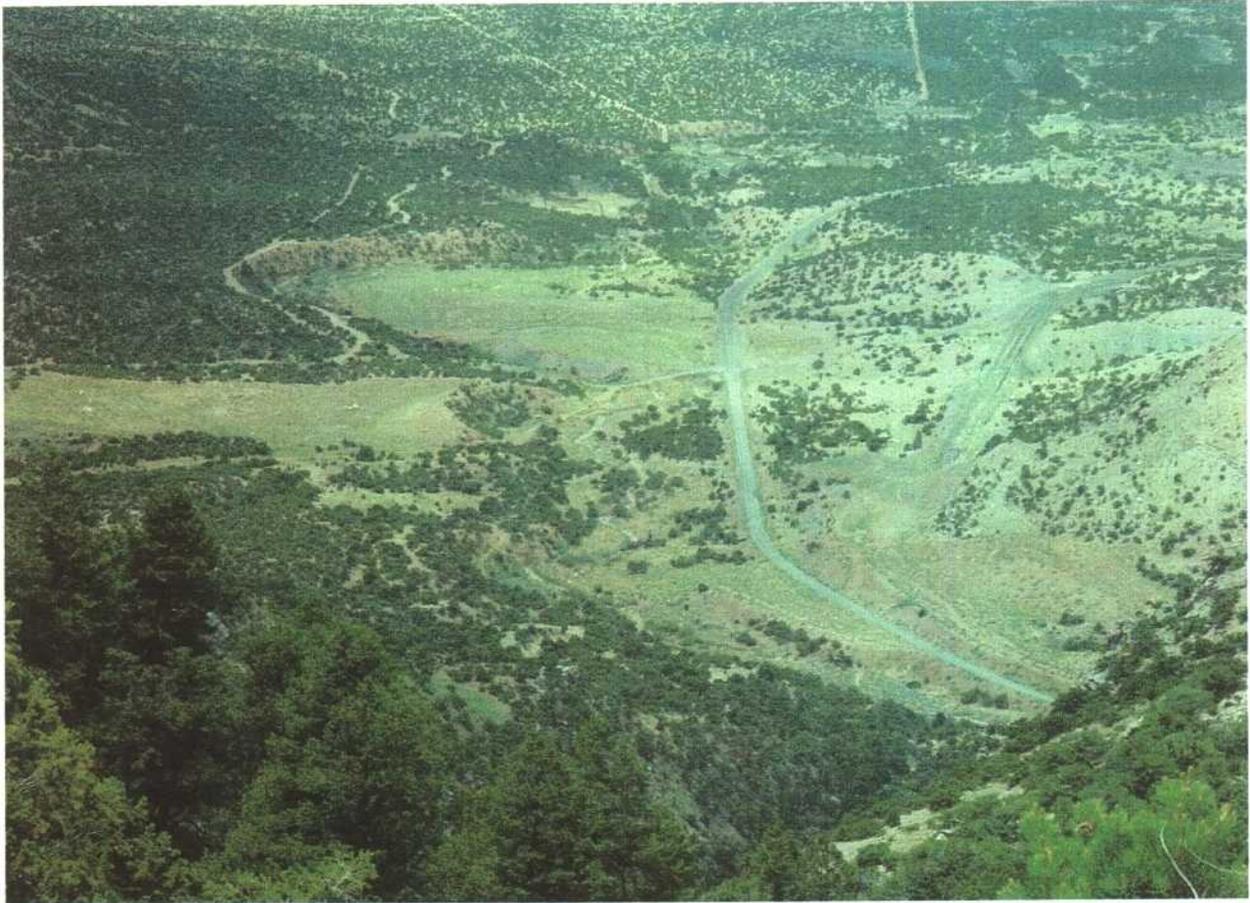


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DIV. OF OIL, GAS & MINING

# Horse Canyon Vegetation Survey - 2003



Submitted by  
**Mike King, Ph.D.**

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## **Abstract**

A vegetation inventory was conducted on 6 revegetation sites on the Horse Canyon Mine property between June and August, 2003. Data were collected regarding percent cover, percent cover by species, and woody plant density at each site. Data were also collected from a reference site located on Bureau of Land Management property adjacent to mine property. Revegetated sites were compared to the reference area with respect to cover and woody plant density to determine similarity. All sites cover averages exceed the cover average for the reference site and should be judged to have satisfactorily exceeded minimum requirements with respect to cover. Woody plant density in all revegetated sites exceeded woody plant density in the reference area. Species diversity was also higher in all revegetated areas when compared to the reference area.

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## **Introduction**

In June of 2003, Dr. Mike King was contacted by Utah American Energy about conducting a vegetation survey on revegetated sites of the Horse Canyon mine site located in eastern Carbon and Emery counties. Meetings were held between Dr. King and Utah American Energy and the Utah Division of Oil, Gas and Mining to discuss and determine the scope of the project. Fieldwork was initiated in June and continued through August 2003. The purpose of the study was to document vegetation condition of a reference area and 6 representative revegetated sites on the Horse Canyon Mine property. It also was conducted to fulfill the sampling requirement for year 9 of reclamation and to substantiate that the vegetation requirements were met for Phase II bond release.

The project was to include vegetation surveys of 6 revegetated sites and a reference area established in 1985 according to Utah Division of Oil, Gas, and Mining (DOG M) permitting requirements. Data collection was to include percent cover, percent cover by species, woody plant density, and species diversity for each site. Similarity indices were to be calculated between revegetated sites and the reference area to determine if the revegetation efforts have satisfactorily met prescribed revegetation standards determined as part of the Horse Canyon Mine reclamation plan.

Vegetative cover was also determined for 5 sloped areas within the revegetated sites. Data from these sites is detailed in Appendix 5.

The information below includes summary and analyses of these vegetation surveys.

## **Materials and Methods**

Six revegetation sites were selected for analysis based on previous survey work conducted on the mine property in 1995 (Table 1). These areas were selected based on revegetation treatment, slope, aspect, and general topographic similarities. The sites correspond to reclamation treatment areas in the horse Canyon Mine reclamation plan. The reference area, located adjacent to the Horse Canyon mine property on Bureau of Land Management land, was selected several years ago as the revegetation plan was established. The Vegetation Surveys were carried out according to the Division of Oil, Gas and Mining (DOG M) vegetation sampling methods (February 1992 Revised DOGM Vegetation Information Guidelines). Data collected during the surveys were used to determine ground cover, cover by species, and woody plant density. A comparison of the reference areas and revegetated areas was made to determine similarity of the 2 areas.

<b>Table 1. Horse Canyon Vegetation Survey Sites*</b>	
<b>Site Number</b>	<b>Description</b>
3	North-facing slope
6	South-facing slope
7	Rabbitbrush treatment; South-facing slope
11,13,14	Flat topography near canyon mouth
16	Borrow pit area
15, 17	Former refuse pile and landfill area
Reference Area	Mature Pinon - Juniper Woodland

\* See Appendix 3 for photographs of each site

### ***Percent Cover***

The point-intercept method was used to sample cover. A total of 15 - 100 ft sampling transects were run at each revegetation site to determine percent cover. Transects were located using coordinates selected from a random number table. Coordinates were paced off and a compass direction was selected using the random number table as well. Once transect start point and compass direction were established, investigators laid out a 100 ft tape in the appropriate direction and then walked the length of the tape to record vegetation. Investigators took samples at 2ft intervals along the length of the tape. A total of 50 points were recorded for each transect. Similar methods were used in the reference area except 30 transects were run rather than 15.

Cover categories included: 1) Physical Features including a) bare ground (rock or soil material less < 12 inches in diameter), b) litter (dead plant material lying on ground surface), c) rock (rock material >12 inches in diameter), 2) Cryptobiotic Soil, 3) Vegetation including a) shrubs b) forbs and succulents (cactus species), c) grasses, and d) trees. When possible, plants were identified to species level. Points were selected by viewing the transect at 2 foot intervals with an ocular viewing device with cross hairs. When there was an overhead canopy, verticle projections were made above the 100 ft tape to include the highest level of vegetation in the sample.

Adequacy of sample size was determined as per DOGM guidelines (DOGM 1992); see

Table 2. Sample adequacy for cover was met at the 90% confidence level with a 10% change in the mean as required by DOGM. Thirty transects were run in the reference area to meet the sample adequacy of 27 and to be consistent with the vegetation surveys conducted in year 5.

<b>Table 2. Minimum sample sizes</b>		
<b>Area</b>	<b>Cover</b>	<b>Woody Plant Density</b>
Reference	27.06	171.24
3	1.66	32.64
6	3.93	10.18
7	10.48	74.56
11/13/14	3.16	40.04
15/17	6.36	25.51
16	9.36	34.67

### ***Woody Plant Density***

Woody plant densities were estimated using the belt transect method (DOGM 1992). A total of 15 - 100 ft X 10ft transects were run in each area to determine woody plant density. Transects were located using coordinates selected from a random number table. Coordinates were paced off and a compass direction was selected using the random number table as well. Once transect start point and compass direction were established, investigators walked the length of the transect and recorded species of all individual shrubs rooted in each belt. Total number of plants per acre was calculated using DOGM guidelines. Minimum sample sizes for adequacy ranged from 10 to 171 (Table 2). To keep sampling consistent and avoid excessive disturbance to sites, shrub densities were estimated using the minimum of 15 transects as was done in the year 5 Vegetation Survey.

### ***Similarity***

Similarity of revegetated sites and the reference area with respect to species composition was determined using the Jaccard's Community Coefficient (DOGM

1992).

### ***Species Diversity***

Species diversity lists were compiled based on data collected during cover sampling.

### **Results**

The survey was conducted during one of the driest years in recent history. Annual precipitation at the Sunnyside City Center weather station (approximately 7 miles north of Horse Canyon) and the Price Warehouses weather station (approximately 30 miles west of horse Canyon) was below long-term averages for both sites. The precipitation for the 2003 water year (Oct 1, 2002-Sept 31,2003) was 10.53 inches compared to the 30 year average of 13.87 inches. Similarly annual precipitation for the Price Warehouses station for the 2003 water year was 5.96 inches compared to a 25 year average of 9.3 inches (Utah Climate Center records, Utah State University, Logan, Utah). This pattern is typical of most regions in Utah due to several years of drought throughout the state. This prolonged period of reduced moisture has no doubt had an effect on plant production and survival throughout the state and the eastern Utah area.

Though plant growth was likely limited during the year, there were no signs of disease or insect damage and plants generally appeared to be in good health. Sagebrush die-off as seen around the Price, Utah area was not detected. Moderate numbers of Mormon Crickets were observed above the mine site and the revegetated areas, but none were observed in either the reference area or revegetated areas.

All areas including the reference area had been used during the previous year to some degree by livestock. Cattle sign was found in all areas, though the use was not extensive. Plants showed no signs of overgrazing. It is assumed that the used was limited to the few days livestock operators in the area moved their cattle to and from summer range in the Range Creek area. Mule deer sign was also observed in all revegetated areas as well as the reference area. Chukar partridges were heard in or near area 16 and also near area 15/17.

### ***Percent Cover***

#### **Reference Area**

Cover data for the Horse Canyon reference area are included in Table 3 (data for each transect are included in Appendix 1). The average vegetation cover for the

Reference area was 32.83%. The vegetative component was comprised of 62.70% trees, 32.10% grasses, 3.00% percent shrubs, and 2.20% forbs and succulents (for relative percent vegetation for each transect see Appendix 1).

**Table 3. Horse Canyon Average Cover Summary**

Cover Type	Area						
	Ref	3	6	7	11,13,14	15,17	16
<b>Shrubs</b>	1.00	33.07	33.60	49.87	24.80	34.27	15.73
<b>Forbs</b>	0.73	6.53	0.93	1.6	1.33	1.20	8.40
<b>Grasses</b>	10.53	46.53	54.53	25.87	42.80	41.87	42.13
<b>Trees</b>	20.57	0	0	0	0	0	0
<b>Total Vegetation</b>	32.83	86.13	89.07	77.33	72.53	77.33	66.27
<b>Cryptobiotic</b>	5.4	0.13	0.53	0	0.53	0	0.13
<b>Physical Features</b>	60.60	13.73	10.13	22.27	26.93	22.67	33.60

**Area 3**

The average vegetation cover for Area 3 was 86.13%. The vegetative component was comprised of 38.40% shrubs, 7.60% forbs and succulents, and 54.00% grasses, (Appendix 1; for relative percent vegetation for each transect also see Appendix 1).

**Area 6**

The average vegetation cover for Area 6 was 89.07%. The vegetative component was comprised of 37.70% shrubs, 1.00% forbs and succulents, and 61.20% grasses, Appendix 1; for relative percent vegetation for each transect also see Appendix 1).

**Area 7**

The average vegetation cover for Area 7 was 77.33%. The vegetative component was comprised of 64.50% shrubs, 2.10% forbs and succulents, and 33.50% grasses, (Appendix 1; for relative percent vegetation for each transect also see Appendix 1).

### **Area 11,13,14**

The average vegetation cover for Area 11/13/14 was 72.53%. The vegetative component was comprised of 34.20% shrubs, 1.80% forbs and succulents, and 59.00% grasses, (Appendix 1; for relative percent vegetation for each transect also see Appendix 1).

### **Area 15,17**

The average vegetation cover for Area 15/17 was 77.33%. The vegetative component was comprised of 42.00% shrubs, 1.60% forbs and succulents, and 54.10% grasses, (Appendix 1; for relative percent vegetation for each transect also see Appendix 1).

### **Area 16**

The average vegetation cover for Area 16 was 66.27%. The vegetative component was comprised of 23.70% shrubs, 12.70% forbs and succulents, and 63.00% grasses, (Appendix 1; for relative percent vegetation for each transect also see Appendix 1).

In order to meet the revegetation plan success standard, 90% of undisturbed reference area, each site should meet or exceed 24.90% cover. Since all sites cover averages exceed the minimum requirement, it should be judged that the treatments have been satisfactory with respect to percent cover.

## Woody Plant Density

Woody plant density data for the Horse Canyon reference area are included in Table 4 (data for each transect are included in Appendix 2).

<b>Area</b>	<b>Average</b>	<b>90% Confidence Interval</b>
Reference	659.21	518.17 - 800.25
3	1957.30	1687.32 - 2227.28
6	3891.36	3591.86 - 4190.86
7	5180.74	4101.85 - 6295.63
11/13/14	1771.41	1501.08 - 2041.74
15/17	2625.22	2305.44 - 2945.00
16	2883.67	2474.20 - 3293.14
Revegetated Areas Average	2709.84	2080.13 - 3339.55

### **Reference Area.**

The Reference area was the least populated area with respect to woody plants. Including tree species, stems/acre ranged from 87.12 to 1132.56, with an average of 659.21 (90% confidence intervals are also listed in Table 4). The most predominant woody plants in the Reference area were Snakeweed (*Gutierrezia sarothrae* - 363 stems/acre, 55.1%) and Utah Juniper (*Juniperus osteosperma* - 246 stems/acre, 37.3%).

### **Area 3.**

Area 3 had an average stems/acre of 1957.30 (90% confidence intervals are listed in Table 4). Individual transect values ranged from 1219.68 - 3441.24. The site was dominated by Sagebrush (*Artemisia tridentata* - 676.63 stems/acre, 34.6%), Four Wing Saltbush (*Atriplex canescens* - 662.11 stems/acre, 33.8%), and Douglas Rabbitbrush (*Chrysothamnus viscidiflorus* - 482.06 stems/acre, 24.6%).

### **Area 6.**

Area 6 had an average stems/acre of 3891.36 (95% confidence intervals are listed in Table 4). Individual transect values ranged from 2744.28 - 4922.28. The site was dominated by Sagebrush (*Artemisia tridentata* - 1655.28 stems/acre, 42.5%), Four Wing Saltbush (*Atriplex canescens* - 1228.39 stems/acre, 31.6%), and Douglas Rabbitbrush (*Chrysothamnus viscidiflorus* - 537.24 stems/acre, 13.8%).

### **Area 7.**

Area 7 had an average stems/acre of 5180.74 (95% confidence intervals are listed in Table 4). Individual transect values ranged from 1873.08 - 11369.16. The site was dominated by Sagebrush (*Artemisia tridentata* - 3746.16 stems/acre, 72.3%) and Four Wing Saltbush (*Atriplex canescens* - 816.02 stems/acre, 15.8%).

### **Area 11,13,14.**

Area 11/13/14 had an average stems/acre of 1771.44 (95% confidence intervals are listed in Table 4). Individual transect values ranged from 261.36 - 2482.92. The site was dominated by Sagebrush (*Artemisia tridentata* - 418.18 stems/acre, 23.6%) and Four Wing Saltbush (*Atriplex canescens* - 1097.71 stems/acre, 62.0%).

### **Area 15,17.**

Area 15/17 had an average stems/acre of 2625.22 (95% confidence intervals are listed in Table 4). Individual transect values ranged from 1873.08 - 4181.76. The site was dominated by Sagebrush (*Artemisia tridentata* - 1193.54 stems/acre, 45.5%) and Four Wing Saltbush (*Atriplex canescens* - 1013.50 stems/acre, 38.6%).

### **Area 16.**

Area 16 had an average stems/acre of 2883.67 (95% confidence intervals are listed in Table 4). Individual transect values ranged from 1418.04 - 4094.64. The site was dominated by Sagebrush (*Artemisia tridentata* - 1405.54 stems/acre, 48.7%) and Four Wing Saltbush (*Atriplex canescens* - 958.32 stems/acre, 33.2%).

### **Average of all Treatment Areas**

An average was calculated combining data for all treatment areas. The average woody plant stems/acre when considering all treatment areas was 2709.84. Calculation of a

90% confidence interval indicates that we can be 90% confident that the actual mean of the population lies between 2080.13 - 3339.55 stems/acre.

With respect to woody plant density, only 2 sites clearly exceeded the standard of 3000 stems/acre established in the revegetation plan for the Horse Canyon area. Area 6 (3891.36) and Area 7 (5180.74) clearly exceeded the 3000 stems/acre standard. Area 15/17 and Area 16 were relatively close to the standard with 90% confidence that the actual mean falls between 2325.22-2945.00 and 2474.20-3293.14 respectively. Areas 3 (1957.30) and 11/13/14 (1771.41) both have averages below 2000. However, when compared to the Reference area (659.21), even areas 3 and 11/13/14 far exceed the undisturbed site with respect to woody plants/acre. Given these data, the woody plant density treatments should be characterized as relatively successful.

### **Species Diversity**

Lists of species for the Reference area and each of the revegetation sites is listed in Table 5. All comparisons show more total species in each of the revegetated sites than in the Reference area.

<b>Table 5. Species Lists for Horse Canyon Inventory Area</b>							
<b>Species</b>	<b>Site</b>						
	<b>Ref.</b>	<b>3</b>	<b>6</b>	<b>7</b>	<b>11, 13,14</b>	<b>15/ 17</b>	<b>16</b>
<b><i>Shrubs</i></b>							
<i>Artemisia nova</i>			x	x			
<i>Artemisia tridentata</i>		x	x	x	x	x	x
<i>Atriplex canescens</i>		x	x	x	x	x	x
<i>Atriplex confertifolia</i>					x	x	x
<i>Ceratoides lanata</i>			x		x	x	x
<i>Chrysothamnus nauseosus</i>		x	x	x	x	x	x
<i>Chrysothamnus viscidiflorus</i>		x	x	x	x	x	x
<i>Cowania mexicana</i>	x			x			
<i>Ephedra viridis</i>	x						
<i>Gutierrezia sarothrae</i>	x			x			
<i>Sarcobatus vermiculatus</i>					x	x	

<b>Forbs &amp; Succulents</b>							
<i>Echinocereus triglochidiatus</i>	x						
<i>Medicago sativa</i>		x	x	x	x	x	x
<i>Melilotus officinalis</i>		x	x		x	x	
<i>Penstemon palmeri</i>		x	x	x			x
<i>Euphorbia fendleri</i>	x				x	x	
<i>Sisymbrium altissimum</i>			x	x			
<i>Sphaeralcia coccinea</i>	x			x			
<b>Grasses</b>							
<i>Agropyron cristatum</i>		x	x		x	x	x
<i>Agropyron smithii</i>			x	x	x	x	
<i>Agropyron spicatum</i>		x	x	x	x	x	x
<i>Bromus inermis</i>			x		x	x	
<i>Bromus japonicus</i>		x	x		x	x	
<i>Bromus tectorum</i>	x	x	x	x	x	x	x
<i>Elymus cinereus</i>		x	x		x	x	
<i>Elymus giganteus</i>			x		x	x	x
<i>Elymus salinus</i>	x	x	x	x	x	x	
<i>Hilaria jamesii</i>	x						
<i>Oryzopsis hymenoides</i>		x	x	x	x	x	x
<i>Sitanion hystrix</i>		x	x		x	x	x
<i>Stipa comata</i>				x	x	x	
<i>Vulpia octaflora</i>	x	x			x	x	
<b>Trees</b>							
<i>Juniperus osteosperma</i>	x						
<i>Pinus edulis</i>	x						
<b>Total Species in each area</b>	12	16	21	17	23	20	14

Also in each revegetation site there were more species with greater than 5% cover than in the Reference area. The Reference area had a total of 12 species with 2 species, Utah juniper (17%) and Salina wild rye (7%), with percent cover greater than 5%. *Only 2 species, 1 tree and 1 grass, exceeded 5%.*

Area 3 had a total of 16 species with 5 species, Bluebunch wheatgrass (29.2%), Fourwing saltbush (13.3%), Big sagebrush (13.3%), Basin wild rye (7.1%), and Douglas rabbitbrush (5.1%), with percent cover greater than 5%. *Five species, 3 shrubs and 2 grasses, exceeded 5%.*

Area 6 had a total of 21 species with 5 species, Cheat grass (27.1%), Bluebunch wheatgrass (22.9%), Fourwing saltbush (18.9%), Big sagebrush (9.9%), and Douglas rabbitbrush (5.5%), with percent cover greater than 5%. *Five species, 3 shrubs and 2 grasses (one of the grasses was the undesirable Cheat grass), exceeded 5%.*

Area 7 had a total of 17 species with 4 species, Cheat grass (22.1%), Bluebunch wheatgrass (22.0%), Fourwing saltbush (12.4%), and Big sagebrush (24.9%), with percent cover greater than 5%. *Four species, 2 shrubs and 2 grasses (one of the grasses was the undesirable Cheat grass), exceeded 5%.*

Area 11/13/14 had a total of 23 species with 4 species, Cheat grass (15.7%), Bluebunch wheatgrass (20.8%), Fourwing saltbush (14.1%), and Big sagebrush (5.7%), with percent cover greater than 5%. *Four species, 2 shrubs and 2 grasses (one of the grasses was the undesirable Cheat grass), exceeded 5%.*

Area 15/17 had a total of 20 species with 4 species, Cheat grass (19.1%), Bluebunch wheatgrass (18.9%), Fourwing saltbush (14.1%), and Big sagebrush (15.1%), with percent cover greater than 5%. *Four species, 2 shrubs and 2 grasses (one of the grasses was the undesirable Cheat grass), exceeded 5%.*

Area 16 had a total of 14 species with 4 species, Cheat grass (6.5%), Bluebunch wheatgrass (28.5%), Fourwing saltbush (5.6%), and Alfalfa (6.7%), with percent cover greater than 5%. *Four species, 1 shrub, 2 grasses (one of the grasses was the undesirable Cheat grass), and 1 forb (alfalfa), exceeded 5%.*

Species diversity with respect to percent cover by species is recorded in Table 6 for each site.

**Table 6. Species Diversity Tables**

Reference Area (12 total species)		Area 3 (16 total species)	
	Species (% cover)		Species (% cover)
> 20 %		> 20%	<i>Agropyron spicatum</i> (29.2)
10 - 20%	<i>Juniperus osteosperma</i> (17.0)	10 - 20%	<i>Atriplex canescens</i> (13.3)
			<i>Artemisia tridentata</i> (13.3)
5 - 10 %	<i>Elymus salinus</i> (7.0)	5 - 10 %	<i>Elymus cinereus</i> (7.1)
			<i>Chrysothamnus viscidiflorus</i> (5.1)
1 - 5%	<i>Pinus edulis</i> (4.0)	1 - 5%	<i>Bromus tectorum</i> (4.1)
	<i>Bromus tectorum</i> (2.0)		<i>Medicago satvia</i> (3.5)
	<i>Gutierrezia sarothrae</i> (1.0)		<i>Melilotus officianalis</i> (1.6)
	<i>Hilaria jamesii</i> (1.0)		<i>Agropyron cristatum</i> (1.5)
	<i>Sphaeralcia coccinea</i> (1.0)		<i>Chrysothamnus nauseosus</i> (1.2)
			<i>Sitanion hystrix</i> (1.1)
< 1%	<i>Vulpia octaflora</i> (0.3)	< 1%	<i>Oryzopsis hymenoides</i> (0.9)
	<i>Epehdra viridis</i> (0.2)		<i>Penstemon palmeri</i> (0.8)
	<i>Euphorbia fendleri</i> (0.1)		<i>Bromus japonicus</i> (0.3)
	<i>Cowania mexicana</i> (0.1)		<i>Elymus salinus</i> (0.3)
	<i>Echinocereus triglochidiatus</i> (0.1)		<i>Vulpia octaflora</i> (0.1)

**Table 6. Species Diversity Tables (cont.)**

<b>Area 6 (21 total species)</b>		<b>Area 7 (17 total species)</b>	
	<b>Species (% cover)</b>		<b>Species (% cover)</b>
> 20 %	<i>Bromus tectorum</i> (27.1)	> 20%	<i>Artemisia tridentata</i> (24.9)
	<i>Agropyron spicatum</i> (22.9)		<i>Bromus tectorum</i> (22.0)
10 - 20%	<i>Atriplex canescens</i> (12.4)	10 - 20%	<i>Atriplex canescens</i> (18.9)
5 - 10 %	<i>Artemisia tridentata</i> (9.9)	5 - 10 %	
	<i>Chrysothamnus viscidiflorus</i> (5.5)		
1 - 5%	<i>Artemisia nova</i> (1.9)	1 - 5%	<i>Chrysothamnus viscidiflorus</i> (4.0)
	<i>Ceratoides lanata</i> (1.6)		<i>Agropyron spicatum</i> (2.0)
			<i>Artemisia nova</i> (1.1)
< 1%	<i>Elymus cinereus</i> (0.8)	< 1%	<i>Stipa comata</i> (0.9)
	<i>Oryzopsis hymenoides</i> (0.7)		<i>Elymus salinus</i> (0.7)
	<i>Chrysothamnus nauseosus</i> (0.5)		<i>Sisymbrium altissimum</i> (0.5)
	<i>Penstemon palmeri</i> (0.4)		<i>Medicago sativa</i> (0.5)
	<i>Elymus giganteus</i> (0.3)		<i>Sphaeralicia coccinea</i> (0.3)
	<i>Elymus salinus</i> (0.3)		<i>Cowania mexicana</i> (0.3)
	<i>Sitanion hystrix</i> (0.3)		<i>Oryzopsis hymenoides</i> (0.3)
	<i>Sisymbrium altissima</i> (0.3)		<i>Gutierrezia sarothrae</i> (0.1)
	<i>Bromus japonicus</i> (0.1)		<i>Penstemon palmeri</i> (0.1)
	<i>Bromus inermis</i> (0.1)		<i>Chrysothamnus nauseosus</i> (0.1)
	<i>Agropyron cristatum</i> (0.1)		<i>Agropyron smithii</i> (0.1)
	<i>Agropyron smithii</i> (0.1)		
	<i>Medicago sativa</i> (0.1)		
	<i>Melilotus officianalis</i> (0.1)		

**Table 6. Species Diversity Tables (cont.)**

<b>Area 11/13/14 (23 total species)</b>		<b>Area 15/17 (20 total species)</b>	
	<b>Species (% cover)</b>		<b>Species (% cover)</b>
> 20 %	<i>Agropyron spicatum</i> (20.8)	> 20%	
10 - 20%	<i>Bromus tectorum</i> (15.7)	10 - 20%	<i>Bromus tectorum</i> (19.1)
	<i>Atriplex canescens</i> (14.1)		<i>Agropyron spicatum</i> (18.9)
			<i>Artemisia tridentata</i> (15.1)
			<i>Atriplex canescens</i> (14.1)
5 - 10 %	<i>Artemisia tridentata</i> (5.7)	5 - 10 %	
1 - 5%	<i>Chrysothamnus nauseosus</i> (2.4)	1 - 5%	<i>Sarcobatus vermiculatus</i> (2.1)
	<i>Atriplex confertifolia</i> (1.7)		<i>Chrysothamnus nauseosus</i> (1.1)
	<i>Chrysothamnus viscidifloris</i> (1.6)		
	<i>Gutierrezia sarothrae</i> (1.6)		
	<i>Oryzopsis hymenoides</i> (1.3)		
< 1%	<i>Medicago sativa</i> (0.8)	< 1%	<i>Stipa comata</i> (0.9)
	<i>Ceratoides lanata</i> (0.7)		<i>Oryzopsis hymenoides</i> (0.8)
	<i>Agropyron cristatum</i> (0.7)		<i>Elymus cinereus</i> (0.7)
	<i>Elymus cinerius</i> (0.7)		<i>Medicago sativa</i> (0.7)
	<i>Agropyron smithii</i> (0.5)		<i>Elymus salinus</i> (0.5)
	<i>Elymus giganteus</i> (0.5)		<i>Ceratoides lanata</i> (0.4)
	<i>Sitanion hystrix</i> (0.5)		<i>Melilotus officianalis</i> (0.4)
	<i>Elymus salinus</i> (0.4)		<i>Atriplex confertifolia</i> (0.4)
	<i>Stipa comata</i> (0.4)		<i>Agropyron smithii</i> (0.3)
	<i>Vulpia octiflora</i> (0.3)		<i>Bromus japonicus</i> (0.3)
	<i>Bromus inermis</i> (0.1)		<i>Sphaeralcia coccinea</i> (0.1)
	<i>Bromus japonicus</i> (0.1)		<i>Gutierrezia sarothrae</i> (0.1)
	<i>Medicago officianalis</i> (0.1)		<i>Chrysothamnus viscidifloris</i> (0.1)
	<i>Euphorbia fendleri</i> (0.1)		<i>Bromus inermis</i> (0.1)

<b>Table 6. Species Diversity Tables (cont.)</b>	
<b>Area 16 (14 total species)</b>	
	<b>Species (% cover)</b>
> 20 %	<i>Agropyron spicatum</i> (28.5)
10 - 20%	
5 - 10 %	<i>Medicago satvia</i> (6.7)
	<i>Bromus tectorum</i> (6.5)
	<i>Atriplex canescens</i> (5.6)
1 - 5%	<i>Artemisia tridentata</i> (4.7)
	<i>Chrysothamnus nauseosus</i> (1.6)
	<i>Elymus giganteus</i> (1.2)
	<i>Atriplex confertifolia</i> (1.1)
< 1%	<i>Penstemon palmeri</i> (0.4)
	<i>Chrysothamnus viscidifloris</i> (0.1)
	<i>Ceratoides lanata</i> (0.1)
	<i>Oryzopsis hymenoides</i> (0.1)
	<i>Agropyron cristatum</i> (0.1)
	<i>Sitanion hystrix</i> (0.1)

Targets for revegetated areas were to have 3 shrubs, 2 grasses, and 1 forb with % cover above 5%. These targets are not reached with respect to forbs in any area with the exception of Area 16. However, the forb which exceeded 5% cover was alfafa, part of the revegetation seed mixture, but not a native species and probably should not be considered.

### Similarity

Comparisons of similarity made between the Reference area and revegetated sites indicates that there are only minor similarities between the revegetated sites and the Reference area (Table 7). Similarity coefficients ranged from 4.0 to 20.8. Similarity is strong when values approach 100. Given the revegetation treatments, it is not surprising

that the areas are dissimilar with respect to species.

Site	Number of Species in Reference Area	Number of Species in Revegetation Site	Number of Species Common to both	Similarity Coefficient
Area 3	12	16	3	12.0
Area 6	12	21	2	6.5
Area 7	12	17	5	20.8
Area 11/13/14	12	23	3	9.4
Area 15/17	12	20	4	14.3
Area 16	12	14	1	4.0

Areas were also different with respect to overall vegetation cover. In each instance, the revegetated areas were more densely vegetated than the reference area. The average percent cover for the Reference area was 32.83%. Percent vegetation cover for the revegetation sites ranged from 66.27% to 89.07% (Table 3).

## References

- Anderson, B. Desert Plants of Utah. EC 376. Cooperative Extension Service, Utah State University, Logan, UT. 146 pp.
- DOGM 1992. Vegetation Information Guidelines. Utah Division of Oil, Gas, and Mining. Salt Lake City, UT.
- Parker, K. G., L. R. Mason, and J. F. Valentine. Utah Grasses. EC 384. Cooperative Extension Service, Utah State University, Logan, UT. 69 pp.
- Welsch, S. L. and G. Moore. 1973. Utah Plants. Brigham Young University Press. Provo, UT. 474 pp.
- Utah Climate Center. January 2004. Utah State University, Logan, Utah.

# **Appendix 1**

## **Percent Cover Data**

## Reference Cover Summary

Cover Type	Transect #														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Shrubs	0	2	2	0	0	0	2	0	4	4	2	0	2	0	0
Forbs	0	0	0	2	2	0	0	0	16	0	0	0	0	0	0
Grasses	12	26	8	4	8	0	0	6	0	2	14	26	14	4	6
Trees	8	6	10	34	16	46	52	12	0	20	16	6	28	20	18
Total Vegetation	20	34	20	40	26	46	54	18	20	26	32	32	44	24	24
Cryptobiotic	0	8	4	4	6	2	6	0	12	0	4	10	10	2	0
Physical Features	80	58	76	56	52	52	40	82	68	74	64	58	46	74	76

Cover Type	Transect #															Site Average	Std. Dev.
	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30		
Shrubs	2	4	0	0	0	2	0	0	0	2	0	0	0	2	0	1.00	1.36
Forbs	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0.73	2.95
Grasses	10	10	4	12	4	8	4	6	0	54	42	16	4	6	6	10.53	12.19
Trees	18	16	30	12	34	46	34	16	18	0	18	28	26	15	14	21.07	13.03
Total Vegetation	30	30	34	28	38	56	38	22	18	56	60	46	30	38	20	33.47	12.27
Cryptobiotic	2	2	10	2	4	4	10	16	6	6	4	4	6	10	8	5.4	4.01
Physical Features	68	68	56	70	58	40	52	62	76	38	36	50	64	52	72	60.60	13.08

## Reference Area Cover Data































































### Area 3 Cover Summary

Cover Type	Transect #															Site Average	Std. Dev.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Shrubs	36	24	32	32	10	32	22	34	26	20	50	42	56	42	38	33.07	11.85
Forbs	2	2	4	6	4	6	20	4	6	10	0	2	8	10	14	6.53	5.26
Grasses	56	58	42	52	78	46	42	56	54	44	28	48	24	30	40	46.53	13.64
Trees	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Vegetation	94	84	78	90	92	84	84	94	86	74	78	92	88	82	92	86.13	6.30
Cryptobiotic	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0.13	.52
Physical Features	6	16	22	10	8	14	16	6	14	26	22	8	12	18	8	13.73	6.27

### Area 6 Cover Summary

Cover Type	Transect #															Site Average	Std. Dev.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
Shrubs	28	32	38	28	26	30	50	36	32	44	30	38	34	34	24	33.60	6.90
Forbs	2	0	0	2	0	0	0	0	0	0	0	6	4	0	0	0.93	1.83
Grasses	66	62	52	58	68	56	48	62	68	46	54	44	46	24	64	54.53	11.80
Trees	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Vegetation	96	94	90	88	94	86	98	98	100	90	84	88	84	58	88	89.07	10.02
Cryptobiotic	0	0	0	0	0	0	0	0	0	0	0	0	0	8	0	0.53	2.07
Physical Features	4	6	10	12	6	14	2	2	0	10	16	12	16	30	12	10.13	7.54

## Area 7 Cover Summary

Cover Type	Transect #															Site Average	Std. Dev.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
<b>Shrubs</b>	64	46	40	50	52	48	44	48	46	34	40	62	60	66	48	49.87	9.40
<b>Forbs</b>	0	0	6	2	0	2	2	4	0	0	2	0	4	0	2	1.6	1.88
<b>Grasses</b>	26	24	10	10	8	30	8	24	40	52	48	24	20	22	42	25.87	14.27
<b>Trees</b>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Total Vegetation</b>	90	70	56	62	60	80	54	76	86	86	90	86	84	88	92	77.33	13.41
<b>Cryptobiotic</b>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Physical Features</b>	10	30	38	38	40	20	46	24	14	14	10	14	16	12	8	22.27	12.80

## Area 11/13/14 Cover Summary

Cover Type	Transect #															Site Average	Std. Dev.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
<b>Shrubs</b>	14	24	36	46	38	22	28	32	30	22	32	28	28	8	38	24.80	9.66
<b>Forbs</b>	0	4	2	0	2	0	0	4	6	2	0	0	0	0	0	1.33	1.95
<b>Grasses</b>	64	30	50	30	32	42	34	30	32	54	62	50	40	58	34	42.80	12.44
<b>Trees</b>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Total Vegetation</b>	78	58	88	76	72	64	62	66	68	78	94	78	68	66	72	72.53	9.72
<b>Cryptobiotic</b>	0	0	0	2	0	0	0	2	0	4	0	0	0	0	0	0.53	1.19
<b>Physical Features</b>	22	42	12	22	28	36	38	32	32	18	6	22	32	34	28	26.93	9.91

## Area 15/17 Cover Summary

Cover Type	Transect #															Site Average	Std. Dev.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
<b>Shrubs</b>	42	14	38	40	36	42	46	52	50	36	22	24	14	28	30	34.27	11.97
<b>Forbs</b>	0	4	0	0	0	2	0	0	0	0	2	6	2	0	2	1.20	1.82
<b>Grasses</b>	34	44	42	42	44	38	32	28	40	50	42	48	60	36	48	41.87	7.95
<b>Trees</b>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Total Vegetation</b>	76	62	80	82	80	82	78	80	90	86	66	78	76	64	80	77.33	7.81
<b>Cryptobiotic</b>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Physical Features</b>	24	38	20	18	20	18	22	20	10	14	34	22	24	36	20	22.67	7.81

## Area 16 Cover Summary

Cover Type	Transect #															Site Average	Std. Dev.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
<b>Shrubs</b>	16	22	28	26	18	14	8	22	2	20	4	12	4	20	20	15.73	8.17
<b>Forbs</b>	0	0	20	12	20	12	16	14	0	8	0	4	4	2	14	8.4	7.45
<b>Grasses</b>	48	32	36	30	40	24	40	18	62	44	56	38	82	42	40	42.13	15.68
<b>Trees</b>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>Total Vegetation</b>	64	54	84	68	78	50	64	54	64	72	60	54	90	64	74	66.27	11.61
<b>Cryptobiotic</b>	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	.13	.52
<b>Physical Features</b>	36	46	16	32	22	50	34	46	36	28	40	46	10	36	26	33.60	11.59

**Area 3 Cover Data**





























































## **Area 6 Cover Data**







Horse Canyon Revegetation Project Tally Sheet

Date: 8/23/03	Area: 7	Transect: 4	UTM: 05553714368081	Heading: 36																											Total	Percent Cover	Relative Vegetative Cover																						
Plant Species	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50					
<b>Shrubs</b>																																																							
Atriplex canescens																																	1	1	1											1	1	1	7	14	22.58				
Atriplex confertifolia																																																			0	0	0.00		
Artemisia nova											1											1	2	3.23																															
Artemisia tridentata tridentata	1						1	1											1	1	1	13	26	41.94																															
Chrysothamnus nauseosus																										1	1											1	1	1	1	1	5	0	0.00										
Chrysothamnus viscidiflorus					1	1											1	1	4	8	12.90																																		
Cowanella mexicana																																																			0	0	0.00		
Ceratoides lanata																																																			0	0	0.00		
Ephedra viridis																																																			0	0	0.00		
Sarcobatus vermiculatus																																																			0	0	0.00		
Gutierrezia sarothrae																																																			0	0	0.00		
<b>Total Shrubs Cover</b>	1	0	1	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	1	0	0	1	0	1	1	1	0	1	1	1	1	1	1	0	1	1	1	1	1	25	50	80.85			
<b>Forbs &amp; Succulents</b>																																																			0	0	0.00		
Mecheranthra canescens																																																			1	2	3.23		
Medicago sativa	1																																																		0	0	0.00		
Meibomia officinalis																																																			0	0	0.00		
Penstemon palmeri																																																			0	0	0.00		
Sphaeralcea coccinea																																																			0	0	0.00		
<b>Total Forb Cover</b>	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	3.23		
<b>Grasses</b>																																																			0	0	0.00		
Agropyron smithii																																																			0	0	0.00		
Agropyron spicatum																																																			0	0	0.00		
Agropyron cristatum																																																			0	0	0.00		
Agropyron trachycaulum																																																			0	0	0.00		
Bromus tectorum																										1	1	1											1	5	10	16.13													
Elymus salinus																																																			0	0	0.00		
Elymus cinereus																																																			0	0	0.00		
Elymus giganteus																																																			0	0	0.00		
Hilaria jamesii																																																			0	0	0.00		
Oryzopsis hymenoides																																																			0	0	0.00		
Sitanion hystrix																																																			0	0	0.00		
Stipa comata																																																			0	0	0.00		
<b>Total Grass Cover</b>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	10	16.13		
<b>Trees</b>																																																			0	0	0.00		
Juniper																																																			0	0	0.00		
Pinon																																																			0	0	0.00		
<b>Total Tree Cover</b>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.00
<b>Total Vegetation Cover</b>	1	1	1	1	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	31	62	100.00
<b>Cryptobiotic</b>																																																			0	0	0.00		
<b>Physical Features</b>																																																			3	6			
Litter						1	1	1											1	1	2																																		
Rock																																																			1	2			
Bare Ground											1	1	1											1	15	30																													
<b>Total Physical Features</b>	0	0	0	0	1	1	0	0	1	0	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	19	38		
<b>Comments:</b>	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	50	100			





**Area 7 Cover Data**



















**Area 11/13/14 Cover Data**































**Area 15/17 Cover Data**































## Area 16 Cover Data































## **Appendix 2**

### **Woody Plant Density Data**

### Horse Canyon Woody Plant Density Comparisons

<b>Site</b>	<b>Average Plants per Acre</b>	<b>St. Deviation</b>
<b>Reference Area</b>	659.21	332.10
<b>Area 3</b>	1957.30	634.98
<b>Area 6</b>	3891.36	705.21
<b>Area 7</b>	5180.74	2540.36
<b>Area 11/13/14</b>	1771.44	636.52
<b>Area 15/17</b>	2626.22	752.95
<b>Area 16</b>	2883.67	964.13















## **Appendix 3**

### **Diversity and Similarity Data**

# Horse Canyon Similarity Comparisons - Reference Area & Area 3

Reference Area			Area 3		
Species	Frequency (per 30 transects)	% Cover (per 1500 points)	Species	Frequency (per 15 transects)	% Cover (per 750 points)
Juniper	26	17.0	Juniper	0	0.0
Salina wild rye	24	7.0	Salina wild rye	2	0.3
Pinyon	13	4.0	Pinyon	0	0.0
Cheat grass	5	2.0	Cheat grass	8	4.1
Globe mallow	3	1.0	Globe mallow	0	0.0
Snake weed	9	1.0	Snake weed	0	0.0
Galleta	8	1.0	Galleta	0	0.0
Six weeks fescue	4	0.3	Six weeks fescue	1	0.1
Ephedra	3	0.2	Ephedra	0	0.0
Purple	2	0.1	Purple	0	0.0
Cliffrose	1	0.1	Cliffrose	0	0.0
Hedgehog cactus	1	0.1	Hedgehog cactus	0	0.0
<b>Similarity Comparison</b>			Bluebunch wheatgrass	14	29.2
Reference Area: 12 species (A)			Fourwing	15	13.3
Area 3: 16 species (B)			Sagebrush	15	13.3
Common species: 3 (C)			Basin wild rye	13	7.1
Jaccard's Community Coefficient:			Douglas rabbitbrush	10	5.1
$S = C / (A + B - C)$			Alfalfa	9	3.5
$S = 3 / (12 + 16 - 3)$			Yellow sweet clover	6	1.6
$S = 12.0$			Crested wheatgrass	3	1.5
			Squirreltail	5	1.1
			Indian rice grass	6	0.9
			Palmer penstemon	4	0.8
			Japanese brome	1	0.3
			Big rabbitbrush	6	1.2
<b>12 Total species; 2 species &gt;5% cover</b>			<b>16 total species; 5 species &gt;5%</b>		

# Horse Canyon Similarity Comparisons - Reference Area & Area 6

Reference Area			Area 6		
Species	Frequency (per 30 transects)	% Cover (per 1500 points)	Species	Frequency (per 15 transects)	% Cover (per 750 points)
Juniper	26	17.0	Juniper	0	0.0
Salina wild rye	24	7.0	Salina wild rye	1	0.3
Pinyon	13	4.0	Pinyon	0	0.0
Cheat grass	5	2.0	Cheat grass	15	27.1
Globe mallow	3	1.0	Globe mallow	0	0.0
Snake weed	9	1.0	Snake weed	0	0.0
Galleta	8	1.0	Galleta	0	0.0
Six weeks fescue	4	0.3	Six weeks fescue	0	0.0
Ephedra	3	0.2	Ephedra	0	0.0
Purple	2	0.1	Purple	0	0.0
Cliffrose	1	0.1	Cliffrose	0	0.0
Hedgehog cactus	1	0.1	Hedgehog cactus	0	0.0
<p><b>Similarity Comparison</b></p> <p>Reference Area: 12 species (A)</p> <p>Area 6: 21 species (B)</p> <p>Common species: 2 (C)</p> <p>Jaccard's Community Coefficient:</p> $S = C / (A + B - C)$ $S = 2 / (12 + 21 - 2)$ $S = 6.50$			Bluebunch wheatgrass	15	22.9
			Fourwing	14	12.4
			Sagebrush	13	9.9
			Douglas rabbitbrush	9	5.5
			Winterfat	8	1.6
			Basin wild rye	3	0.8
			Alfalfa	1	0.1
			Yellow sweet clover	1	0.1
			Crested wheatgrass	1	0.1
			Squirreltail	1	0.3
			Indian rice grass	2	0.7
			Palmer penstemon	1	0.4
			Japanese brome	1	0.1
			Smooth brome	1	0.1
			Big rabbitbrush	3	0.5
			Western wheat grass	1	0.1
			Tumble mustard	1	0.3
			Black sagebrush	3	1.9

	Giant wild rye	1	0.3
12 Total species; 2 species >5% cover	21 Total species; 5 species >5% cover		

## Horse Canyon Similarity Comparisons - Reference Area & Area 7

Reference Area			Area 7		
Species	Frequency (per 30 transects)	% Cover (per 1500 points)	Species	Frequency (per 15 transects)	% Cover (per 750 points)
Juniper	26	17.0	Juniper	0	0.0
Salina wild rye	24	7.0	Salina wild rye	1	0.7
Pinyon	13	4.0	Pinyon	0	0.0
Cheat grass	5	2.0	Cheat grass	15	22.0
Globe mallow	3	1.0	Globe mallow	2	0.3
Snake weed	9	1.0	Snake weed	1	0.1
Galleta	8	1.0	Galleta	0	0.0
Six weeks fescue	4	0.3	Six weeks fescue	0	0.0
Ephedra	3	0.2	Ephedra	0	0.0
Purple	2	0.1	Purple	0	0.0
Cliffrose	1	0.1	Cliffrose	2	0.3
Hedgehog cactus	1	0.1	Hedgehog cactus	0	0.0
<b>Similarity Comparison</b>			Bluebunch wheatgrass	15	2.0
Reference Area: 12 species (A)			Fourwing	15	18.9
Area 7: 17 species (B)			Sagebrush	15	24.9
Common species: 5 (C)			Douglas rabbitbrush	12	4.4
Jaccard's Community Coefficient:			Alfalfa	3	0.5
$S = C / (A + B - C)$			Needle and Thread	4	0.9
$S = 5 / (12 + 17 - 5)$			Indian rice grass	2	0.3
$S = 20.80$			Palmer penstemon	1	0.1
			Big rabbitbrush	1	0.1
			Western wheat grass	1	0.1
			Tumble mustard	4	0.5
			Black sagebrush	4	1.1
12 Total species; 2 species >5% cover			17 Total species; 3 species >5% cover		

# Horse Canyon Similarity Comparisons - Reference Area & Area 11/13/14

Reference Area			Area 11/13/14		
Species	Frequency (per 30 transects)	% Cover (per 1500 points)	Species	Frequency (per 15 transects)	% Cover (per 750 points)
Juniper	26	17.0	Juniper	0	0.0
Salina wild rye	24	7.0	Salina wild rye	2	0.4
Pinyon	13	4.0	Pinyon	0	0.0
Cheat grass	5	2.0	Cheat grass	13	15.7
Globe mallow	3	1.0	Globe mallow	0	0.0
Snake weed	9	1.0	Snake weed	0	0.0
Galleta	8	1.0	Galleta	0	0.0
Six weeks fescue	4	0.3	Six weeks fescue	0	0.0
Ephedra	3	0.2	Ephedra	0	0.0
Purple	2	0.1	Purple	1	0.1
Cliffrose	1	0.1	Cliffrose	0	0.0
Hedgehog cactus	1	0.1	Hedgehog cactus	0	0.0
<b>Similarity Comparison</b>			Bluebunch wheatgrass	15	20.8
Reference Area: 12 species (A)			Fourwing	13	14.1
Area 11/13/14: 23 species (B)			Sagebrush	12	5.7
Common species: 3 (C)			Douglas rabbitbrush	5	1.6
Jaccard's Community Coefficient:			Winterfat	5	0.7
$S = C / (A + B - C)$			Alfalfa	4	0.8
$S = 3 / (12 + 23 - 3)$			Needle and Thread	1	0.4
$S = 9.4$			Indian rice grass	6	1.3
			Shadscale	3	1.7
			Big rabbitbrush	6	2.4
			Greasewood	2	1.6
			Crested wheatgrass	2	0.7
			Basin wild rye	3	0.7
			Western wheatgrass	3	0.5
			Giant rye grass	3	0.5
			Squirrel tail	2	0.5
			Six weeks fescue	2	0.3

	Smooth brome	1	0.1
	Japanese brome	1	0.1
	Yellow sweet clover	1	0.1
<b>12 Total species; 2 species &gt;5% cover</b>		<b>23 Total species; 4 species &gt;5% cover</b>	

# Horse Canyon Similarity Comparisons - Reference Area & Area 15/17

Reference Area			Area 15/17		
Species	Frequency (per 30 transects)	% Cover (per 1500 points)	Species	Frequency (per 15 transects)	% Cover (per 750 points)
Juniper	26	17.0	Juniper	0	0.0
Salina wild rye	24	7.0	Salina wild rye	1	0.5
Pinyon	13	4.0	Pinyon	0	0.0
Cheat grass	5	2.0	Cheat grass	13	19.1
Globe mallow	3	1.0	Globe mallow	1	0.1
Snake weed	9	1.0	Snake weed	1	0.1
Galleta	8	1.0	Galleta	0	0.0
Six weeks fescue	4	0.3	Six weeks fescue	0	0.0
Ephedra	3	0.2	Ephedra	0	0.0
Purple	2	0.1	Purple	0	0.0
Cliffrose	1	0.1	Cliffrose	0	0.0
Hedgehog cactus	1	0.1	Hedgehog cactus	0	0.0
<b>Similarity Comparison</b>			Bluebunch wheatgrass	15	18.9
Reference Area: 12 species (A)			Fourwing	15	14.1
Area 15/17: 20 species (B)			Sagebrush	15	15.1
Common species: 4 (C)			Douglas rabbitbrush	1	0.1
Jaccard's Community Coefficient:			Winterfat	2	0.4
$S = C / (A + B - C)$			Alfalfa	4	0.7
$S = 4 / (12 + 20 - 4)$			Needle and Thread	2	0.9
$S = 14.30$			Indian rice grass	3	0.8
			Shadscale	3	0.4
			Big rabbitbrush	5	1.1
			Greasewood	7	2.1
			Basin wild rye	4	0.7
			Western wheatgrass	2	0.3
			Yellow sweet clover	3	0.4
			Smooth brome	1	0.1
			Japanese brome	2	0.3
12 Total species; 2 species >5% cover			20 Total species; 4 species >5% cover		

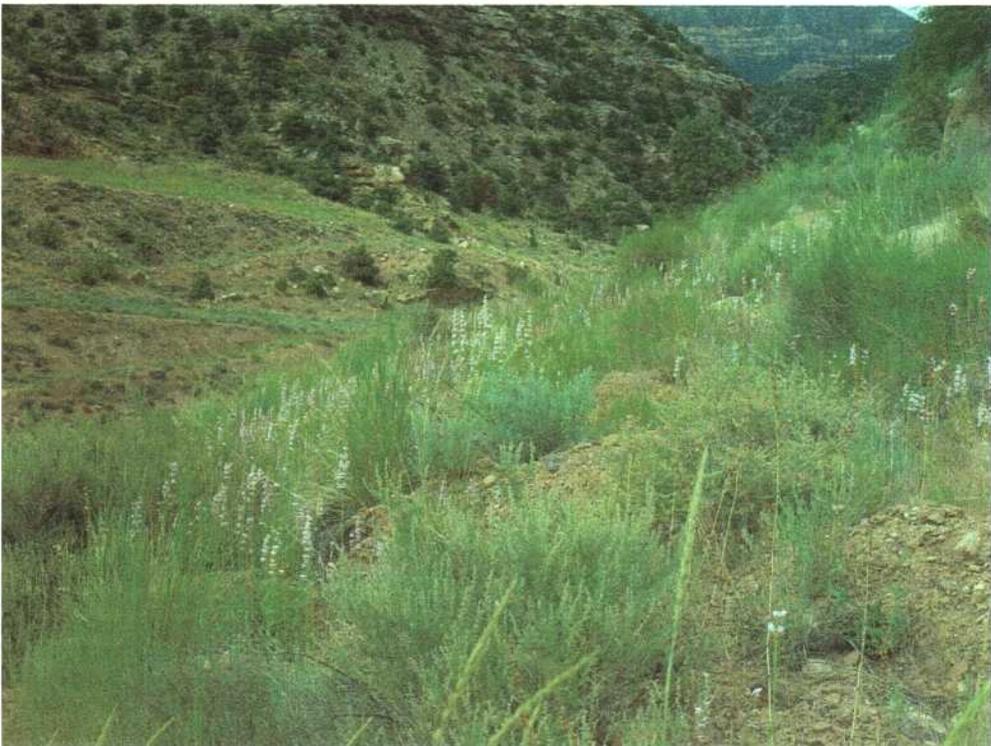
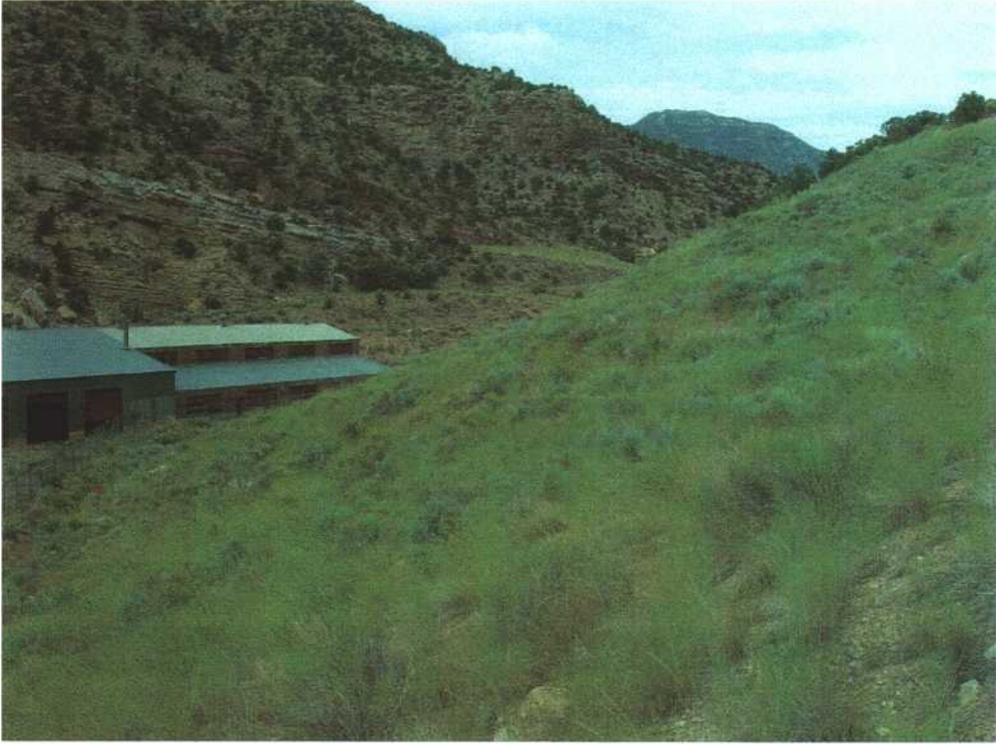
## Horse Canyon Similarity Comparisons - Reference Area & Area 16

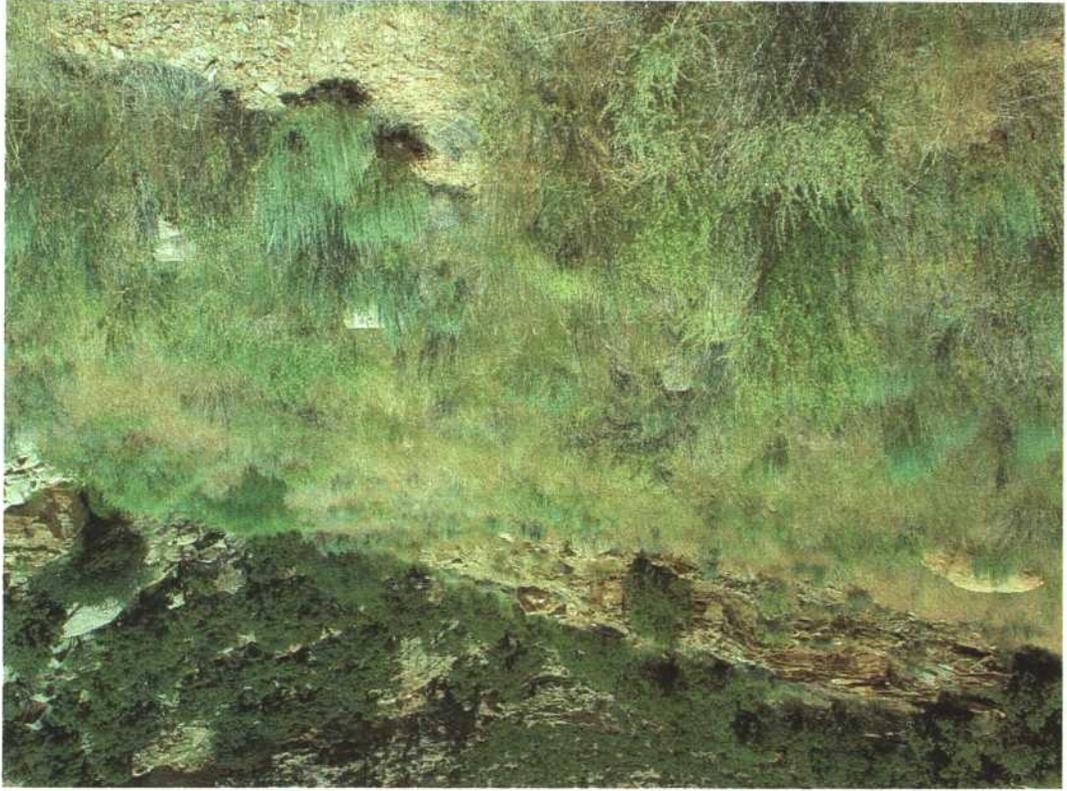
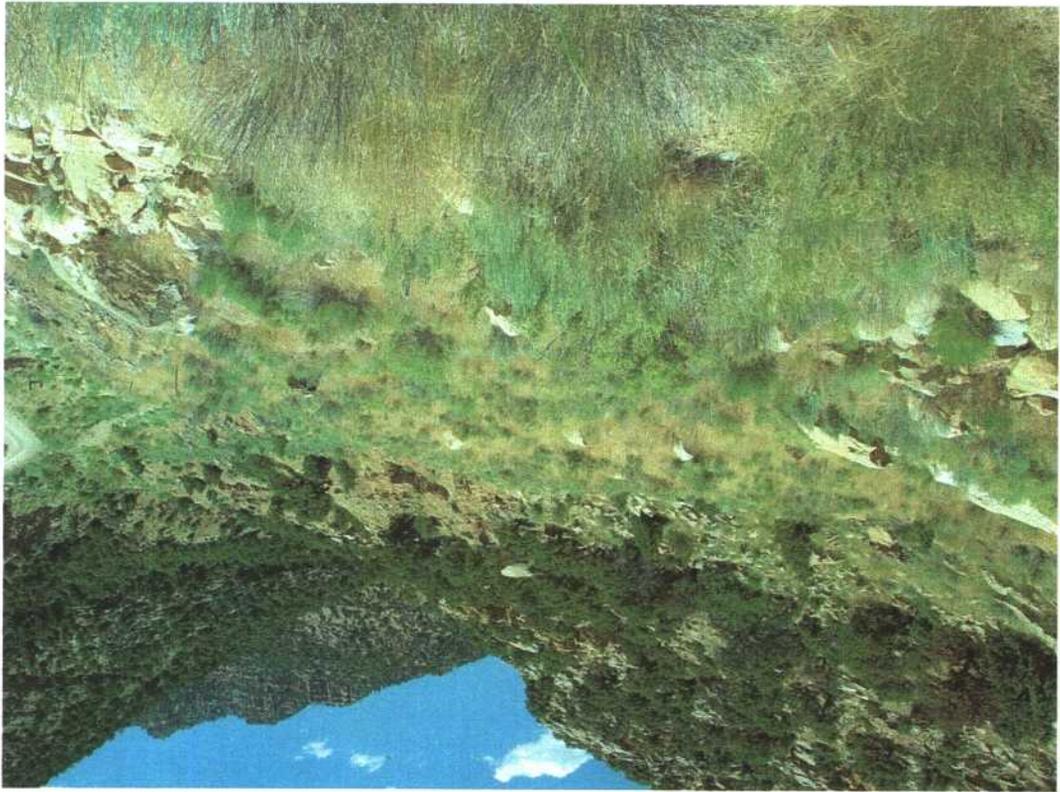
Reference Area			Area 16		
Species	Frequency (per 30 transects)	% Cover (per 1500 points)	Species	Frequency (per 15 transects)	% Cover (per 750 points)
Juniper	26	17.0	Juniper	0	0.0
Salina wild rye	24	7.0	Salina wild rye	0	0.0
Pinyon	13	4.0	Pinyon	0	0.0
Cheat grass	5	2.0	Cheat grass	9	6.5
Globe mallow	3	1.0	Globe mallow	0	0.0
Snake weed	9	1.0	Snake weed	0	0.0
Galleta	8	1.0	Galleta	0	0.0
Six weeks fescue	4	0.3	Six weeks fescue	0	0.0
Ephedra	3	0.2	Ephedra	0	0.0
Purple	2	0.1	Purple	0	0.0
Cliffrose	1	0.1	Cliffrose	0	0.0
Hedgehog cactus	1	0.1	Hedgehog cactus	0	0.0
<b>Similarity Comparison</b>			Bluebunch wheatgrass	13	28.5
Reference Area: 12 species (A)			Fourwing	9	5.6
Area 16: 14 species (B)			Sagebrush	8	4.7
Common species: 1 (C)			Douglas rabbitbrush	1	0.1
Jaccard's Community Coefficient:			Winterfat	1	0.1
$S = C / (A + B - C)$			Alfalfa	10	6.7
$S = 1 / (12 + 14 - 1)$			Palmer penstemon	1	0.4
$S = 4.00$			Indian rice grass	1	0.1
12 Total species; 2 species >5% cover			Shadscale	5	1.1
			Big rabbitbrush	7	1.6
			Crested wheatgrass	1	0.1
			Giant rye grass	2	1.2
			Squirrel tail	1	0.1
			14 Total species; 4 species >5% cover		

**Appendix 4**

**Site Photographs**

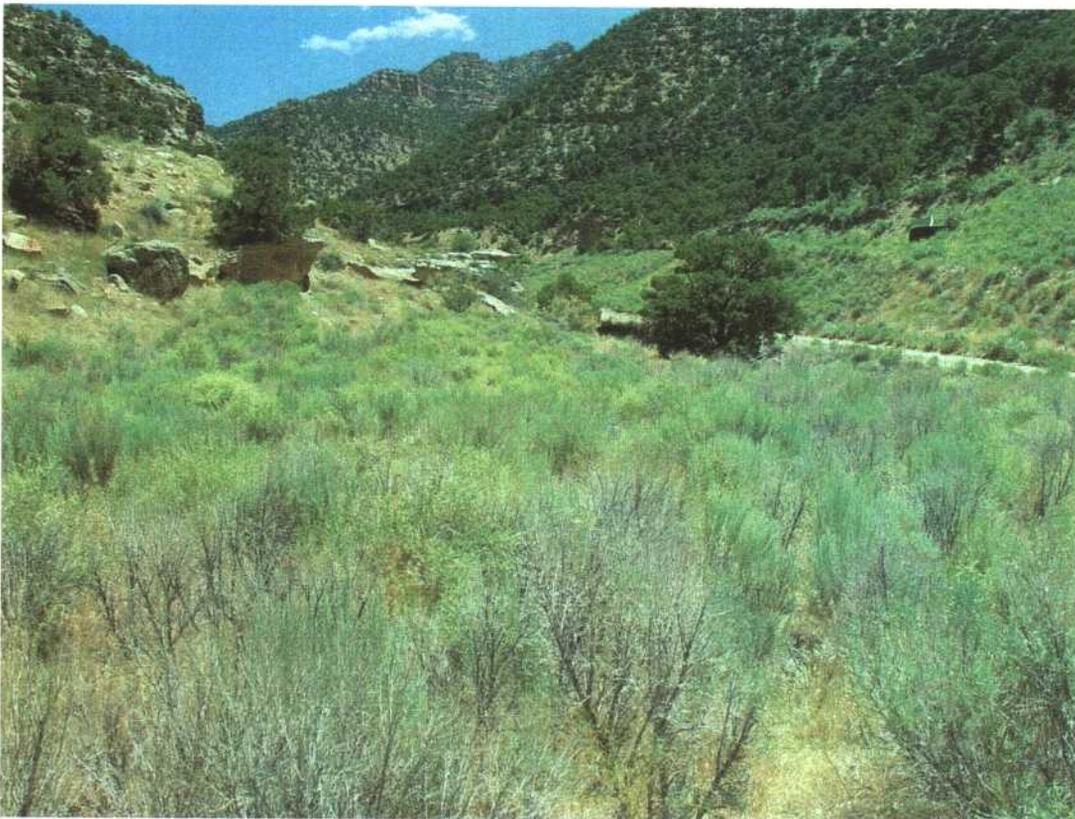
## Area 3





**Area 6**

**Area 7**



**Area 11/13/14**



**Area 15/17**



**Area 16**



## **Appendix 5**

### **Sloped Areas Cover Data**

## **Slopes Cover**

UtahAmerican Energy asked for a survey of percent cover for 5 sloped areas on the Horse Canyon Mine property. The 5 survey areas were 1) sloped areas around the portal area (Portal Slopes Area) , 2) sloped areas on the north-facing slope above the mine buildings (Area 3 Slopes Area), 3), sloped areas immediately adjacent to the fence on the south side of the mine buildings (Fence Slopes Area) 4) sloped areas surrounding the magazine area (Magazine Slopes Area), and 5) sloped areas adjacent and just north of the pond area (Pond Slopes Area).

A minimum of 3 transects were run at each site, and when sufficient space was available, a maximum of 5 transects were run. Fifty points were collected from each 100 foot transect. Transects were not located randomly because of the restrictively small size of the sloped areas. Data for percent cover for each area are summarized in the tables and data sheets that follow. These data include vegetation category and species for each transect at each site.

### **Portal Slopes Area**

In the Portal slopes area, 5 transects were run. Average percent cover of all vegetation in the area was 64.80 percent. Dominant vegetative type at the site was shrubs; 41.20%, followed by grasses; 23.60 %.

### **Area 3 Slopes Area**

In the Area 3 slopes area, 5 transects were run. Average percent cover of all vegetation in the area was 63.60 percent. Dominant vegetative type at the site was grasses; 28.80%, followed by shrubs; 27.20%).

### **Fence Slopes Area**

In the Fence slopes area, 3 transects were run. Average percent cover of all vegetation in the area was 56.67 percent. Dominant vegetative type at the site was grasses; 24.00%, followed by forbs; 19.33%, and shrubs; 13.33%).

### **Magazine Slopes Area**

In the Magazine slopes area, 5 transects were run. Average percent cover of all

vegetation in the area was 60.40 percent. Dominant vegetative type at the site was shrubs; 38.00%, followed by grasses; 20.80%).

### **Pond Slopes Area**

In the Pond slopes area, 4 transects were run. Average percent cover of all vegetation in the area was 57.00 percent. Dominant vegetative type at the site was grasses; 27.50%, followed by shrubs; 26.00%).

Vegetation in these sloped areas appeared to be in good condition, with no signs of disease, insect damage or overgrazing. Though total vegetative cover in the sloped areas (range 57.00% to 64.80%) is less than the revegetated areas (range 66.27% to 89.07%), there is overlap between the two. In all cases, the sloped sites were more densely vegetated than the Horse Canyon reference area which had an average vegetative cover of 33.47%.

There are more areas of bare ground in the sloped areas than are present in the revegetation study areas, but no signs of excessive erosion were observed. In general, the sloped areas appear to have satisfactory levels of vegetation.

Slopes Cover Data

Area 3 Slopes		Transect Number						
Percent								
Cover		1.00	2.00	3.00	4.00	5.00	Average	Std. Dev.
Shrubs		46.00	50.00	48.00	22.00	40.00	41.20	11.37
Forbs		0.00	2.00	0.00	0.00	0.00	0.40	0.89
Grasses		16.00	28.00	22.00	28.00	24.00	23.60	4.98
Trees		0.00	0.00	0.00	0.00	12.00	2.40	5.37
Total Vegetation		62.00	80.00	68.00	50.00	64.00	64.80	10.83
Cryptobiotic		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Physical Features		38.00	20.00	32.00	50.00	36.00	35.20	10.83

Building Slopes Data		Transect Number						
Percent								
Cover		1.00	2.00	3.00	4.00	5.00	Average	Std. Dev.
Shrubs		32.00	14.00	40.00	32.00	18.00	27.20	10.83
Forbs		2.00	12.00	10.00	14.00	0.00	7.60	6.23
Grasses		38.00	34.00	6.00	18.00	48.00	28.80	16.71
Trees		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Vegetation		72.00	60.00	56.00	64.00	66.00	63.60	6.07
Cryptobiotic		0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total Physical Features		28.00	40.00	44.00	36.00	34.00	36.40	6.07

Fence Slopes Data		Transect Number				
Percent						
Cover		1.00	2.00	3.00	Average	Std. Dev.
Shrubs		8.00	22.00	10.00	13.33	7.57
Forbs		34.00	2.00	22.00	19.33	16.17
Grasses		12.00	36.00	24.00	24.00	12.00
Trees		0.00	0.00	0.00	0.00	0.00
Total Vegetation		54.00	60.00	56.00	56.67	3.06
Cryptobiotic		0.00	0.00	0.00	0.00	0.00
Total Physical Features		46.00	40.00	44.00	43.33	3.06

Magazine Slopes Data										
		Transect Number								
Percent										
Cover		1.00	2.00	3.00	4.00	5.00		Average	Std. Dev.	
Shrubs		38.00	50.00	40.00	42.00	20.00		38.00	11.05	
Forbs		0.00	0.00	2.00	0.00	0.00		0.40	0.89	
Grasses		28.00	22.00	38.00	4.00	12.00		20.80	13.31	
Trees		0.00	0.00	0.00	0.00	6.00		1.20	2.68	
Total Vegetation		66.00	72.00	80.00	46.00	38.00		60.40	17.74	
Cryptobiotic		0.00	0.00	0.00	0.00	4.00		0.80	1.79	
Total Physical Features		34.00	28.00	20.00	54.00	58.00		38.80	16.53	

Pond Slopes Data										
		Transect Number								
Percent										
Cover		1.00	2.00	3.00	4.00			Average	Std. Dev.	
Shrubs		26.00	26.00	32.00	20.00			26.00	4.90	
Forbs		2.00	6.00	2.00	0.00			2.50	2.52	
Grasses		14.00	40.00	20.00	36.00			27.50	12.48	
Trees		0.00	4.00	0.00	0.00			1.00	2.00	
Total Vegetation		42.00	76.00	54.00	56.00			57.00	14.09	
Cryptobiotic		0.00	0.00	0.00	4.00			1.00	2.00	
Total Physical Features		58.00	24.00	46.00	40.00			42.00	14.14	

## Portal Slopes Cover Data





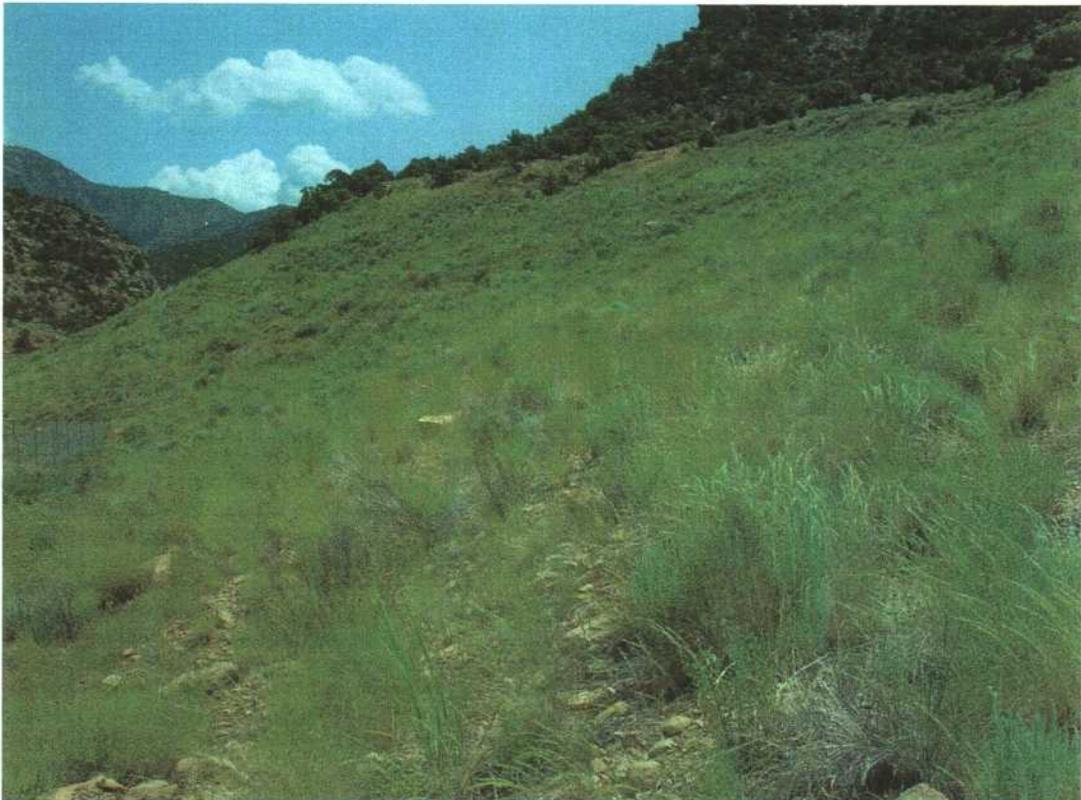








## Area 3 Slopes Cover Data













# Fence Slopes Cover Data

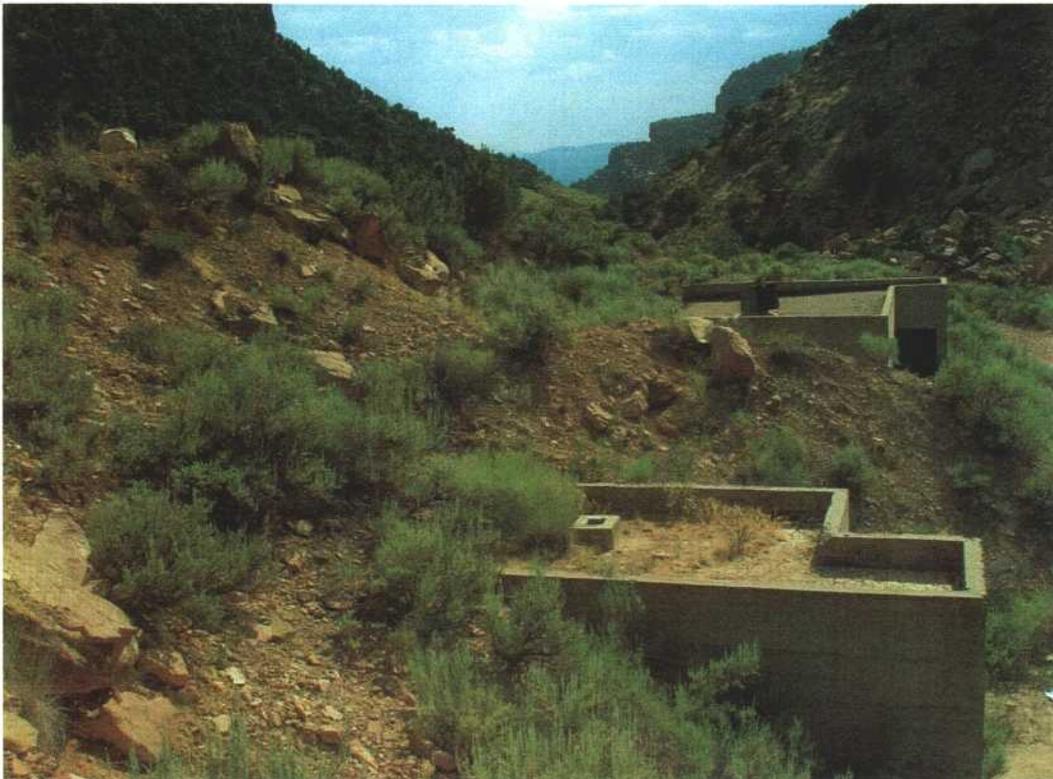








## Magazine Slopes Cover Data













## Pond Slopes Cover Data

