ANNUAL RECLAMATION REPORT

STAR POINT MINES

Plateau Mining Company

January 1984

INTRODUCTION

Mining has been conducted at the Plateau Mining Company's Star Point Mines location since 1917. The operation consists of three portals for the underground recovery of coal reserves from the Wattis and Hiawatha seams. Surface areas that have been affected by the mining operation over the years and the associated reclamation and reclamation study areas are shown on the attached Plateau Mining Company 1983 Reclamation Map #1 and Plateau Mining Company 1983 Reclamation Map #2.

Reclamation of disturbed areas began in 1980. During the Summer and Fall of 1980, all disturbed areas which could be reclaimed without affecting the operation were seeded using hand operated cyclone broadcast seeders. About 20 lbs/acre of the seed mix presented in Table 1, 1980 Seed Mixture, was planted. This was followed by mechanically blowing about 3,000 lbs/acre of cereal grain straw mulch over the area. Areas that could not be reached by the blower were mulched by hand. The area seeded comprised approximately 120.67 acres and represents all of the green areas shown on the attached maps. In November 1981, much of the same area, 55.28 acres was reseeded with about 24 lbs/acre of the same seed mixture used in 1980. The seed was incorporated with 140 lbs/acre of tackifier and mechanically sprayed over the area. Following seeding, the area was oversprayed with 2,000 lbs/acre of Conwed hydromulch. Again in 1983, portions of the same area on which revegetation was poor, was reseeded with the seed mixture given in Table 3, 1983 Seed Mix. The 1983 reclamation contained 10.07 acres which were seeded at a rate of 22 lbs/acre. After seeding, the areas were hydromulched with 2,000 lbs/acre of Conwed hydromulch.

A total of 120.67 acres have been seeded. This comprises all of the disturbed land currently available for reclamation.

The following annual reclamation report presents results of the 1983 reclamation monitoring program. This report is in fulfillment of the agreement between Plateau Mining Company and the Utah State Division of

Oil, Gas and Mining to provide annual progress of the reclamation effort and reclamation study results. Additional information is included on the Wildlife Mitigation Area stipulated as part of the Minor Modification of the Refuse Pile Expansion Plan submitted May 28, 1982.

TABLE 1
1980 SEED MIXTURE

	% MIXTURE
Russian Wildrye	15%
Streambank Wheatgrass	11%
Mountain Brome	5%
Big Sage Brush	5%
Fourwing Saltbush	8%
Western Wheatgrass	15%
Pubescent Wheatgrass	15%
Indian Ricegrass	5%
Rabbitbrush	3%
Alfalfa "Ranger"	10%
Yellow Sweetclover	10%

TABLE 2
1983 SEED MIXTURE

	POUNDS PLS/A
Pubescent Wheatgrass	3
Smooth Brome	3
Alsike Clover	1
Ladak Alfalfa	2
Great Basin Wildrye	1
Fourwing Saltbrush	2
Shadscale	1
Cicer Milkvetch	1
Rubber Rabbitbrush	0.25

1983 RECLAMATION MONITORING

In mid-July 1983, field data was collected on reclaimed and reclamation study sites as well as on the Wildlife Mitigation Area.

Reclaimed sites sampled were restricted to 1981 seedings. Study areas sampled were the Barrow Area, Refuse Pile Topsoil, Office-Road-Cut, Road Side Mulch, and Wildlife Mitigation Area. Locations are presented on Plateau Mining Company 1983 Reclamation Map 1 and Plateau Mining Company 1983 Reclamation Map 2. Each of these areas are described in the following narrative along with a discussion of the results and conclusion that can be made from the 1983 data.

Methods

The parameters measured on the various sites presented in this report includes plant cover, current annual plant production, plant densities, plant vigor, plant survival, and site factor descriptions. Not all parameters were measured on all sites, but where any of these were measured, the following descriptions of methods and procedures were used. A list of the measurements taken on each site is presented in the description section associated with each particular site.

Plant cover was estimated using a ten-point frame. The frame was placed every five meters (m) along a randomly placed 50m transect. A total of 100 data points were recorded for each transect and summarized by species. The transect average represents one datum.

Plant production was measured by clipping current annual production from a $\frac{1}{4}m^2$ quadrat. Five quadrats were randomly placed along the same 50m transect used for cover estimates. Grasses and forbs were clipped at ground level and the current annual twigs and leaves were clipped from shrubs. Production was not estimated for trees. Old plant material was removed from each sample which was segregated by species, oven dried and weighed to within 0.01 grams.

Plant densities were determined by counting the number of plants rooted within a quadrat. Woody plants density was measured using a 1 x 50m belt transect except on reclaimed sites where a 2 x 50m belt was used. The tape which was used to set up the 50m transect provided one side of the belt transect and a meter stick was used to determine if the woody plant was rooted within the quadrat. On the Barrow Area study plots, the Refuse Pile study plots, and the subsoil stockpile, herbaceous plant densities were estimated from ¼m^2 circular quadrats.

Plant vigor was recorded on shrub seedlings planted on the Barrow Area study plots and the Wildlife Mitigation Area study plots. Vigor was rated subjectively on a scale of 1 to 10 with 10 being the most vigorous. Consideration was given to the height, health and overall development of each individual plant. The vigor ratings presented in this report is an average for the particular species. The average was calculated by summing the numeric ratings given to each plant and dividing by the number of surviving plants for that species.

Percent plant survival was calculated by dividing the total number of seedings that were transplanted of a given species into the number of seedlings that were still alive.

On the Barrow Area study plots, site characteristics were recorded for each surviving transplanted shrub or tree. Site factors were micro relief, presence of herbivory, and presence of competing herbaceous vegetaion. Micro-relief is defined as being a depression which would accumulate surface water or a ridge which would not accumulate surface water. If soil moisture is a limiting factor for a particular species, transplanting them into depressions could influence the survival rate. The palatability of a species has been thought to affect the survival potential of that species due to herbivory by animals and insects. Removal of plant material by either animals or insects was recorded for each surviving plant. Likewise, competing herbaceous vegetation has the potential for reducing the survival and vigor of a transplanted shrub or tree. Transplants which had herbaceous vegetation growing within 10cm of a stem were recorded. An

average by species was calculated for each factor and expressed as the percent of the total surviving plants for that species.

Statistical analysis was performed on the effects of treatment on herbaceous seedling densities for the Barrow Area and the Refuse Pile study plots. An analysis of variance was used and the results subjected to a Duncan's Multiple-Range Test. All of the analysis was performed at the 0.05 level and run on Getty Oil Company's IBM computer network, SAS Institute, Statistical Analysis System.

1981 RECLAMATION SEEDING

Description

All of the reseeded areas shown on Plateau Mining Company 1983 Reclamation Map #1 and Plateau Mining Company 1983 Reclamation Map #2 were originally seeded and mulched with cereal grain straw in 1980. Portions of area was hydroseeded with 140 lbs/acre of tackifier in November of 1981 with the seed mixture shown in Table 1, 1980 Seed Mixture. After seeding, the area was hydromulched with 2,000 lbs/acre of Conwed. There were approximately 55.28 acres seeded in 1981. Data collected included cover, production, and woody plant density. Estimates are based on 12 transects plus an additional 24 clip plots for production.

Results

Reclamation monitoring results are presented in Table 3, Summary of Plant Cover On Reseeded Sites, Table 4, Summary of Production for Reseeded Sites, Table 5, Summary of Woody Plant Density on Reseeded Sites.

Cover on the 1981 reclamation averaged 15.67%. This compares with 45.6% total cover and 21.8% herbaceous cover, on the Mixed Sagebrush-Grass-Mountain Brush Community as presented in the Star Point Mines Mining and Reclamation Plan, Permit 006/007 Volume III, Appendix 9F, page 20. Cover on the 1982 reclamation was made up of approximately 38% grasses and 62% forbs. Sweetvetch represents the most dominant species with 42.55% of the overall relative composition. Wheatgrasses make up 23.9% and yellow sweetclover-alfalfa comprises 19.15%. The remaining 14.36% is attributed

TABLE 3

SUMMARY OF PLANT COVER ON RESEEDED SITES

SPECIES	PERCENT COVER	COMPOSITION
Grasses		
Desert Wheatgrass	0.67	04.26
*Wheatgrasses	2.92	18.62
Western Wheatgrass	0.08	00.53
Intermediate Wheatgrass	0.08	00.53
Bromegrass	1.33	08.51
Orchardgrass	0.75	04.79
Timothy	0.17	01.06
Forbs		
Sweetvetch	6.67	42.55
**Yellow Sweetclover/Alfalfa	3.00	19.15
TOTAL	15.67	100.00

*Wheatgrasses which could not be positively identified to species.

**Yellow sweetclover and alfalfa could not be identified to species due to lack of phenological development.

TABLE 4

SUMMARY OF PRODUCTION FOR RESEEDED SITES

SPECIES	GRAMS/M^2	COMPOSITION
Grasses		
Desert Wheatgrass	0.793	05.6
*Wheatgrasses	4.499	31.6
Western Wheatgrass	0.206	01.4
Bromegrass	1.662	11.7
Orchardgrass	0.110	00.8
Timothy	0.029	00.2
Forbs		
Sweetvetch	3.423	24.0
**Yellow Sweetclover/Alfalfa	3.515	24.7
Annual Forbs	0.008	00.6
TOTAL	14.245	100.0

*Wheatgrasses which could not be positively identified to species.

**Yellow sweetclover and alfalfa could not be separated by species at present growth stage development that prevailed at sampling time.

TABLE 5

SUMMARY OF WOODY PLANT DENSITY ON RESEEDED SITES

SPECIES	NO./100M^2	COMPOSITION
Big Sagebrush	0.84	22.7
Fourwing Saltbrush	0.66	18.2
Rubber Rabbitbrush	1.50	40.9
Douglas Rabbitbrush	0.34	09.1
Snowberry	0.34	09.1
TOTAL	3.68	100.0

to brome, orchardgrass, and timothy. Alfalfa and yellow sweetclover were combined in Table 1, Summary of Plant Cover on Reseeded Sites and Table 2, Summary of Production of Reseeded Sites because of the difficulty in separating them in the field at this time of year.

Plant production on the 1981 reseeded sites was 14.245 g/m^2 (127 lbs/acre). 51% of the production was produced by grasses and 49% by forbs. Of the grasses, approximately 39% of the production came from wheatgrasses, and 12% from brome. Sweetvetch and yellow sweetclover-alfalfa makeup almost 49% with the sweetvetch producing 24% and the yellow sweetclover-alfalfa producing 25%.

Additional production data were collected along the upper access road cut and fill. This data is not presented in a Table. The fill areas are dominated with mature, 1980 seeded vegetation. From the 24 clip plots on the fill material, it is estimated that it is producing 16.98 g/¼m^2 or 606 lbs/acre. There were 27 plots clipped on the cut side of the road which is predominately 1981 vintage plant material. It is producing 5.84 g/¼m^2 or 208 lbs/acre. Plots were not clipped by species and represents comparative differences in total production for cut and fill slopes. No cover or shurb density data were collected at these sites.

Woody plant density was 3.68/100m^2 on the 1981 reseeding. This converts to 150 stems per acre. Relative composition is madeup of 41% rubber rabbitbrush, 23% sagebrush, 18% fourwing saltbrush, 9% snowberry, and 9% green rabbitbrush.

Conclusions

Data collected on the 1981 reseeded sites represents two full growing season. Even though plant cover (15.67%) is less than on surrounding natural areas, as described above, it is expected to increase significantly as the stand matures over the next couple of years. Production estimates are likewise low in comparison, 127 to 208 lbs/acre on the 1981 seeding to 606 lbs/acre on the 1980 seeded fill slopes. The 1981 production is expected to increase as the stand matures. Woody plant density (150/acre)

is low, but still comprises a mean distance of one shrub every 17 feet. Since the species present have a strong tendency to propagate, it is expected tha woody plant density will continue to increase as the existing woody plants mature and become a seed source.

TOPSOIL AND SUBSOIL STOCKPILES

Description

Topsoil and subsoil stockpiles are located north of the refuse pile and loadout facility as shown on Plateau Mining Company 1983 Reclamation Map #2. These stockpiles store the topsoil material removed from the refuse pile expansion area as described in the May 29, 1982 Plateau Mining Company's request for a minor modification of the refuse pile expansion plan. Seedlings of the stockpiles was completed in the Fall of 1982 with the seed mixture described in Table 6, Topsoil Stockpile Seed Mixture. Seed was applied using a hydroseeding method at a rate of 42 lbs/acre in conjunction with 200 lbs/acre of 16-16-8 commercial fertilizer. Oats and barley was seeded at 20 lbs/acre to insure stabilization.

Monitoring was performed on July 14, 1983 and consisted of cover measurements on the topsoil stockpile and seedling density on the subsoil stockpile.

Results

Results are found on Table 7, Summary of Percent Plant Cover on Topsoil Stockpiles and Table 8, Summary of Seedling Density on the Subsoil Stockpile.

Cover on the topsoil stockpiles averaged 45.55%. Better than half, 56% was composed of annual species. Almost all of the annual forbs were Russian thistle with some mustards and pigweeds. Perennial grasses made up 38% of the cover.

TABLE 6
TOPSOIL STOCKPILE SEED MIXTURE

	PLS/ACRE
GRASSES	
Fairway Crested Wheatgrass	2
Smooth Brome (Southern Strains)	2
Intermediate Wheatgrass	2
Pubescent Wheatgrass	2
Bluestem Wheatgrass	2
Orchardgrass	2
Russian Wildrye	2
Sandbury Bluegrass	2
Subtotal	16
FORBS	
Alfalfa (Nomad)	2
Ladak - Equal Parts	2
Yellow Sweetclover	2
Subtotal	6
TOTAL PERENNIALS	22
COVER CROP	
Barley and Oats	20
OVERALL TOTAL	42

Seedling density was estimated on the subsoil stockpile as a more realistic measure of revegetation success because of the lack of plant development. Overall seedling density was $9.88/\frac{1}{4}m^2$. This is the equivalent to 3.67 per square foot. Perennial grasses represents 49%, perennial forbs 7%, and cereal grains, which were used as a cover crop/mulch, 44%. Perennial plant density is $5.52/\frac{1}{4}m^2$ or $2.05/ft.^2$.

TABLE 7

SUMMARY OF PERCENT PLANT COVER ON TOPSOIL STOCKPILES

SPECIES	PERCENT COVER	COMPOSITION
Grasses		
Desert Wheatgrass	01.78	03.90
*Wheatgrasses	01.67	03.66
Cheatgrass	06.44	14.15
Foxtail	07.44	16.34
Forbs		
**Yellow Sweetclover/Alfalfa	00.89	02.00
Scarlet Globemallow	00.11	00.24
Annual Forb	25.44	55.85
Shrubs		
Fourwing Saltbrush	01.78	03.90
TOTAL	45.55	100.04

*Wheatgrasses which could not be positively identified to species.

**Yellow sweetclover and alfalfa could not be separated at time of sampling.

TABLE 8

SUMMARY OF SEEDLING DENSITY ON THE SUBSOIL STOCKPILE

SPECIES	NO./1/4M^2	NO./SQ. FOOT
Cereal Grains	4.36	1.62
Perennial Grasses	4.85	1.80
Perennial Forbs	0.67	0.25
TOTAL	9.88	3.67

Conclusion

Topsoil stockpiles were seeded and hydromulched in the Fall of 1982. After the first growing season, total cover (45.55%) is adequate to control erosion in as much as there were no erosion features observed. As observed in the past, the annual forbs which represent 56% of the cover will diminish as the perennial species mature and become established. The subsoil stockpile has an excellent density (2.05/ft.^{2}) of perennial plants.

Standards for successful seedling establishment on improved range have been established for the foothill ranges of Utah. Cook, Stoddart and Sims (Effects of Season, Spacing and Intensity of Seeding on the Development of Foothill Range Grass Stands, 1967, Utah Agricultural Experiment Station Bulletin 467), evaluated successful stand establishment after the third year as "satisfactory" if there were 0.25 plants per square foot, "good" if there were an average of 0.50 plants per square foot, and "excellent" if there were an average of 0.75 or more plants per square foot.

In the Northern Great Plains, where precipitation and site potential is considerably greater than that of the Plateau Mine area, a "good" grass stand is one with 1.0 plants or more per square foot, "fair" if there were 0.5 to 1.0 plants per square foot and "poor" if there was less than 0.5 plants per square foot (Great Plains Agricultural Council, 1966, A Stand Establishment Survey of Grass Plantings in the Great Plains, Nebraska Agricultural Experiment Station Report 23).

In view of these success ratings, it is concluded that a first year seedling establishment of 2.05 plants per square foot on the subsoil stockpile represents acceptable revegetation success.

BARROW AREA STUDY

Description

Site preparation began in 1980 on the Barrow Area Study plots as shown on Plateau Mining Company 1983 Reclamation Map 2. It was seeded with the

seed mixtures presented in Table 9, Low Grass Seed Mix and Table 10, High Grass Seed Mix and mulched with 3,000 lbs/acre of grass hay mulch in the fall of that year. Containerized shrub seedlings (tubelings) were transplanted in April 1981 and the first year's survival data were taken five months later in mid-September 1981.

A total of 48, 12 x 12 foot plots were established. A diagram of the plot layout is given in Figure 1, Planting Pattern for the Barrow Area. Plots were designed to test cultural treatments, seed mixtures, and shrub transplant densities. The purpose of the study was to evaluate reclamation practices at the Star Point Mine site. The study was implemented by Native Plants Incorporated of Salt Lake City, Utah. A copy of the first year results is given in Star Point Mines, Mining and Reclamation Plan, Permit No. 007/006, Volume III, Appendix 9I.

Cultural practices established on the plots were mulch and no mulch. Approximately 3,000 lbs/acre of grass hay mulch was applied immediately after seeding in October 1980. Mulch was spread by hand, but was not incorporated or tacked to ground.

Seeding treatments consisted two seed mixtures and a no seed treatment. Both mixtures were hand broadcasted at a rate of 30 PLS/acre and raked into the soil. One seed mixture, Table 9, Low Grass Seed Mix, contained 15% grasses and 85% forbs and shrubs. The other seed mixture, Table 10, High Grass Seed Mix, was composed of 85% grasses and 15% forbs with no shrubs.

Shrub transplants (tublings) were planted at two densities and a no tubling treatment. A high tubling density treatment contained nine plants per plot. This amounts to a density of 2,723 plants per acre or approximately one shrub every 3 feet. The low tubling density contained four shrubs per plot, a stocking rate of 1,210 stems per acre or a shrub every 6 feet.

TABLE 9

LOW GRASS SEED MIX USED ON THE EXPERIMENTAL TEST PLOTS

LOW GRASS/HIGH FORB AND SHRUB MIX	PERCENT OF MIX*
Russian Wildrye	2.5
Western Wheatgrass	2.5
Streambank Wheatgrass "Sodar"	2.5
Pubescent Wheatgrass	2.5
Mountain Brome	2.5
Indian Ricegrass	2.5
Northern Sweetvetch	12.0
Sainfoin	2.0
Big Sagebrush	8.0
Hoary Aster	3.0
Rubber Rabbitbrush	10.0
Rocky Mountain Penstemon	3.0
White Yarrow	2.0
Fourwing Saltbush	10.0
Shadscale	9.0
Gardner Saltbush	7.0
Prairie Sage	4.0
True Mountain Mahogany	3.0
Green Mormon Tea	3.0
Curlleaf Mtn. Mohogany	3.0
Utah Serviceberry	3.0
TOTAL	100.0%

*Percentages calculated on a dry weight basis

TABLE 10

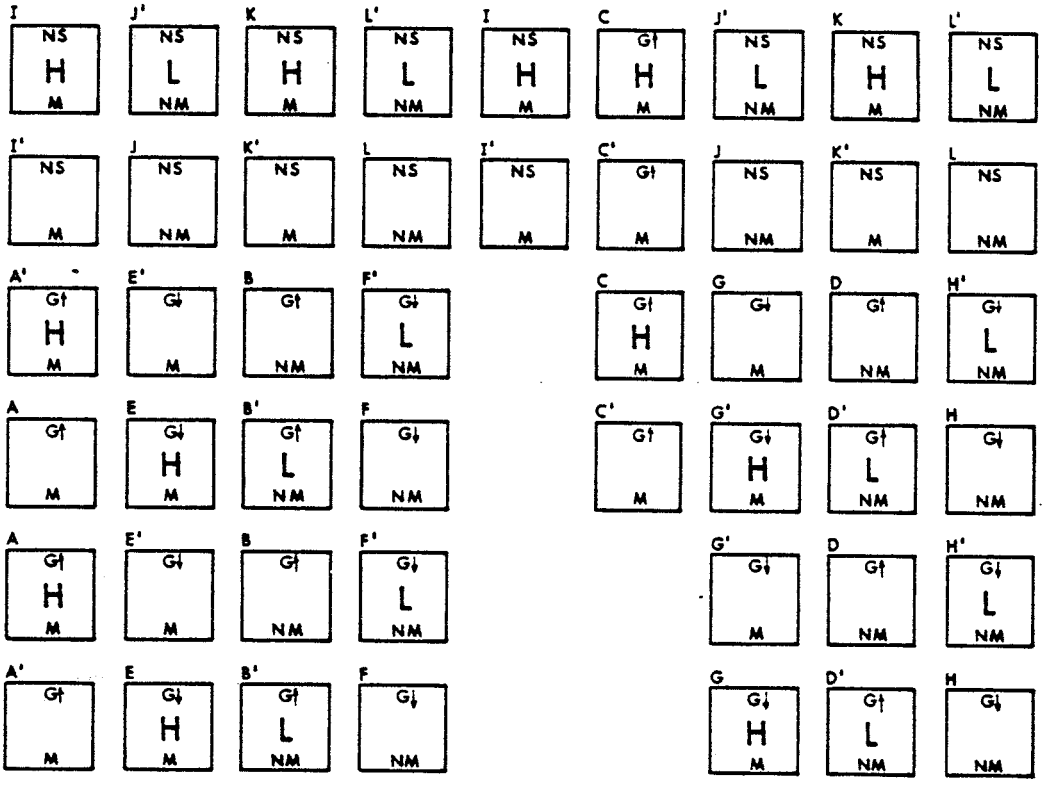
HIGH GRASS SEED MIX USED ON THE EXPERIMENTAL TEST PLOTS

HIGH GRASS/HIGH FORB AND SHRUB MIX	PERCENT OF MIX*
Western Wheatgrass	14
Indian Ricegrass	14
Pubescent Wheatgrass	14
Streambank Wheatgrass	14
Russian Wildrye	14
Mountain Brome	14
Northern Sweetvetch	4
Sainfoin	4
Alfalfa "Ranger"	4
Yellow Sweetclover	4
TOTAL	100%

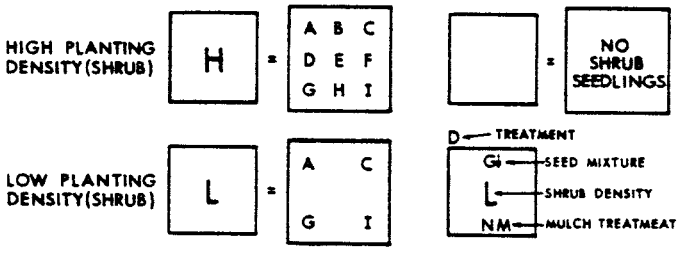
*Percentages calculated on a dry weight basis.

FIGURE 1

PLANTING PATTERN FOR THE BORROW AREA



TREATMENT KEY



A - Four-wing saltbush
B - Serviceberry
C - Rocky mtn. juniper
D - Gambels oak
E - Black sage
F - Siberian peavine
G - Rubber rabbitbrush
H - Curlleaf mtn. mahogany
I - True mtn. mahogany

G↑ = High grass seed mix
G↓ = Low grass seed mix
NS = No seed mix
M = Mulch
NM = No Mulch

The 1983 data presented in the following results section, were collected on July 13 and 14 and represents the third growing season.

Results

A summary of the results is given in Table 11, Comparison of 1983 and 1981 Shrub Survival, Barrow Area Plots, Table 12, Shrub Survival and Contributing Site Factors, Table 13, Perennial Seedling Density, Table 14, Comparison of the Relative Percent Seedling Composition to Mulched and Unmulched Plots, and Table 15, Comparison of Relative Percent Seedling Composition to Mulch and Seed Treatments.

Average shrub survival for 1983 is 54.5%. This compares to 78.8% in 1981. For this period of time, changes in survival ranged from no change for black sagebrush to a reduction of 53% for true mountain mahogany. Along with these data, an important field observation on fourwing saltbush was made. Fourwing saltbush survival declined from 96% in 1981 to 54.2% in 1981. Mortality apparently occurred from winter kill. Of those surviving in 1983, field notes indicate that the majority of them had severly suffered from the last winter. On almost all of the surviving plants, the above ground material had died and new growth was initiating from the root or the base of the stem. Apparently, the origin of the tublings was not adapted to the site. Dead material was about 30 cm high.

In general, none of the surviving shrubs had exceptional vigor. Favorable precipitation during the spring and early summer of this year had resulted in a flush of new growth, but the condition of the plants as indicated by the old growth and poor height reduced the overall vigor rating. Many of the plants had competing herbaceous vegetation within 10 cm of the stem and herbivory was the greatest on serviceberry and curlleaf mountain mahogany.

The results of the statistical analysis revealed that there was no significant differences in perennial plant density due to treatments of either the high and low seeding rate, mulch, or shrub (tubeling) density. There was, as might be expected, a significant difference between no seed

TABLE 11

COMPARISON OF 1983 AND 1981 SHRUB SURVIVAL ON THE BARROW AREA PLOTS

(# PLANTED)

SPECIES	(%) 1983	(%) 1981	% CHANGE
Serviceberry	41.7	67.0	-38
Black Sagebrush	50.0	50.0	0
Fourwing Saltbush	54.2	96.0	-44
Peashrub	59.3	92.0	-36
Curleaf Mtn. Mahogany	59.3	83.0	-30
True Mtn. Mahogany	29.1	62.0	-53
Rubber Rabbitbrush	62.5	71.0	-12
Rocky Mtn. Juniper	83.3	100.0	-17
Gambel Oak	41.7	75.0	-44
TOTAL	54.5	78.8	-31

TABLE 12

SHRUB SURVIVAL AND CONTRIBUTING SITE FACTORS

ON THE BARROW AREA EXPERIMENTAL PLOT

SPECIES	(%) SURVIVAL	(1-10) VIGOR	(%) FLUSHING	(CM) HEIGHT	(%) HERB	(%) TOPO	(%) COMPT
Serviceberry	41.7	3.6	40	11.0	60	80	60
Black Sagebrush	50.0	4.1	56	13.2	11	56	33
Fourwing Saltbush	54.2	4.4	75	19.1	58	67	42
Peashrub	59.3	5.3	80	14.2	70	60	40
Curleaf Mtn. Mahogany	59.3	4.7	73	11.7	91	54	18
True Mtn. Mahogany	29.1	2.6	71	07.0	14	71	14
Rabbitbrush	62.5	4.8	63	16.3	13	56	31
Rocky Mtn. Juniper	83.3	3.8	15	11.6	5	45	40
Gambel Oak	41.7	5.0	0	13.8	40	80	60

NOTE:
- VIGOR = Scale of 1 to 10 with 10 being the most vigorous
- FLUSHING = Shrubs exhibiting a flush of active new growth
- HERB = Shrubs exhibiting herbivory and/or insect damage
- TOPO = Shrubs growing in a surface depression on a micro relief basis
- COMPT = Shrubs with competing herbaceous vegetation within 10 cm of the stem

TABLE 13

PERENNIAL SEEDLING DENSITY ON THE BARROW STUDY PLOTS

TREATMENTS		DENSITY (#/M^2)
High Grass Mix	- Mulched	34.52
High Grass Mix	- Unmulched	32.80
Low Grass Mix	- Mulched	31.12
Low Grass Mix	- Unmulched	36.72
No Seeding	- Mulched	32.60
No Seeding	- Unmulched	18.60

TABLE 14

BARROW AREA STUDY PLOT

COMPARISON OF THE RELATIVE PERCENT SEEDLING COMPOSITION

TO MULCHED AND UNMULCHED PLOTS

SEED MIXTURE	% OF MIX	MULCHED	UNMULCHED	AVERAGE
High Grass/Low Forb/No Shrub				
Grasses	84	79	61	70
Legumes	16	20	39	30
Shrubs	0	1	2	2
Non-seeded grasses*	(0)	(4)	(12)	--
Non-seeded shrubs*	(0)	(0.3)	(0.4)	--
Low Grass/Forb/High Shrub				
Grasses	15	71	73	72
Legumes	14	24	25	25
Shrubs	63	5	3	4
Other Forbs	5	0.3	0	0
Non-seeded Grasses*	(0)	(11)	(15)	--
Non-seeded Shrubs*	(0)	(0.6)	(0)	--
No Seed				
Grasses	0	86	82	84
Legumes	0	11	15	13
Shrubs	0	1	2	2
Non-seeded Grasses*	(0)	(10)	(5)	--
Non-seeded Shrubs*	(0)	(1)	(0.1)	--

*Non-seeded grass species are orchardgrass and timothy - both not available from either seed mixes or local seed producing plants - probable source is mulch material. Non-seeded shrubs are bitterbrush, oak, juniper, winterfat - probably local source.

TABLE 15

SEEDLING BARROW STUDY PLOTS COMPARISON OF

RELATIVE PERCENT COMPOSITION TO MULCH AND SEED TREATMENTS

	MULCHED			UNMULCHED		
	HS*	LS*	NS*	HS*	LS*	NS*
Grasses						
Wheatgrass	70	53	68	44	50	63
Bromes	5	8	8	3	8	15
Indian Ricegrass	.3	--	--	--	--	--
Orchardgrass	4	9	7	11	15	5
Timothy	--	2	3	1	.3	--
Unknown Grass	--	--	--	1	--	--
Forbs						
Alfalfa	5	10	11	12	13	14
Sweetvetch	15	13	1	27	12	1
Yarrow	--	.3	--	--	--	--
Shrubs						
Fourwing Saltbrush	.3	2	1	--	1	1
Fringe Sagebrush	--	--	.4	--	--	--
Sagebrush	1	.3	--	--	--	.1
Bitterbrush	--	.3	.4	--	--	--
Juniper	--	--	.4	.4	--	.1
Rabbitbush	--	2	--	1	1	1
Ephedra	--	.3	--	--	1	--
Winterfat	--	.3	--	--	--	--
Oak	.3	--	--	--	--	--

*HS - High grass/low forb/no shrub seed mix

*LS - Low grass/high forb/high shrub seed mix

*NS - No seed planted

treatment plots and those that were seeded. The information presented in Table 13, Perennial Seedling Density on the Barrow Study Plots, shows that the highest perennial plant density, occurred in the low grass, unmulched treatment (36.72/m^2). The lowest perennial plant density was the no seeding, unmulched treatment (18.6/m^2). In contrast, the no seeding, mulched treatment (32.6/m^2) had densities similar to the plots that were seeded. Where neither seed, nor mulch was applied, a significantly lower density resulted. However, it is important to note that the lowest density of 18.6 perennial plants per m^2 (75,274/acre or 1.73/$ft.^2$) represents acceptable densities on reclaimed mined land using the documentation provided on page 14 in the Results Topsoil and Subsoil section. In that reference, herbaceous plant densities that averaged 0.5 plants per square foot were considered "good", where those stands with densities of 0.75 and greater were considered "excellent". Table 14, Barrow Study Plots, Comparison of Seed Mixtures to the Relative Percent Composition, and Table 15, Comparison of Relative Percent Seedling Composition to Mulch and Seed Treatments contains a comparison of the seed mixtures to the relative percent composition, based on density, of the mulched and unmulched plots. Relative percent composition of mulched and unmulched plots and high, low and no seed mixtures shows close similarity in the distribution of grasses, legumes/forbs, and shrub density. Where no seed was applied to the plots, realtive percent composition was about 10% higher for grasses and 10% lower for legumes compared to seeded plots.

Conclusion

After three growing seasons, there were no significant affects on perennial plant densities due to the ratio of grasses to forbs and shrubs in the mixtures. Where grasses made up 85% of the seed mixture, grasses represented about 70% of the reseeded plant community. In plots where grasses made up only 15% of the seed mixture, grasses still represented about 72% of the reseeded plant community. Likewise, seed mixtures which contained shrubs resulted in only slightly higher shrub densities, 2% where no shrubs were seeded and 4% where shrub seeds made up 63% of the mixture. From this, it can be concluded that the seeding of high rates of shrub seeds does not result in an increase in initial shrub densities.

Mulching combined with the high grass seed mixture had a detrimental affect on legumes (49% decrease), whereas either mulching or no-mulching combined with the low grass seed mix, or the no-seed mix did not affect the legume establishment. However, the opposite effect was observed for the wheatgrass and brome. Mulch resulted in a 37% increase in the wheatgrass and a 40% increase in the bromes. Orchardgrass tended to become better established on unmulched plots. Dissemination of the orchardgrass and timothy, which were introduced to the study area in the mulch, to unmulched plots is explained by the fact that the mulch which was not tacked down was blown by the wind. This was indicated on page 13, Appendix 9I, Star Point Mines Mining and Reclamation Plan, Volume III, which states that the mulch was not incorporated or otherwise anchored and the low snow year allowed the mulch to be scattered.

Shrub establishment from seed was highest in the mulched plots which had been seeded with the high-shrub seed mixture and the only mixture that contained shrub seed. Five seeded shrub species were growing in these plots whereas only two species were found in the unmulched, high shrub seed mixture plots.

Overall transplanted shrub seedling survival after three growing seasons was good at 54.5%, a 31% decrease from the first year percent survival. Vigor was only fair even with a high flushing rate. In general, herbivory, micro-relief, and competing herbaceous vegetation does not appear to have had a high correlation with survival. The planting of shrub seedlings in small surface depressions benefited four of the nine species evaluated in this study. Five species did not appear to benefit from being planted in depressions. Herbivory by animals and insects is not a factor significantly affecting shrub survival while competing herbaceous vegetation appears to have only a slightly negative affect. Attempts should be made to place shrub transplants away from competing herbaceous vegetation. Of these three micro-site factors, topographic manipulation is the only factor that can be controlled to any meaningful extent in the reclamation process and this appears to be benificial only when planting serviceberry, gambel oak, true mountain mahogany, and fourwing saltbush.

Lasting effects of planting seedlings away from competition from herbaceous vegetation would be minimal. Once the shrub seeding has been planted, control of intruding vegetation would be impossible. This is especially true where seedlings are planted in small depressions.

REFUSE PILE TOPSOIL STUDY

Description

The study plots on the refuse pile were installed in the Fall of 1982 as stipulated by the Utah Division of Oil, Gas and Mining as part of the modification to the Refuse Pile Expansion Plan. Three topsoil treatments were applied to the coal refuse pile to determine the most successful method of reclaiming the refuse pile.

The location of the study plots is given on Plateau Mining Company 1983 Reclamation Map #2. In Figure 2, Refuse Pile Vegetation - Topsoil Test Plots, the physical layout of the treatment plots is shown. The treatments are as follows:

1. Soil material: subsoil, toposoil, topsoil over subsoil, and refuse material.

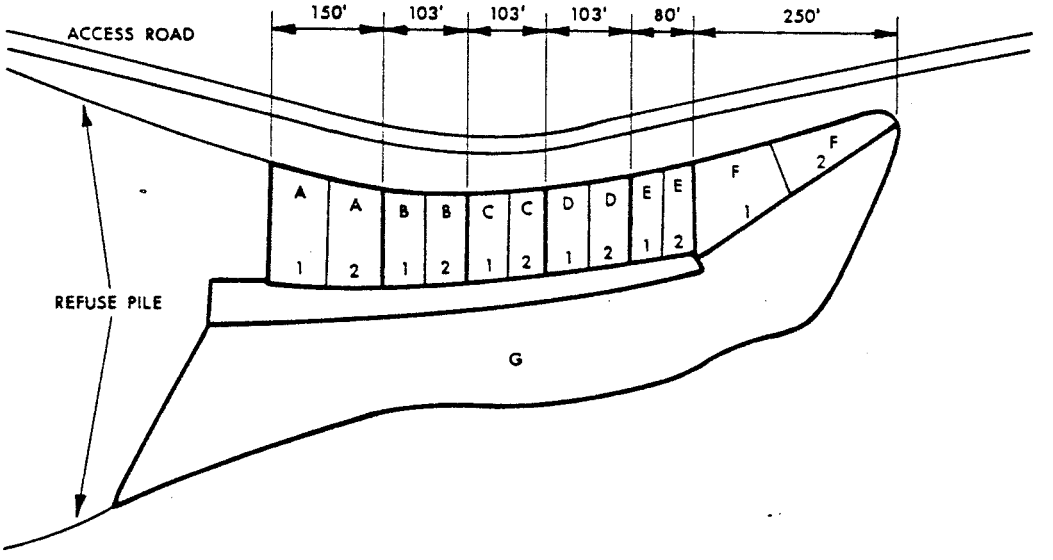
2. Soil depth: each soil material was applied at 10" and 20", and 10" of topsoil over 10" of subsoil.

3. Fertilization (16-16-8) at 100 lbs. per acre and 200 lbs. per acre.

The objective of the 1983 field sampling was to evaluate the influence of these treatments on germination and seedling establishment and to determine which one is the most favorable for successful reclamation of the refuse pile.

FIGURE 2

REFUSE PILE VEGETATION - TOPSOIL TEST PLOT LAYOUT



PLOT	TREATMENT KEY (INCHES) SOIL MATERIAL & DEPTH	(16-160-8) FERTILIZER LBS/ACRE	SEED MIX SPECIES	POUNDS PLS/ACRE
A1	Coal Waste	100	Slender Wheatgrass	3.0
A2	Coal Waste	200	Western Wheatgrass	3.0
B1	20" Subsoil	200	Tall Fescue	2.0
B2	20" Subsoil	100	G.B. Wildrye	3.0
C1	10" Topsoil/10" Subsoil	100	Blue Bunch Wheatgrass	3.0
C2	10" Topsoil/10" Subsoil	200	Scarlet Globemallow	0.5
D1	10" Subsoil	200	Penstemon	0.5
D2	10" Subsoil	100	Cicer Milkvetch	1.0
E1	20" Topsoil	100	Yellow Sweetclover	1.0
E2	20" Topsoil	200	Rubber Rabbitbrush	0.5
F1	10" Topsoil	200	Big Sagebrush	0.1
F2	10" Topsoil	100	Green Ephedra	2.0
G	10" Subsoil	100	4-wing Saltbrush	1.0
			TOTAL	20.6

Results

The results of the 1983 monitoring is given in Table 16, Summary of Perennial Seedling Density, Table 17, Summary of Annual Weed Density, and Table 18, 1983 Seedling Density. The highest perennial seedling density, 45.76/m^2, occurred on the 20" subsoil material which had received 200 lbs. of fertilizer per acre. The lowest perennial seedling density, 9.70/m^2, occurred on the 10" topsoil material which had received 100 lbs. of fertilizer per acre. On the raw refuse material plot, there were 7.68 perennial seedlings per square meter.

Statistically significant differences in perennial plant densities exist within treatment levels for soil material, soil depth, and fertilizer rate, but not between these treatments. Perennial plant densities attributed to topsoil and subsoil are 13.01/m^2 and 37.15/m^2; 10" and 20" depth of soil material are 21.66/m^2 and 28.50/m^2; 100 lbs/acre and 200 lbs./acre of fertilizer are 23.10/m^2 and 27.47/m^2 respectfully. Thus, density is significantly (2.9X) greater for subsoil than for topsoil and only 1.3X greater for 20" soil depth over 10" soil depth and 1.2X greater for 200 lbs/acre fertilizer rate as opposed to 100 lbs./acre.

Where 10" of topsoil was placed over 10" of subsoil, there were 21.47/m^2 with 100 lbs/acre of fertilizer and 26.84/m^2 with 200 lbs/acre of fertilizer. In contrast to all of the soil treatments, perennial plant densities on the coal waste plot was 7.68/m^2.

Conclusion

First year germination and seedling establishment results from the refuse pile topsoil study reveals a highly significant difference between topsoil and subsoil material and to a lesser degree, between soil depths. However, the long term affects of these treatments on reclamation success needs to be evaluated. Of special interest in this arid region is the affect of fertilizer. The ultimate recommendation will have to be based on the lasting effects of these treatments. It should be noted that even the density on the refuse material (7.68/m^2 or 0.71/$ft.^2$) could represent acceptable reclamation, based on the documentation presented on page 14 of

TABLE 16

SUMMARY OF PERENNIAL SEEDLING DENSITY,

REFUSE PILE STUDY, FIRST YEAR GERMINATION, 1983

PERENNIAL SEEDLING DENSITY (#/M^2)

	FERTILIZER TREATMENTS		
SOIL DEPTHS	"0" LBS/A	100 LBS/A	200 LBS/A
20" Subsoil	---	38.42	45.76
10" Subsoil	---	30.00	34.40
20" Topsoil	---	12.00	17.82
10" Topsoil	---	9.70	12.52
10" Topsoil/10" Subsoil	---	21.47	26.84
10" Topsoil (South Aspect)	---	27.00	---
Coal Waste	7.68	---	---
Average	7.68	23.10	27.47

TABLE 17

SUMMARY OF ANNUAL WEED DENSITY, REFUSE PILE STUDY,

FIRST YEAR GERMINATION, 1983

WEED DENSITY (#/M^2)

	FERTILIZER TREATMENTS		
SOIL DEPTHS	"0" LBS/A	100 LBS/A	200 LBS/A
20" Subsoil	---	7.16	9.88
10" Subsoil	---	8.04	7.52
20" Topsoil	---	13.96	17.28
10" Topsoil	---	18.44	17.64
10" Topsoil/10" Subsoil	---	9.84	6.20
10" Topsoil (South Aspect)	---	6.36	---
No Soil	10.64	---	---
Average	10.64	8.93	11.70

TABLE 18

1983 SEEDLING DENSITY REFUSE PILE STUDY

FIRST YEAR GERMINATION

	DENSITY (#/M^2)				
	A	B2	B1	C2	C1
TREATMENT:	No Soil	20" Subsoil	20" Subsoil	10" Topsoil 10" Subsoil	10" Topsoil 10" Subsoil
FERTILIZER RATE:	"0" lbs/a	200 lbs/a	100 lbs/a	200 lbs/a	100 lbs/a
Perennial Plants					
Seeded Species					
Grasses					
Wheatgrass	06.04	40.08	26.04	20.88	13.60
Tall Fescue	01.00	00.96	09.24	01.60	04.16
SUBTOTAL	07.04	41.04	35.28	22.48	17.76
Forbs					
Cicer Milkvetch	00.16	00.52	01.68	01.12	01.60
Yellow Sweetclover	00.16	01.88	00.80	01.16	01.48
Scarlet Globemallow	00.00	00.00	00.00	00.00	00.00
SUBTOTAL	00.32	02.40	02.48	02.28	03.08
Shrubs					
Big Sagebrush	00.00	00.08	00.00	00.16	00.00
Fourwing Saltbush	00.16	01.24	00.36	01.16	00.28
Rabbitbrush	00.00	00.00	00.00	00.00	00.00
Green Ephedra	00.16	00.96	00.28	00.52	00.28
SUBTOTAL	00.32	02.28	00.64	01.84	00.56
TOTAL SEEDED	07.68	45.72	38.40	26.60	21.40
Volunteer	00.00	00.04	00.02	00.24	00.07
TOTAL PERENNIAL	07.68	45.76	38.42	26.84	21.47
Volunteer Annuals					
Grasses	00.00	01.16	00.08	00.80	00.88
Forbs	10.64	08.72	07.08	05.40	08.96
SUBTOTAL	10.64	09.88	07.16	06.20	09.84
OVERALL TOTAL:	18.32	55.64	45.58	33.04	31.31

TABLE 18

1983 SEEDLING DENSITY REFUSE PILE STUDY

FIRST YEAR GERMINATION

(Cont'd)

DENSITY (#/M^2)

TREATMENT:	D1 10" Subsoil	D2 10" Subsoil	E2 20" Topsoil	E1 20" Topsoil	F2 10" Topsoil
FERTILIZER RATE:	100 lbs/a	200 lbs/a	200 lbs/a	100 lbs/a	200 lbs/a
Perennial Plants					
Seeded Species					
Grasses					
Wheatgrass	20.96	28.80	13.96	07.84	09.68
Tall Fescue	05.76	00.52	00.08	01.88	00.28
SUBTOTAL	26.72	29.32	14.04	09.72	09.96
Forbs					
Cicer Milkvetch	01.24	00.80	00.44	00.72	00.52
Yellow Sweetclover	01.08	01.44	00.96	00.80	00.52
Scarlet Globemallow	00.00	00.08	00.00	00.00	00.00
SUBTOTAL	02.32	02.32	01.40	01.52	01.04
Shrubs					
Big Sagebrush	00.00	00.00	00.08	00.00	00.00
Fourwing Saltbush	00.16	01.76	01.16	00.72	00.64
Rabbitbrush	00.00	00.00	00.80	00.00	00.52
Green Ephedra	00.72	00.96	00.16	00.00	00.36
SUBTOTAL	00.88	02.72	02.20	00.72	01.52
TOTAL SEEDED	29.92	34.36	17.64	11.96	12.52
Volunteer	00.08	00.04	00.18	00.04	00.00
TOTAL PERENNIAL	30.00	34.40	17.82	12.00	12.52
Volunteer Annuals					
Grasses	03.04	00.96	09.44	06.68	10.56
Forbs	05.00	06.56	07.84	07.28	07.08
SUBTOTAL	08.04	07.52	17.28	13.96	17.64
OVERALL TOTAL:	38.04	41.92	35.10	25.96	30.16

TABLE 18

1983 SEEDLING DENSITY REFUSE PILE STUDY

FIRST YEAR GERMINATION

(Cont'd)

DENSITY (#/M^2)

TREATMENT: FERTILIZER RATE:	F1 10" Topsoil 100 lbs/a	G (South Aspect) 10" Topsoil 100 lbs/a	Average #/M^2
Perennial Plants			
Seeded Species			
Grasses			
Wheatgrass	05.44	21.92	17.94
Tall Fescue	01.76	02.48	02.48
SUBTOTAL	07.20	24.40	20.42
Forbs			
Cicer Milkvetch	01.16	00.12	00.84
Yellow Sweetclover	00.44	01.96	01.06
Scarlet Globemallow	00.00	00.00	00.01
SUBTOTAL	01.60	02.08	01.91
Shrubs			
Big Sagebrush	00.00	00.00	00.03
Fourwing Saltbush	00.88	00.20	00.73
Rabbitbrush	00.00	00.12	00.12
Green Ephedra	00.00	00.20	00.38
SUBTOTAL	00.88	00.52	01.26
TOTAL SEEDED	09.68	27.00	23.59
Volunteer	00.02	00.00	00.06
TOTAL PERENNIAL	09.70	27.00	23.65
Volunteer Annuals			
Grasses	09.96	00.12	03.64
Forbs	08.48	06.24	07.44
SUBTOTAL	18.44	06.36	11.08
OVERALL TOTAL:	28.14	33.36	34.73

the Topsoil and Subsoil section where reseeded grass stands with 0.75/ft.^{2} were given a rating of "excellent".

It may be concluded at this point, however, that the selective replacement of soil horizons did not have an advantage over subsoil alone and might indicate that a mixing of the horizons would not only be more economical, but provide near optimum revegetation potential.

OFFICE-ROAD-CUT STUDY PLOTS

Description

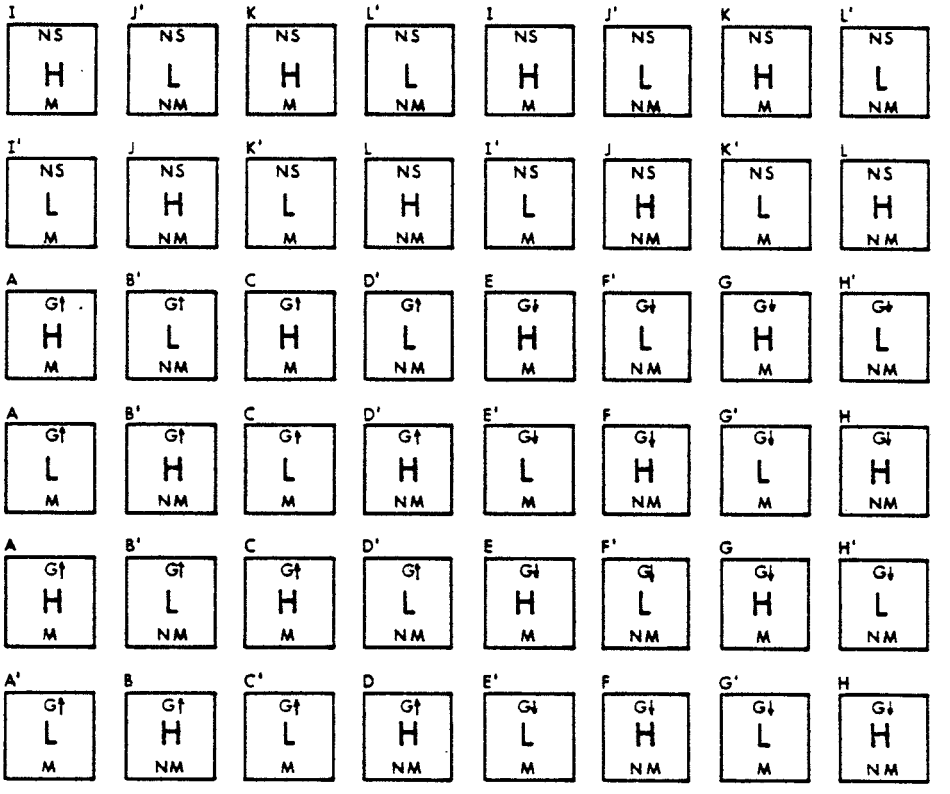
The study plots are located below the office and parking lot at the Lion Deck Portal area, as shown on Plateau Mining Company 1983 Reclamation Map 1. They are on a 70%, east southeast (30 degrees) facing slope. The plots were installed in October 1980. Seed mixtures, given in Table 9 and Table 10, were hand seeded at a rate of 30 pounds PLS/acre and raked into the soil. A grass hay mulch was applied at about 3,000 pounds per acre after seeding. Plots received mulch, and no-mulch treatments. Shrubs seedlings (tubelings) were planted at two rates; 9 tublings in the high density plots and 4 tublings in the low density. Plots are 12 x 12 feet square. A diagram of the plots and treatments is presented in Figure 3, Planting Pattern for the Office Road Cut.

All 48 plots, 24 plots with 9 per plot and 24 plots with 4 tubelings per plot, were planted with tubelings; each tubeling received an Agriform fertilizer pellet (10-20-10) placed in the hole with the tubeling. Tubelings were planted in April 1981 after seeding and mulching the previous Fall. The first year survival data were taken in mid-September, 1981. 1983 survival data were collected on July 7, after three growing seasons.

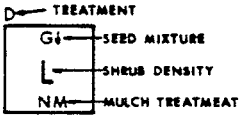
Shrub survival was the only parameter sampled in 1983.

FIGURE 3

PLANTING PATTERN FOR THE OFFICE ROAD CUT



TREATMENT KEY



Artemisia tridentata*
Quercus gambelii
Atriplex canescens*
Chrysothamnus nauseosus
Rhus trilobata
Amelanchier utahensis
Cercocarpus ledifolius*
Cercocarpus montanus
Juniperus scopulorum*

G↑ = High grass seed mix
G↓ = Low grass seed mix
NS = No seed mix
M = Mulch
NM = No Mulch

*Species used in low density plantings

Results

Percent shrub survival is presented in Table 19, Percent Shrub Survival on the Office Road Cut Study Plots. This table shows a comparison of 1983 and 1981 survival. In 1983, survival was 21% as compared to 59% in 1981. Of the nine species planted, only one, gambel oak, has completely died out. One plant of oak sumac, (one out of twenty-four) was still living. Big sagebrush had the highest survival at 46%.

Conclusion

After three growing seasons, the overall survival is low at 21%. Factors that might be affecting survival may be the course rock that makes up the surface of the fill material on which the plots are located. This effect could stem from a reduced water holding capacity of the soil surface in the tubeling root zone or from rodent damage due to the favorable habitat created for rodents by the large rocks. Big sagebrush, rubber rabbitbrush, mountain mahogany, and fourwing saltbrush represent relatively successfully species for transplanting on this site (elevation 8,500'). Those species that did poorly are gambles oak, oak sumac, serviceberry, and Rocky Mountain juniper.

ROAD SIDE MULCH STUDY PLOTS

Description

During mid-March 1982, the mulch study plots were installed on steep road cuts, shown on Plateau Mining Company 1983 Reclamation Map 1, which had not been successfully revegetated due to excessive sloughing. Fourteen plots were established, each with Terra Tack II tackifier at 140 lbs/acre, fertilizer (16-16-8) at 200 lbs/acre, and 22 lbs/acre of the seed mix presented in Table 20, Roadside Mulch Study Plot Seed Mixture.

TABLE 19

PERCENT SHRUB SURVIVAL ON THE OFFICE-ROAD CUT STUDY PLOT

SPECIES	(%) 1983	(%) 1981	% CHANGE
Big Sagebrush	46	77	-40
Gambel Oak	0	54	-100
Fourwing Saltbush	17	79	-78
Rubber Rabbitbrush	29	29	0
Oak Sumac	4	75	-95
Utah Serviceberry	8	29	-72
Curleaf Mountain Mahogany	10	67	-85
True Mountain Mahogany	21	71	-70
Rocky Mountain Juniper	8	35	-77
TOTAL	21	59	-64

TABLE 20
ROADSIDE MULCH STUDY PLOT SEED MIXTURE

		POUNDS PLS/ACRE
GRASSES		
1.	Fairway Crested Wheatgrass	2
2.	Smooth Brome (Southern Strains)	2
3.	Intermediate Wheatgrass	2
4.	Pubescent Wheatgrass	2
5.	Bluestem Wheatgrass	2
6.	Orchardgrass	2
7.	Russian Wildrye	2
8.	Sandbury Bluegrass	2
FORBS		
	Alfalfa (Nomad)	2
	Ladak - Equal Parts	2
	Yellow Sweetclover	2
	TOTAL	22
	Test plots 11, 12, 13, 14 have 10 lbs. of barley and 10 lbs. of rye	20
	TOTAL	42

Treatments for each plot are given in Table 21, Description of the Roadside Mulch Study Treatments.

The plots were first monitored July 1982. Because of sloughing, many of the plot identification stakes have been lost. Eight of the 14 plots could be identified in the field and were sampled July 13, 1983. In general, the upper portions of the plots have few plants due to soil movement down the steep slope. Sampling as done on the mid-portions of the plot. A total of ten $\frac{1}{4}m^2$ quadrats were read per plot.

TABLE 21

DESCRIPTION OF THE ROADSIDE MULCH STUDY TREATMENTS

Plot #1 -	Seed & Tack & Fertilizer - Jute mesh - over spray Conwed 2,000 mulch
*Plot #2 -	Seed & Tack & Fertilizer - Jute mesh
*Plot #3 -	Seed & Tack & Fertilizer - 1" over-cover straw
*Plot #4 -	Seed & Tack & Fertilizer - 1" over-cover straw held jute mesh
*Plot #5 -	Seed & Tack & Fertilizer - Nylon mesh
Plot #6 -	Seed & Tack & Fertilizer - Nylon mesh - over spray 2,000 lbs. Conwed - 2,000 mulch
*Plot #7 -	Seed & Tack & Fertilizer - Covered with cellulose blanket
*Plot #8 -	Seed & Tack & Fertilizer - Cellulose blanket - over spray 2,000 lbs/acre over spray Conwed 2,000 mulch
Plot #9 -	Seed & Tack & Fertilizer - 2,000#/acre - Conwed 2,000 mulch
*Plot #10 -	Seed & Tack & Fertilizer - No mulch/net treatment
*Plot #11 -	Seed & Tack & Fertilizer - 20 lbs. cover crop seed
*Plot #12 -	Seed & Tack & Fertilizer - 20 lbs. cover crop seed over spray 2,000 lbs. Conwed 2,000 mulch
Plot #13 -	Seed & Tack & Fertilizer - 20 lbs. cover crop seed - nylon mesh
Plot #14 -	Seed & Tack & Fertilizer - 20 lbs. cover crop seed - nylon mesh over spray 2,000 lbs/acre Conwed 2,000 mulch

*Sampled in 1983, the only plots with stakes that can still be located in the field.

The purpose of this study was to determine the most cost efficient method of stabilizing slopes prone to sloughing for a period adequate to reestablish vegetation. This objective is stated in a memo to Coal File, March 24, 1982, Plateau Mining Company, and signed by Lynn M Kunzler, Reclamation Biologist, Utah Division of Oil, Gas, and Mining.

Results

A summary of the Results are given in Table 22, Perennial Seedling Density - Treatment Cost Comparison. Perennial seedling densities are highest where no mulch or netting had been applied. In Plot No. 10 where only seed, tackifier, and fertilizer were applied, the seedling density was 4.422/ft.^{2}. This plot not only had the highest density, but it was also the lowest treatment cost per acre ($238/acres) and the lowest cost per surviving seedling ($0.001). The next highest densities are on the nylon mesh plot with 2.560/ft.^{2} and $0.057/seedling and the cereal cover crop with Conwed at 2.267/ft.^{2} and $0.010/seedling. The lowest densities were on the straw mulch plot which had 0.223/ft.^{2} at $0.073/seedling.

Conclusions

After two growing seasons, there appears to be some definite trends on the affect of mulch and netting material on the survival and establishment of perennial plants on steep road cuts. All treatments had a negative effect on seedling densities compared to Plot No. 10 which had received no mulch or netting. It had almost 2 times the number of seedlings over the next highest densities. The Plot #10 also had the lowest cost per acre and the lowest cost per surviving seedling (see Table 22). The application of Conwed did have a strong positive influence on the cereal cover crop treatment. The cereal cover crop with Conwed mulch had the fourth lowest cost per acre and the second highest seedling density.

Objectives of the study includes both the revegetation success and the economics of reclaiming the steep road cuts. In meeting these objectives and based on the 1983 data and application cost, it is recommended that no netting or mulch be used in reseeding steep slopes. Straw mulch alone had the lowest and most unacceptable seedling densities and is not recommended. From an economical standpoint, the use of the lowest cost netting (nylon) which had acceptable seedling densities (2.56/ft.^{2}) is 27 times more expensive than the no treatment plot (4.422/ft.^{2}), which had the highest seedling density. It is concluded that neither netting or mulch be used to revegetate steep road cuts.

TABLE 22

PERENNIAL SEEDLING DENSITY

TREATMENT COST COMPARISON, ROADSIDE MULCH STUDY

PLOT NO.	TREATMENT	($) COST/ACRE	(#/ft.^{2}) DENSITY	($) COST/SEEDLING
3	Straw	709	0.223	0.073
4	Jute/Straw	9,901	1.003	0.227
5	Nylon Mesh	6,358	2.560	0.057
7	Cello-Blanket	11,034	1.264	0.200
8	Cello-Blanket/Conwed*	11,824	1.747	0.155
10	No Treatment	238	4.422	0.001
11	Cereal Cover Crop	263	0.956	0.006
12	Cereal Cover Crop/Conwed	1,033	2.267	0.010

*Conwed = 2,000 lbs/acre Conwed Hydromulch over-spray

WILDLIFE MITIGATION AREA

Description

During the Fall of 1982, approximately 16 acres of the 40 acre wildlife mitigation area, shown on Plateau Mining Company 1983 Reclamation Map 2, was treated in an attempt to improve the site for deer winter range. The treatments consisted of (1) dozing pinyon and juniper trees that were enchroaching on a big sagebrush community; (2) crushing mature serviceberry shrubs to make new growth available for deer; (3) reseeding with the mixture given in Table 24, Wildlife Mitigation Area Seed Mixture and fertilizing at 200 lbs/a of 16-16-8; and (4) transplanting shrub seedlings into the scalps and other disturbed areas created by dozing and crushing the pinyon, juniper, and serviceberry trees. Shrub seedings were transplanted in April 1983 at an estimated density of 4,000/acres in the scalps and mechanically disturbed areas. The shrub species transplanted are given in Table 23, Shrubs Tranplanted on the Wildlife Mitigation Area.

On July 9 and 10, 1983 the treatment area and the adjacent control area were sampled. Parameters measured were plant cover, current annual plant production, and woody plant density. Percent shrub survival was taken on a test plot located within the treatment area. The test plot was established at the same time and using the same plant material used on the rest of the treatment area. Test shrubs were planted in a row with 3' distance separating each plant.

TABLE 23

SHRUBS TRANPLANTED ON THE WILDLIFE MITIGATION AREA.

SPECIES	NO. PLANTED	SOURCE
Fourwing saltbrush	500	Container
Bitterbrush	1,000	"
Serviceberry	700	"
Currant	300	"
Mormon Tea	500	"
True Mountain Mahogany	500	"

TABLE 24

WILDLIFE MITIGATION AREA SEED MIXTURE

	POUNDS LBS/ACRE
Pubescent Wheatgrass	1
Fairway Crested Wheatgrass	1
Russian Wildrye	3
Prostrat Kochia	1
Ladak Alfalfa	3
Pacific Aster	1
Yellow Sweet Clover	1
Blue Flax	1
Desert Globemallow	1
Small Burnet	1
Fourwing Saltbrush	2
	16

Mitigation work is in response to Stipulation 9-22-2 which concerns the deer winter range improvement to compensate disturbances associated with the refuse pile expansion and the unit train loadout.

Field sampling involved a total of 20 transects in the 16 acre treatment area and 20 in the 16 acre control area. Procedures are described in the Methods section.

Results

Results are summarized in Table 25, Summary of Plant Cover and Production, Wildlife Mitigation Treatment Area and Control Area; Table 26, Summary of Woody Plant Density, Wildlife Mitigation Area; and Table 27, Shrub Transplant Survival Test Plots, Wildlife Mitigation Area. Table 28, Plant Species Identified on or Adajacent to the Permit Area, contains the names of the plant species identified in the wildlife mitigation area as well as all of those identified in the other areas sampled in 1982 and 1983.

A review of Table 25 reveals that there is no difference in grass cover between the treatment and control areas, but there has been a significant increase in forb and shrub cover. By comparing relative percent cover composition between the treatment and control areas, it is evident that there has been a shift in composition in the treatment area. Grasses cover represents 34% and forbs 65% more of the cover on the treatment area than on the control. As may be expected from the impacts of the equipment used as well as the actual mechanical treatments on the treated area, the relative percent shrub cover on the treatment area is 38% less than the relative percent shrub cover on the control area. Increases in the relative forb composition on the treatment area is attributed to annual forbs and seeded forb species. Annual forbs would naturally increase as a result of openings in the natural plant community from surface disturbances. Non-seeded perennial forb cover remains about the same for both the treated and control areas.

TABLE 25

SUMMARY OF PLANT COVER AND PRODUCTION, WILDLIFE MITIGATION TREATMENT AREA AND CONTROL AREA, 1983

	COVER (%)		PRODUCTION (g/m^2)	
SPECIES*	TREATMENT	CONTROL	TREATMENT	CONTROL
Grasses				
Wheatgrass	1.55	2.30	5.888	7.412
Desert Wheatgrass	0.40	0.05	0.432	0.000
Intermediate Wheatgrass	0.00	0.05	0.000	0.000
Blue Grama	5.00	3.95	4.600	3.028
Cheatgrass	0.35	0.10	0.268	0.004
Foxtail	0.00	0.35	0.000	0.000
Indian Ricegrass	0.00	0.45	0.080	1.208
Bluegrasses	0.00	0.00	0.016	0.000
Squirreltail	1.00	0.05	1.488	1.332
Needle & Thread	1.10	2.25	1.888	3.840
SUBTOTAL	9.40	9.55	14.660	16.788
Forbs				
Yarrow	0.00	0.00	0.008	0.000
Mtn. Dandelion	0.00	0.00	0.004	0.000
Locoweed	0.30	0.75	0.920	1.536
Segolily	0.00	0.00	0.000	0.040
Indian Paintbrush	0.00	0.10	0.000	0.080
Cryptantha	0.00	0.25	0.024	0.644
Fleabane	0.20	0.00	0.440	0.000
Buckwheat	0.05	0.00	0.000	0.240
Sweetvetch	0.15	0.00	0.040	0.180
Yellow Sweetclover	0.85	0.00	0.360	0.000
Plantain	0.00	0.00	0.020	0.000
Scarlet Globemallow	1.35	0.15	1.480	0.180
Annual Forb	2.10	1.20	4.948	1.600
SUBTOTAL	5.00	2.45	8.244	4.500

TABLE 25

SUMMARY OF PLANT COVER AND PRODUCTION,

WILDLIFE MITIGATION TREATMENT AREA AND CONTROL AREA, 1983

(Cont'd)

	COVER (%)		PRODUCTION (g/m^2)	
SPECIES*	TREATMENT	CONTROL	TREATMENT	CONTROL
Shrubs				
Serviceberry	0.30	0.60	0.046	0.184
Big Sagebrush	9.40	22.50	12.088	12.380
Fourwing Saltbrush	0.00	0.00	0.032	0.000
Winterfat	0.05	0.00	0.000	0.000
Rubber Rabbitbrush	0.00	0.00	0.062	0.000
Green Rabbitbrush	0.40	0.70	0.000	1.956
Juniper	0.00	0.15	0.000	0.000
Prickly Pear	0.05	0.15	0.000	0.000
Pinyon Pine	0.00	1.95	0.000	0.000
Currant	0.00	0.00	1.494	0.000
SUBTOTAL	10.20	25.90	13.722	14.520
TOTAL:	24.60	37.90	36.626	36.808

TABLE 26

SUMMARY OF WOODY PLANT DENSITY,

WILDLIFE MITIGATION TREATMENT AREA, 1983

SPECIES	TREATMENT	CONTROL
Serviceberry	0.030	0.061
Big Sagebrush	0.890	1.240
Winterfat	0.001	0.003
True Mtn. Mahogany	0.004	0.000
Rubber Rabbitbrush	0.001	0.000
Green Rabbitbrush	0.077	0.170
Juniper	0.000	0.001
Pinyon Pine	0.022	0.046
Bitterbrush	0.001	0.000
Currant	0.001	0.000
TOTAL	1.027	1.521

*Plant symbols are identified in Table 22

TABLE 27

SHRUB TRANSPLANT SURVIVAL TEST PLOTS,

WILDLIFE MITIGATION AREA

SPECIES	(1-10) VIGOR*	(cm) HEIGHT	PLANTED	PLANTED	% SURVIVAL
Fourwing Saltbush	6	08.0	42	17	40.5
Bitterbrush	7	03.5	39	24	61.5
Serviceberry	3	04.0	52	12	23.1
Currant	8	17.9	41	30	73.2
Morman Tea	2	04.0	33	8	24.2
True Mtn. Mahogany	5	07.5	39	7	17.9

*Vigor values 1-10 with 10 being the most vigorous

**NOTE: Plants were transplanted April 26, 1983. Survival data was collected July 14, 1983.

TABLE 28
PLANT SPECIES IDENTIFIED ON OR ADJACENT TO THE PERMIT AREA

PLANT SYMBOL	SCIENTIFIC NAME	COMMON NAME
GRASSES		
Agsm	Agropyron smithii	western wheatgrass
Agtr	Agropyron trachycaulum	slender wheatgrass
Agin	Agropyron intermedium	intermediate wheatgrass
Agex	Agrostis exarata	red top
Avba	Avena barbata	wild oats
Bogr	Bouteloua gracilis	blue grama
Brma	Bromus marginatus	mountain brome
Brte	Bromus tectorum	cheat grass
Calam	Calamagrostis spp.	reed grass
Dagl	Dactylis glomerata	orchard grass
Elci	Elymus cinereus	basin wildrye
Elsa	Elymus salina	salina wildrye
Elgl	Elymus glaucus	blue wildrye
Hoju	Hordeum jubatum	foxtail
Hovu	Hordeum vulgare	barley
Kocr	Koeleria cristata	June grass
Orhy	Oryzopsis hymenoides	Indian ricegrass
Poa	Poa spp.	blue grass
Sihy	Sitanion hystrix	squirreltail
Stco	Stipa comata	needle and thread
GRASS LIKE		
Carex	Carex spp.	sedge
Scirp	Scirpus maritimus	bulrush
FORBS		
Acmi	Achillea millefolium	western yarrow
Anten	Antennaria spp.	pussy toes
Aggl	Agoseris glauca	mountain dandelion

TABLE 28
PLANT SPECIES IDENTIFIED ON OR ADJACENT TO
THE PERMIT AREA
(Cont'd)

PLANT SYMBOL	SCIENTIFIC NAME	COMMON NAME
FORBS		
Arco	Arnica cordifolia	heartleaf arnica
Ascle	Asclepias spp.	milkweed
Astra	Astragalus spp.	locoweed
Asco	Astragalus convallarius	narrowleaf vetch
Canu	Calochortus nuttallii	segolily
Casti	Castilleja spp.	Indian paint brush
Ceras	Cerastium spp.	chickweed
Chdo	Chaenactis douglasii	false yarrow
Cirs	Cirsium spp.	thistle
Clco	Clematis columbiana	clematis
Coar	Convolvulus arvense	bindweed
Cora	Cordylanthus ramosus	bird's beak
Crse	Cryptantha sericea	cryptantha
Erum	Eriogonum umbellatum	buckwheat
Erige	Erigeron spp.	fleabane, daisy
Eriog	Eriogonum spp.	buckwheat
Erysi	Erysimum spp.	wallflower
Fraga	Fragaria spp.	strawberry
Galiu	Galium spp.	bedstraw
Grsq	Grindelia squarrosa	gumweed
Hafl	Hackelia floribunda	false forget-me-not
Hebo	Hedysarum boreale	sweetvetch
Heuch	Heuchera spp.	alum root
Hepa	Heuchera parvifolia	alum root
Ipag	Ipomopsis aggregata	scarlet gilia
Kosc	Kochia scoparia	summer cypress
Lala	Lathyrus lanzwertii	peavine
Lathy	Lathyrus spp.	peavine

TABLE 28
PLANT SPECIES IDENTIFIED ON OR ADJACENT TO THE PERMIT AREA
(Cont'd)

PLANT SYMBOL	SCIENTIFIC NAME	COMMON NAME
FORBS		
Lygr	Lygodesmia grandiflora	skeleton weed
Meci	Mertensia ciliata	bluebells
Meof	Melilotus officinalis	sweet clover
Orfa	Orobanche fasciculata	broomrape
Osoc	Osmorhiza occidentalis	sweetanice
Oxytr	Oxytropis spp.	locoweed
Oxla	Oxytropis lambertii	locoweed
Penst	Penstemon spp.	penstemon
Peea	Penstemon eatonii	firecracker penstemon
Phace	Phacelia spp.	scorpion weed
Phid	Phacelia idahoensis	scorpion weed
Phau	Physaria australis	bladderpod
Plant	Plantago spp.	plantain
Saib	Salsola iberica	Russian thistle
Sedum	Sedum spp.	stonecrop
Sela	Sedum lanceolatum	stonecrop
Senec	Senecio spp.	oldman
Smst	Smilacina stellata	false soloman seal
Spco	Sphaeralcea coccinea	scarlet globemallow
Stpi	Stanleya pinnata	prince's plume
Taof	Taraxacum officinale	dandelion
Thfe	Thalictrum fendleri	meadow rue
Trdu	Tragopogon dubius	oster plant
Vicia	Vicia spp.	vetch
Viola	Viola spp.	violet

TABLE 28
PLANT SPECIES IDENTIFIED ON OR ADJACENT TO
THE PERMIT AREA
(Cont'd)

PLANT SYMBOL	SCIENTIFIC NAME	COMMON NAME
HALF-SHRUBS		
Arno	Artemisia nova	black sagebrush
Arfr	Artemisia frigida	fringe sagebrush
Atcu	Atriplex cuneata	mat saltbrush
Bere	Berberis repens	Oregon grape
Xasa	Xanthocephalum sarothrae (Gutierrezia sarothrae)	snake weed
Yucca	Yucca spp.	yucca
Yuha	Yucca harrimaniae	yucca
SHRUBS		
Amut	Amelanchier utahensis	service berry
Amal	Amelanchier alnifolia	service berry
Artr	Artemisia tridentata	sagebrush
Atco	Atriplex confertifolia	shadscale
Atcu	Atriplex cuneata	mat saltbush
Cela	Ceratoides lanata	winterfat
Chna	Chrysothamnus nauseosus	rubber rabbitbrush
Chvi	Chrysothamnus viscidiflorus	green rabbitbrush
Epvi	Ephedra viridis	green mormon tea
Eriog	Eriogonum spp.	buckwheat
Opunt	Opuntia spp.	prickly pear
Phmo	Physocarpus monogynus	nine bark
Putr	Purshia tridentata	bitterbrush
Rimo	Ribes montegeum	currant
Rowo	Rosa woodsii	wild rose
Sambu	Sambucus spp.	elderberry
Same	Sambucus melanocarpa	elderberry
Save	Sarcobatus vermiculatus	greasewood

TABLE 28
PLANT SPECIES IDENTIFIED ON OR ADJACENT TO THE PERMIT AREA
(Cont'd)

PLANT SYMBOL	SCIENTIFIC NAME	COMMON NAME
SHRUBS		
Syor	Symphoricapos oreophilus	snowberry
Syal	Symphoricarpos albus	snowberry
Tape	Tamarix pentandra	tamarix
TREES		
Acgr	Acer grandidentatum	maple
Abla	Abies lasiocarpa	subapline fir
Cele	Cercocarpus ledifolius	curlleaf mountain mahogany
Cemo	Cercocarpus montanus	true mountain mahogany
Jusc	Juniperus scopulorum	rocky mountain juniper
Juos	Juniperus osteosperma	Utah juniper
Pied	Pinus edulis	pinyon pine
Pofr	Populus fremontii	cottonwood
Potr	Populus tremuloides	aspen
Prvi	Prunus virginiana	chokecherry
TREES		
Psme	Pseudotsuga menziesii	Douglas fir
Quga	Quercus gambellii	gambel oak
Salix	Salix spp.	willow
Tape	Tamarix pentandra	tamarix

Grass and shrub production and cover values between the treatment and control areas remained unchanged while forb production was approximately 45% greater on the treated area. Annual forb production was 68% greater on the treatment area. Perennial forb production was about the same for both areas.

As presented in Table 26, Summary of Woody Plant Density, the control area has a shrub density of 1.521/m^2 (6,155/acre) while the treatment area contains 1.027/m^2 (4,156/acre). The overall difference is 0.494/m^2 or a reduction of 2,000 stems per acre on the treated area. The treatment area contains 0.35/m^2 (1,416/acre) fewer big sagebrush plants. There were also 0.093/m^2 (376/acre) fewer green rabbitbrush shrubs and 0.031/m^2 (125/acres) fewer serviceberry plants on the treatment area.

Overall shrubs seedling transplant survival is 39.8%. By species, currant seedling transplants maintained the highest survival (73.2%) followed by bitterbrush (61.5%). The lowest percent survival was for true mountain mahogany (17.9%). Vigor ratings were also higher for current and bitterbrush (8 and 9), but the lowest value (2) was for Mormon tea.

Conclusions

First year's treatment affect on the vegetation was compared to the adjacent control area. The current year's data indicates that grass cover and grass production is unchanged. Forb cover and production on the treatment area was about 2X that of the control. This increase on the treated area was due to annual forb growth. A treatment affect is seen in the average production per woody plant. The treatment area has a woody plant density of 0.49/m^2 (2,000/acre) less shrubs; however, production was the same as the control area. This is especially true for sagebrush where 0.35/m^2 (1,416/acre) fewer stems on the treated area produced the same amount of biomass as the control area. This difference might be attributed to the influence of the fertilizer on sagebrush production.

Based on the first year percent shrub survival on the Wildlife Mitigation Area test plot, there are probably about 1,620 live shrub transplants growing on the scalps and disturbed areas within the treatment area. Bitterbrush and currant transplants show the most promise, but conclusions should not be made until more long term data is available.