increases were primarily the result of black medic and sweet clover, although spotted knapweed was a significant problem on the Fertilizer Control (Table 3). It should be noted that, while sweet clover is listed as an unseeded species, this should not imply that sweet clover growth is necessarily an undesirable result. Also, it is important to note that several plots (i.e. Biosolids, Potlatch Log Yard Waste, Eko Compost, and Biosol) exhibited very little to no weed species.

The majority of the unseeded species can be classified as common weeds of the northwest (Whitson, 1999) that are easily disseminated by wind, animals, and other vectors. However, given the disproportionately high percentage of unseeded vegetation present in the Topsoil Control in Year 1, it is likely that many weed seeds were transported to the site in the topsoil amendment. The role of topsoil as a seed bank is well established and imported soil has been reported to introduce both desirable and undesirable invasive species (Zhange et al., 2001; Polster et al., 2006). In addition to introduction via topsoil, the 2004 data indicate that weeds endemic to the surrounding landscape are beginning to invade the plots. In particular, sweet clover, black medic, and knapweed numbers have increased significantly. Although knapweed was not perceived to be a major problem during the July 2004 plot assessments, a significant invasion was observed by the end of August. Project personnel (McGeehan and Zilka) decided to cut and remove the aboveground knapweed plants in an effort to reduce reseeding. Knapweed was judged to be a continuing problem in 2005 and, as such, the plots were spot-treated with a broadleaf herbicide (containing triclopyr and clopyralid as active ingredients).

One additional note regarding unseeded vegetation – moss (of an unknown species) was observed to actively growing on every plot. Active moss growth occurred early in the season (i.e. May-June), afterwhich it appeared to flower and eventually die back. The extent of moss coverage varied with the plot amendment and tended to be more extensive on heavily vegetated plots. These plots maintained a thick layer of decomposing plant residue and relatively high surface moisture, which appears to create favorable conditions for the moss. It is unclear as to the significance of moss growth in the overall revegetation picture.

Table 3. Density of unseeded vegetation on the demonstration plots.

Plot	Common Name	Scientific Name	Weed Density (plants/m^2)				
			2003	2004	2005	2006	2007
A	Sedge	*Carex sp.*	53	0	0	0	0
	Black Clover (black medic)	*Medicago lupulina*	31	175	154	224	36
	Hare's Foot Clover	*Trifolium arvense*	9	29	102	4	12
	Oxeye Daisy	*Leucanthemum vulgare*	6	7	12	14	42
	Moss	unknown	0	0	0	26	0
	*encountered infrequently: toadflax, potentilla, knapweed, chickweed, mullin						
B	Sedge	*Carex sp.*	8	0	0	0	0
	Moss	unknown	0	0	0	4	0
C	Cheatgrass	*Bromus tectorum.*	NA	2	0	0	0
	Moss	unknown	0	0	0	4	0
D	Sedge	*Carex sp.*	22	0	0	0	0
	Black Medic	*Medicago lupulina*	5	2	54	18	38
	Sweet Clover	*Melilotus albus*	0	0	76	52	198
	Moss	unknown	0	0	0	18	0
	*encountered infrequently: knapweed, lambsquarter						
E	Sedge	*Carex sp.*	2	0	0	0	0
	Sweet Clover	*Melilotus albus*	0	0	10	2	6
	Moss	unknown	0	0	0	26	0
F	Sedge	*Carex sp.*	10	1	0	0	0
	Black Medic	*Medicago lupulina*	0	19	0	0	0
	Sweet Clover	*Melilotus albus*	0	0	276	22	0
	Moss	unknown	0	0	0	24	0
G	Sedge	*Carex sp.*	27	4	0	0	0
	Black Medic	*Medicago lupulina*	0	19	0	4	0
	Moss	unknown	0	0	0	0	0
	*encountered infrequently: horsetail, black clover, common tansy						
H	Sedge	*Carex sp.*	7	0	0	0	0
	Black Medic	*Medicago lupulina*	0	0	6	0	0
	Sweet Clover	*Melilotus albus*	0	0	348	698	102
	Moss	unknown	0	0	0	40	0
	*encountered infrequently: red clover, prickly lettuce, maple						
I	Sedge	*Carex sp.*	14	0	0	0	0
	*encountered infrequently: moss, knapweed						
J	Sedge	*Carex sp.*	24	0	0	0	0
	Spotted Knapweed	*Centaurea maculosa*	0	0	42	39	90
	Sweet Clover	*Melilotus albus*	0	0	68	98	96
	*encountered infrequently: red clover, lotus clover, oxeye daisy, sweet clover						

Impact of Available Nitrogen

Several studies in the literature show that the impact of nitrogen in mine site reclamation projects goes beyond basic plant nutrition considerations. For example, high nitrogen availability was found to improve overall productivity but at a cost of lower diversity (Willems and van Nieuwstadt, 1996; Baer et al., 2003). This was certainly the case in the Silver Dollar study - plots receiving high nitrogen amendments (i.e. Biosolids, Eko Compost, and Potlatch Log Yard Waste) favored the establishment and growth of grasses over forbs, and this pattern was consistent throughout the five year study. As Figure 7 illustrates, between 75 and 90% of the total vegetation is accounted for by grass species in these high fertility plots. The more detailed vegetative assessment (see Individual Plots) identified wheatgrass as the dominant species. A visual inspection of these plots confirms the presence of large, very robust plants; a growth habit that is characteristic of high levels of available nitrogen. In contrast, plots receiving lower N inputs (i.e. both Controls, Kiwi Power, and Glacier Gold plots) exhibited a greater diversity of forbs (including yarrow, clovers, and milkvetch) intermixed with the grasses.

An additional characteristic of the high nitrogen plots is an almost complete lack of unseeded vegetation (Figure 7). Several studies report increased weed growth and competition in high nitrogen environments (Carlson and Hill, 1985; Jornsgard et al., 1996). However, in the case of the Silver Dollar plots, just the opposite was observed. As Figure 9 clearly shows, an inverse relationship between available nitrogen and unseeded vegetation is evident. That is, high available N is associated with low weed density and vice versa. In contrast, low nitrogen fertility lead to a high incidence of weed species. It should be stressed that, while this relationship is very clear across the ten Silver Dollar plots, different sites are likely to exhibit different interactions between nitrogen and weeds. In particularly, the nitrogen use efficiency of the weed vs. the species of seeded vegetation is expected to play a critical role (Carlson and Hill, 1985; Jornsgard et al., 1996).

Several mechanisms have been proposed to explain the relationship between high nutrient availability and low species diversity. Once nutrient limitations are removed, diversity is believed to be controlled by competition for light as a result of dense above-ground biomass, as well as above- and below-ground competition between neighboring roots and shoots (Wilson and Tilman, 1991; Rajaniemi, 2002; Baer et al., 2003). Thus, it appears that high levels of available nitrogen provide robust grasses such as wheatgrass and bromes with a competitive advantage relative to other vegetation. This has the desirable outcome of promoting high plant coverage while also controlling invasive unseeded vegetation, but at a cost of low species diversity (essentially producing a monoculture).

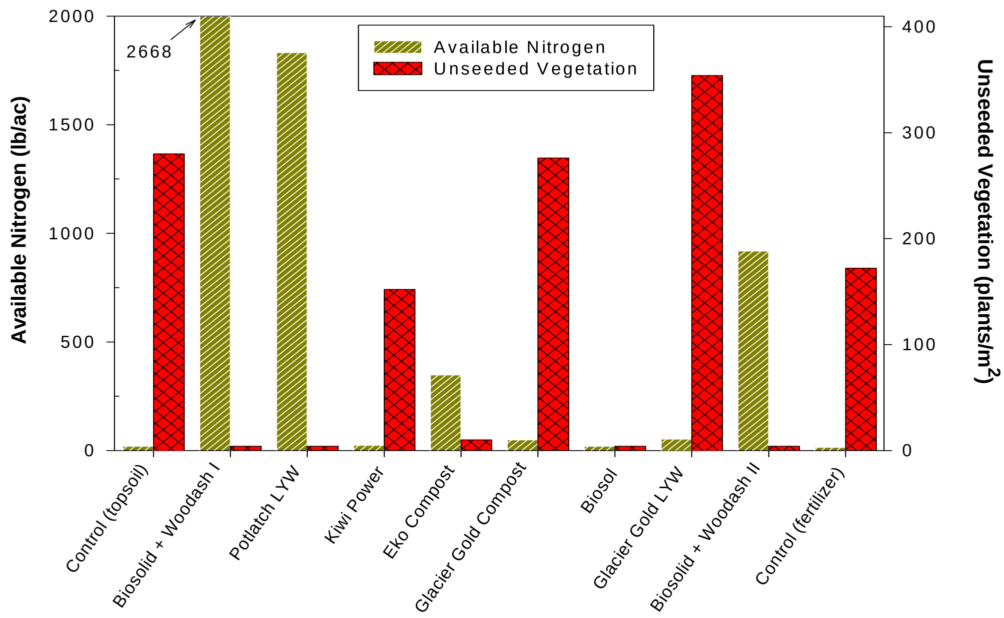


Figure 9. The relationship between available nitrogen and density of unseeded vegetation.

Generalized Vegetative Profiles

The plot assessments suggest that the plant growth tended to fall into one of two generalized vegetative profiles, and the specific profile appears to be selected by the nature of the amendment. In particular, available nitrogen appears to be a key variable in determining the vegetative profile and dominant characteristics of each plot. Although this categorization grossly oversimplifies the very complex nature of plot assessment, it is worthwhile as a beginning step in understanding the interrelationships between vegetation response to the properties of the growth media:

Profile #1: Higher Plant Coverage/Lower Plant Density

- associated with higher fertility amendments; available N generally >100 lb/ac
- coverage generally > 75%, density generally < 450 plants/m^2
- characterized by large robust vegetation and very full canopies
- lower diversity, dominated by grasses, low density of weeds
- e.g. Biosolid/Wood Ash, Eko Compost, Potlatch Log Yard Waste (urea amended)

Profile #2: Lower Plant Coverage/Higher Plant Density:

- associated with lower fertility amendments; available N generally <100 lb/ac
- coverage generally <75%, density generally >450 plants/ m^2
- characterized by small thrifty vegetation and sparse and open canopies
- higher species diversity, but also greater density of weeds
- e.g. Kiwi Power, Biosol, Glacier Gold Compost and Log Yard Waste

General Ecology: High Fertility Plots

As discussed above, the high fertility plots were dominated by grasses. In most cases, slender wheatgrass (*Agropyron trachycaulum*) was the dominant species during the first two years of the study. Wheatgrass is a valuable component of reclamation seed mixes for revegetation and erosion control due to its rapid development, ability to increase soil organic matter, and extensive root system. Wheatgrass responds extremely well to high nutrient availability and is know for its ability to sequester excess available nitrogen. This not only decreases the potential for runoff N, but also helps reduce weed problems. Decreasing the available nitrogen pool is also believed to assist plant succession by improving conditions for late seral species that are typically low N tolerant (Ogle et al, 2003). Slender wheatgrass is relatively short-lived (3-5 years) and, as the vegetation assessments show (Figure 7), is beginning to diminish in favor of the bromes.

The brome species, mountain brome (*Bromus marginatus*) and meadow brome (*Bromus bieberteinii*) reach full productivity in 1-3 years and are both shade and nitrogen tolerant, making these grasses well suited to replace wheatgrass in the succession of high fertility plots. Mountain brome is short-lived and will be replaced by long-lived species over time including meadow brome, sheep fescue (*Festuca ovina*), and Idaho fescue (*Festuca idahoensis*). Meadow brome is an important early seral species due to its aggressive sod forming character and notable ability to suppress weed species and control erosion (Ogle et al., 2003). Declines in available N facilitate this succession, creating favorable conditions for the late seral grasses. The fescues take several years to develop but, once established, provide excellent cover, erosion control, and weed suppression (Ogle et al., 2003). Both species grow well in 10+ inch precipitation zones and can tolerate steep north-facing slopes. The three bluegrass species, Canada bluegrass (*Poa compressa*), big bluegrass (*P. ampla*), and canby bluegrass (*P. canbyi*) also possess growth characteristics that will fill niches in the demonstration plot plant communities. Canada bluegrass is slow to establish and tolerant of shade, making it another likely species to increase as wheatgrass declines. Growth occurs early in the spring providing good ground cover and, once established, is very persistent. Big bluegrass is very slow to establish, requiring as much as 4 to 8 years, but does well in mixed vegetation sites at 2000 to 6000 feet. Canby bluegrass is a long-lived species that is commonly crowded out when season-long moisture is available. In sites with dry summers, this species thrives on early season moisture and goes dormant quickly to resist drought.

General Ecology: Low Fertility Plots

The low fertility plots exhibited a more diverse mixture of forb and grass species. White yarrow (*Achillea millefolium*) was the most commonly encountered forb. This observation is not surprising as white yarrow is one of the most widely distributed forbs in the western United States (Ogle et al., 2003). White yarrow spreads by seed and rhizomes and is well adapted to disturbed and depleted soils exemplified by the Silver Dollar site. White clover (*Trifolium repens var. Landino*) is a long-lived perennial legume that is well-suited to the shallow soils and is an effective erosion control plant on cool, moist, winter snow- covered mountain slopes. In particular, white clover responds well to low N soils with adequate P and K, such as the Glacier Gold Compost and Log Yard Waste. Cicer milkvetch (*Astragalus cicer*) is a long-lived, late maturing legume that is slow to establish due to very hard seed. It is well adapted to cold temperatures and will substitute for the other legumes when winterkill is a problem. Although Rocky Mountain penstemon (*Penstemon strictus*) and blue flax (*Linum lewisii*) were not encountered at the same frequency as the other forbs, both have been shown to do well when seeded in mixtures on disturbed seedbeds. Both penstemon and blue flax will tolerate some competition from grasses, but their production improves in more open communities (Ogle et al., 2003). Each of these forbs provides forage for grazing wildlife and the seeds are a good food source for birds.

General Ecology: Expected Future Trends
Slender wheatgrass should continue to decline, regardless of amendment. The bromes and Canada bluegrass are expected to replace the wheatgrass on plots with higher available N. Low available N will favor Idaho fescue, sheep fescue, and Canby bluegrass. Big bluegrass is not likely to persist as this species is prone to leaf rust in higher moisture environments. Yarrow and cicer milkvetch are likely to persist on the lower fertility plots.

Stable plant communities are expected on the solid-based amendments (biosolids, composts, and log yard wastes). These plots should maintain 4-6 inches of topsoil-like growth media with good water holding capacity and >3% organic matter. Under these conditions, nutrient levels should become more cyclical, thereby promoting a self-sustaining plant cover. A key question will be grass performance on plots with the highest available N. If conditions favor too much grass growth, lodging and disease problems could occur. This also could create an opportunity for establishment of weed species (Mark Stannard, NRCS, personal communication).

Organic matter content, through its impact on fertility and nutrient cycling, is the most critical factor impacting sustainable plant growth in revegetated sites (Prodgers et al., 2000). A degrading plant community is expected on plots with weak organic matter development (e.g. <1%). Under these conditions, grasses will comprise no more than 25% of the above ground biomass. Milkvetch and clover productivity should fluctuate year to year, and conditions will be favorable for broadleaf weed invasions (Mark Stannard, NRCS, personal communication).

It remains to be seen how effective each treatment will be in maintaining a sustainable plant cover over a longer-term time frame as it can take a decade or more for growth-limiting site factors to manifest themselves. Thus, while the data presented in this report provide a clear picture of short- and mid-term treatment performance, it is likely that the dynamic factors of soil fertility and plant succession have yet to stabilize.

<u>Cost Evaluation</u>
Costs for the demonstration plots were broken down as follows:

- cost of the amendment or treatment material
- cost of hauling the material to the site
- cost of placing or installing the material
- cost of seed
- cost of placing the seed

This information was obtained directly from the vendors, or vendor's invoices, and from subcontractors working at the site. Given the diverse nature of the amendments and treatments, not all of the above can be uniformly applied to each plot. Additionally, in some cases, assumptions were made using the best available information (i.e. topsoil costs, hauling costs). These cost data are expressed as total cost per 2000 ft^2 plot and also extrapolated to cost per acre (Table 8).

Actual costs ranged from $5276 per acre for the Fertilizer Control plot to $41,899 per acre for the Potlatch Log Yard Waste + Fertilizer plot. The remaining plots ranged from $9447 (Biosol) to $15, 637 (Glacier Gold Compost). Seed costs were a constant $15.46 for each plot and hydroseeding costs were also fairly consistent ($175). Note that seed placement costs for Kiwi Power and Biosol were factored into the material placement costs. Another exception to note was the Eko Compost plot, which was hand-seeded by the vendor. It is assumed that under a more typical (project-level) scenerio, the Eko amendment would also undergo standard hydroseeding resulting in a higher seeding cost than is listed in Table 8.

Price of the amendment material plus cost to place the material represented the majority of overall amendment cost, exceeding 60% of the total cost in all cases and over 90% in the Potlatch, Kiwi Power, Eko Compost, and Biosol plots. A wide range in material costs is evident in Table 8. The highest material cost ($1687 per plot) belongs to the Potlatch plot. This very high material cost is due primarily to the mixing of urea fertilizer with the log yard waste at a rate of 10% by volume. This rate is significantly above accepted agronomic nitrogen rates and much higher than necessary to offset nitrogen immobilization by the high carbon organics. Hence, it is likely that this amendment cost could be decreased significantly by a lower fertilizer addition, although the costs of debris processing and hauling would still be significant. Although the Coeur d'Alene Waste Water Treatment Plant does not charge for biosolids, transportation of this material to the site is a significant cost (assumed to be $9 per yard in Table 8). With fuel costs continuing to rise, it stands to reason that hauling costs will remain a significant factor for solids-based amendments like biosolids, composts, and log yard waste. In contrast, transportation costs are minimized for liquid-based amendments (i.e. Kiwi Power and Biosol) as these materials are hauled in a concentrated dry formulation and mixed with water on-site.

It was recognized that the data listed in Table 8 do not account for several factors that would impact the true costs of each treatment for future work at project-level. Table 9 lists adjusted treatment costs in an effort to normalize these factors and provide an equitable comparison of treatment alternatives.

As mentioned above, cost of seed placement should be considered in evaluation of the Eko Compost plot. For this reason, this cost has been adjusted upward to account for the cost of hydroseeding (Table 9). The cost of the Biosol treatment was adjusted downward slightly to reflect the cost of straw mulch recommended by the vendor. The cost for both Glacier Gold products (compost and log yard waste) was adjusted downward to account for reduce placement labor if the material was shipped in open trucks instead of the Super Sacs. And, as already discussed, the cost for the Potlatch Log Yard Waste could be reduced by decreasing the amount of urea fertilizer added.

The adjusted cost data show a range of $5276 per acre (Fertilizer Control) to $31,706 per acre for the Potlatch plot. Of the remaining treatments, three (Biosol, Glacier Gold Log Yard Waste, and Kiwi Power) are below $10,000 per acre and all (except the Topsoil Control and Potlatch Log Yard Waste) are below $15,000 per acre. This last point mertis emphasis since topsoil placement is a very typical approach to revegetation of mine-impacted sites. As the results clearly show, there are many treatment options that promote a sustainable plant cover at a lower cost than topsoil placement.

It should be noted that, while the cost data are specific this study, they do provide a useful means to compare treatment alternatives. However, additional factors, including vegetative performance, nutrient dynamics and runoff, and application method must be considered for any revegetation or reclamation project. Hence, project-specific factors, such as proximity to a water body and site accessibility, may determine the product selected. Additionally, costs are continually changing and up-to-date numbers will be critical when evaluating each treatment alternative in the future.

Table 8. Actual cost of amendment materials and seeding for each demonstration plot.

Amendment	Material Used	Material Cost	Material Placement Time	Material Placement Cost	Seed Placement Time & Materials	Seed Placement Cost	Total Cost Per Plot	Total Cost Per Acre	Notes
Control (topsoil)	40 yd^3	$400.00	1 h	$80.00	3 bags mulch 1 h hydroseeder	$204.85	$700.31	$15,253	Assumed $10/ yd^3 topsoil cost
Biosolid + Woodash I	26 yd^3	$234.00	0.75 h	$60.00	3 bags mulch 1 h hydroseeder	$204.85	$513.75	$11,190	Assumed $9/ yd^3 hauling cost from CDA; no cost for material from vendor (if material is available)
Potlatch Log Yard Waste	48 yd^3	$1,687.20	0.75 h	$60.00	3 bags mulch 1 h hydroseeder	$204.85	$1,967.51	$42,852	Material cost includes debris processing: $3.15/$yd^3$, urea fertilizer: $19.50/$yd^3$, and hauling cost from St. Maries: $12.50 yd^3
Kiwi Power	0.25 gal Kiwi Power 200 lb Fertil-Fibers	$87.34	2 h (hydroseeder)	$350.00	NA (in material placement cost)	NA	$452.80	$9,862	None
Eko Compost	20 yd^3	$360.00	1.25 h	$100.00	NA (hand placement by vendor)	NA	$475.46	$10,356	No seed placement cost since vendor applied by hand; if applied by hydroseeder (1 h), representative costs would be $650.48 per plot or $14,167 per acre
Glacier Gold Compost	20 yd^3	$280.00	2.25 h	$248.00	1 h hydroseeder	$175.00	$717.96	$15,637	Placement cost includes 1.5 h to unload Super Sacs; representative cost without Super Sacs would be $530.46 per plot or $11,553 per acre
Biosol	83 lb Biosol 5 lb mulch	$68.28	2 h (hydroseeder)	$350.00	NA (in material placement cost)	NA	$433.74	$9,447	None
Glacier Gold Log Yard Waste	20 yd^3	$180.00	2.25 h	$248.00	1 h hydroseeder	$175.00	$617.96	$13,459	Placement cost includes 1.5 h to unload Super Sacs; representative cost without Super Sacs would be $430.46 per plot or $9375 per acre
Biosolid + Woodash II	26 yd^3	$234.00	1.5 h	$120.00	3 bags mulch 1 h hydroseeder	$204.85	$574.31	$12,508	Assumed $9/$yd^3$ hauling cost from CDA; Note: greater material placement time since these biosolids were wetter and more difficult to spread
Control (fertilizer)	50 lb fertilizer	NA	NA	NA	4 bags mulch 1 bag fertilizer 1 h hydroseeder	$226.26	$242.26	$5,276	None

General Notes:

1. Plot size: 20 X 100 ft or 2000 ft^2
2. Seed cost: $15.46 per plot or $336.76 per acre
3. Unit costs: D5 Dozer $50/h; backhoe/tractor $30/h; Operator $30/h; Superintendent $65/h; hydroseeder $175/h
4. Place ment of material was by D5 Dozer and Operator unless otherwise noted
5. Cost/acre data represent actual 'as-placed' costs and are not normalized

Table 9. Cost per acre for each amendment (adjusted where applicable).

Amendment	Total Cost Per Acre	Cost Adjustment
Control (topsoil)	$15,253	none
Biosolid + Woodash I	$11,948	none
Potlatch Log Yard Waste	$31,706	Cost reduced to reflect 50% less fertilizer
Kiwi Power	$9,862	none
Eko Compost	$14,167	Cost increased to reflect the cost of hydroseeding
Glacier Gold Compost	$11,553	Cost reduced to represent labor savings if material shipped in trucks instead of Super Sacs
Biosol	$9,261	Cost reduced to reflect the cost of straw recommended by vendor
Glacier Gold Log Yard Waste	$9,375	Cost reduced to represent labor savings if material shipped in trucks instead of Super Sacs
Biosolid + Woodash II	$12,508	none
Control (fertilizer)	$5,276	none

CONCLUSIONS AND RECOMMENDATIONS

The overall goal of this study was to identify alternatives to topsoil that are suitable for reclamation and revegetation of waste rock piles and other disturbed sites in the Coeur d'Alene Mining District. This goal was achieved by each of eight treatments (in addition to the two controls) as each plot was successful in establishing plant cover during the first growing season and sustaining this cover throughout the five-year study. In addition, each amendment resulted in significant improvements in soil fertility parameters and soil physical properties.

The fertility status of each amendment had a strong impact on the type of cover produced. More specifically, available nitrogen was a critical factor in determining the species distribution and incidence of unseeded vegetation. For example, high nitrogen amendments promoted a grass-dominated cover with low numbers of forbs. Wheatgrass was the dominant species in these plots during Years 1 and 2 but a more equal distribution of wheatgrass, bromes, fescues, and bluegrass was observed in Years 3-5. Throughout the study, these plots had the highest plant coverage and maintained very robust and thick grass growth. These characteristics were successful in preventing the establishment and spread of invasive weed species. In contrast, amendments with lower available nitrogen promoted a more diverse grass-forb mixture. No single grass species was dominant; instead a variety of grasses was intermixed with white yarrow, white clover, and cicer milkvetch. These plots had lower plant coverage and more patchy plant growth. Consequently, a higher incidence of invasive weed species (including black medic, knapweed, and yellow sweet clover) was observed.

The fertility status of each plot also had a strong impact on the nutrient content of the surface runoff. As would be expected, amendments associated with high available nitrogen and phosphorus also exhibited high N and P concentrations in the runoff. Although runoff nutrient levels decreased substantially by Year 5, phosphorus concentrations exceeded EPA criteria for surface water quality in several early samplings. Erosion was minimal to non-existent during the study. A minor amount of sediment was observed in the erosion traps of several plots during Year 1 and small to medium rills were present. However, additional evidence of erosion was not observed during Years 2-5.

This study has shown that each treatment is capable of promoting rapid plant establishment and growth and, in this respect, each is quite suitable for meeting future project goals such as establishing a vegetative barrier, controlling erosion, and improving aesthetics of disturbed sites. In addition to vegetative success, other criteria will be equally important in selecting an approach to a future revegetation problem. Each amendment has specific advantages and, in some cases, disadvantages, with respect to initial nutrient availability, the ability to promote long-term nutrient retention and nutrient cycling, and enhancing soil physical properties such as water holding capacity and overall tilth. In addition, each revegetation project will pose its own set of unique challenges, including the presence of contaminants, low fertility, poor seed bed characteristics, steep slopes, and other access limitations. The character of nearby native vegetation should also be considered since it is often desirable for the revegetated site to 'blend in'. In some cases, the method of application will be a major consideration. Many reclamation projects are located in remote sites with very limited access. Long hauling distances and the difficulties associated with spreading solid materials, versus application of amendments via hydroseeding, could be an important consideration in selecting a treatment. Cost is of course a critical factor and this study provides the basis to compare relative plot performance to treatment cost, and also provides several options to reduce costs. As the results clearly show, there are multiple treatment options that promote a sustainable plant cover at a lower cost than conventional topsoil placement.

The overall revegation objective should be carefully considered when evaluating treatment alternatives. If a thick, grass-dominated, low weed system is the primary objective, a high nitrogen amendment must be considered. But, care should be taken in avoiding excessive nutrient addition for the sake of controlling surface runoff quality. If a more diverse mixture of grasses and forbs is sought, a lower available nitrogen amendment might be more suitable. However, this can result in a patchy, more open vegetative cover that is susceptible to invasive weeds.

This study answered many questions and provided a unique opportunity to compare eight alternatives to topsoil placement in revegetation projects. Despite the large amount of information contained in this report, there are several questions left unanswered. It is recommended that attempts be made to answer these questions, either by additional field studies or through use of other reports, as part of the evaluation process for future revegetation projects:

1. How would these treatments perform on a metals-impacted site? Some evidence suggests that organic amendments can mobilize heavy metals and facilitate both phytotoxicity and leaching. Other studies have shown that organic materials, particularly humic acids, can immobilize heavy metals.
2. How would these treatments perform under lower amendment rates? Optimization work is needed to identify the minimum rate necessary to achieve acceptable performance. This will reduce the overall treatment costs and also minimize nutrient runoff.
3. Should the seed mix be blended to match the fertility status of the amendment? As the results clearly show, some seed components did not grow in the high fertility plots whereas a more diverse plant cover grew on the lower fertility amendments. It might be possible to reduce seed costs by omitting species unlikely to grow on a given amendment.
4. Will the characteristics of the plots continue to change? Previous reports suggest this will be the case. It would be worthwhile to conduct low-cost monitoring of the plots on a periodic (i.e. 3-5 y) basis in an effort to collect longer-term performance results.

As a final thought, it should be clearly stated that the goal of this study was not to select winners and losers. Instead, the objective was to develop a set of tools that can be used for future revegetation projects. This was done using side-by-side, ‘apples-to-apples’ comparisons under ‘real world’ conditions in order to identify the beneficial characteristics of each treatment alternative. It will be the task of future project managers to select the alternative that best addresses the unique challenges of their respective revegetation project.

ACKNOWLEDGMENTS

I am grateful to Nick Zilka and John Lawson of the Idaho Department of Environmental Quality, Jerrry Lee and Tom Bourque of TerraGraphics Environmental Engineering, and Mark Stannard of the USDA-NRCS for their support of this project and the helpful discussions. I also thank Don Keil (Coeur d'Alene Wastewater Treatment Plant), Bernie Wilmarth (Potlatch Corp.), Peter McRae (Quattro Environmental, Inc.), Joe Jackson (Eko Compost), David Larson (Glacier Gold, LLC), and Tom Bowman (Rocky Mountain Bio Products) – this project would not have been possible without their participation.

LITERATURE CITED

ASL, 2003. Laboratory Quality Management Plan, University of Idaho Analytical Sciences Laboratory, University of Idaho, Moscow, ID. September, 2003.

Baer, S.G., J.M. Blair, S.L. Collins, and A.K. Knapp. 2003. Soil resources regulate productivity and diversity in newly established tallgrass prairie. Ecology*,* 84(3):724–735

Elzinga, C.E., D.W. Salzer, and J.W. Willoughby. 1998. Field Techniques for Measuring Vegetation. In: Measuring and Monitoring Plant Populations. BLM Technical Reference 1730-1.

EPA, 1982. Handbook for Sampling and Sample Preservation of Water and Wastewater, EPA-600/4-82-029, Environmental Monitoring and Support Laboratory, U.S. Environmental Protection Agency, Cincinnati, OH.

EPA, 1983. Methods for Chemical Analysis of Water and Wastes, EPA-600/4-79-020, U.S. Environmental Protection Agency, Cincinnati, OH.

EPA, 1986A. Test methods for Evaluating Solid Waste, Physical/Chemical Methods, SW-846, 3rd Edition.

EPA, 1986B. Quality criteria for water 1986. U.S. Environmental Protection Agency Report 440/5-86-001. Office of Water, Washington, D.C.

Carlson, H.L., and J.E. Hill. 1985. Wild oat (Avena fatua) competition with spring wheat: effects of nitrogen fertilization. Weed Sci. 34:29-33.

Carpenter, S.R., N.F. Caraco, and D.L. Correll, R.W. Howarth, A.N. Sharpley, and V.H. Smith. 1998. Nonpoint pollution of surface waters with phosphorus and nitrogen. Ecological Applications 8(3):559-568.

Johnson, C. 2002. Silver Dollar Growth Media Test Workbook.

Jornsgard, B., K. Rasmussen, J. Hill, and J.L. Christiansen. 1996. Influence of nitrogen on competition between cereals and their natural weed populations. Weed Res. 36(6):461-470.

McGeehan, S.L., N. Zilka, and C. Johnson. 2003. Silver Dollar Growth Media Demonstration Plots, Annual Report – Year 1.

McGeehan, S.L., N. Zilka, and J. Lawson. 2004. Silver Dollar Growth Media Demonstration Plots, Annual Report – Year 2.

McGeehan, S.L., N. Zilka, and J. Lawson. 2005. Silver Dollar Growth Media Demonstration Plots, Annual Report – Year 3.

McGeehan, S.L., N. Zilka, and J. Lawson. 2006. Silver Dollar Growth Media Demonstration Plots, Annual Report – Year 4.

Mendoza, C., N.W. Assadian and W. Lindemann. 2006. The fate of nitrogen in a moderately alkaline and calcareous soil amended with biosolids and urea. *Chemosphere* 63:1933-1941.

Miller, R.O., J.Kotuby-Amacher, and J.B. Rodriguez. 1997. Western States Laboratory Proficiency Testing Program, Soil and Plant Analytical Methods, Version 4.00.

Miller, B.L., D.B. Parker, J.M. Sweeten, and C. Robinson. 2001. Response of seven crops and two soils to application of beef cattle feedyard effluent. *Trans. ASAE* 44:309–315.

Ogle, D., L. St. John, M. Stannard, and L. Holzworth. 2003. Technical Note: Grass, grass-like, forb, legume, and woody species for the Intermountain West. USDA-NRCS TN Plant Materials No. 24, January 2003.

Polster, D.F., J. Soll, and J. Myers. 2006. Managing Northwest Invasive Vegetation. In: Restoring the Pacific Northwest: The Art and Science of Ecological Restoration in Cascadia, D. Apostol and M. Sinclair (Eds.), Island Press.

Prodgers, R.A., T. Keck, and L.K. Holzworth. 2000. Revegetation evaluations – how long must we wait? Billings Land Reclamation Symposium, March 20 - 24, 2000, Billings, Montana.

Rajaniemi, T.K. 2002. Why does fertilization reduce plant species diversity? Testing three competition-based hypotheses. Journal of Ecology 90 (2), 316-324.

Robinson, M.B., P.J. Polglase, and C.J. Weston. 2002. Loss of mass and nitrogen from biosolids applied to a pine plantation. *Australian Journal of Soil Research* 40:1027–1039.

Robinson, M.B. and H. Röper. (2003) Volatilisation of nitrogen from land applied biosolids. *Australian Journal of Soil Research* 41:711–716.

Sims, J.R. and V.A. Haby. 1971. The colorimetric determination of soil organic matter. *Soil Science* 112:137-141.

Sullivan, D.M., S.C. Fransen, C.G. Cogger, and A.I. Bary. 1997. Biosolids and dairy manure as nitrogen sources for prairie grass on a poorly-drained soil. *Journal of Production Agriculture* 10:589–596.

Whitson, T.D. 1999. Weeds of the West, 5th Ed. University of Wyoming Press.

Willems, J.H, and M.G.L. van Nieuwstadt. 1996. Long-Term after Effects of Fertilization on Above-Ground Phytomass and Species Diversity in Calcareous Grassland. Journal of Vegetation Science. 7(2):177-184.

Wilson, S.D., and D. Tilman. 1991. Components of plant competition along an experimental gradient of nitrogen availability. Ecology 72(3):1050-1065.

Zhang, Z. Q., W. S. Shu, C. Y. Lan, M. H. Wong. 2001. Soil seed bank as an input of seed source in revegetation of lead / zinc mine tailings. *Restoration Ecology* 9 (4), 378–385.

October 2002

Plot A: Control – Topsoil

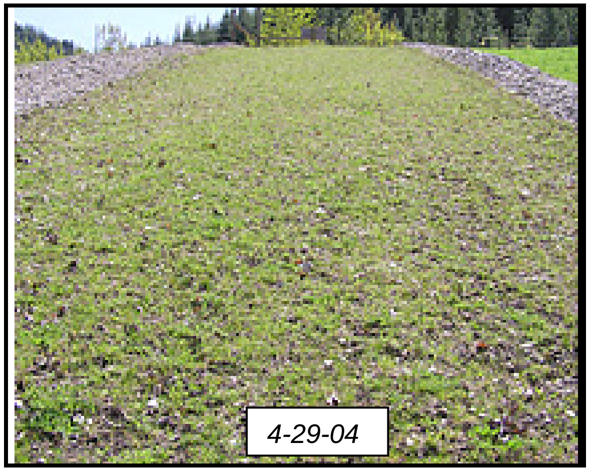
Topsoil was collected from City of Coeur d'Alene (new jail site). Approximately 40 yd^3 of topsoil was spread to a depth of 6" and consolidated by track-walking with the Cat D5. The plot was hydroseeded on10/2/02.

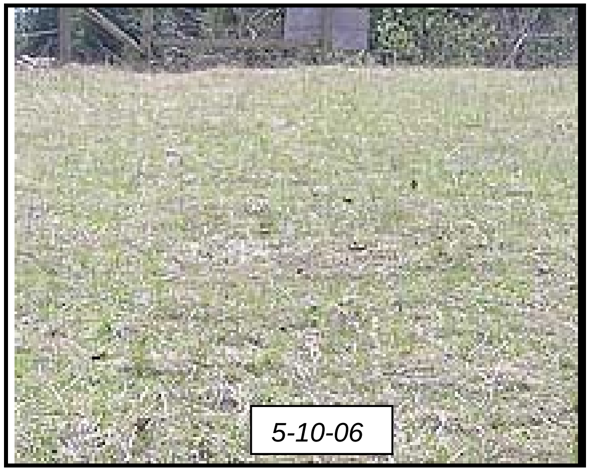
5-14-03

6-12-03

8-25-03

Plot A: Control – Topsoil




5-10-06


6-4-06


7-2-06


4-26-07


5-30-07


7-8-07

Table 10A. Plot Assessment for Plot A (Control – Topsoil) for 2003, 2004, 2005, 2006, and 2007.

April 2003	Good germination (> 30 seedlings per 0.1 m^2); both grasses and forbs present, most grasses at 10-leaf stage and forbs at 4-leaf stage. No sediment in trap or other evidence of erosion.
May 2003	Plot exhibiting good germination and growth; most grasses at 10-leaf stage or greater with some seed heads forming; most forbs at 10-leaf stage or greater with some immature flowers forming; good balance between grasses and forbs with good color characteristics in both plant types; germination and growth conditions uniform throughout plot.
June 2003	Plot continues to exhibit good plant vigor and growth, high diversity of vegetation, many species present that were not components of seed mix; conditions are uniform throughout plot; most grasses are small, still green with few seed heads; clovers doing well (spreading and seeding)
May 2004	Plot exhibits medium regrowth with approximately 50% coverage. Good diversity of vegetation with a nearly equal distribution of grasses and forbs. Dicot vegetation consists primarily of clover and yarrow. Most vegetation is exhibiting good color and vigor. No sediment in trap or other evidence of erosion.
June 2004	Plot continues to exhibit medium growth and coverage is relatively uniform throughout plot. Most grasses are at 10-leaf stage or greater with some seed heads forming. Yarrow is also at 10-leaf stage or greater with some immature flowers forming.
July 2004	Most plants are at or near seed stage with growth stages at least one month ahead of 2003. There is a high diversity of vegetation with forbs more frequent than grasses (Figure 5-1A). Yarrow and white clover comprise the most common forbs while Idaho fescue, brome, and bluegrass are the most common grasses. There is also a high frequency of unseeded vegetation. Black medic is the dominant unseeded species although several common noxious weeds, such as oxeye daisy and knapweed, are present. In some parts of the plot, black medic and yarrow are present as masses of young seedlings (very high densities). This appears to be the result of reseeding should lead to further establishment and colonization of these unseeded species
April 2005	Actively growing with greater than 90% coverage. Vegetation is exhibiting good color and vigor, with mixture of grasses and forbs. Primary grasses are fescues and bromes, with wheatgrass in places. Yarrow and clovers are extensive throughout plot. No sediment in trap or other evidence of erosion.
May 2005	Plot exhibiting good growth characteristics with uniform coverage. Most grasses are at 10 plus-leaf stage or greater, although wheatgrass is at 5 leaf stage. Yarrow is at 5 to 10 leaf stage and clovers are exhibiting evidence of spreading – via seed germination and creeping.
June 2005	Plot continues to exhibit good plant vigor and growth with high diversity of vegetation. Grass species are dominated by fescues and bromes while forbs consist primarily of yarrow and clovers. Relatively high numbers of unseeded species present including knapweed, toadflax, black medic, and rabbits foot clover.
April 2006	Actively growing with 70-80% coverage. Vegetation is exhibiting good color and vigor, with diverse mixture of grasses and forbs. Grasses exhibiting 10+ leaves

	while forbs are in the 6-8 leaf stage. Approx. 10% of plot surface coverage by plant residue from previous season. Light moss growth is evident throughout plot. No sediment in trap or other evidence of erosion.
May 2006	Plot exhibiting good growth characteristics with uniform coverage. Relatively equal mix of grasses and forbs. Black medic beginning to flower and fescue exhibiting seed heads. Clovers are spreading via seed germination and creeping. Moss growth is declining.
June 2006	Plot is still actively growing with diverse communities of grasses, forbs, and unseeded vegetation. Soil surface is dry but vegetation is still green. Grasses and forbs are flowering and producing seed heads. Black medic and hares foot clover still growing but does not appear to be spreading.
April 2007	Actively growing with 90-95% coverage. Fescue at 10+ leaf stage and bromes exhibit 3-5 leaves. Yarrow at 10+ leaf stage and other forbs exhibiting good growth (as is unseeded vegetation). All vegetation exhibiting good color and vigor. Light residue from previous year's growth is present. Moss is covering approximately 50% of the soil surface. No sediment in trap or other evidence of erosion.
May 2007	Plot exhibiting good growth overall with good color, vigor, and coverage. A diverse mixture of grasses and forbs is present. Actively growing grasses include fescue, wheatgrass, bromes, and bluegrass; forbs include yarrow and penstamon. The most common unseeded species are black medic and knapweed. Vegetation is still green and actively growing (fescue seed heads have emerged). The soil surface is dry approximately 5 d after rain.
June 2007	A diverse community of grasses, forbs, and unseeded vegetation is present with a mixture of fescue, brome, vetch, and yarrow. Black medic, oxeye daisy, and rabbits foot clover are found throughout the plot. Soil surface is dry but vegetation is still green and actively growing although most vegetation has flowered and produced seeds.

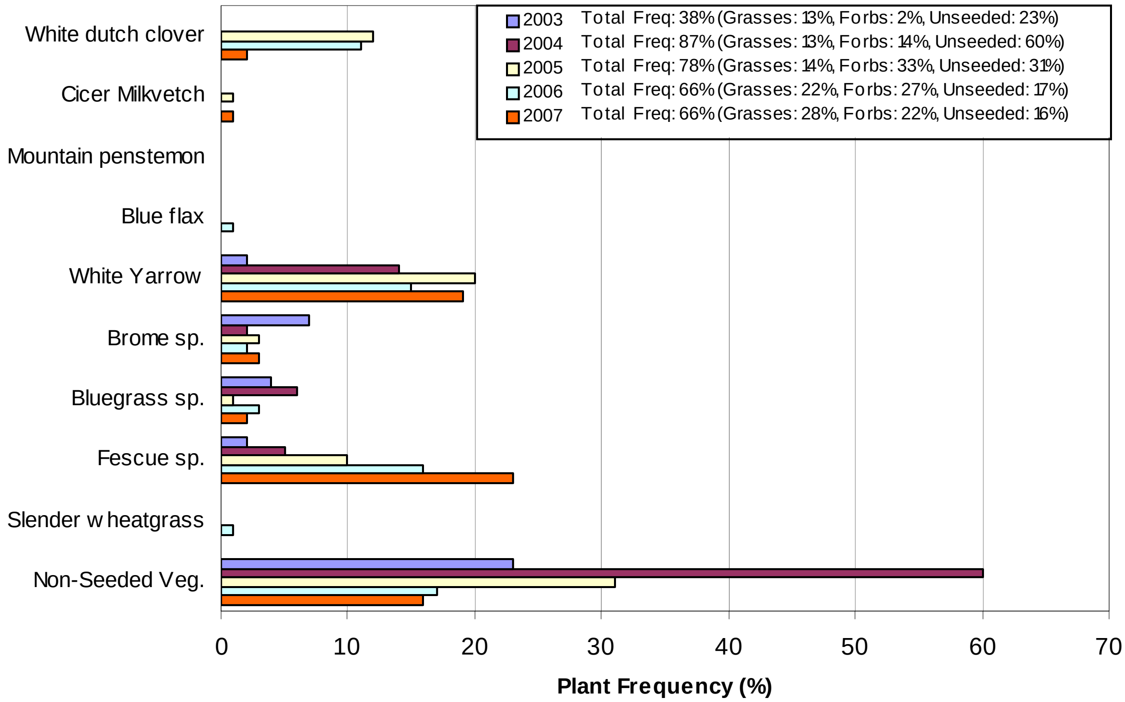


Figure 10-1A. Plant frequency on Plot A (Control-Topsoil) in 2003, 2004, 2005, 2006, and 2007.

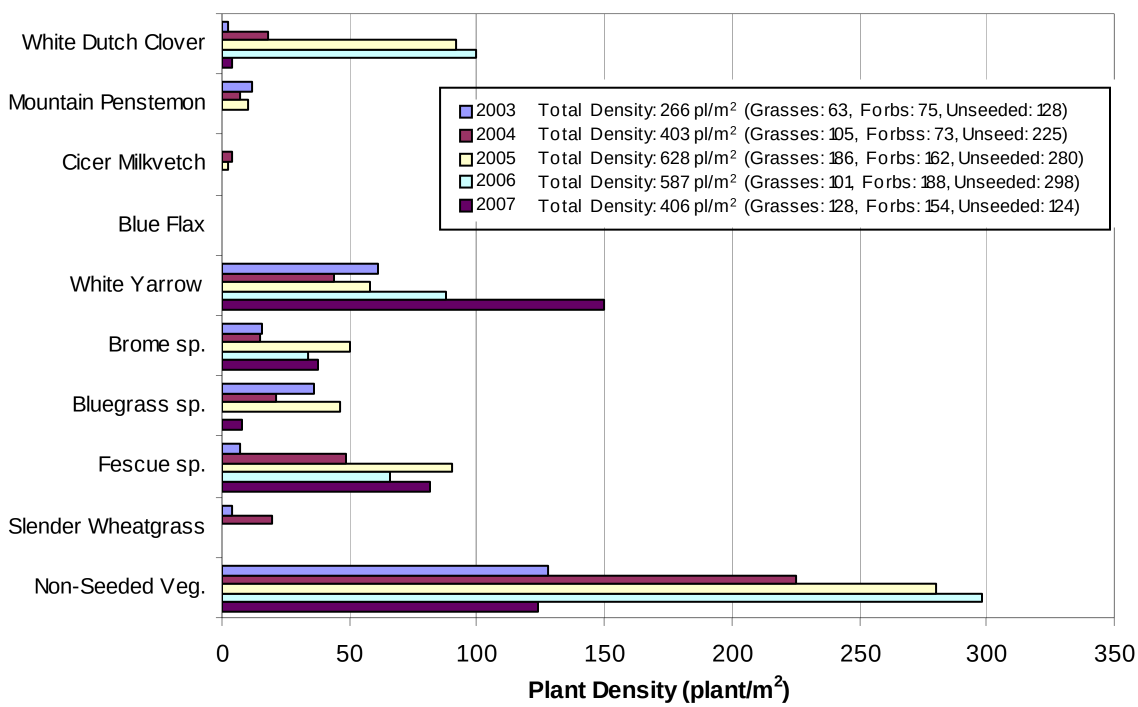


Figure 10-2A. Plant density on Plot A (Control-Topsoil) in 2003, 2004, 2005, 2006, and 2007.

October 2002

Plot B: Coeur d'Alene Biosolids + Avista Wood Ash (0.75:1)

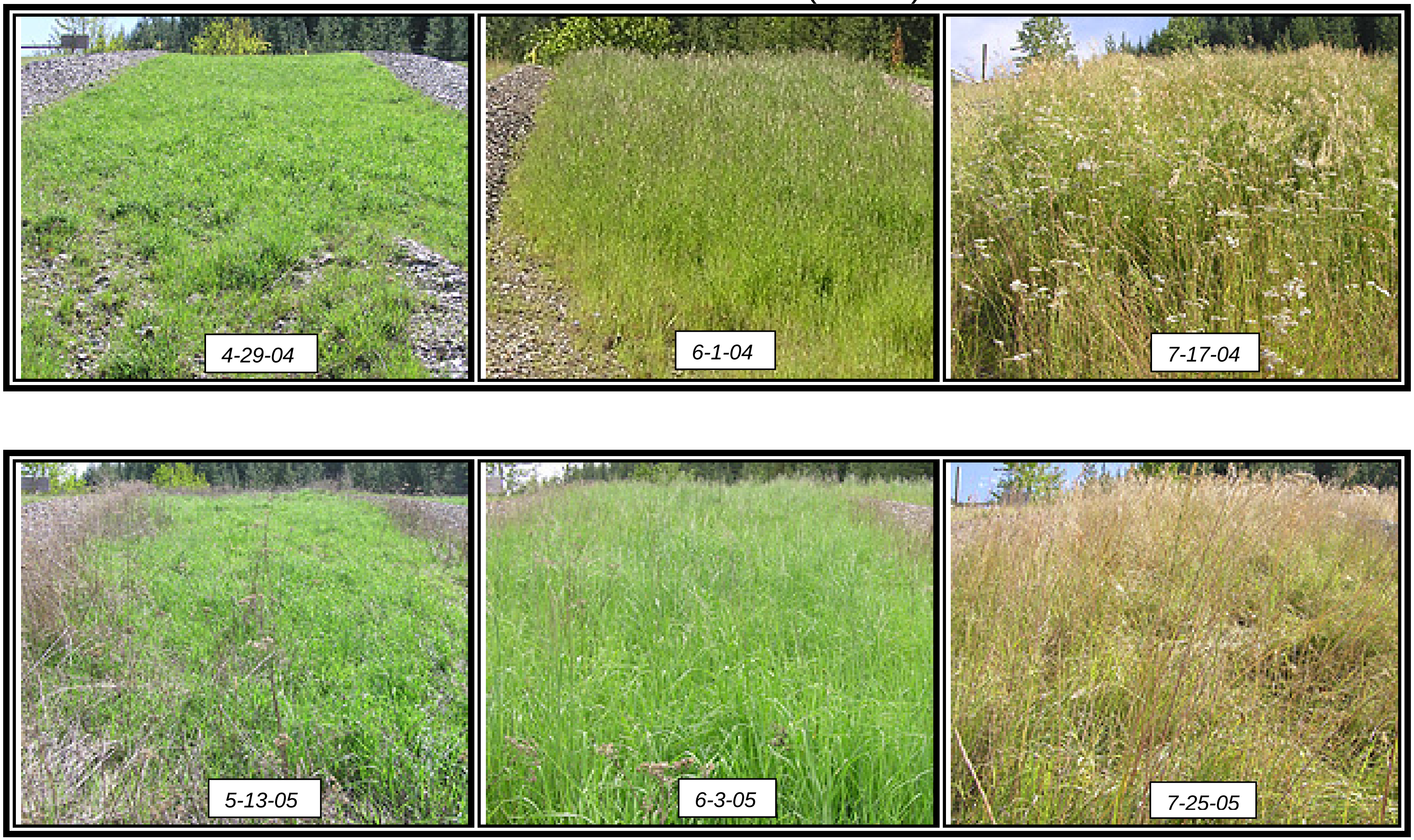
Class B Biosolids were mixed with Avista Wood Ash 0.75:1. Approximately 26 yd^3 of the mixture was applied using the Cat D5. The plot was hydroseeded on 10/21/02.

5-14-03

6-12-03

8-25-03

Plot B: Coeur d'Alene Biosolids + Avista Wood Ash (0.75:1)




5-10-06
6-4-06
7-2-06


4-30-07
5-30-07
7-8-07

Table 10B. Plot Assessment Plot B (Coeur d'Alene Biosolids + Avista Wood Ash, 0.75:1) for for 2003, 2004, 2005, 2006, and 2007.

April 2003	Good germination (> 30 seedlings per 0.1 m^2); both grasses and forbs present, most grasses at 2-leaf stage and forbs at 2-leaf stage. No sediment in trap or other evidence of erosion.
May 2003	Plot exhibiting good germination and growth; most grasses at 10-leaf stage or greater with large clumps forming; most forbs at 6-leaf stage or greater with some immature flowers forming; grasses more frequent than forbs with good color characteristics in both plant types; germination and growth confined to upper two thirds of plot while lower third of plot is sparsely vegetated.
June 2003	Plot is dominated by grasses (primarily wheatgrass and bluegrass), very thick vegetation in upper two-thirds of plot; very large plants with vigorous growth; wheatgrass has seeded, other grasses are less mature but very healthy; clover and yarrow are doing better at bottom of plot where vegetation is thinner; biosolids are now soft and powdery but still moist one week after rain.
May 2004	Excellent regrowth with 90-95% coverage. As was observed in 2003, these growth conditions are confined to upper two thirds of plot while lower third of plot is sparsely vegetated. Vegetation is dominated by grasses (primarily wheatgrass) with yarrow interspersed throughout. All plants exhibiting excellent color and vigor. No sediment in trap or other evidence of erosion.
June 2004	Plot continues to exhibit thick, lush plant growth. Most grasses are at 10-leaf stage or greater with large clumps forming. Although vegetation is now further along that in June 2003, it is not as mature as Plot A (no seed heads forming).
July 2004	Plot remains dominated by grasses with wheatgrass and meadow brome forming an overstory and Idaho fescue, sheep fescue, and yarrow present as an understory. In areas where the fescues are thick, yarrow is not present. Vegetation is very robust and dense with little evidence of unseeded vegetation. Both the total frequency and density data (Figure 5-1B and 5-2B, respectively) show a significant change in species distribution between 2003 and 2004. In 2003, wheatgrass was clearly the dominant grass while the 2004 data show a more equal distribution between wheatgrass, bromes, and fescues. This trend is most evident in the density data (Figure 5-2B).
April 2005	Actively growing with greater than 90% coverage. Vegetation is exhibiting good color and vigor. Vegetation is dominated by wheatgrass, with small yarrow plants in understory; larger yarrow plants are growing along edges of plot. Plot is heavily mulched with wheatgrass and yarrow residue from previous season. No sediment in trap or other evidence of erosion.
May 2005	Plot exhibiting excellent growth characteristics with uniform coverage throughout. Vegetation is exhibiting excellent color and vigor despite the heavy residue mulch. Both wheatgrass and yarrow are at 10 plus-leaf stage or greater.
June 2005	Plot continues to exhibit good plant vigor and growth with mixture of wheatgrass and brome. Both grass species are exhibiting seedheads. Yarrow also growing well but not as mature as grasses. Very few weed species are present.

April 2006	Actively growing with greater than 90% coverage. Vegetation is exhibiting good color and vigor. Vegetation is dominated by grass species. Both grasses and forbs are at 6-8 leaf stage. Plot is heavily mulched with approx. 60% of the surface covered with wheatgrass and yarrow residue from previous season. Heavy moss growth also evident. No sediment in trap or other evidence of erosion.
May 2006	Plot exhibiting excellent growth characteristics although coverage is patchy in spots. This appears to be caused by the heavy residue mulch. Vegetation is exhibiting excellent color and vigor despite the heavy residue mulch. No evidence of flowering in grass species or forbs. Moss growth has declined.
June 2006	Plot continues to exhibit excellent plant vigor and growth with 95% coverage. The soil surface is still moist beneath the thick vegetation and heavy mulch, and the plants are still green. The grass species, primarily wheatgrass and bromes, have produced seedheads.
April 2007	Actively growing with 95% coverage. Primary vegetation is wheatgrass at 3-5 leaf stage; fescue is at 10+ leaf stage. Yarrow is at 10+ leaf stage. All vegetation exhibiting excellent color and vigor. Very heavy plant residue from last year's growth is present throughout plot. Soil surface is covered with moss and thick organic layer of decomposing grass residue. No sediment in trap or other evidence of erosion.
May 2007	Very heavy vegetative growth; primarily wheatgrass and bromes with yarrow as understory. All vegetation exhibiting excellent color and vigor. Coverage is patchy in spots due to the heavy residue mulch. Moss growth has declined and the soil surface is moist beneath the thick residue layer.
June 2007	Plot continues to exhibit excellent plant vigor and growth. Grass species, primarily wheatgrass and bromes, are the dominant vegetation. Grasses have produce many full seedheads. Coverage is 90-95% although more patchy than in previous years. The soil surface is still moist beneath the thick vegetation and heavy mulch, and the plants are still green.

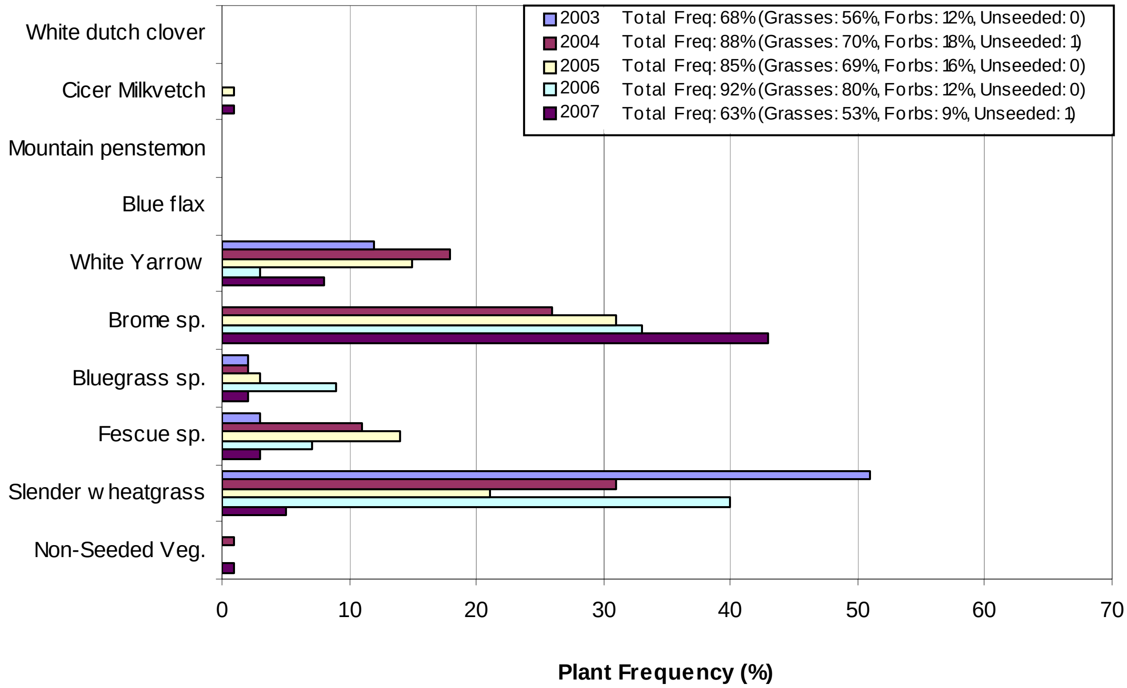


Figure 10-1B. Plant frequency on Plot B (Coeur d'Alene Biosolids + Avista Wood Ash) in 2003, 2004, 2005, 2006, and 2007.

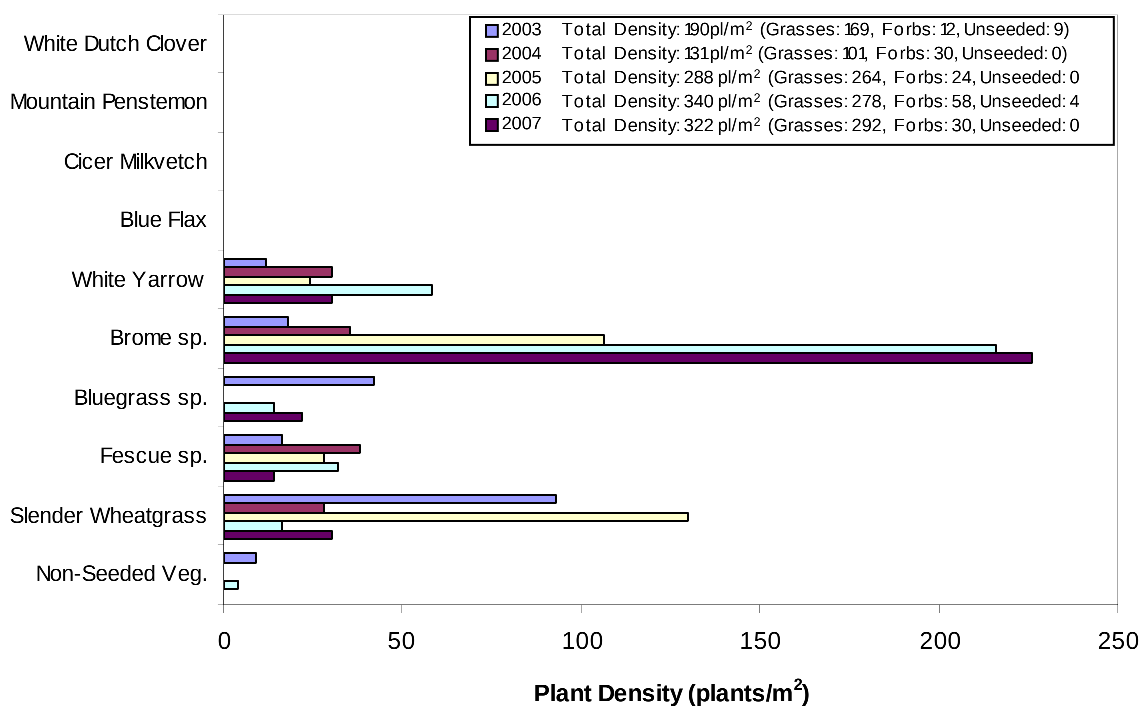


Figure 10-2B. Plant density on Plot B (Coeur d'Alene Biosolids + Avista Wood Ash) in 2003, 2004, 2005, 2006, and 2007.

October 2002

Plot C: Potlatch (St. Maries) Log Yard Waste + Fertilizer

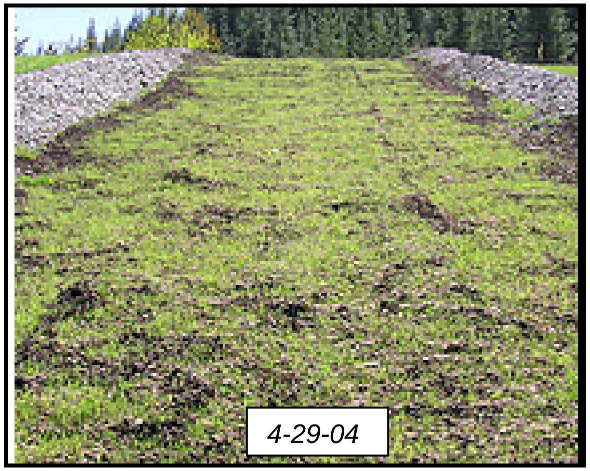
Log yard waste was reclaimed tO remove wood debris and rocks. The log yard fines (<3/4") were mixed with urea fertilizer. Approximately 48 yd^3 material was spread, scarified, and track-walked using the Cat D5. The plot was hydroseeded on 10/21/02

5-14-03

6-12-03

8-25-03

Plot C: Potlatch (St. Maries) Log Yard Waste + Fertilizer


4-29-04


6-1-04


7-17-04


5-13-05


6-3-05


7-25-05


5-10-06
6-4-06
7-2-06


4-26-07
5-30-07
7-8-07

Table 10C. Plot Assessment for Plot C (Potlatch - St. Maries Log Yard Waste + Fertilizer) for 2003, 2004, 2005, 2006, and 2007.

April 2003	Poor germination (< 10 seedlings per 0.1 m^2); very few seedlings present. No sediment in trap or other evidence of erosion.
May 2003	Plot exhibiting poor germination and growth; primary grass germination along edge of log yard waste, forbs are beginning to germinate in center of plot; grasses and forbs at 2-leaf stage; color is good for both plant types; conditions are uniform throughout plot.
June 2003	Plot re-seeded by hand; vegetation almost non-existent although some growth (yarrow, bluegrass) occurring at plot edges.
May 2004	Most plants appear to have germinated within the past 2 weeks. Both grasses and forbs are growing well, although forbs are less mature. Grasses at 3-5 leaf stage and forbs (i.e. yarrow) at 1-2 leaf stage. Approximately 30-40% coverage with uniform conditions throughout plot. Plants exhibiting good color and vigor. No sediment in trap nor other evidence of erosion.
June 2004	Vegetation is dominated by grasses (similar to 2003 biosolids plots). Good diversity among grass species, including wheatgrass, fescues, and bluegrass. Color and vigor is very good throughout plot. Little evidence of unseeded vegetation.
July 2004	Grasses continue to dominate with wheatgrass and bromes the frequently observed species. Very few forbs are present with yarrow being the most common. The yarrow plants are quite small and appear to be crowded by the larger, more robust wheatgrass. Vegetation is noticeably greener than that observed on adjacent plots. This might be due to less mature plants as this vegetation is in its first year.
April 2005	Actively growing with greater than 90% coverage. Vegetation is exhibiting good color and vigor. Vegetation is dominated by grass species, with a mixture of wheatgrass, fescues, and bromes. Plot is moderately mulched with grass residue from previous season. Heavy growth of moss at bottom of plot. No sediment in trap or other evidence of erosion.
May 2005	Plot exhibiting excellent growth with uniform coverage throughout. Vegetation has excellent color and vigor with majority of grasses at 10 plus-leaf stage. Very thick grass growth with good diversity of species (wheatgrass, bromes, and fescues). Vetch and yarrow plants are growing best along the sides of the plot.
June 2005	Plot continues to exhibit good vigor and growth among all grass species. Both wheatgrass and brome are exhibiting seedheads. Few weed species are present.

April 2006	Actively growing with greater than 90% coverage. Vegetation is exhibiting good color and vigor. Vegetation is dominated by grass species, with plants in the 6-8 leaf stage. Plot is heavily mulched with approx. 90% of surface covered by grass residue from previous season. Moderate moss growth of moss throughout plot with heaviest growth at edges. No sediment in trap or other evidence of erosion.
May 2006	Plot exhibiting excellent growth although coverage is patchy in spots. This appears to be due to the heavy residue mulch. Vegetation has excellent color and vigor despite heavy mulch. Moss growth has flowered and growth has declined.
June 2006	Plot continues to exhibit good growth although coverage remains patchy in areas. The soil surface is still moist beneath the thick vegetation and heavy mulch, and the plants are still green. Very few forbs present except sweet clover on plot border. The grass species, primarily wheatgrass and bromes, have produced seedheads.
April 2006	Actively growing with 95% coverage. Plot is dominated by grasses, primarily wheatgrass at 3-5 leaf stage and fescue at 10+ leaf stage. Some yarrow present in understory. All vegetation exhibiting excellent color and vigor. Very heavy plant residue from last year's growth is present throughout plot. Soil surface is covered with moss and thick organic layer of decomposing grass residue. No sediment in trap or other evidence of erosion.
May 2006	Plot exhibiting heavy growth of wheatgrass, bromes, and fescues. Profuse and full seed heads have emerged from bromes. Coverage is good although patchy in spots, particularly in the middle of the plot where surface residue is heaviest. Vegetation has excellent color and vigor despite heavy mulch. Moss growth has has declined and soil surface is moist beneath thick layer of decomposing organic matter.
June 2006	Plot continues to exhibit a diverse mixture of grasses with few forbs present. All grasses are producing profuse full seed heads. Vigor and color are good although coverage remains patchy in areas. The soil surface is still moist beneath the thick vegetation and heavy mulch, and the plants are still green.

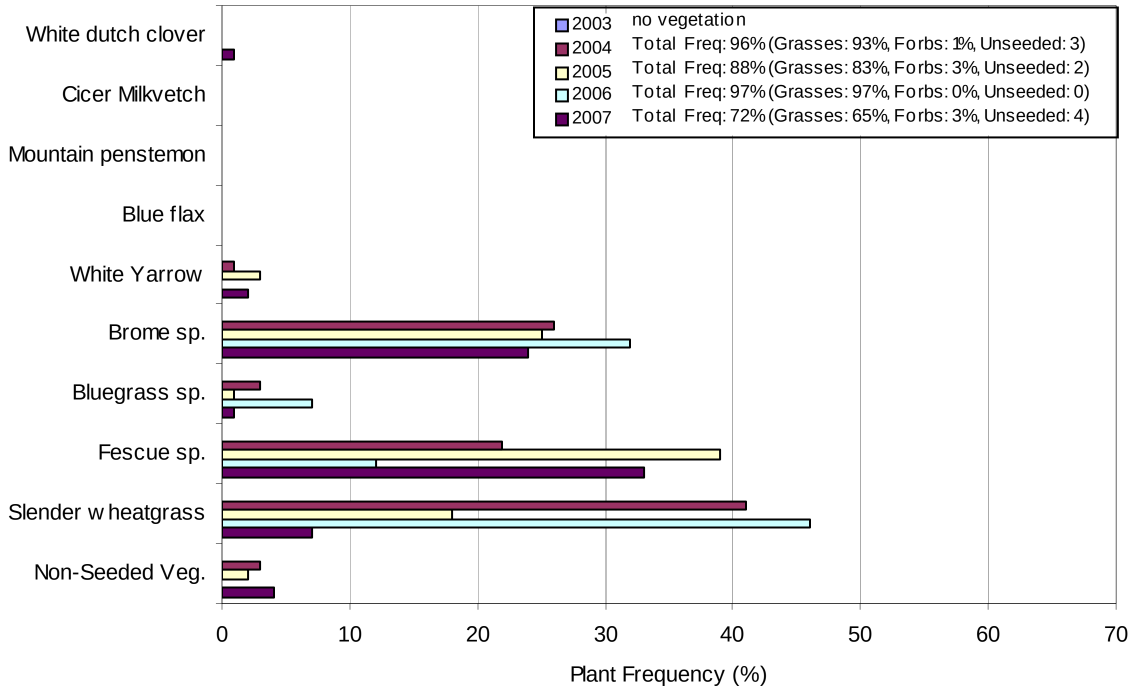


Figure 10-1C. Plant frequency on Plot C (Potlatch Log Yard Waste + Fertilizer) for 2003, 2004, 2005, 2006, and 2007.

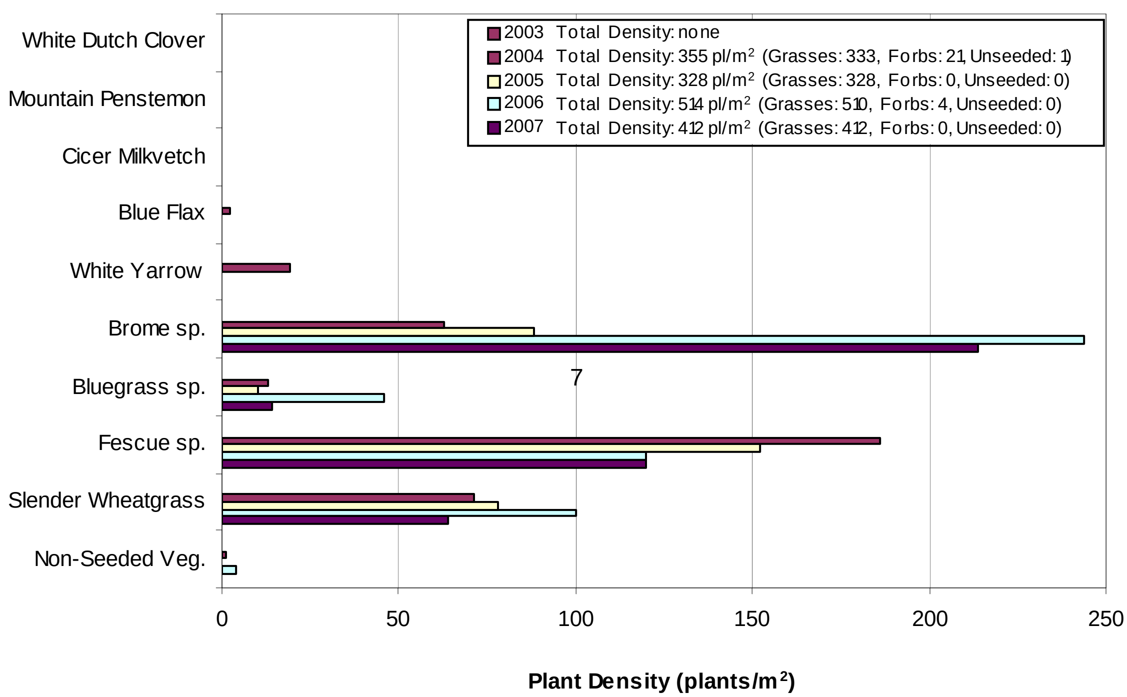


Figure 10-2C. Plant density on Plot C (Potlatch Log Yard Waste + Fertilizer) for 2003, 2004, 2005, 2006, and 2007.

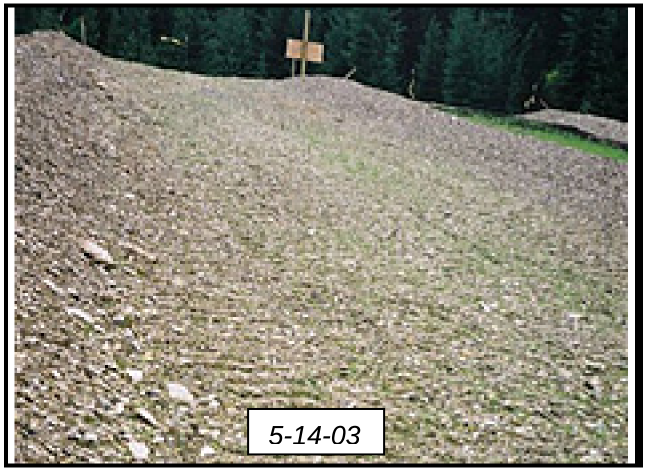
October 2002

<u>Plot D: Kiwi Power – Quattro Environmental, Inc.</u>

The following components were mixed in the hydroseeder tank:

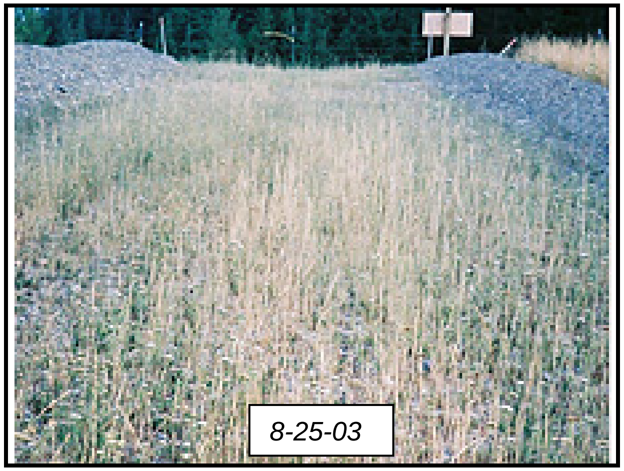
- 200 lb Fertil-Fibers Plus
- 0.25 gal Kiwi Power
- 2 lb Stronghold Fibers
- 3.25 gal Atlas SoilLok

The seed mix was added and the entire mixture was applied using the hydroseeder on 10/21/02.



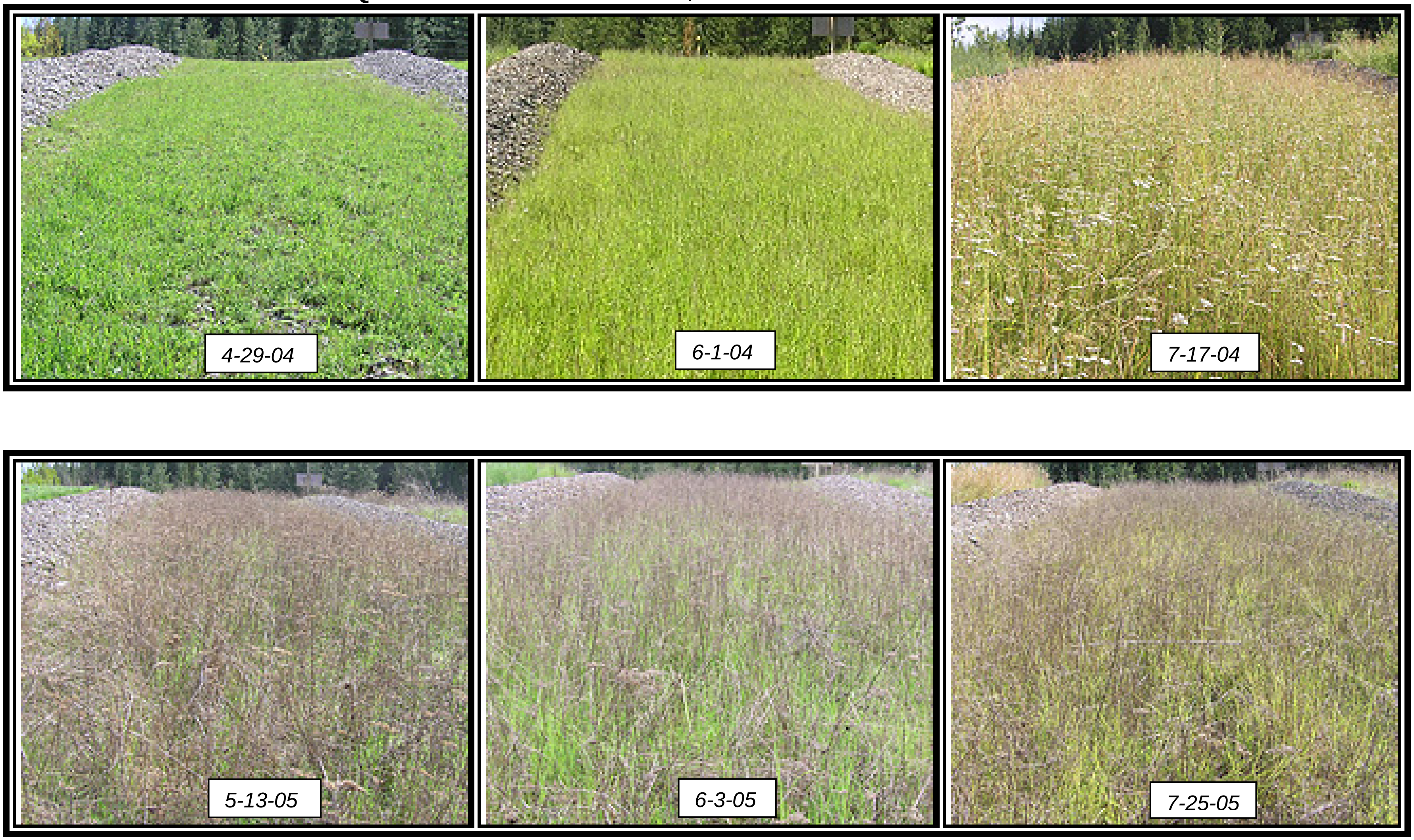
5-14-03

6-12-03



8-25-03

Plot D: Kiwi Power – Quattro Environmental, Inc.




5-10-06
6-4-06
7-2-06


4-25-07
5-30-07
7-8-07

Table 10D. Plot Assessment for Plot D (Kiwi Power – Quattro Environmental) for 2003, 2004, 2005, 2006, and 2007.

April 2003	Poor germination (< 10 seedlings per 0.1 m^2); both grasses and forbs are just beginning to emerge. A minor amount (< 5 kg) of sediment present in trap and rills evident in bottom half of plot (3-5” wide X 1-3” deep).
May 2003	Plot exhibiting moderate germination and growth (approx. 10 seedlings per 0.1 m^2); grasses at 4 to 8-leaf stage, most forbs at 2 to 4-leaf stage; grasses more frequent than forbs, color is moderate (pale green) in both plant types; germination and growth is uniform except for a sparsely vegetated patch at top.
June 2003	Plot exhibiting great diversity of plant types; vegetation is somewhat patchy but plants showing good growth and vigor; bluegrass and wheatgrass have headed out, bromes growing well but less mature; yarrow is flowering, clovers present but not spreading; plot is dry compared with other plots amended with organic materials.
May 2004	Good regrowth with 70-80% coverage. Good balance between forbs and grasses with yarrow being the primary dicot. Grasses and yarrow are at 10-leaf growth stage. Vegetation exhibiting good color and vigor, and conditions are uniform throughout plot. Although some erosion was observed in 2003, no additional erosion was observed during 2004.
June 2004	Vegetation appears to be about one month ahead of 2003 observations. Yarrow is the frequently encountered species (Figure 5-1D) with scattered grasses (mostly wheatgrass and bromes). Open areas have higher frequency of unseeded vegetation.
July 2004	Nice mix of grasses interspersed with forbs. Good diversity of grasses including wheatgrass, bromes, fescues, and bluegrass. The density of wheatgrass decreased between 2003 and 2004 with a concurrent increase in bromes, fescues, and bluegrass (Figure 5-2D). The most dominant dicot - yarrow – increased in both frequency and density. The overstory is open relative to other plots and is not dominated by grasses. This lower density may be beneficial in terms of allowing greater diversity. However, some of this diversity comes in the form of unseeded vegetation, including knapweed.
April 2005	Actively growing with approximately 50% coverage. Vegetation is exhibiting moderate to good color and vigor. Vegetation is grass (primarily fescues and bromes) and yarrow. Plot is moderately mulched with yarrow residue from previous season. Moss is growing in places, with heaviest growth at bottom of plot. Although some erosion was observed in 2003, no additional erosion was observed during 2004.
May 2005	Plot exhibiting good growth and coverage. Good diversity with relatively even mixture of grasses and dicot vegetation. Majority of grasses at 5- to10-leaf stage and yarrow is at the 10 plus-leaf stage. Relatively heavy residue doesn’t appear to be reducing growth of this year’s vegetation.
June 2005	Plot has a more open canopy than ‘B’ and ‘C’, and this appears to give rise to greater diversity. Yarrow, clover, wheatgrass, brome, and fescues are all growing relatively well; although not as vigorous as in the higher fertility plots. Maturity of vegetation (i.e. seedhead production) is also lagging the other plots.

April 2006	Actively growing with approximately 40-50% coverage. Vegetation is exhibiting moderate to good color, although plants are small in comparison to other plots. Diverse vegetation with both grasses and forbs at the 3-5 leaf stage. Plot is moderately mulched with 40-50% of surface covered by yarrow residue from previous season. Moderate moss growth, with heaviest growth at bottom of plot. Although some erosion was observed in 2003, no additional erosion was observed during 2006.
May 2006	Plot exhibiting good growth although coverage is patchy in spots. The patchy growth pattern doesn't appear to be related to heavy residue. Plant color is good and vigor is moderate. Black medic is beginning to flower; other vegetation is still in leaf stage. Moss is still actively growing with light to moderate coverage.
June 2006	Vegetation is still actively growing with approx. 75% coverage. Soil surface is very dry. Bluegrass is flowering and other grasses are stunted in comparison to neighboring plots. Forbs are doing well; particularly sweet clover and yarrow
April 2007	Actively growing with approximately 80-90% coverage; extent of coverage is significantly better than in previous years. Vegetation consists of a diverse mixture of grasses and forbs with wheatgrass at the 3-5 leaf stage and fescue at the 10+ stage. Both yarrow and clover at the 5-10 leaf stage. Vegetation is exhibiting good color and vigor. Moderate residue is present and moss is covering approximately 50% of the soil surface. Soil surface is dry and no organic layer is present. Although some erosion was observed in 2003, no additional erosion was observed during 2007.
May 2007	A diverse mixture of grasses (bromes and fescues) and forbs (yarrow and white clover) is present. Fireweed is also present although in low numbers. The primary unseeded vegetation is black medic. Vegetation exhibiting good growth and vigor although coverage is patchy in spots. Unlike neighboring plots, the patchy growth pattern doesn't appear to be related to heavy residue.
June 2007	Vegetation is still actively growing with approx. 75% coverage. Growth consists of a relatively equal mixture of grasses and forbs. Grasses appear to stunted in comparison to neighboring plots; forb growth appears to be less limited. Black medic is commonly encountered and appears to be spreading. Soil surface is very dry and lacks the organic layer present in the adjacent plots with heavier grass growth.

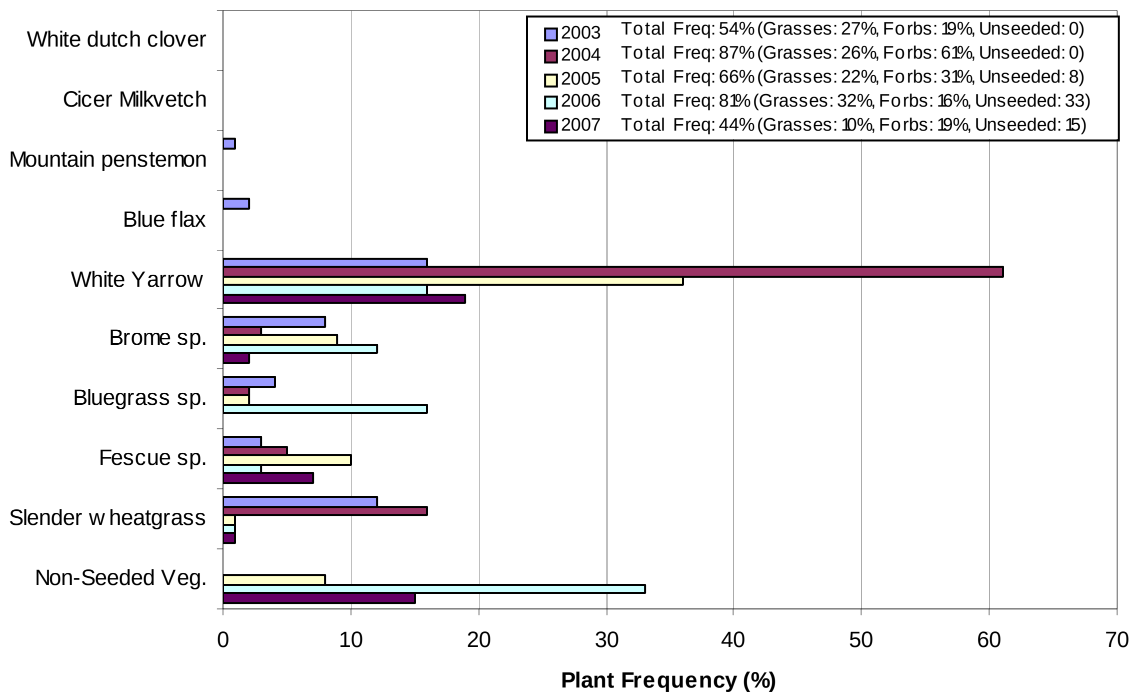


Figure 10-1D. Plant frequency on Plot D (Kiwi Power – Quattro Environmental) in 2003, 2004, 2005, 2006, and 2007.

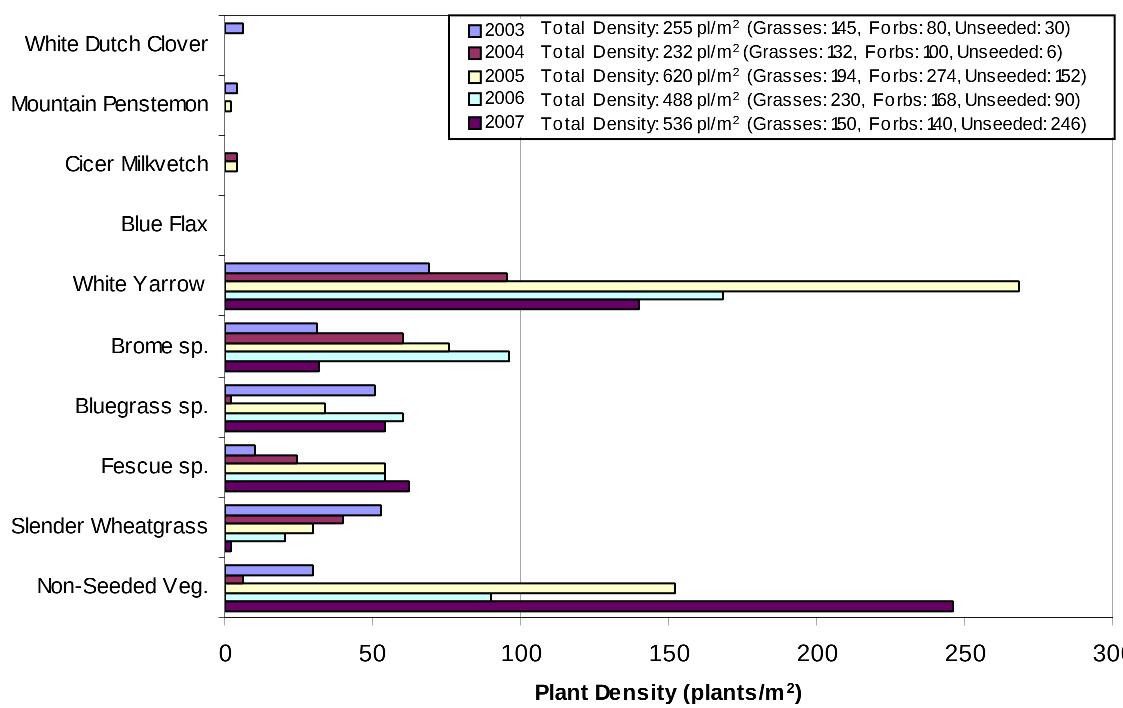


Figure 10-2D. Plant density on Plot D (Kiwi Power – Quattro Environmental) in 2003, 2004, 2005, 2006, and 2007.

October 2002

Plot E: Eko Compost

Approximately 20 yd^3 of compost was spread to a depth of 6”. Seed mix was applied in dry form (whirlybird and hand thrown). The seeded compost was track-walked with two passes of the Cat D5 on 9/25/02.

5-14-03

6-12-03

8-25-03

Plot E: Eko Compost


5-10-06
6-4-06
7-2-06
4-26-07
5-30-07
7-8-07

Table 10E. Plot Assessment for Plot E (Eko Compost) for 2003, 2004, 2005, 2006, and 2007.

April 2003	Germination good to excellent (> 30 seedlings per 0.1 m^2) on upper-plot but poor to medium on lower-plot; grasses at 2 to 4-leaf stage, forbs at 2-leaf stage. Minor amount (< 5 kg) of sediment in trap with rills evident in bottom half of plot (2-3" wide X 1-2" deep)
May 2003	Plot exhibiting excellent germination and growth with vegetation noticeably thicker at top; good balance between grasses and forbs although forbs appear to have germinated later; most grasses at 10-leaf stage or greater with large clumps forming; most forbs at 6-leaf stage; color is good in both plant types.
June 2003	Vegetation is dominated by grasses, primarily wheatgrass and bromes, very dense vegetation with excellent growth and vigor, grasses are large relatively to the same species present on other plots; wheatgrass, brome, and bluegrass have headed out; yarrow growing well but very few flowers (plants are immature); more dicot growth observed at edges of plot where grasses are less dense; plot still damp one week after rain.
May 2004	Excellent regrowth with approximately 90% coverage. Grasses have formed large clumps with 10+ leaves and yarrow is 5-10 leaf stage. Plants are exhibiting excellent color and vigor, and conditions are uniform throughout plot. Although some erosion was observed in 2003, no new erosion was observed in 2004
June 2004	Plant growth is much further along now than in June 2003. Vegetation is dominated by grasses (primarily wheatgrass); yarrow is the primary forb.
July 2004	Plot dominated by grasses but the composition has changed. In 2003, wheatgrass was dominant while the current composition is a roughly equal blend of wheatgrass and bromes. This trend is most evident in the frequency data (Figure 5-1E). The overstory is very full (consisting of wheatgrass and bromes), and the understory is comprised of small yarrow and bluegrass plants. Although the coverage is very high (total vegetative frequency is 98%), total density is low relative to other plots. This is due primarily to the relatively large size of the grasses. Bromes have reseeded and are very thick in the understory (almost carpet-like in some areas).
April 2005	Actively growing with greater than 90% coverage. Vegetation is exhibiting excellent color and vigor. Primary vegetation is wheatgrass and yarrow. Plot is heavily mulched with grass and yarrow residue from previous season. Moss growth is evident throughout plot. No sediment in trap or other evidence of erosion.
May 2005	Plot continues to exhibit excellent growth, color, and vigor. Vegetation is dominated by wheatgrass with yarrow interspersed throughout. Both wheatgrass and yarrow are at the 10 plus-leaf stage. The heavy residue doesn't appear to be reducing growth of this year's vegetation.
June 2005	Diversity in grass species becoming more apparent as the season progresses. Wheatgrass is still dominant, but bromes and fescues are also growing well. Yarrow is interspersed among the grasses. No evidence of clover and vetch, which might be due to the dense grass canopy. Grasses are not exhibiting seedhead production.

April 2006	Actively growing with 90-95% coverage. Vegetation is exhibiting excellent color and vigor. Vegetation is dominated by grass species with forbs interspersed in understory. All plants are in 10+ leaf stage. Plot is heavily mulched with 50-60% of surface covered by grass and yarrow residue from previous season. Moderate moss growth is evident throughout plot. No sediment in trap or other evidence of erosion.
May 2006	Good growth characteristics although coverage is patchy in spots. This appears to be due to heavy residue mulch. The vegetation is dominated by grasses but yarrow is establishing in patches. Plants exhibiting excellent color and vigor but no flowering at this point. Heavy moss growth is evident beneath residue.
June 2006	Plot is actively growing and plants exhibit excellent growth and vigor. The soil surface is still moist beneath the thick vegetation and heavy mulch, and the plants are still green. The grass species, primarily wheatgrass and bromes, have produced seedheads. Cicer milkvetch has also established and is growing very well.
April 2007	Actively growing with 90-95% coverage. Vegetation is dominated by wheatgrass (3-5 leaf stage), fescue (10+ leaf stage), and yarrow in the understory at 10+ leaf stage. Vegetation is exhibiting excellent color and vigor. Very heavy plant residue from last year's growth is present throughout plot. Soil surface is covered with moss and thick organic layer of decomposing grass residue. No sediment in trap or other evidence of erosion.
May 2007	Very heavy growth with primary vegetation consisting of wheatgrass with yarrow understory. Coverage is excellent although patchier than in previous years, most likely due to the very heavy surface residue. Plant color and vigor remains excellent. Heavy moss growth is evident beneath thick layer of decomposing organic matter.
June 2007	Primary growth remains dominated by grasses; wheatgrass, fescue, and bromes are present and actively growing. Forbs are also present – primarily yarrow and, to a lesser extent, milkvetch. Coverage is patchier than in previous years but still near 95%. Plot continues to exhibit excellent growth and vigor although.

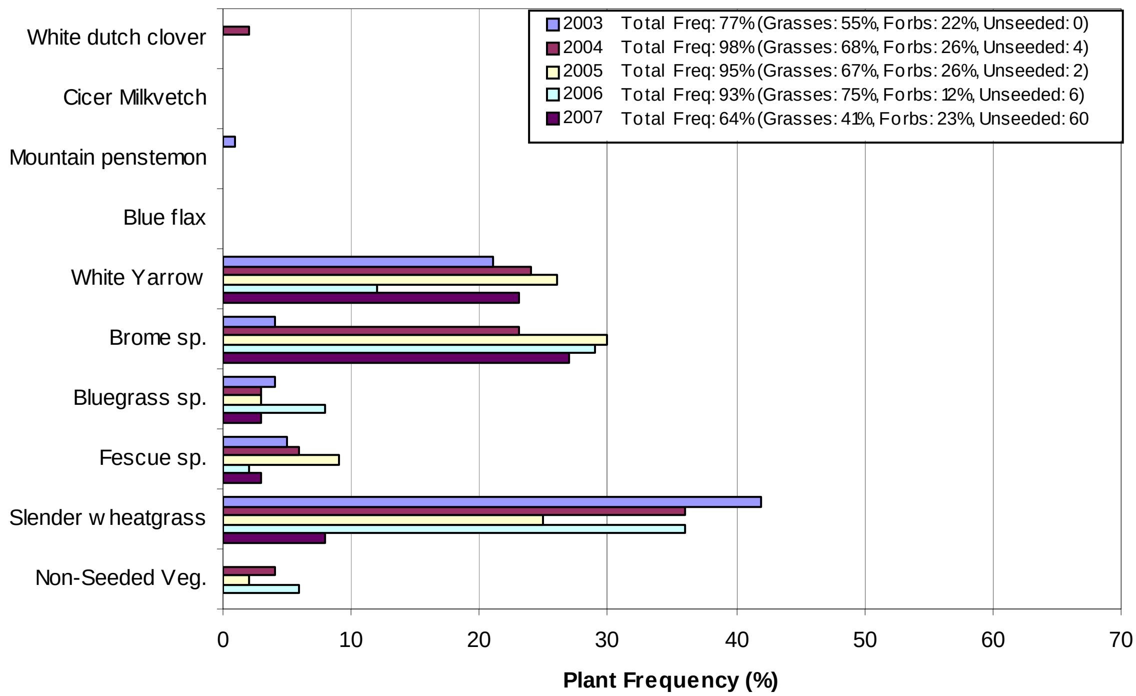


Figure 10-1E. Plant frequency on Plot E (Eko Compost) for 2003, 2004, 2005, 2006, and 2007.

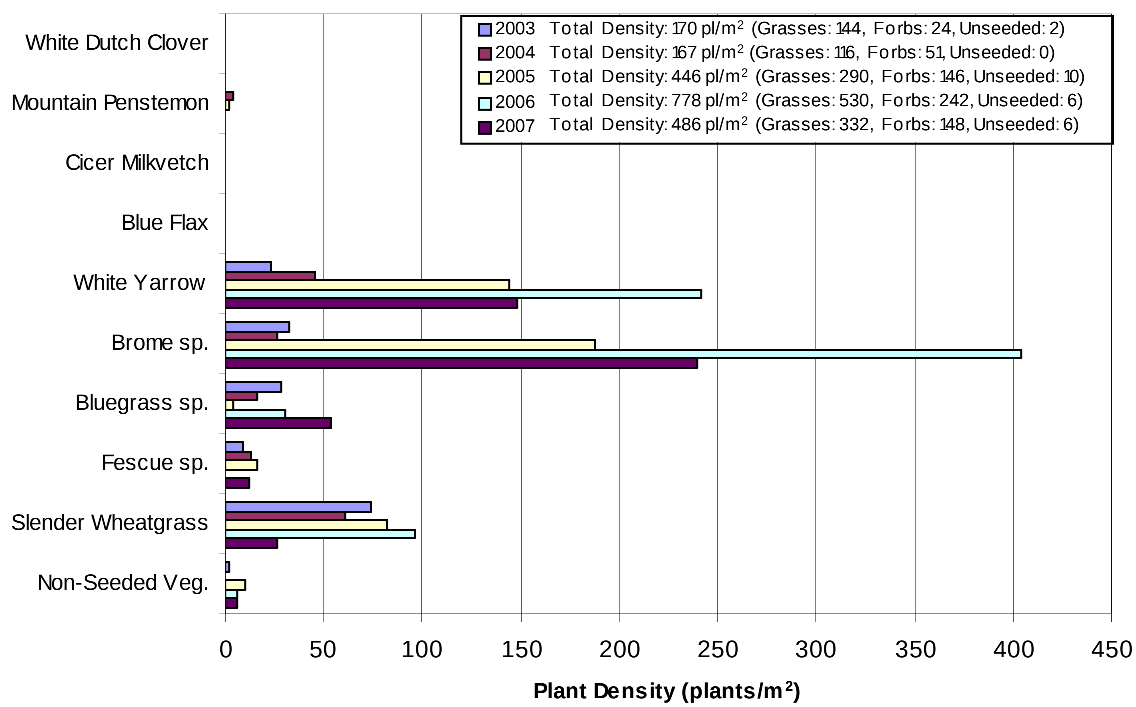


Figure 10-2E. Plant density on Plot E (Eko Compost) for 2003, 2004, 2005, 2006, and 2007.

October 2002

Plot F: Glacier Gold Compost

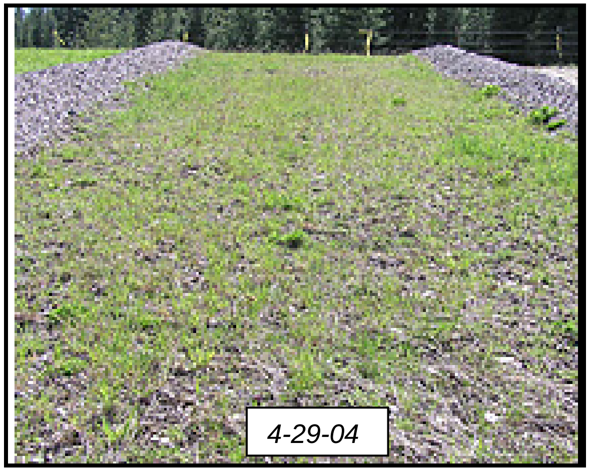
Approximately 20 yd^3 of compost was spread to a depth of 6”, scarified and track-walked using the Cat D5. The plot was hydroseeded on 10/3/02.

5-14-03

6-12-03

8-25-03

Plot F: Glacier Gold Compost


4-29-04


6-1-04


7-17-04


5-13-05


6-3-05


7-25-05


5-10-06


6-4-06


7-2-06


4-26-07


5-30-07


7-8-07

Table 10F. Plot Assessment for Plot F (Glacier Gold Compost) for 2003, 2004, 2005, 2006, and 2007.

April 2003	Poor to medium germination (< 10 seedlings per 0.1 m^2); grasses at 2 to 4-leaf stage, forbs at 2-leaf stage. Approximately 10 kg sediment in trap with rills present in bottom half of plot (4-6" wide X 1-2" deep).
May 2003	Germination and growth noticeably improved from the April assessment (now at 10-30 seedlings per 0.1 m^2); good balance between grasses and forbs; most grasses at 4 to 6-leaf stage; most forbs at 2 to 4-leaf stage; color is good in both plant types, growth conditions are uniform throughout plot.
June 2003	Plot exhibits good diversity of plant types; vegetation is patchy but plants are vigorous and healthy; wheatgrass and bluegrass have headed out, brome is less mature but growing well; yarrow is abundant with many flower heads; many penstemon present that appear to have recently germinated.
May 2004	Medium regrowth with approximately 50% coverage. The vegetation is patchy in places. Good diversity with several grass species present along with yarrow and white clover. Vegetation color and vigor noticeably better than that observed during May 2003. Although some erosion was observed in 2003, no new erosion was observed in 2004.
June 2004	Vegetation continues to do well with good balance between grasses and forbs. Wheatgrass, bromes, bluegrass and fescues are present with no single species dominating the others. Yarrow and white clover are also doing well with clover plants becoming quite large.
July 2004	Vegetation is patchy but plants are vigorous and healthy. Plot exhibits an open canopy, which seems to be correlated with greater plant diversity. Although the plants are not as large and robust as on other plots, the grasses, yarrow, and clover are doing well. In particular, the yarrow has reseeded resulting in dense clumps of seedlings. The frequency of bare soil has decreased (Figure 5-1F) with concurrent increases in total vegetative frequency and density (Figures 5-1F and 5-2F, respectively). The quantities of unseeded vegetation, most notably black medic, also increased between 2003 and 2004.
April 2005	Actively growing with 50-75% coverage. Vegetation is exhibiting moderate to good color and vigor. Diverse mixture of vegetation present with bromes, fescues, clovers, and yarrow. Clovers appear to be spreading with large pockets in places. Light to moderate mulch present due to grass, yarrow, and clover residue from previous season. Moss growth is evident throughout plot. No sediment in trap or other evidence of erosion.
May 2005	Plot continues to good growth with fairly uniform coverage throughout plot. Good diversity with several species of grasses and forbs growing. Grasses are at the 5- to10-leaf stage, yarrow is at the 10 plus-leaf stage, and clover and vetch are spreading. The moderate residue doesn't appear to be reducing growth of this year's vegetation.
June 2005	Relatively open canopy appears to favor vegetation diversity as the season progresses. Several grass species (bromes, fescues, wheatgrass) doing well, and forbs (clovers and vetch) are spreading out. Yarrow is also growing well. All vegetation beginning to produce seedheads.

April 2006	Actively growing with 80% coverage. Vegetation is exhibiting good color and vigor and is dominated by forbes. All vegetation is in 10+ leaf stage. Light to moderate mulch with 25% of surface covered by grass, yarrow, and clover residue from previous season. Heavy moss growth is evident throughout plot. No sediment in trap or other evidence of erosion.
May 2006	Plot continues to exhibit good growth characteristics with uniform coverage throughout plot. The moderate residue doesn't appear to be reducing growth of this year's vegetation. Plant color and vigor are good. Vetch and clover appear to be crowding out the grass species. Moss is still actively growing with moderate coverage.
June 2006	Plot is actively growing and plant coverage has increased significantly compared to previous years. This is due to the establishment and growth of sweet clover and vetch. The soil surface is still moist beneath the thick vegetation and heavy mulch, and the plants are still green.
April 2007	Actively growing with 95% coverage. Vegetation consists of a diverse mixture of grasses (wheatgrass at 3-5 leaf stage, bromes at 3-5 leaf stage, and fescue at 10+ leaf stage) and forbes (yarrow and milk vetch, both at 10+ leaf stag)e. All vegetation exhibiting excellent color and vigor. Very heavy plant residue from last year's growth of vetch is present throughout plot. Soil surface is covered with moss (~70%) and moderate organic layer of decomposing grass residue. No sediment in trap or other evidence of erosion.
May 2007	Plot continues to exhibit good growth of both grasses and forbs. Coverage remains very high and the surface residue doesn't appear to be reducing growth of this year's vegetation. Plant color and vigor are excellent. Soil surface is moist beneath surface organic layer.
June 2007	Plot is actively growing with diverse mix of vegetation. Grasses are doing well and both yarrow and milk vetch are thriving and appear to be spreading with many seed heads. Vegetation is still green and exhibiting good color and vigor. The soil surface is still moist beneath the thick vegetation and heavy mulch.

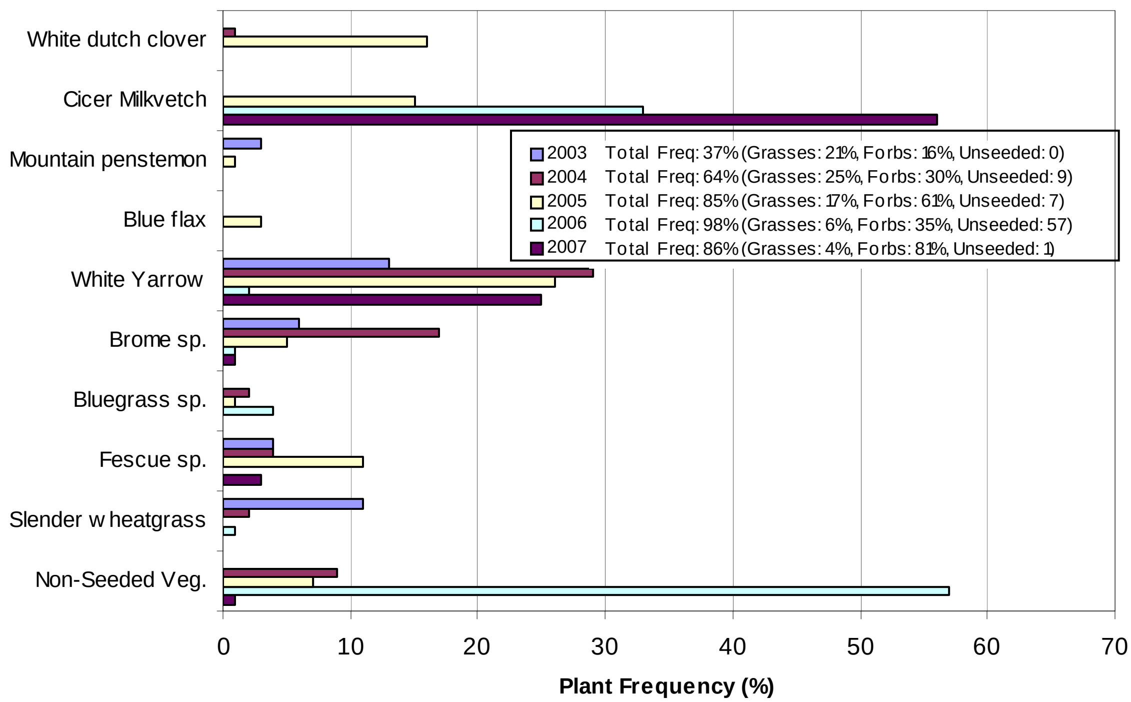


Figure 10-1F. Plant frequency on Plot F (Glacier Gold Compost) in 2003, 2004, 2005, 2006, and 2007.
.

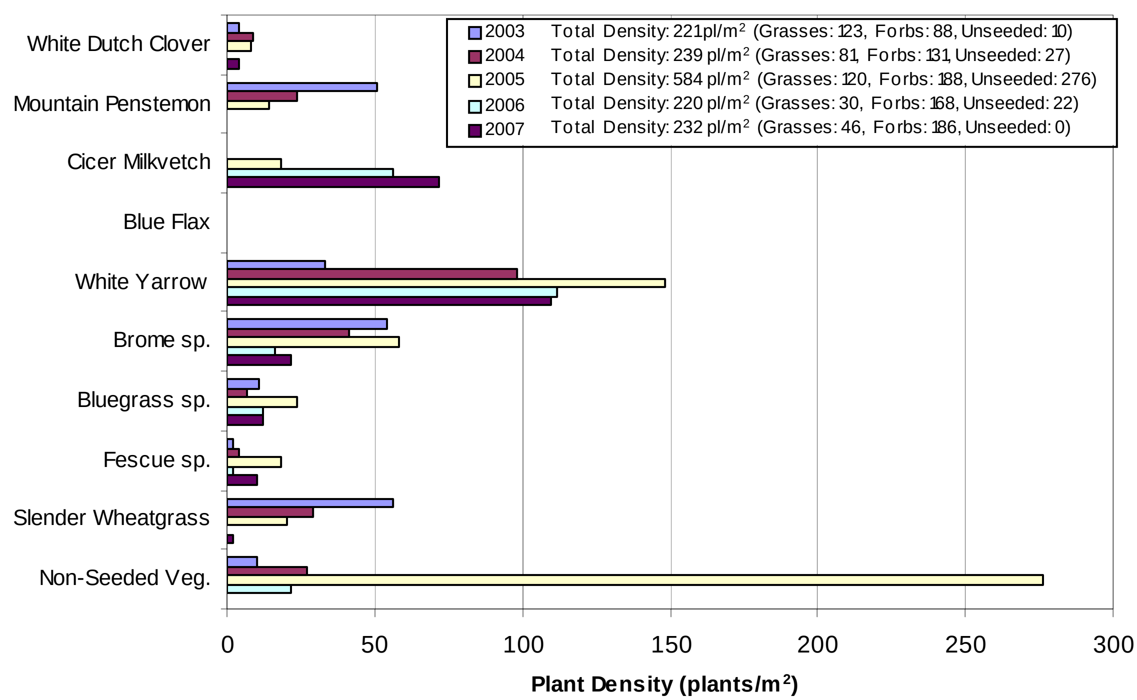


Figure 10-2F. Plant density on Plot F (Glacier Gold Compost) 2003, 2004, 2005, 2006, and 2007.

October 2002

Plot G: Biosol – Rocky Mountain Bio Products

The following components were mixed in the hydroseeder tank:

- 83 lb Biosol Mix (7-2-3)
- 5 lb Wood Fiber Mulch
- seed mix

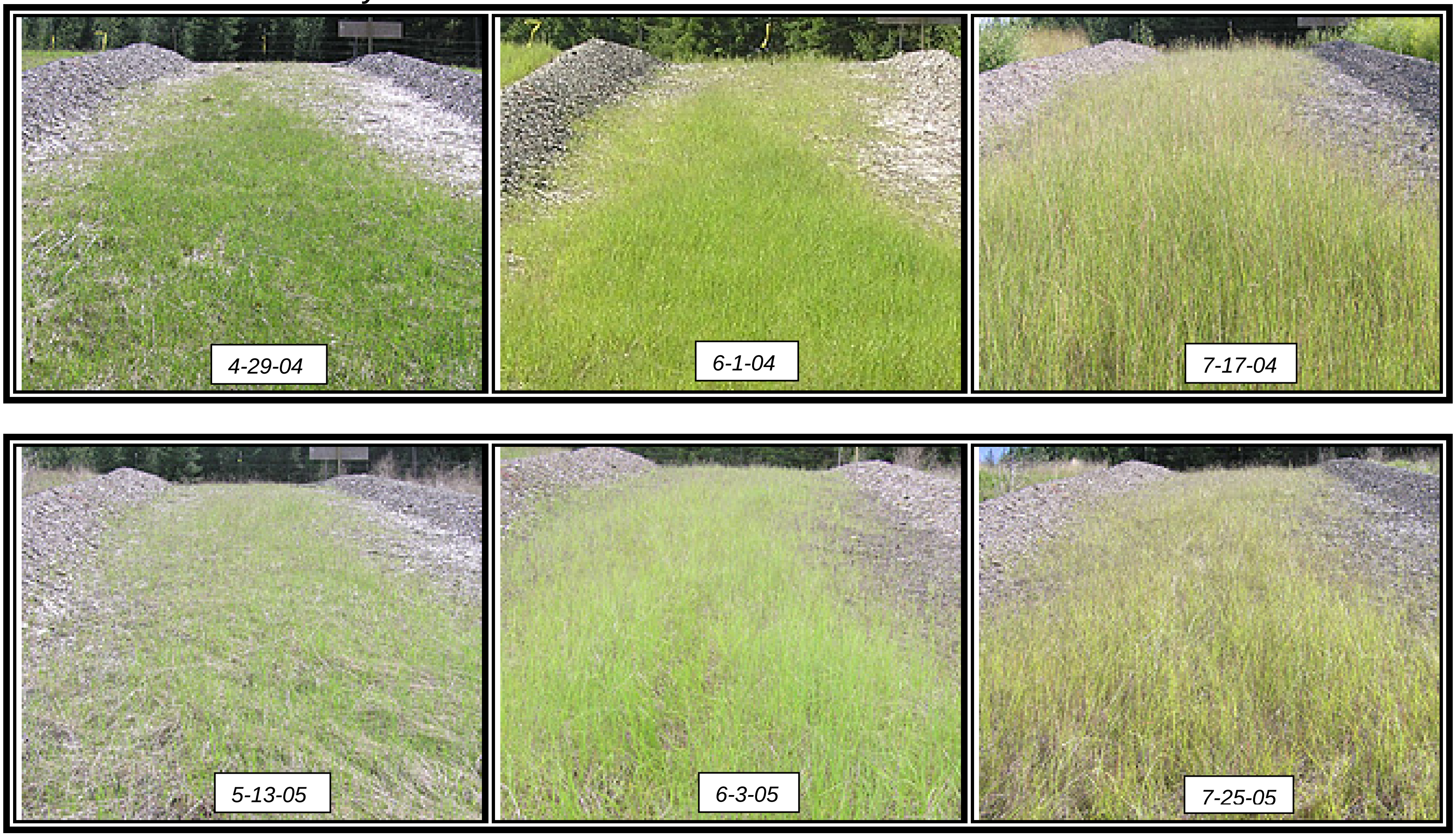
The Biosol + seed mix was applied using the hydroseeder on 10/2/02. Wheat straw was spread over plot and 4 lb Guardian Tackifier applied using the hydroseeder.

5-14-03

6-12-03

8-25-03

Plot G: Biosol – Rocky Mountain Bio Products




5-10-06
6-4-06
7-2-06


4-26-07
5-30-07
7-8-07

Table 10G. Plot Assessment for Plot G (Biosol – Rocky Mountain Bio Products) for 2003, 2004, 2005, 2006, 2007.

April 2003	Good germination (> 30 seedlings per 0.1 m^2); grasses at 10-leaf stage, forbs at 2-leaf stage. No sediment in trap or other evidence of erosion.
May 2003	Germination and growth good to excellent; good balance between grasses and forbs; most grasses at 10-leaf stage or greater with large clumps; most forbs at 2 to 4-leaf stage; color is good forbs and on young grass leaves, noticeable chlorosis with yellow-orange coloration on many older grass leaves, growth conditions are uniform throughout plot.
June 2003	Plot appears to be sparsely vegetated but a closer examination indicates lots of growth, plants are small, immature and appear to be stunted; leaf color is generally good, many plants appear to have germinated late in the season, plot exhibiting better growth at bottom.
May 2004	Good regrowth with 70-80% coverage on most of plot (with the exception of the upper-right portion). Vegetation is dominated by grasses, which are generally in clumps at the 10-leaf stage or greater. Color and vigor is good throughout the plot. No sediment in trap or other evidence of erosion.
June 2004	Good mixture of grasses including wheatgrass, bromes, and fescues. No single grass species is dominating the others. Yarrow is present but the plants are small. Overall, the vegetation is pale and less vigorous compared to other plots with higher nitrogen.
July 2004	Grasses continue to dominate the vegetation. Although yarrow is present, it appears to be stunted. And, while the grasses are well established, they often exhibit pale color with few seed heads. The lower half of the plot is noticeably more dense and exhibiting better growth characteristics. Overall, the frequency of bare soil decreased (Figure 5-1G) and total frequency and density increased between 2003 and 2004 (Figures 5-1G and 5-2G, respectively). These changes were primarily the result of increases in wheatgrass, Idaho fescue, and bluegrass.
April 2005	Actively growing with 50-75% coverage. Vegetation is exhibiting poor to moderate color and vigor. Diverse mixture of vegetation present with bromes, fescues, wheatgrass, and yarrow. Heavy mulch from wheatstraw, applied during plot installation, is still present. Residue from previous crop residue is relatively light. No sediment in trap or other evidence of erosion.
May 2005	Plot exhibiting moderate growth and coverage. Good diversity with several species of grasses and yarrow growing. White clover is also present, although this species is not exhibiting the profuse growth and spreading observed on other plots. Grasses are at the 5- to10-leaf stage and yarrow is at the 10 plus-leaf stage.
June 2005	Relatively open canopy, which is favoring growth of diverse vegetation. Several grass species (bromes, fescues, wheatgrass) present with none dominant. Yarrow is exhibiting good color and vigor. However, most vegetation is slightly chlorotic and somewhat stunted in comparison to adjacent plots.

April 2006	Actively growing with 20-30% coverage. Vegetation is exhibiting moderate color and vigor, and is small in comparison to other plots. Grass species are predominant and are in the 1-3 leaf stage. Heavy mulch from wheatstraw, applied during plot installation, is still present. Residue from previous crop residue is relatively light. Moss growth is light throughout plot. No sediment in trap or other evidence of erosion.
May 2006	Plot exhibiting moderate growth and coverage. Plant color and vigor is moderate. Heavy residue mulch might be restricting growth, although low fertility appears to be a significant factor. Moss is actively growing beneath residue with moderate coverage.
June 2006	Vegetation is patchy with 40-50% coverage. Plants are very stunted and pale suggesting low fertility. Soil surface is very dry and vegetation is turning brown. Vegetation is primarily grass species; most have flowered but low numbers of seedheads were produced.
April 2007	Actively growing vegetation with approximately 50% coverage. Grass species are predominant with brome in the3-53 leaf stage and fescue in the 10+ leaf stage. Yarrow is also present (10+ leaf stage) and there are a few patches of clover. Vegetation is exhibiting moderate color and vigor, and is small in comparison to other plots. Residue from previous year's growth is light but heavy mulch from wheatstraw, applied during plot installation, is still present. Moss growth is light throughout plot and soil surface is dry. No sediment in trap or other evidence of erosion.
May 2007	Plot exhibiting moderate growth and coverage with diverse mixture of grasses (wheatgrass, brome, and fescue). Yarrow is the most commonly observed forb. Growth of yarrow is small in comparison to adjacent plots and most plant are beginning to flower. Plant color and vigor is moderate to poor, and vegetation is showing signs of nitrogen and perhaps phosphorus deficiency (pale green, reddening of grass leaves, and stunting).
June 2007	Vegetation is primarily grass species (bromes and fescues) with small yarrow plants interspersed; Most plants have flowered with low numbers of seed heads. Very patch growth pattern with 40-50% coverage. Plants are very stunted and pale green indicating low nitrogen. Soil surface is very dry and vegetation is turning brown.

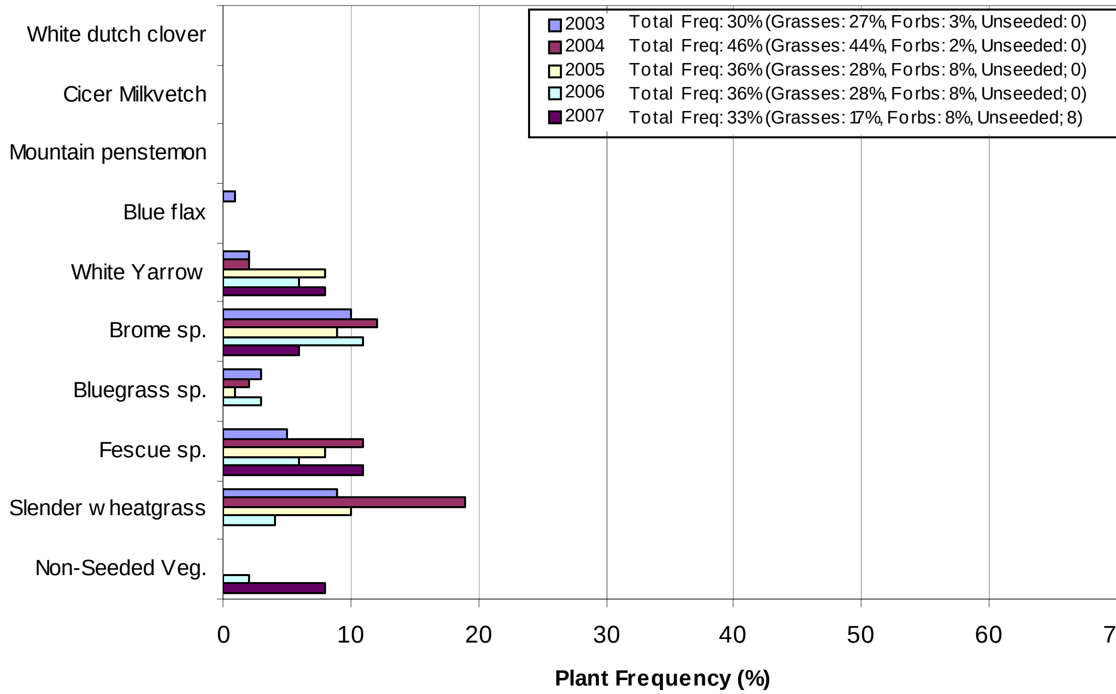


Figure 10-1G. Plant frequency on Plot G (Biosol – Rocky Mountain Bio Products) for 2003, 2004, 2005, 2006, and 2007.

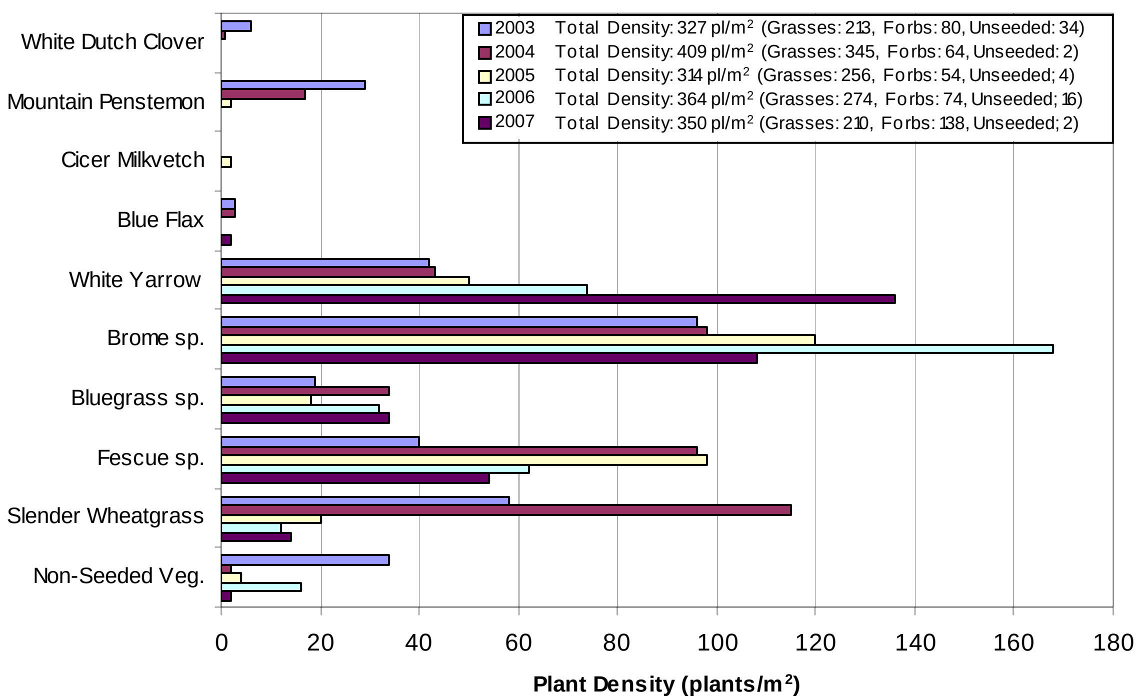


Figure 10-2G. Plant density on Plot G (Biosol – Rocky Mountain Bio Products) for 2003, 2004, 2005, 2006, and 2007.

October 2002

Plot H: Glacier Gold Log Yard Waste

Approximately 20 yd^3 of log yard waste was spread to a depth of 6”, scarified and track-walked using the Cat D5. The plot was hydroseeded on 10/3/02.

5-14-03

6-12-03

8-25-03

Plot H: Glacier Gold Log Yard Waste


5-10-06
6-4-06
7-2-06


4-26-07
5-30-07
7-8-07

Table 10H. Plot Assessment for Plot H (Glacier Gold Log Yard Waste) for 2003, 2004, 2005, 2006 and 2007.

April 2003	Poor germination (< 10 seedlings per 0.1 m^2); grasses at 2-leaf stage, forbs at 2-leaf stage. Minor erosion with rills evident in bottom half of plot, but no sediment in trap.
May 2003	Poor germination; equal proportion of grasses and forbs; most grasses at 2 to 4-leaf stage; most forbs at 2 to 4-leaf stage; color is poor to moderate (pale green) in both plant types with some grasses exhibiting reddish-purple streaks, growth conditions are uniform throughout plot.
June 2003	Plot exhibits a diversity of plant types; vegetation is patchy but plants are healthy; wheatgrass and brome are the primary grasses, both are immature but growing well; yarrow is abundant but small with few flowers; many small penstemon plants that appear to have recently germinated.
May 2004	Medium regrowth with 40-50% coverage. Good diversity in vegetation with both grasses and forbs established. Color and vigor is also good and conditions, although patchy, are uniform throughout plot. Although some erosion was observed in 2003, no new erosion was observed in 2004.
June 2004	Forbs becoming more dominant, particularly white clover and yarrow. Wheatgrass and brome plants are scattered throughout plot but are not thriving. Many plants are showing pale color and stunted growth.
July 2004	Plot exhibits a diversity of plant species, although the forbs (primarily white clover and yarrow) are doing better than the grasses. Although vegetative frequency increased between 2003 and 2004 (Figure 5-1H), density numbers are relatively low (Figure 5-2H). This is primarily due to a patchy, irregular vegetative coverage (i.e. a few large clovers interspersed with small grass clumps). This type of coverage also explains the discrepancy between the frequency data (Figure 5-1H) and density data (Figure 5-2H). Overall, the most significant change in vegetation was the large increase in white clover frequency (Figure 5-1H).
April 2005	Actively growing with approximately 75% coverage. Vegetation is exhibiting good color and vigor. Diverse mixture of grasses (bromes, fescues, wheatgrass) and forbs (primarily yarrow) present. Clover is also present and spreading, with large pockets in places. Moderate to heavy mulch from previous crop residue. No sediment in trap or other evidence of erosion.
May 2005	Plot exhibiting moderate growth and coverage. Good diversity with several species of grasses growing along with yarrow, clover, and vetch. All vegetation is at the 10 plus-leaf stage. Mulch does not appear to be limiting grow of this year's vegetation. Large upright debris from white clover also present.
June 2005	Good diversity of vegetation. Bromes, fescues, wheatgrass are present but are not thriving. In contrast, vetch and clover are vigorously growing and spreading, and yarrow is also doing well. In particular, vetch is much more prevalent than in previous years.

April 2006	Actively growing with approximately 60-70% coverage. Vegetation is exhibiting good color and vigor. Diverse mixture of grasses and forbs present with most plants at 5-10 leaf stage. Moderate to heavy mulch with 50% of surface covered with previous crop residue. Moderate moss growth throughout plot. No sediment in trap or other evidence of erosion.
May 2006	Plot exhibiting moderate to good growth and coverage with good color and vigor. Grass species doing better in areas where vetch is not growing, suggesting vetch might be crowding out the grasses. Mulch does not appear to be limiting grow of this year's vegetation. Moss still actively growing with moderate coverage.
June 2006	Plot is actively growing and plant coverage has increased significantly compared to previous years. This is due to the establishment and growth of sweet clover and vetch. Grass species are also present and have produced seedheads. Color and vigor of vegetation is good. The soil surface is still moist beneath the thick vegetation and heavy mulch, and the plants are still green.
April 2007	Actively growing with 95% coverage. Primary vegetation is wheatgrass and brome at 3-5 leaf stage; fescue is at 10+ leaf stage. Yarrow is at 10+ leaf stage; clover and milk vetch also present throughout plot. All vegetation exhibiting good color and vigor. Very heavy plant residue from last year's growth is present and soil surface is covered with moss and thick organic layer of decomposing organic matter. No sediment in trap or other evidence of erosion.
May 2007	Very heavy vegetative growth with diverse mixture of grasses (bromes and fescues) and forbs (yarrow and milk vetch). Coverage is patchy in places due to thick surface residue. Vetch also appears to be crowding out grasses. Plants exhibiting good color and vigor. Moss still actively growing and soil surface is moist.
June 2007	Plot continues to exhibit thick vegetative cover with heavy growth of milk vetch. Grass species are also present and all vegetation appears to be spreading and producing many seed heads. Color and vigor of vegetation is excellent. The soil surface is still moist beneath the thick vegetation and heavy mulch, and the plants are still green.

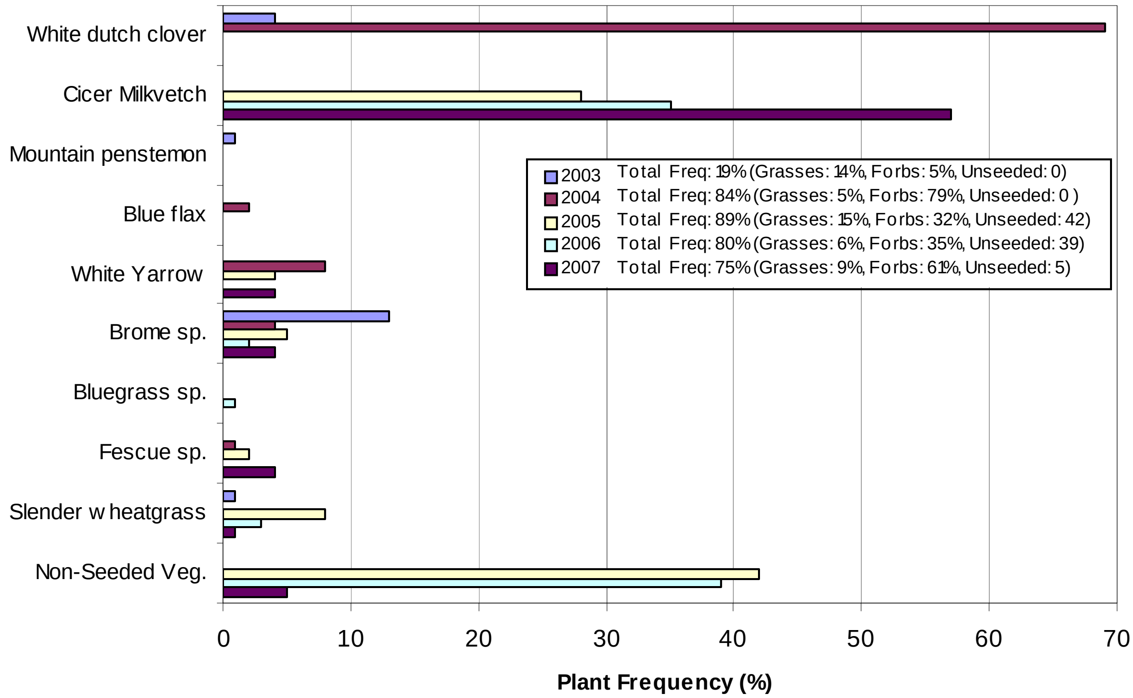


Figure 10-1H. Plant frequency on Plot H (Glacier Gold Log Yard Waste) for 2003, 2004, 2005, 2006, and 2007.

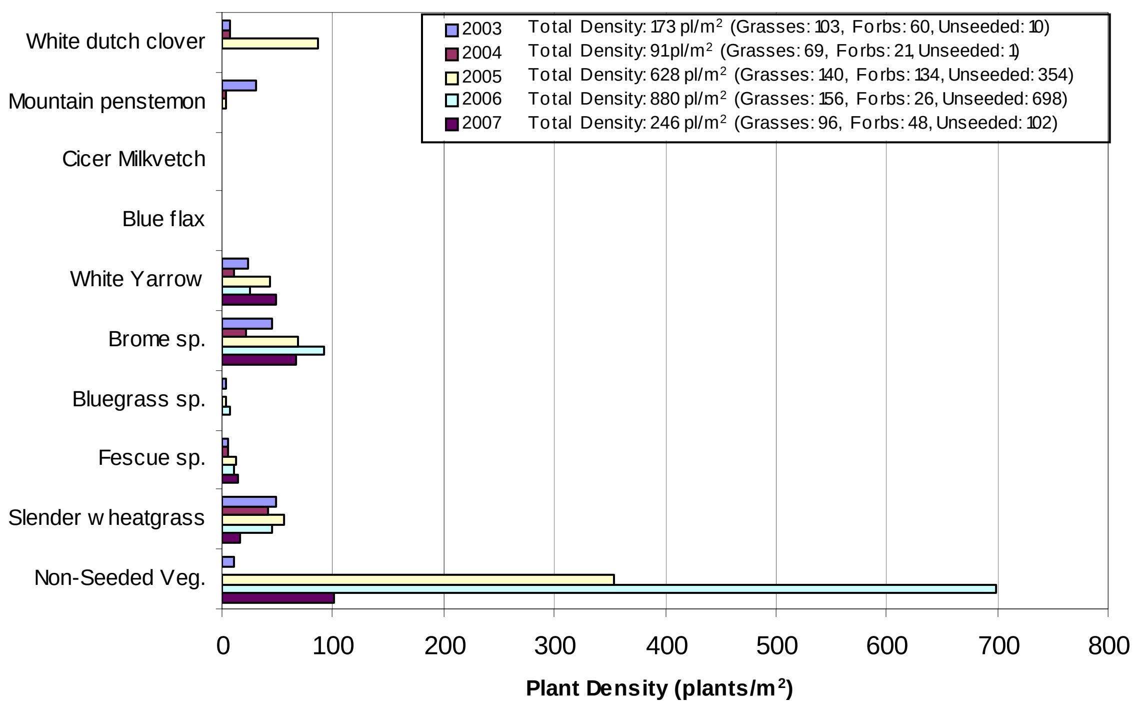


Figure 10-2H. Plant density on Plot H (Glacier Gold Log Yard Waste) for 2003, 2004, 2005, 2006, and 2007.

October 2002

Plot I: Coeur d'Alene Biosolids + Wood Ash (1:1)

Class B Biosolids were mixed with Avista Wood Ash 1:1. Approximately 26 yd^3 of the mixture was applied using the Cat D5. Attempts to achieve even coverage and scarification using the D5 were unsuccessful due to the slick consistency of the material. The plot was hydroseeded on 10/21/02.

5-14-03

6-12-03

8-25-03

Plot I: Coeur d'Alene Biosolids + Wood Ash (1:1)


5-10-06


6-4-06


7-2-06


4-26-07


5-30-07


7-8-07

Table 10I. Plot Assessment for Plot I (Coeur d'Alene Biosolids + Wood Ash, 1:1) for 2003, 2004, 2005, 2006, and 2007.

April 2003	Good germination (> 30 seedlings per 0.1 m^2); grasses at 2-leaf stage, forbs at 2-leaf stage. No sediment in trap or other evidence of erosion.
May 2003	Good to excellent germination and growth; most grasses at 10-leaf stage or greater with large clumps forming; most forbs at 4-leaf stage; grasses more frequent than forbs, good color characteristics in both plant types.
June 2003	Plot is dominated by wheatgrass and bluegrass, bromes also present but less numerous; Idaho fescue and sheep fescue are frequent but immature; large plants with vigorous growth; wheatgrass has seeded out; yarrow and white clover present at edges of plot.
May 2004	Excellent regrowth with 90-95% coverage. Grasses are dominating the plot with most forming large clumps at the 10+ leaf stage. Color and vigor is very good, and conditions are uniform throughout the plot. No sediment in trap or other evidence of erosion.
June 2004	Grasses continue to dominate, particularly at the center of the plot. Wheatgrass is most prevalent, although bromes, fescues, and bluegrass are interspersed. The few forbs present consist of yarrow and clover growing mostly at the edge of the plot. Plant growth stages appear to be at least 1 month ahead of 2003.
July 2004	Plot overstory is dominated by wheatgrass that has produced profuse large seed heads. Bromes, fescues, and bluegrass are frequent but are less mature and tend to occupy the understory. Yarrow has also flowered and seeded, and large white clover plants are present at the edge of the plot. All plants are very large and robust, and many wheatgrass plants have lodged. Overall, total vegetative frequency increased between 2003 and 2004, with the greatest increase in wheatgrass and bromes (Figure 5-1H). Total density decreased, most likely as a result of the relatively large size of the vegetation. The presence of unseeded vegetation is relatively low, with only an occasional observation of Argrostis sp. (red top grass).
April 2005	Actively growing with greater than 90% coverage. Vegetation is exhibiting excellent color and vigor. Vegetation is dominated by wheatgrass and yarrow. Moderate to heavy mulch, primarily from previous year's wheatgrass residue. No sediment in trap or other evidence of erosion.
May 2005	Plot exhibiting excellent growth and coverage. Vegetation largely dominated by wheatgrass; bromes and fescues are also present but are not as vigorous. Yarrow is interspersed among grass. Wheatgrass is at the 10 plus-leaf stage while yarrow and other grasses are at the 5- to 10-leaf stage. Mulch does not appear to be limiting grow of this year's vegetation.
June 2005	Plot continues to exhibit very lush growth with wheatgrass clearly dominating. Yarrow, fescues, and bromes are present in understory. All vegetation exhibiting excellent color and vigor. Immature seedheads present on wheatgrass.

April 2006	Actively growing with greater than 95% coverage. Vegetation is exhibiting excellent color and vigor with grass species and yarrow doing well. All plants at 10+ leaf stage. Heavy mulch with 75% of surface covered with previous year's wheatgrass residue. Moderate moss growth throughout plot. No sediment in trap or other evidence of erosion.
May 2006	Plot exhibiting excellent growth, although coverage is patchy in spots due to heavy residue mulch. Plants exhibiting excellent color and vigor. Some grasses have produced seed heads but no flowers on yarrow. Moss growth has declined.
June 2006	Plot continues to exhibit excellent plant vigor and growth with 95% coverage. Vegetation is dominated by grass species, primarily wheatgrass and bromes, and both species have produced profuse seedheads. Plant color and vigor is very good. The soil surface is still moist beneath the thick vegetation and heavy mulch, and the plants are still green.
April 2007	Actively growing with 95% coverage. Primary vegetation is wheatgrass and yarrow, both at 10+ leaf stage. All vegetation exhibiting excellent color and vigor. Grass and yarrow plants are poking through the very heavy plant residue from last year's growth. Soil surface is covered with moss and thick organic layer of decomposing grass residue. No sediment in trap or other evidence of erosion.
May 2007	Very heavy growth, primarily of wheatgrass and bromes. Coverage is patchy in places due to pockets of heavy plant residue. All vegetation exhibiting excellent color and vigor. Bromes have produced seed heads but no flowers on yarrow. Moss growth has declined and soil surface remains moist beneath thick vegetation and organic layer.
June 2007	Good mixture of grasses (wheatgrass, bromes, and fescues) with lesser growth of forbs. Yarrow is the most commonly observed forb and is present in the understory and at plot edges. Plot continues to exhibit excellent plant vigor and color with 95% coverage. Plants are beginning to turn brown and have produced many full seed heads. The soil surface is still moist beneath the thick vegetation and heavy mulch..

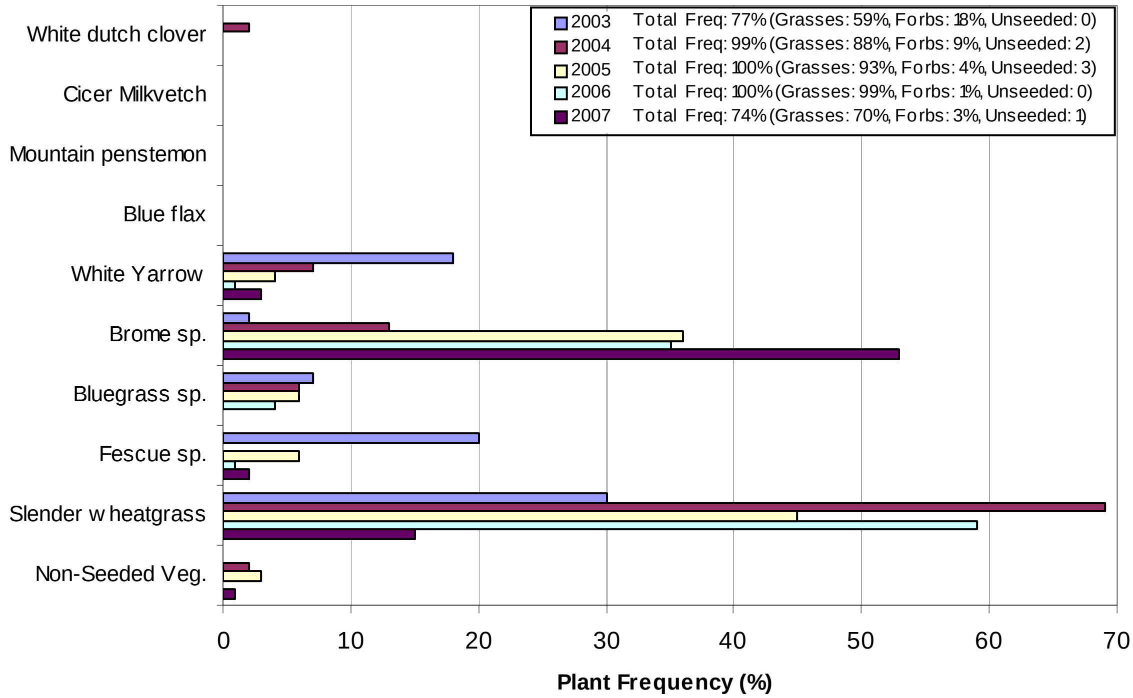


Figure 10-1I. Plant frequency on Plot I (Coeur d'Alene Biosolids + Wood Ash) for 2003, 2004, 2005, 2006, and 2007.

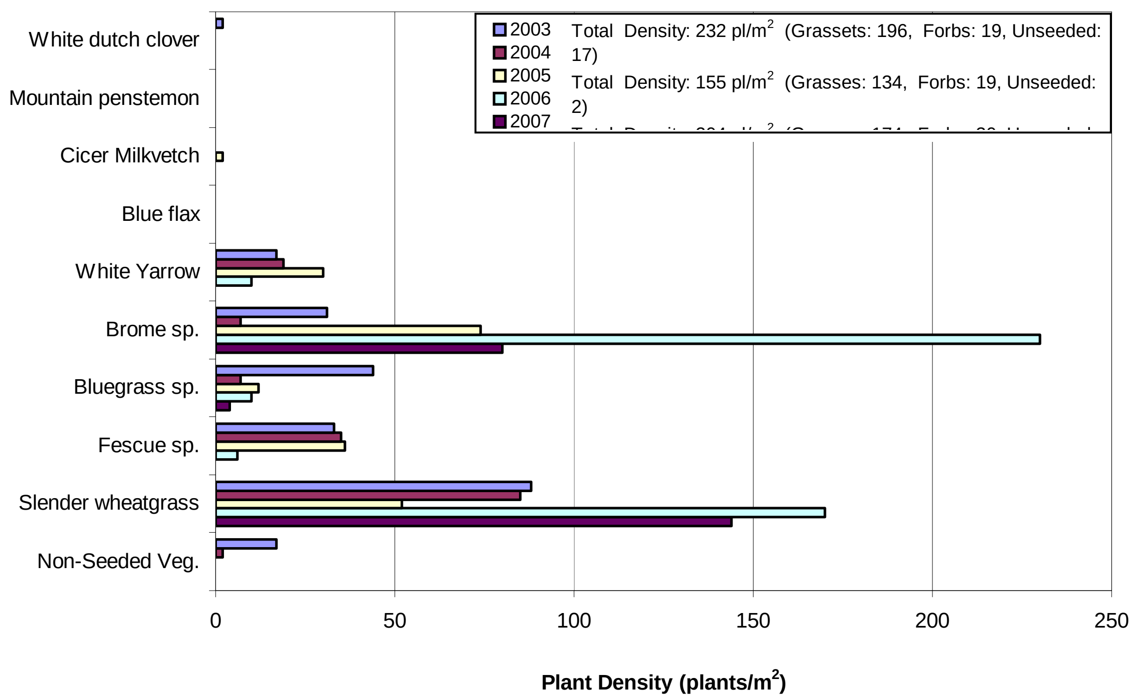


Figure 10-2I. Plant density on Plot I (Coeur d'Alene Biosolids + Wood Ash) for 2003, 2004, 2005, 2006, and 2007.

October 2002

Plot J: Control – Fertilizer + Berms

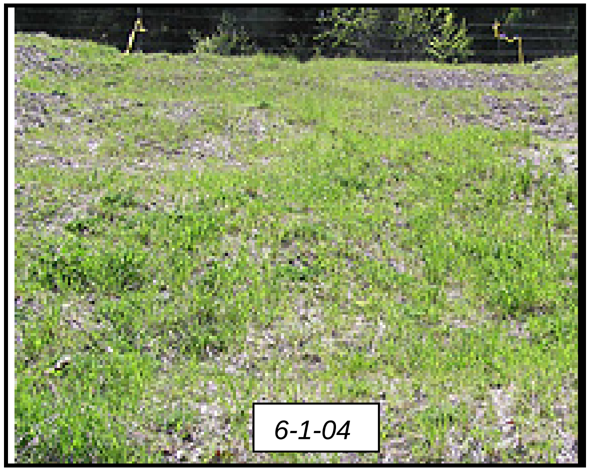
Plot surface was shaped with Cat D5 to produce 1-2’ berms. Fertilizer (50 lb of 16-16-16), seed mix, and tackifier were mixed in the hydroseeder tank and applied on 10/2/02. Bluegrass straw applied as a mulch on bottom-half of plot.

5-14-03

6-12-03

8-25-03

Plot J: Control – Fertilizer + Berms




5-10-06
6-4-06
7-2-06


4-26-07
5-30-07
7-8-07

Table 10J. Plot Assessment for Plot J (Control – Fertilizer + Berms) for 2003, 2004, 2005, 2006, and 2007.

April 2003	Poor germination (< 10 seedlings per 0.1 m^2) on upper-half (no mulch), poor to medium germination on bottom-half (straw mulch); grasses at 2-leaf stage, forbs at 2-leaf stage. Erosion occurred on upper-half of plot; large rills evident with eroded sediment caught in berm. No sediment in trap.
May 2003	Moderate germination and growth on upper-half, primary vegetation is grass at 4-leaf stage, color is good, conditions are patchy; moderate germination and growth on lower-half, primary vegetation is grass at 4-leaf stage with very few forbs, color is poor to moderate with pale green leaves and some reddish-purple coloration, conditions are uniform.
June 2003	Numerous wheatgrass plants in both top and bottom but very immature; brome is also frequent as is white yarrow; all plants are very small with stunted growth pattern; grasses are still green on bottom half of plot due to mulch but little other difference in growth and vigor between upper and lower plot.
May 2004	Medium regrowth with 40-50% coverage. Vegetation is patchy, particularly in upper-half of plot. Good diversity in vegetation with both grasses and forbs established. Color and vigor are good. Although some erosion was observed in 2003, no new erosion was observed in 2004.
June 2004	Plot continues to exhibit good growth, with the lower-half looking slightly better. Both grasses and forbs are much smaller than the neighboring plot, and color is noticeably paler. Grasses are typically at the 10-leaf stage forming small clumps. Yarrow is at the 5-10 leaf stage and clover appears to be well established..
July 2004	Upper section of plot has less vegetative coverage compare with the lower-half (where bluegrass mulch was applied). Both sections of the plot have a diverse group of grasses (wheatgrass, bromes, fescues, and bluegrass) but wheatgrass is much more frequent, and less stunted, in the bottom section. Overall, plants are noticeably larger and appear to be better established in bottom section with particularly good growth of sweet clover, wheatgrass, and bromes. Additionally, non-seeded vegetation, including black medic and knapweed, is present.
April 2005	Upper half of plot is actively growing with approximately 50% coverage. Vegetation is exhibiting moderate to good color and vigor. Vegetation comprised of mixture of grasses, clover, and yarrow. Light mulch present in isolated pockets. Lower half of plot exhibiting 50-75% coverage with similar mixture of species. Plant color and vigor is moderate to good. Moderate mulch from previous year's vegetation, along with light remnants of bluegrass straw mulch applied during plot installation. No sediment in trap or other evidence of erosion.
May 2005	Plot exhibiting moderate growth and coverage. Lower half of plot exhibiting slightly better growth characteristics than top half. Good mixture of grasses (primarily bromes and fescues), yarrow, and white clover. Clover is exhibiting the profuse growth observed on adjacent (higher fertility) plots. Mulch does not appear to be limiting grow of this year's vegetation.
June 2005	Upper-half of plots continues be less densely vegetated, compared with lower-half. Several species of grasses are established, but are slightly chlorotic and stunted. Yarrow and clover are exhibiting better color and vigor. Immature seedheads are present on brome.

April 2006	Actively growing with approximately 50% coverage (lower half of plot exhibiting slightly higher coverage). Vegetation is exhibiting moderate to good color and vigor. Vegetation comprised of mixture of grasses, clover, and yarrow. Most plants are in the 5-10 leaf stage. Light to moderate mulch with 50% of surface covered with residue from previous year's vegetation (residue is heavier in bottom half of plot). Light to moderate moss growth. No sediment in trap or other evidence of erosion.
May 2006	Plot exhibiting moderate growth and coverage with lower half of plot exhibiting slightly better growth characteristics than top half. Lower coverage on top half could be due erosion or the lack of bluegrass residue mulch. Plants exhibiting good color and vigor although plants are smaller than other plots. Fescues and bromes beginning to produce seed heads. Moss growth has declined.
June 2006	Vegetation on top-half of plot is sparse and plants are much smaller than neighboring plots. However, plant color is good. A diverse mix of grasses and forbs is present and most plants have flowered. The soil surface is very dry. The bottom-half has better coverage (60-70%). The plants are still green and flowering, but the soil surface is dry. Clover is common but poor vigor and only slightly spreading.
April 2007	Actively growing with coverage varying from 50-75% in upper-half of plot and 80-90% in lower-half. A diverse mixture of grasses is present with wheatgrass at 3-5 leaf stage and fescue at 10+. Yarrow is also present throughout plot at 10+ leaf stage. Vegetation is exhibiting moderate to good color and vigor. Vegetation comprised of mixture of grasses, clover, and yarrow. Top of plot has small amount of moss growth while bottom has ~30% of the surface covered by moss. Light to moderate mulch with 50% of surface covered with residue from previous year's vegetation (residue is heavier in bottom half of plot). No sediment in trap or other evidence of erosion.
May 2007	Top – patchy growth with diverse mixture of grasses (bromes, fescues, and wheatgrass). Yarrow, white clover, and milk vetch are the most commonly observed forbs and knapweed is the most common weed. Plant color and vigor is moderate and soil surface is dry. Bottom – coverage is noticeably higher; grass and forb species present are similar to top-half with both knapweed and black medic observed. Plants exhibiting good color and vigor although plants are smaller than other plots. Soil surface is moist under bluegrass mulch.
June 2007	Grasses and forbs continuing to grow although vegetation on top-half of plot is sparse. Plants on top and bottom of plot are much smaller than neighboring plots and there is evidence of stunting. The plants are still green and flowering, but the soil surface is dry.

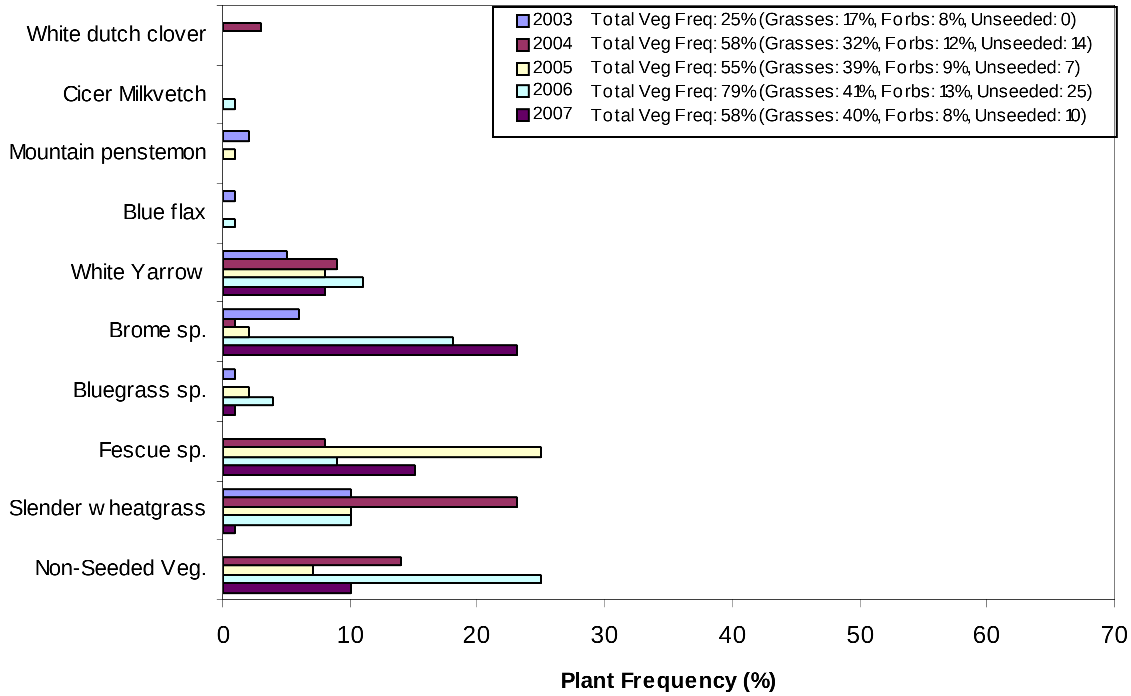


Figure 10-1J. Plant frequency on Plot J (Control – Fertilizer + Berms) for 2003, 2004, 2005, 2006, and 2007.

.

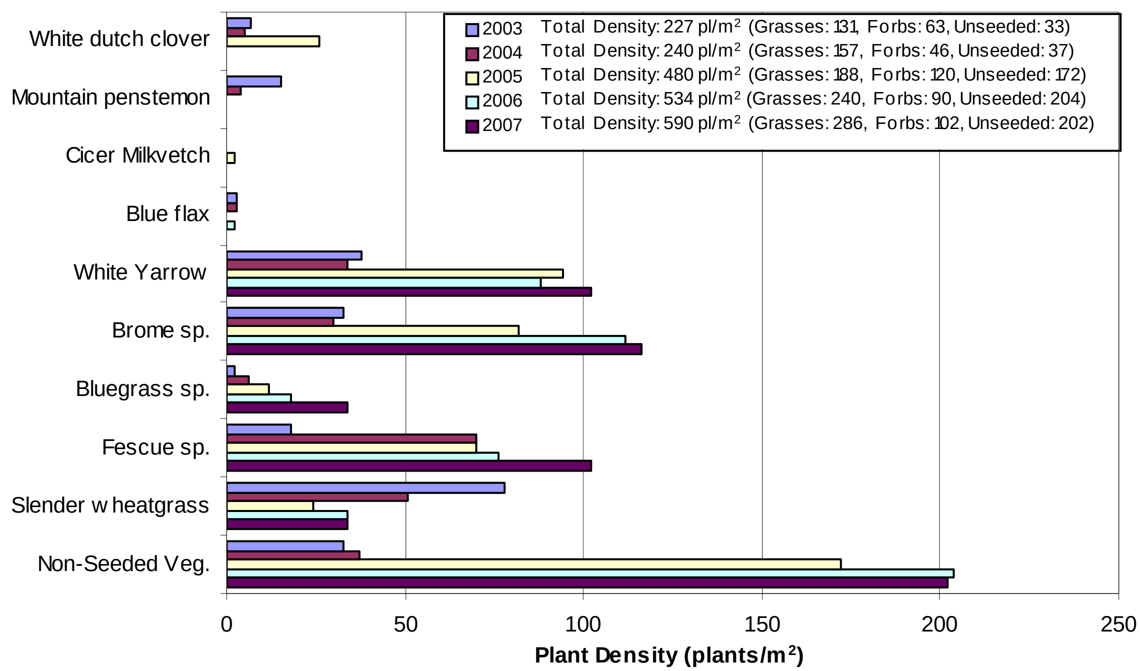


Figure 10-2J. Plant density on Plot J (Control – Fertilizer + Berms) for 2003, 2004, 2005, 2006, and 2007.