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Annual Report Hiawatha

UNITED STATES FUEL COMPANY

VEGETATION TEST PLOTS

YEAR 5 FINAL REPORT

Hiawatha, Utah

UNITED STATES FUEL COMPANY

VEGETATION TEST PLOTS

YEAR 5 FINAL REPORT

Hiawatha, Utah

Prepared for

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1.0 INTRODUCTION

A vegetation test plot program was submitted with the mine permit applications by U.S. Fuels to satisfy OSM regulations for a tested revegetation program. This final report covers the 5th year of the program, or the 4th growing season, and summarizes the results from the previous years. The results of the 1st and 2nd growing seasons are contained in tne 1985 and 1986 progress reports respectivly (Appendix 1&2). Under the plan originally submitted to the DOGM, tne growth of the 3rd growing season (1987) was not to be measured.

The test plot program was installed in 1984 with the preparation of the plot sites and the seeding of various seed mixes that fall. The 1985 growing season was generally "dry" and "mild". The soil was dry when the plots were measured in August for the first monitoring report. The precipitation in the 1986 growing season was "normal" but the summer was dry. The soil was dry when the first plots were read on August 20th but rain fell that afternoon and continued the next day, saturating the soil. The 1988 year was considered a "drought" year, with little winter or spring moisture. There was scattered late summer storms, that provided some moisture late in the growing season.

2.0 METHODS

Photos were taken at each photo station established in 1985, the first year of monitoring. Thus, each photo station was photographed in the 1st(1985), 2nd(1986), and 4th(1988) growing seasons. The various treatments were sampled by the methods explained in the 1985 progress report. In 1988, the live, above-ground growth was clipped, air-dried, and weighed to obtain data on productivity.

Plots and subplots sampled:

Study Site #1
"old coal refuse substrate"
subplots 1,2,3,4,5 and 6

"new coal refuse substrate"
subplots A,B,C,D,E and F

Study Site #2
Plot #1
Plot #2

Canyon Plots
Middle Fork Plot

South Fork Plot

Riparian Plot

3.0 RESULTS

3.1 Study Site #1

The "drought" years of 1987 and 1988 have hindered plant growth and slowed the rate of succession. This site is slowly progressing from a plant cover of adventative species in the 1st growing season, through a cover of annual species, to a sparse cover of perennial species mixed with a few annual species. The establishment of mature perennial plants has greatly increased the plant cover. The presence of more perennial grass has also greatly increased the densities of basal stems, when compared to the 2nd seasons growth. See Table 3.1.1.

Table 3.1.1 Transect Data, 1988

Subplot	Percent of Bare	Rock	Litter	Cover	Productivity Dry Weight lbs/acre	Basal Stems Per Quad
A. New Coal Refuse Substrate						
A	17*	0	36	47	438	50.3
B	7	0	49	44	750	46.0
C	13	0	42	45	938	58.8
D	11	0	46	43	438	61.3
E	2	0	50	48	875	57.2
F	1	0	58	41	500	43.9
Means	8.5	0.0	46.8	44.7	656	53.0
B. Old Coal Refuse Substrate						
1	8*	0	48	44	688	55.7
2	7	0	50	43	1063	56.1
3	9	1	44	46	750	55.3
4	4	0	47	49	1125	67.0
5	0	1	22	77	625	40.8
6	3	1	41	55	1000	57.0
Means	5.2	0.5	42.0	52.3	875	55.4

* Coal fines, from adjacent refuse piles, have blown onto these two subplots producing bare areas with no vegetative growth.

The litter accumulation is slightly greater in the new substrate when compared with the old substrate. The percentage of plant cover and the productivity of the old substrate is greater than the new substrate, and is significant at the 5% level respectivly. The densities of plant growth in each substratum is nearly equal, as judged by basal stems per unit area.

The differences in substrate where compared by separating the

applications of the two seed mixes and the topsoil depths. Generally the new substrate is superior where seed mix #1 was applied. However, with seed mix #2, the old substrate proves superior as a growing medium over the new substrate.

When the combined means of the seed mix applications are compared, the #2 seed mix is superior to the #1 seed mix in litter accumulation, productivity and plant stem density (litter and productivity at 5% level). Seed mix #1 is slightly superior in plant cover.

Table 3.1.2 Seed Mix and Substrate Comparisons

Subplot	Percent of Bare	Rock	Litter	Cover	Productivity Dry Weight lbs/acre	Basal Stems Per Quad
Seed Mix #1-New Substrate						
A	17*	0	36	47	438	50.3
C	13	0	42	45	938	58.8
E	2	0	50	48	875	57.2
Means	10.7	0	42.7	46.7	750	55.4
Old Substrate						
1	8*	0	48	44	688	55.7
3	9	1	44	46	750	55.3
5	0	1	22	77	625	40.8
Means	5.7	0.7	38	55.7	688	50.6
Combined Means	8.2	0.3	40.3	51.2	719	53.0
Seed Mix #2-New Substrate						
B	7	0	49	44	750	46.0
D	11	0	46	43	438	61.3
F	1	0	58	41	500	43.9
Means	6.3	0	51	42.7	563	50.4
Old Substrate						
2	7	0	50	43	1063	56.1
4	4	0	47	49	1125	67.0
6	3	1	41	55	1000	57.0
Means	4.7	0.3	46	49	1063	60.0
Combined Means	5.5	0.1	48.5	45.6	813	55.2

Table 3.1.3 compares the topsoil applications with the old and new substrates. There were three topsoil depths used in the

plot design, 6",12", and 18". Generally the old substrate is superior to the new substrate in plant growth despite the topsoil depths. The litter acumulation is greater on the new substrate. The increase in topsoil depth does not seem to change the differences between the old and new substrate.

When topsoil depth is considered, regardless of old or new substrates, the increase from 6" to 12" depths has the greatest affect on plant growth (productivity and basal stems). The 12" topsoil depth is sufficient to establish the best plant cover attainable on these types of substrates. The few repetitions in each plot do not allow for statistical testing.

Table 3.1.3 Topsoil Depths and Substrates

Subplot	Percent of Bare	Rock	Litter	Cover	Productivity Dry Weight lbs/acre	Basal Stems Per Quad
6"-New Substrate						
A	17*	0	36	47	438	50.3
B	7	0	49	44	750	46.0
Means	12	0	42.5	45.5	594	48.2
6"-Old Substrate						
1	8*	0	48	44	688	55.7
2	7	0	50	43	1063	56.1
Means	7.5	0	49	43.5	876	55.9
Combined Means	9.75	0	45.8	44.5	735	52.0
12"-New Substrate						
C	13	0	42	45	938	58.8
D	11	0	46	43	438	61.3
Means	12	0	44	44	688	60.0
12"-Old Substrate						
3	9	1	44	46	750	55.3
4	4	0	47	49	1125	67.0
Means	6.5	0.5	45.5	47.5	937	61.2
Combined Means	9.2	0.2	44.7	45.7	813	60.6
18"-New Substrate						
E	2	0	50	48	875	57.2
F	1	0	58	41	500	43.9
Means	1.5	0	54	44.5	688	50.6
18"-Old Substrate						
5	0	1	22	77	625	40.8
6	3	1	41	55	1000	57.0
Means	1.5	1	31.5	66	813	48.9
Combined Means	1.5	0.5	42.7	55.2	750	49.8

Table 3.1.4 Species Composition Test Site #1, 1988

Species	Total # Plots	Ave. # Stems/Quad	Percent of Total Cover
A. New Coal Refuse Substrate			
Agropyron smithii	3	3.59	3.00
Agropyron sp.	5	8.56	10.48
Agropyron cristatum	1	2.85	3.49
Bromus tectorum	6	26.25	57.08
Oryzopsis hymenoides	4	5.46	6.52
Stipa comata	1	0.40	0.70
Sitanion hystrix	1	1.25	0.47
Salsola kali	5	1.10	3.96
Astragalus ciceri	1	0.25	0.47
Linium lewisii	3	1.92	5.13
Grindelia squarrosa	4	0.47	4.67
Ceratoides lanata	4	0.48	2.80
Atriplex canescens	2	0.17	0.70
unknowns	1	0.25	0.47
Total Species	13		
B. Old Coal Refuse Substrate	30 quads		
Agropyron smithii	1	2.26	1.54
Agropyson spicatum	1	1.02	0.58
Agropyron sp.	5	16.26	21.23
Agropyron cristatum	2	3.92	3.47
Bromus tectorum	6	20.67	40.92
Oryzopsis hymenoides	3	4.39	2.51
Sitanion hystrix	1	1.11	0.19
Stipa comata	1	0.21	0.19
Astragalus ciceri	2	0.32	0.58
Grindelia squarrosa	4	1.20	11.19
Linium lewisii	2	1.47	3.86
Salsola kali	4	0.48	2.12
Artemisia tridentata	1	0.17	1.93
Ceratoides lanata	5	1.81	8.68
Chrysothamnus viscidiflorus	1	0.11	0.39
Total Species	15		

3.2 Study Site #2

This site, where 12" of topsoil was removed, has shown an increase in seeded species. The annual grasses have been replaced by perennial grasses and shrubs, the forbs are still a major part of the seeded communities. The developing seeded plant cover has diversity as grasses, forbs and shrubs are all present on the sites. Seed Mix #1 appears at this time to be superior to Seed Mix #2 (Table 3.2.1, cover and density at 5% level).

Table 3.2.1 Transect Data, 10 quadrants per seed mix

Percent of Bare	Rock	Litter	Cover	Basal Stems/Quadrant
A. Seed Mix #1				
31.4	0.0	44.4	24.2	37.1
B. Seed Mix #2				
29.7	0.0	55.1	15.2	26.7

Table 3.2.2 Species Composition on Subplots, 1988

Species	Total # Plots	Total # Stems	Mean # /Quad	Percent of Total Cover
A. Seed Mix #1				
Agropyron trachycaulum*	7	134	19.1	25.61
Oryzopsis hymenoides *	4	39	9.8	7.43
Sitanion hystrix	1	17	17.0	4.00
grass seedlings	2	8	4.0	2.00
Grass Subtotal				39.04
Astragalus cicer	1	4	4.0	4.13
Lathyrus sp.	3	9	3.0	7.02
Linium lewissi	10	92	9.2	45.88
Sphaeralcea coccinea	3	3	1.0	1.65
Forb Subtotal				58.78
Ceratoides lanata *	1	2	2.0	1.23
Chrysothamnus nauseosus	*4	22	5.5	5.37
Shrub Subtotal				6.60
* seeded species				39.64
Total # of Species	11			
B. Seed Mix #2				
Agropyron sp. *	4	73	18.5	17.76
Oryzopsis hymenoides *	3	8	2.4	3.29
Bromus tectorum	1	18	18.0	3.29
Grass Subtotal				24.34
Linium lewisii *	3	21	7.0	4.60
Melilotus officinalis *	1	1	1.0	0.66
Penstemon Palmeri	3	37	12.3	15.79
Forb Subtotal				21.05
Ceratoides lanata *	2	3	1.5	5.26
Chrysothamnus nauseosus	*4	28	7.0	18.42
Chrysothamnus viscidiflorus	4	35	8.8	23.03
Shrub Subtotal				46.71
* seeded species				49.99
Total # of Species	9			

The percentage of seeded species is higher in the plant community established in the plot seeded with seed mix #2. However, the number of seeded species present in both plant

communities is similar(6 in #1, 7 in #2). The #1 seed mix community also has a greater total number of species than the #2 seed mix community. The percentage of grass is higher in the seed mix #1 plant community than the #2 mix, but the opposite is true for the shrub component of the respective seeded communities. Generally the distribution of the major plant groups is more even in the #2 seed mix community. There appears to have been some crossover of seeded species in each plot apparently due to proximity of plots and/or sloppiness of seeding efforts. This confuses the analysis and renders statistical analysis valueless.

3.3 Canyon Plots

The three plots have produced good stands of seeded grasses and forbs. Most of the species had flowered or were flowering during the field work in August. Generally grasses have increased on the plots and matured. Also species diversity has increased but total vegetative cover has decreased. This is probably due to the decrease in the total number of plants in the plots as evidenced by the reduction in basal stems per quadrant from 1985 and 1986 (Table 3.3.1).

Table 3.3.1 Transect Data, 1988 5 quadrants

Percent of				Productivity	Basal Stems
Bare	Rock	Litter	Cover	lbs./acre	/Quadrant
A. Middle Fork					
10	0	57	33	788	58.10
B. South Fork					
9	7	42	42	1088	56.80
C. Riparian					
14	1	52	33	375	21.00

The Middle Fork and South Fork plots have an excellent stand of seeded and seral plants. The amount of litter and production of forage is equal to that normally produced on adjacent indigeneous plant communities. The amount of litter on the Riparian Plot has increased and bare ground has decreased. The low forage production is a result of the shading by the tree stand.

Table 3.3.2 Species Composition

Species	Total # Plots	Total # Plants	Mean # /Quad	Percent of Total Cover
A. Middle Fork				
Agropyron spicatum *	3	22	7.4	5.40
Bromus marginatus *	5	21	4.2	6.60
Dactylis glomerata *	5	53	10.6	52.40
Elymus sp. *	5	26	5.2	13.00
Phleum alpinum *	5	63	12.6	17.40
Grass Subtotal				94.80
Hedysarum boreale *	1	1	1.0	1.20
unknown forbs	1	2	2.0	1.20
Forb Subtotal				2.40
Symphoricarpos * oreophilus	1	1	1.0	1.80
B. South Fork				
Agropyron subsecundum	4	23	5.8	5.20
Bromus marginatus *	2	16	8.0	4.06
Dactylis glomerata *	5	112	22.4	45.50
Phleum alpinum *	4	29	7.3	19.80
Oryzopsis hymenoides *	4	54	13.5	9.00
Grass Subtotal				83.56
Cynoglossum officinale	1	1	1.0	2.36
Hedysarum boreale *	2	3	1.5	8.50
Viguiera multiflora	2	8	4.0	3.30
Unknown Forb	1	1	1.0	0.47
Forb Subtotal				14.63
Cercocarpus ledifolius *	1	1	1.0	0.47
Symphoricarpos oreophilus *	1	4	4.0	1.42
Shrub Subtotal				1.89
C. Riparian				
Agropyron smithii *	1	4	4.0	1.23
Bromus marginatus *	4	41	10.2	25.15
Dactylis glomerata *	3	43	14.3	22.70
Elymus sp. *	2	7	3.5	4.29
Phleum alpinum *	1	36	36.0	9.20
Grass Subtotal				62.57
Cynoglossum officinale	1	1	1.0	3.06
Hedysarum boreale	1	1	1.0	1.84
Mahonia repens	4	19	4.8	29.45
Forb Subtotal				34.35

Table 3.3.2 Con't.

Abies sp.	1	1	1.0	1.84
Populus tremuloides	1	1	1.0	1.23
Shrub Subtotal				3.07

The plant communities established in the South and Middle Forks are a grass/forb type with a very minor shrub component. The seeded grass species account for most of the grasses in the communities. The grasses in the Riparian seeded community are similar to those of the South and Middle Forks communities, even thougn a different seed mix was used in the Riparian plot.

4.0 Summary of Results

This section provides a summary of the change in the plots through the years and a comparison of seed mixtures and sites.

4.1 Study Site #1

Table 4.1.1 Species Composition Changes, 1985-1988

Species	Total # Plots 1985	1986	1988	Percent of Total Cover 1985	1986	1988
A. New Coal Refuse Substrate, 30 quads						
Agropyron smithii	-	-	3	-	-	3.00
Agropyron sp.	-	7	5	-	56.00	10.48
Agropyron cristatum	-	-	1	-	-	3.49
Bromus tectorum	-	-	6	-	-	57.08
Oryzopsis hymenoides	-	-	4	-	-	6.52
Stipa comata	-	-	1	-	-	0.70
Sitanion hystrix	2	-	1	0.01	-	0.47
grass seedlings	7	6	-	0.01	9.00	-
Astragalus ciceri	1	-	-	-	-	0.47
Chenopodium sp.	25	-	-	5.80	-	-
Grindelia squarrosa	1	-	5	tr	-	4.67
Kochia scoparia	28	4	-	19.50	13.00	-
Linium lewisii	-	-	3	-	-	5.13
Salsola kali	30	4	5	72.30	4.00	3.96
Ceratoides lanata	5	7	4	0.01	12.00	2.80
Atriplex canescens	-	1	2	-	2.00	0.70
unknowns	1	-	1	tr	-	0.47
B. Old Coal Refuse Substrate	30 quads					
Agropyron smithii	-	-	1	-	-	1.54
Agropyson spicatum	-	-	1	-	-	0.58
Agropyron sp.	-	3	5	-	3.00	21.23
Agropyron cristatum	-	5	2	-	28.00	3.47
Bromus tectorum	-	-	6	-	-	40.92
Oryzopsis hymenoides	-	3	3	-	10.00	2.51
Sitanion hystrix	-	2	1	-	3.00	0.19
Stipa comata	-	-	1	-	-	0.19
grass seedlings	1	7	-	tr	6.00	-
Astragalus ciceri	-	-	2	-	-	0.58
Chenopodium sp.	23	1	-	3.60	1.00	-
Descuriana sp.	-	1	-	-	3.00	-
Grindelia squarrosa	-	5	4	-	28.00	11.19
Linium lewisii	-	-	2	-	-	3.86
Kochia scoparia	30	6	-	25.10	13.00	-
Salsola kali	30	2	4	70.00	1.00	2.12
Artemisia tridentata	-	-	1	-	-	1.93
Ceratoides lanata	9	-	5	0.60	-	8.68
Chrysothamnus viscidiflorus	-	-	1	-	-	0.39
unknowns	3	-	-	0.60	-	-

The Chenopodium sp. and the Kochia scoparia were the early pioneers of these seeded disturbed sites. These plants quickly faded as the perennial seeded species, especially the grasses, began to become established and eventually dominate the new plant community. It was amazing that Bromus tectorum, an invader annual grass, did not become established until the 3rd or 4th growing season.

The Ceratoides lanata became the dominant species of seeded shrubs. The only seeded forbs to become established were the Linium lewisii and Astragalus ciceri. The seeded grass species that formed a dominant part of the plant community were the Agropyron spp. and the Oryzopsis hymenoides.

4.2 Study Site #2

Table 4.2.1 Species Composition Changes, 1985-1988

Species	Total # of Plots 1985	1986	1988	Percent of Total Cover 1985	1986	1988
A. Seed Mix #1						
Agropyron trachycaulum*	-	4	7	-	15.00	25.61
Oryzopsis hymenoides *	-	1	4	-	1.00	7.43
Sitanion hystrix	-	1	-	-	4.00	-
grass seedlings	6	2	2	10.50	2.00	2.00
Elymus sp.	-	1	-	-	14.00	-
Grass Subtotal				10.50	36.00	35.04
Aster chilensis *	-	1	-	-	1.04	-
Astragalus cicer	1	2	1	0.70	3.64	4.13
Chenopodium sp.	1	-	-	0.70	-	-
Convolvulus sp.	1	1	-	4.50	1.04	-
Grindelia squarrosa	2	5	-	4.20	29.70	-
Kochia scoparia	4	-	-	7.00	-	-
Lathyrus sp.	-	-	3	-	-	7.02
Linium lewisii	4	5	10	7.30	13.02	45.88
Melilotus officinalis *	2	1	-	6.30	5.21	-
Salsola kali	10	-	-	53.70	-	-
Sphaeralcea coccinea	-	4	3	-	7.81	1.65
Forb Subtotals				84.40	61.46	58.68
Ceratoides lanata *	3	2	1	1.00	1.04	1.23
Chrysothamnus nauseosus *	2	4	4	1.70	5.21	5.37
Purshia tridentata	-	1	-	-	0.52	-
Shrub Subtotals				2.70	6.77	6.60
* seeded species				9.00	42.50	39.64
B. Seed Mix #2						
Agropyron sp. *	-	6	4	-	20.32	17.76
Oryzopsis hymenoides *	-	2	3	-	1.62	3.29
Bromus tectorum	-	-	1	-	-	3.29
grass seedlings	7	-	-	11.80	-	-
Grass Subtotal				11.80	21.94	24.34
Astragalus cicer *	-	1	-	-	0.81	-
Cardaria sp.	-	2	-	-	2.44	-
Chenopodium sp.	4	-	-	3.10	-	-
Erigeron sp.	1	1	-	1.50	1.62	-
Grindelia squarrosa	3	4	-	6.10	19.70	-
Helianthus sp.	1	-	-	1.50	-	-
Kochia scoparia	3	-	-	9.70	-	-
Linium lewisii *	4	5	3	4.60	23.60	4.60
Melilotus officinalis *	2	1	1	1.50	5.69	0.66

Table 4.2.1 Con't.

Penstemon Palmeri	-	-	3	-	-	15.79
Salsola kali	9	-	-	46.10	-	-
Spharaelcea coccinea	2	1	-	2.10	tr.	-
Forb Subtotal				76.20	51.68	21.05
Ceratoides lanata *	3	1	2	2.60	5.24	5.26
Chrysothamnus nauseosus	*4	7	4	2.10	21.14	18.42
Chrysothamnus viscidiflorus	-	-	4	-	-	23.03
Purshia tridentata *	1	-	-	0.50	-	-
Shrub Subtotal				5.20	26.38	46.71
* seeded species				11.30	78.42	49.99

The amount of differences, in bare ground, between the two seed mixes is neglible. Most of the basic difference is in a greater litter occurrence in Seed Mix #2, and a greater plant cover in Seed Mix #1.

The first years' growth in both plots was dominated by adventative species, similar to those found a Study Site #1. However, by the second year of growth the seeded species and other perennials had largely replaced the adventative species. By the fourth year of growth, the seeded species accounted for 40-50% of the plant cover.

The plant cover in the Seed Mix #1 plot is composed mostly of grasses and forbs, while that in Seed Mix #2 has a greater amount of shrubs. The comparisons of the two seed mixes is not clear due to an apparent mixing of seeded species from one plot to another. The proximity has allowed the seed mixes to cross from one plot to another, either at seeding or during subsequent seed production by the seeded species. Both plots have very similar appearances.

4.3 Canyon Plots

Table 4.3.1 Species Composition Changes, 1985-1988

Species	Total # of Plots 1985	1986	1988	Percent of Total Cover 1985	1986	1988
A. Middle Fork						
Avena fatua	1	-	-	0.90	-	-
Agropyron spicatum *	-	2	3	-	6.60	5.40
Bromus marginatus *	3	5	5	0.90	12.00	6.60
Dactylis glomerata *	-	4	5	-	15.60	52.40
Elymus sp. *	-	3	5	-	14.40	13.00
Phleum alpinum *	1	4	5	0.90	31.80	17.40
grass seedling *	5	1	-	91.30	0.60	-
Grass Subtotal				94.00	81.00	94.80
Chenopodium sp.	1	-	-	0.50	-	-
Hedysarum boreale *	-	-	1	-	-	1.20
Kochia scoparia	-	3	-	-	7.80	-
Monolepsis nuttallianus	1	1	-	0.90	2.40	-
unknown forbs	1	2	1	0.50	1.80	1.20
Forb Subtotal				1.90	12.00	2.40
Symphoricarpos * oreophilus	-	-	1	-	-	1.80
Populus tremuloides	-	2	-	-	4.80	-
Shrub Subtotal				-	4.80	1.80
* seeded species				93.10	81.00	97.80
B. South Fork						
Avena fatua	-	1	-	-	0.54	-
Agropyron subsecundum	2	1	4	2.20	0.54	5.20
Bromus marginatus *	4	5	2	7.40	43.74	4.06
Dactylis glomerata *	-	4	5	-	29.16	45.50
Phleum alpinum *	4	1	5	2.20	0.54	19.80
Oryzopsis hymenoides *	-	-	4	-	-	9.00
grass seedlings *	5	1	-	64.80	0.54	-
Grass Subtotal				76.60	82.62	83.56
Cleome serrulata	2	-	-	6.60	-	-
Chenopodium album	2	-	-	1.40	-	-
Chenopodium sp.	1	-	-	tr.	-	-
Cynoglossum officinale	2	-	1	2.70	-	2.36
Hedysarum boreale *	-	-	2	-	-	8.50
Melilotus officinale	2	4	-	1.40	5.94	-
Salsola kali	1	-	-	1.40	-	-
Viguiera multiflora	1	2	2	0.50	3.78	3.30
Unknown Forb	5	-	1	9.40	-	0.47
Forb Subtotal				23.40	9.72	14.63
Cercocarpus ledifolius* Symphoricarpos	-	-	1	-	-	0.47

Table 4.3.1 Con't.

oreophilus *	-	1	1	-	0.54	1.42
Shrub Subtotal				-	0.54	1.89
* seeded species				74.40	74.52	88.75
C. Riparian						
Agropyron smithii *	-	2	1	-	38.18	1.23
Bromus ciliatus *	-	3	4	-	28.41	25.15
Dactylis glomerata	-	1	3	-	1.33	22.70
Elymus sp.	-	-	2	-	-	4.29
Phleum alpinum *	-	-	1	-	-	9.20
Poa pratensis *	1	1	-	2.50	2.22	-
grass seedlings *	5	-	-	93.10	-	-
Grass Subtotal				95.60	70.14	62.57
Balsamorhiza sagitta *	1	-	-	0.60	-	-
Cynoglossum officinale	-	-	1	-	-	3.06
Hedysarum boreale	-	-	1	-	-	1.84
Vicia americana *	1	-	-	1.90	-	-
Mahonia repens	1	2	4	0.60	5.77	29.45
Melilotus officinale	-	1	-	-	1.33	-
Mertensia sp.	1	1	-	1.20	8.88	-
Forb Subtotal				4.30	15.98	34.35
Abies sp.	-	-	1	-	-	1.84
Populus tremuloides	-	-	1	-	-	1.23
Shrub Subtotal				-	-	3.07
* seeded species				98.10	68.81	35.88

The seeded grasses and forbs did very well in the Middle and South Fork plots, establishing a good ground cover. The seeded shrub species were not evident in these plots. In the Riparian Plot, the seeded species initially provided much of the ground cover. However, with time other native species, common to riparian communities, colonized the plot and became co-dominant with the seeded species.

APPENDIX 1

UNITED STATES FUEL COMPANY

VEGETATION TEST PLOTS

YEAR 2 PROGRESS REPORT

Hiawatha, Utah

by

Joseph M. Jarvis

Biologist

INTRODUCTION

A vegetation test plot program was submitted with the mine permit applications by U.S. Fuels to satisfy OSM regulations for a tested revegetation program. This revegetation program would be applied at mine shutdown for the reclamation of disturbed sites and material. The test plot program is to be monitored for five years to judge plant response to the various revegetation techniques tested. The complete details of the program are available in the OSM/DOGM mine permit applications. This progress report covers the 2nd year of monitoring. with subsequent reports due in year 3 (1986) and 5 (1988).

The test plot program was installed in 1984 with preparation of plot sites and seeding of various seed mix designs in the fall. 1983 and 1984 were "wet years" with above normal precipitation and below normal temperatures. The winter of 1985 started wet and cold but turned mild and dry by early spring. Spring was early, dry and mild with summer warm and dry. The only summer precipitation coming from heavy rain storms in July. The plots were read in August when soil conditions were dry. A succession of annual grasses and forbs had colonized the plots at lower elevations with a dense stand of living and dead plants. The plots in the canyons at higher elevations (8200') had produced vigorous stands of seeded species and some adventive species.

METHODS

Photo stations were established at each plot. Subplots in Study Sites 1 and 2 were also photographed. Each treatment in the plots or subplots were sampled with a 1/4 square meter quadrant at five random stations. Additional samples were taken if sampling error exceeded 10% except in the small canyon plots due to lack of space. Estimates of percent living and non-living cover were taken as were basal stem counts of all species in the quadrant. This provided the degree of cover, a total plant count per unit and species composition in the plots.

This data was collected and formatted to allow comparisons on a yearly basis and between treatments. The 2nd year data was not statistically analysed for differences in plant response to treatment.

Plots and subplots sampled:

Study Site #1
"old coal refuse substrate"
subplots 1,2,3,4,5 and 6

"new coal refuse substrate"
subplots A,B,C,D,E and F

Study Site #2
Plot #1
Plot #2

Middle Fork Plot

South Fork Plot

Riparian Plot

RESULTS

Study Site #1

The site was covered with a dense plant growth of living and dead annual grasses and forbs. The disturbance of the soil placed as topsoil on the coal refuse apparently provided an ideal growth environment for the adventive plants. This placed these "weedy species" in a strong competitive position and probably affected germination of seeded species in 1985 by shading the soil surface and depriving these desired species of soil moisture. The seeded species accounted for less than 1% of the plant species.

The adventive species were both early season and late season types indicating growth from spring moisture and later growth from the July moisture. The quick growth of these species on test plots is a situation repeatedly observed in test plot programs. This is generally due to the distubance of the site in seedbed preparation providing ideal environmental conditions. These adventive species usually fade from the plant community in the test plots as seeded species become established and soil conditions stablize.

The only differences between treatments, that was readily observable in the data, was the greater number of plants and plant cover in the old coal refuse substrate versus the new coal refuse substrate. Differences in plant response to treatments within the substrates was not detected.

Table I Transect Data

Subplot	Percent of Bare	Rock	Litter	Cover	Basal Stems Per Quad
A. New Coal Refuse Substrate					
A	18	0	58	24	17.2
B	11	6	62	21	21.0
C	9	0	59	32	25.8
D	6	0	54	40	26.4
E	11	0	54	35	26.6
F	9	0	67	24	27.2
Means	10.7	1.0	59	29.3	24.0
B. Old Coal Refuse Substrate					
1	11	0	64	25	23.4
2	13	0	54	33	28.4
3	9	1	56	34	32.4
4	2	0	62	36	28.4
5	2	0	64	32	28.6
6	2	0	64	32	35.4
Means	6.5	0.2	60.7	32	29.4

Table II Species Composition

Species	Total # Plots	Total # Plants	Ave. # /Quad	Percent of Total Cover
A. New Coal refuse Substrate		30 Quads		
Salsola kali	30	524	17.5	72.3
Kochia scoparia	28	128	4.6	19.5
Chenopodium sp.	25	35	1.4	5.8
grass seedlings *	7	15	2.1	0.01
Ceratoides lanata *	5	11	2.2	0.01
Hilaria jamesii	2	7	2.0	0.01
Grindelia squarrosa	1	1	1.0	0.001
unknown forbs	1	1	1.0	0.001
B. Old Coal refuse Substrate		30 Quads		
Salsola kali	30	601	20.0	70.0
Kochia scoparia	30	241	8.0	25.1
Chenopodium sp.	23	34	1.5	3.6
Ceratoides lanata *	9	9	1.0	0.6
unknown forbs	3	3	1.0	0.6
grass seedlings *	1	1	1.0	0.001

* seeded species

Study Site #2

This site, where 12" of topsoil was removed, was also covered with a heavy growth of annual grasses and forbs. The disturbance to the soils and removal of established groundcover provided conditions ideal for adventive plant species. Some seeded species were evident but there was no discernable difference between the two seed mixes used here.

Table I Transect Data, 10 quadrants per seed mix

Percent of Bare	Rock	Litter	Cover	Basal Stems/Quadrant
A. Seed Mix #1				
18.9	0	52.4	28.7	18.2
B. Seed Mix #2				
19.6	0	52.5	27.9	13.0

Table II Species Composition on Subplots

Species	Total # Plots	Total # Plants	Mean # /Quad	Percent of Total Cover
A. Seed Mix #1				
Salsola Kali	10	67	6.7	53.7
grass seedlings *	6	38	6.3	10.5
Linium lewisii	4	29	7.2	7.3
Kochia scoparia	4	13	3.2	7.0
Ceratoides lanata *	3	4	1.3	1.0
Convolvulus sp.	2	9	4.5	4.5
Melilotus officinalis *	2	5	2.5	6.3
Chrysothamnus naseosus *	2	5	2.5	1.7
Grindelia squarrosa	2	2	1.0	4.2
Chenopodium sp.	1	1	1.0	0.7
Astragulas sp.	1	1	1.0	0.7
Unknown forbs	6	8	1.3	2.4
B. Seed Mix #2				
Salsola kali	9	53	5.9	46.1
grass seedlings *	7	36	5.1	11.8
Kochia scoparia	3	10	3.3	9.7
Linum lewisii *	4	9	2.2	4.6
Chrysothamnus nauseosus *	4	5	1.2	2.1
Chenopodium sp.	4	4	1.0	3.1
Ceratoides lanata	3	4	1.3	2.6
Grindelia squarrosa	3	4	1.3	6.1
Melilotus officinalis *	2	2	1.0	1.5
Sphaeralcea coccinea	2	2	1.0	2.1
Erigeron sp.	1	2	2.0	1.5
Purshia tridentata *	1	1	1.0	0.5
Helianthus sp.	1	1	1.0	1.5
Unknown forbs	4	6	1.2	4.1

* seeded species

Canyon Plots

The three plots in the canyons produced good stands of the seeded species. Some of the grasses were in the flower stage during the field work period in August. The cover percentage was fairly consistent between quadrants. The riparian interseeding seeded cover was less than the other two plots but considering the conditions of shade and established plant cover it was moderately successful.

Table I Transect Data 5 quadrants

Percent of Bare	Rock	Litter	Cover	Basal Stems per Quadrant
A. Middle Fork				
2	3	42	53	74.5
B. South Fork				
4	4	21	71	70.2
C. Riparian				
41	11	34	14	32.0

Table II Species Composition

Species	Total # Plots	Total # Plants	Mean # /Quad	Percent of Total Cover
A. Middle Fork				
grass seedlings *	5	284	56.8	91.3
Bromus sp. *	3	6	2.0	0.9
Avena fatua	1	2	2.0	0.9
Phleum alpinum *	1	2	2.0	0.9
Monolepis nuttallianus	1	2	2.0	0.9
Chenopodium sp.	1	1	1.0	0.5
unknown forbs	1	1	1.0	0.5
B. South Fork				
grass seedlings	5	278	55.6	64.8
Bromus sp. *	4	27	6.7	7.4
Phleum alpinum *	4	7	1.8	2.2
Cynoglossum officinale	2	11	5.5	2.7
Agropyron sp. *	2	7	3.5	2.2
Melilotus officinale *	2	5	2.5	1.4
Chenopodium album	2	3	1.5	1.4
Cleome serrulata	2	3	1.5	6.6
Chenopodium sp.	1	1	1.0	-
Salsola kali	1	1	1.0	1.4
Viguiera multiflora	1	1	1.0	0.5
unknown forbs	5	17	3.4	9.4
C. Riparian				
grass seedlings *	5	149	29.8	93.1
Poa sp. *	1	4	4.0	2.5
Lathyrus sp.	1	3	3.0	1.9
Mertensia sp.	1	2	2.0	1.2
Mahonia repens	1	1	1.0	0.6
Balsamorhiza sagittata *	1	1	1.0	0.6

1985 PHOTOS

APPENDIX 2

UNITED STATES FUEL COMPANY

VEGETATION TEST PLOTS

YEAR 3 PROGRESS REPORT

Hiawatha, Utah

by

Joseph M. Jarvis

Biologist

September, 1986

INTRODUCTION

A vegetation test plot program was submitted with the mine permit applications by U.S. Fuels to satisfy OSM regulations for a tested revegetation program. This progress report covers the 3rd year of the program or the results of the 2nd growing season. The results of the 1st growing season are contained in the 1985 progress report.

The test plot program was installed in 1984 with the preparation of the plot sites and the seeding of various seed mixes that fall. The 1985 growing season was generally "dry" and "mild". The soil was dry when the plots were measured in August for the first monitoring report. The precipitation in the 1986 growing season was "normal" but the summer was dry. The soil was dry when the first plots were read on August 20th but rain fell that afternoon and continued the next day saturating the soil.

METHODS

Photos were taken at each photo station established in 1985, the first year of monitoring. The various treatments were sampled by the methods explained in the 1985 progress report.

Plots and subplots sampled:

Study Site #1
"old coal refuse substrate"
subplots 1,2,3,4,5 and 6

"new coal refuse substrate"
subplots A,B,C,D,E and F

Study Site #2
Plot #1
Plot #2

Middle Fork Plot

South Fork Plot

Riparian Plot

RESULTS

Study Site #1

The site was covered with a dense dry growth of cheatgrass. The adventive "weedy species" so prominent in 1985 were now only a small part of the plant cover. The lack of summer moisture may have affected the growth of the warm season forbs or the increase in litter and cheatgrass may have altered environmental conditions at the soil surface to reduce germination success of these annuals. At this time it appears that the adventive forbs are fading from the plant community but have not yet been replaced by the seeded species.

The seeded species are present as immatures in thinly scattered stands. The presence of perennial grass seedlings and immature white sage plants indicates that the seeded species may yet establish an adequate ground cover on the plots. Certainly the dry summers of the 1985 and 86 growing seasons have been a hindrance to plant growth.

The meager amount of measurable plants in the subplots does not now allow for a comparison of results between subplots. Generally the data does support the assumption that plant growth is better on the old coal refuse substrate versus the new coal refuse substrate (Table I).

Table II Species Composition, 1986

Species	Total # Plots	Total # Plants	Ave. # /Quad	Percent of Total Cover
A. New Coal Refuse Substrate		30 quads		
Elymus sp.	7	72	2.40	55
Agropyron sp.	1	1	0.03	1
grass seedlings	6	16	0.53	9
Kochia scoparia	4	13	0.43	13
Salsola kali	4	4	0.13	4
Ceratoides lanata	7	18	0.60	12
Atriplex canescens	1	1	0.03	2
Total Species	7			
B. Old Coal Refuse Substrate		30 quads		
Elymus sp.	5	53	1.76	28
Oryzopsis hymenoides	3	24	0.80	10
Agropyron sp.	3	3	0.10	3
Sitanion hystrix	2	5	0.16	3
grass seedlings	7	11	0.36	6
Grindelia squarrosa	5	13	0.43	28
Kochia scoparia	6	30	1.00	13
Salsola kali	2	2	0.06	1
Descuriana sp.	1	1	0.03	3
Chenopodium sp.	1	5	0.16	1
Total Species	10			

Study Site #2

This site, where 12" of topsoil was removed, has shown an increase in seeded species. The annual grasses and forbs are still present but are not dominant on the subplots as they were in 1985. The developing seeded plant cover has diversity as grasses, forbs and shrubs are all present on the sites. Seed Mix #1 appears at this time to be superior to Seed Mix #2.

Table I Transect Data, 10 quadrants per seed mix

Percent of				
Bare	Rock	Litter	Cover	Basal Stems/Quadrant
A. Seed Mix #1				
15.4	0.4	65.0	19.2	29.4
B. Seed Mix #2				
12.7	0.0	75.3	12.3	21.6

Table II Species Composition on Subplots

Species	Total # Plots	Total # Plants	Mean /Quad	Percent of Total Cover
A. Seed Mix #1				
Agropyron sp. *	4	62	15.5	15.00
Elymus sp. *	1	27	27.0	14.00
Oryzopsis hymenoides *	1	2	2.0	1.00
Sitanion hystrix	1	17	17.0	4.00
grass seedlings	2	8	4.0	2.00
Grass Subtotal				36.00
Aster chilensis *	1	3	1.5	1.04
Astragalus cicer	2	10	5.0	3.64
Convolvulus sp.	1	4	4.0	1.04
Grindelia squarrosa	5	50	10.0	29.70
Linium lewissi	5	62	12.4	13.02
Melilotus officinalis *	1	6	6.0	5.21
Sphaeralcea coccinea	4	13	3.2	7.81
Forb Subtotal				61.46
Ceratoides lanata *	2	6	3.0	1.04
Chrysothamnus nauseosus *	4	20	5.0	5.21
Purshia tridentata	1	3	3.0	0.52
Shrub Subtotal				6.77
* seeded species				42.50
B. Seed Mix #2				
Agropyron sp. *	6	76	12.7	20.32
Oryzopsis hymenoides *	2	7	3.5	1.62
Grass Subtotal				21.94
Astragalus cicer *	1	3	3.0	0.81
Cardaria sp.	2	2	1.0	2.44
Erigeron sp.	1	1	1.0	1.62
Grindelia squarrosa	4	13	3.2	19.70
Linium lewisii *	5	77	15.4	23.60
Melilotus officinalis *	1	5	5.0	5.69
Spharaelcea coccinea	1	1	1.0	tr.
Forb Subtotal				51.68
Ceratoides lanata *	1	5	5.0	5.24
Chrysothamnus nauseosus *	7	26	3.7	21.14
Shrub Subtotal				26.38
* seeded species				78.42

Canyon Plots

The three plots have produced good stands of seeded grasses and forbs. Most of the species had flowered or were flowering during the field work in August. Generally grasses have increased on the plots and matured. Also species diversity has increased but total vegetative cover has decreased. This is probably due to the decrease in the total number of plants in the plots as evidenced by the reduction in basal stems per quadrant from 1985 (Table I).

Table I Transect Data, 5 quadrants

Percent of				
Bare	Rock	Litter	Cover	Basal Stems/Quadrant
A. Middle Fork				
12	2	53	33	64.60
B. South Fork				
7	6	50	37	59.80
C. Riparian				
30	5	20	45	24.60

Table II Species Composition

Species	Total # Plots	Total # Plants	Mean # /Quad	Percent of Total Cover
A. Middle Fork				
Agropyron spicatum *	2	27	13.5	6.60
Bromus marginatus *	2	34	17.0	12.00
Dactylis glomerata *	2	26	13.0	15.60
Elymus sp. *	5	46	9.2	14.40
Phleum alpinum *	4	114	57.0	31.80
grass seedlings	1	1	1.0	0.60
Grass Subtotal				81.00
Kochia scoparia	3	22	7.3	7.80
Monolepis nuttallianus	1	5	5.0	2.40
unknown forbs	2	3	1.5	1.80
Forb Subtotal				12.00
Populus tremuloides	2	7	3.5	4.80
B. South Fork				
Avena fatua	1	5	5.0	0.54
Bromus marginatus *	5	140	28.0	43.74
Dactylis glomerata *	4	72	18.0	29.16
Elymus sp. *	3	33	11.0	8.10
Phleum alpinum *	1	3	3.0	0.54
grass seedlings	1	6	6.0	0.54
Grass Subtotal				82.62
Melilotus officinalis	4	24	6.0	5.94
Viguiera multiflora	2	9	4.5	3.78
Forb Subtotal				9.72
Symphoricarpos oreophilus *	1	5	5.0	0.54
C. Riparian				
Agropyron smithii *	2	55	27.5	38.18
Bromus marginatus *	3	45	15.0	28.41
Dactylis glomerata *	1	3	3.0	1.33
Poa pratensis *	1	10	10.0	2.22
Grass Subtotal				70.14
Mertensia sp.	1	6	6.0	8.88
Mahonia repens	2	4	2.0	5.77
Melilotus officinalis	1	2	2.0	1.33
Forb Subtotal				15.98

* seeded species

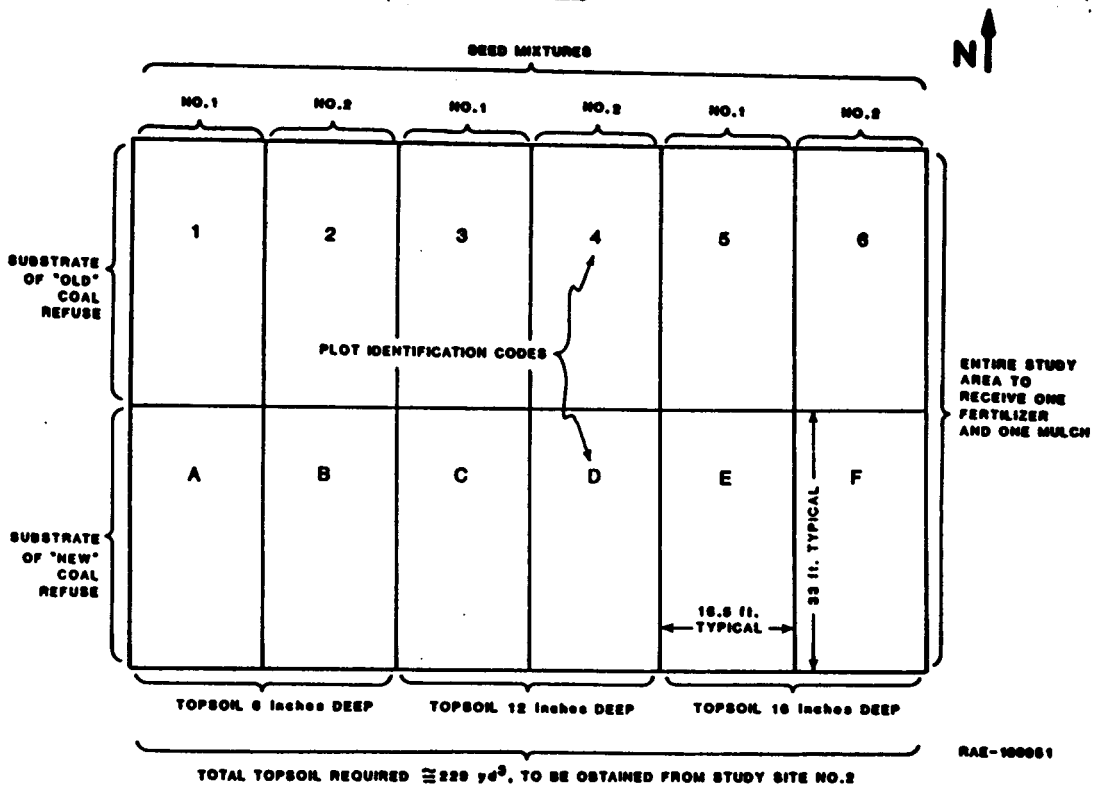

FIGURE IX-1. LAYOUT OF "STUDY SITE NUMBER 1" TO BE LOCATED IN COAL REFUSE IMPOUNDMENT AREA.

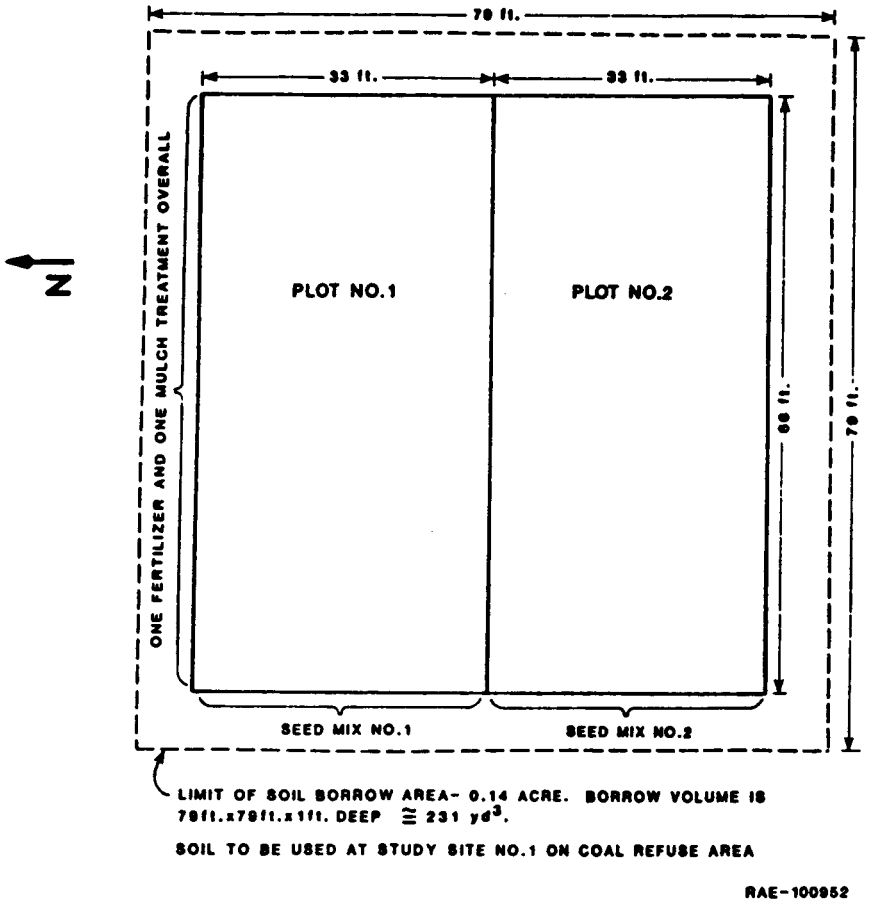

FIGURE IX-2. LAYOUT OF "STUDY SITE NUMBER 2" TO BE LOCATED AT BORROW SITE IN SAGEBRUSH VEGETATION ZONE EAST OF COAL SLURRY IMPOUNDMENTS.