

Revegetation Monitoring
Sediment Pond Area
Year 4
2010

Des-Bee-Dove Mine Site
Emery County, Utah



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March 2011



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INTRODUCTION

Located approximately 10 miles northwest of the town of Castle Dale, Utah, the Des-Bee-Dove Mine site is an area rich in coal mining history. In 1987, however, the site terminated its mining activities and went into what is called *temporary cessation*. Later in 2003, most of the disturbed areas of the mine site were reclaimed to their approximate pre-mining contours and then re-seeded with native plant species. The only areas not reclaimed were those that were to remain as sediment control measures for the reclaimed site. These areas were the Sediment Pond Area and the access road to it. Finally, in 2006 the Sediment Pond Area and Sediment Pond Access Road were also reclaimed.

The purpose of this study is to provide revegetation monitoring information for **Year-4** of the *10-Year "Responsibility Period"*, or the period of time required following final revegetation of coal mines before the land owner may apply for *Phase III or Final Bond Release* through the State of Utah, Division of Oil, Gas & Mining (DOG M).

In order to achieve approval for Phase III Bond Release, vegetation of the reclaimed site must meet specific standards for revegetation success. Consequently, a "reference area", or a native, undisturbed plant community is often chosen beforehand to provide future revegetation success standards following final reclamation of the mine site. The native plant community for the Des-Bee-Dove Sediment Pond Area was called the Saltbush Shrub Reference Area.

Prior to disturbance by mining, the native vegetation in the Sediment Pond Areas was typical of the semi-arid salt deserts of eastern Utah that are mostly dominated by plant communities supporting saltbush species (*Atriplex* spp.), pinyon-pine (*Pinus edulis*) and Utah juniper and (*Juniperus osteosperma*). Elevation of the study site ranged between 6,700 ft and 7,100 ft above sea level.

METHODS

Transect Placement

Transect lines for quantitative sampling were randomly placed for the entire length of the Reclaimed Sediment Pond Area, the Reclaimed Access Road and the Saltbush Shrub Reference Area in an attempt to adequately represent the entire sample area. From these transect lines, sample locations were chosen using random numbers on both sides and at right angles to them.

Cover, Frequency and Composition

Cover estimates were made using ocular methods with meter square quadrats. Species composition and relative frequencies were also assessed from the quadrats. Additional information recorded on the raw data sheets were: estimated precipitation, slope, exposure, grazing use, animal disturbance and other appropriate notes. Plant nomenclature follows "*A Utah Flora*" (Welsh et al. 2008).

Density

Density estimates for the woody plant species on the reclaimed and reference areas were made using a distance method called the point-quarter method. In this method, random points were placed on the sample sites and measured into four quarters. The distances to the nearest woody plant species were then recorded in each quarter. The average point-to-individual distance was equal to the square root of the mean area per individual.

Sample Adequacy

Sample adequacy for cover and density was attempted with the goal that 80%

of the samples were within 10% of the true mean for the plant communities in the area. The following formula was used:

$$nMIN = \frac{t^2 s^2}{(dx)^2}$$

where,

- $nMIN$ = minimum adequate sample
- t = appropriate confidence t-value
- s = standard deviation
- x = sample mean
- d = desired change from mean

Diversity

Two diversity indices have been employed to the datasets in this document for comparisons. To begin, *MacArthur's Diversity Index* was calculated. This index is an effective diversity measurement and is computed using the equation $1/\sum pi^2$ (MacArthur and Wilson 1976, *The Theory of Island Biogeography*, Princeton: Princeton University Press). In this equation pi is the proportion of sum frequency contributed by the i th species in the sample area of concern. The proportional contribution of each species is then squared and the values for all species in the sample areas are summed. This index integrates the number of species and the degree to which frequency of occurrence was equitably distributed among those species. In other words, this index provides greater weight to those species that are present more often (with greater frequency) than those that are merely "present" in one or two quadrats.

The *average number of species* per sample quadrat is another measure of species diversity provided from the data in this report.

Photographs & Sample Location Maps

Color photographs were taken of the sample areas and are included in this report. Maps showing the sample areas have also been include herein.

RESULTS

The Reclaimed Sediment **Pond Area** (Map 1) dataset was separated from the Reclaimed Sediment Pond **Access Road** (Map 2) in this report to enable a more accurate depiction of each revegetated area individually rather than together. At the end of the *Responsibility Period* when it is time to sample for final bond release, the datasets from the Reclaimed Sediment Pond Area and the Reclaimed Sediment Pond Access Road will probably be “lumped” together for final comparisons with the Saltbush Shrub **Reference area** (also shown on Map 1).

Color photographs and maps of the sample areas have been included following the Summary Tables in this report.

Reclaimed Sediment Pond Area

The dominant plant species in the Reclaimed Sediment Pond Area were four-wing saltbush (*Atriplex canescens*) and Gt. Basin wildrye (*Elymus cereus*). Other important species in the sample quadrats by cover and frequency in descending order here were halogeton (*Halogeton glomeratus*), thickspike wheatgrass (*Elymus lanceolatus*) and Gardner saltbush (*Atriplex gardneri*). There were several other species present in the area, all of which are shown on Table 1.

The total living cover of the Reclaimed Sediment Pond Area was estimated at 41.63% (Table 2-A). Of that total, 45.61% was represented by shrub species, 37.84% grasses and 16.54% were forbs (Table 2-B).

Woody species density was also recorded in the field study. The total density of the area was estimated at 2,870 individuals per acre (Table 3). The density was dominated by four-wing saltbush, Gardner saltbush, winterfat (*Ceratoides lanata*), shadscale (*Atriplex confertifolia*) and prostrate kochia (*Bassia prostrata*).

Reclaimed Sediment Pond Access Road

The access road to the Sediment Pond Area was dominated by prostrate kochia, halogeton, Gardner saltbush, four-wing saltbush, thickspike wheatgrass and western wheatgrass (*Elymus smithii*). For a list of all species present in the sample quadrats along the access road, refer to Table 4.

The total living cover for the Reclaimed Sediment Pond Access Road was estimated at 36.13% (Table 5-A), of which 55.67% were shrubs, 22.37% forbs and 21.96% were grass species (Table 5-B).

Woody species density in this area was dominated by broom snakeweed (*Gutierrezia sarothrae*), prostrate kochia, four-wing saltbush, rubber t rabbitbrush (*Chrysothamnus nauseosus*), Gardner saltbush and shadscale. The total density of the area was estimated at 1,612 individuals per acre (Table 6).

Saltbush Shrub Reference Area

The area chosen to be compared to the reclaimed areas and to represent final revegetation success was called the Saltbush Shrub Reference Area. The dominant species in this area were Salina wildrye (*Elymus salinus*), Gardner saltbush, shadscale and corymb buckwheat (*Eriogonum corymbosum*). All species listed by cover and frequency in the reference area are shown on Table 7.

The total living cover for the reference area was estimated at 35.13% (Table 8-A). The cover's lifeform composition was comprised of 57.82% shrubs, 41.52% grasses and only 0.67% forbs (Table 8-B).

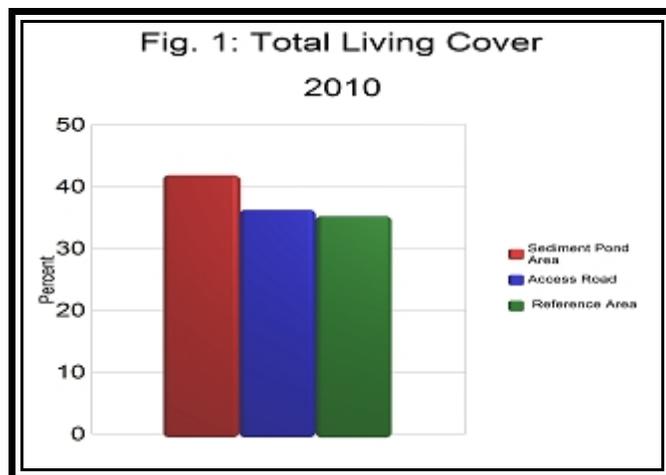
Woody species density in the reference area totaled 3,695 individuals per acre and was dominated by Gardner saltbush, shadscale corymb buckwheat and greasewood (*Sarcobatus vermiculatus*). For a list of all density estimates, refer to Table 9.

Total Living Cover Comparisons

The data in the tables mentioned above show that both reclaimed areas, the Sediment Pond Area and the Sediment Pond Access Road, had more total living cover than the Saltbush Shrub Reference Area (see also Fig. 1).

When the reclaimed cover values are compared statistically with the reference area, the Reclaimed Sediment Pond Area had

significantly more living cover (Table 10-A). Next, when the total living cover of the Reclaimed Sediment Pond Access Road was compared to the Saltbush Shrub Reference Area, the differences were not significant statistically (Table 10-B).

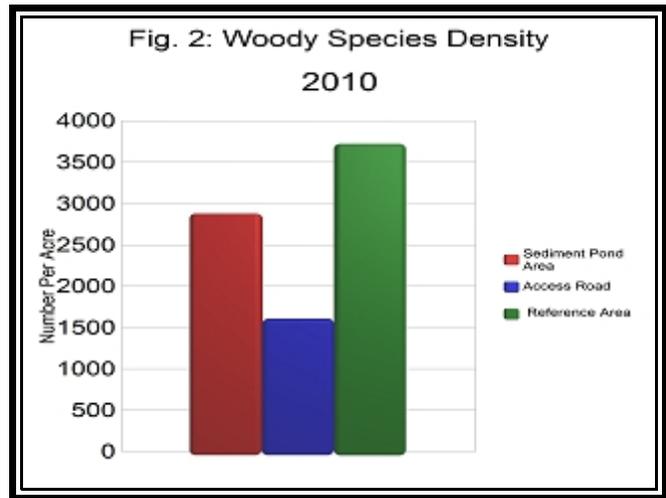


It should also be noted that at this time period there were some "weedy", exotic plant species such as halogeton and Russian thistle (*Salsola tragus*) growing in the cover of the reclaimed areas, but most of the plant species in

the cover were more desirable and native perennials.

Woody Species Density Comparisons

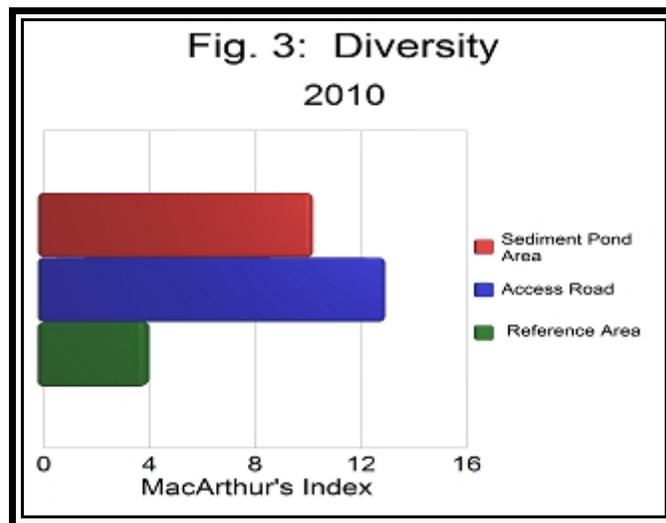
The woody species density comparisons suggest some differences (Fig. 2), some of which were significant statistically. When comparing the Reclaimed Sediment Pond Area's total density value with the density of the Saltbush Shrub Reference Area, the later was greater, although the differences were not significant statistically (Table 11-A).



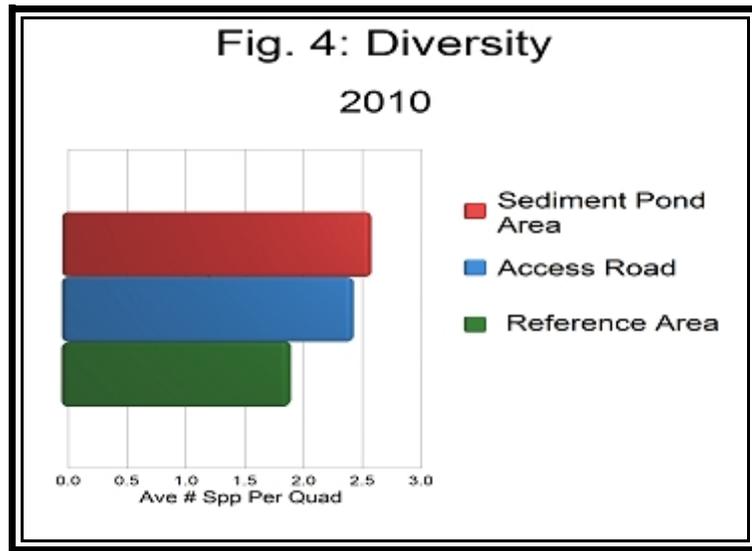
Similarly, the reference area density was also greater than the Reclaimed Sediment Pond Access Road, but statistical comparisons suggest the differences were significant in this case (Table 11-B).

Diversity Comparisons

Two different diversity indices were also compared between the reclaimed and reference areas. MacArthur's Index suggest both reclaimed areas were more diverse than the reference area (Fig. 3).



The average number of species per sample quadrat can also be used as a diversity index. When these values were calculated, the reclaimed areas again were more diverse than the reference area (Fig. 4).



SUMMARY & CONCLUSIONS

A portion of the areas that were disturbed by previous mining activities at the Des-Bee-Dove Mine site were reclaimed and re-seeded in 2006. Mined land operators have a 10-year time frame before an application can be submitted to acquire final bond release of an area that has been reclaimed. This time frame, called the *responsibility period* is thought to be long enough to judge whether or not reclaimed lands have met pre-set standards of revegetation success. State and federal regulations require the reestablished vegetation cover must be: a) diverse, effective, and permanent, b) the plant species be compatible with the approved post-mining land use, c) will have the same seasonal characteristics of growth as the original vegetation, d) are capable of self-regeneration and plant succession and d) be compatible with the plant and animal species of the area.

In 2010, four years after reclamation and revegetation was accomplished, these areas were sampled to monitor the growth, establishment, and current condition of the re-established vegetation. Quantitative sampling demonstrated that the Reclaimed Sediment Pond Area and Reclaimed Sediment Pond Access Road had as much or more total living **cover** than the undisturbed site chosen to represent final revegetation success, the Saltbush Shrub Reference Area. Additionally, the sampling shows that in one area, the Reclaimed Sediment Pond Area, the woody species **density** was not significantly different than the reference area. Yet in another area, or the Reclaimed Sediment Pond Access Road, the reference area had significantly more woody plants per acre. When two different **diversity** indices compared the reclaimed areas with the reference areas, results suggested that the reclaimed areas were more diverse.

In conclusion, at the 4-year mark of the 10-year *responsibility period* the data suggest that, although final revegetation standards may not be fully met at this time, the reestablished vegetation in the reclaimed areas at the Des-Bee-Dove mine site is progressing well and expected to achieve final revegetation success at the end of the responsibility period.

SUMMARY TABLES

Table 1: Des-Bee-Dove Mine Site. Total cover, standard deviation and frequency by species (2010).

Reclaimed Sediment Pond Area			n=40
	Mean Percent	Standard Deviation	Percent Frequency
SHRUBS			
<i>Atriplex canescens</i>	13.13	17.81	50.00
<i>Atriplex confertifolia</i>	1.00	4.90	5.00
<i>Atriplex gardneri</i>	2.25	7.66	10.00
<i>Bassia prostrata</i>	0.88	3.52	7.50
<i>Ceratoides lanata</i>	1.38	3.35	17.50
<i>Chrysothamnus nauseosus</i>	1.50	4.77	10.00
<i>Gutierrezia sarothrae</i>	0.63	2.29	7.50
FORBS			
<i>Bassia scoparia</i>	1.75	7.29	7.50
<i>Eriogonum gordonii</i>	0.50	3.12	2.50
<i>Halogeton glomeratus</i>	3.63	8.14	27.50
<i>Malcomia africana</i>	0.38	1.73	5.00
<i>Salsola tragus</i>	0.25	1.56	2.50
GRASSES			
<i>Agropyron cristatum</i>	1.50	4.64	10.00
<i>Bromus tectorum</i>	0.13	0.78	2.50
<i>Elymus cinereus</i>	6.63	11.26	32.50
<i>Elymus lanceolatus</i>	2.75	4.99	30.00
<i>Elymus smithii</i>	1.75	4.94	15.00
<i>Stipa hymenoides</i>	1.63	4.09	15.00

Table 2: Des-Bee-Dove Mine Site. Total Cover and composition (2010).

Reclaimed Sediment Pond Area		n=40
	Mean Percent	Standard Deviation
A. TOTAL COVER		
Total Living Cover	41.63	11.53
Litter	9.50	5.10
Bareground	29.63	10.51
Rock	19.25	6.67
B. % COMPOSITION		
Shrubs	45.61	33.25
Forbs	16.54	31.44
Grasses	37.84	32.66

Table 3: Des-Bee-Dove Mine Site. Woody Species Density (2010).

Reclaimed Sediment Pond Area		n=40
SPECIES	Number/Acre	
<i>Atriplex canescens</i>	1417.12	
<i>Atriplex confertifolia</i>	251.14	
<i>Atriplex corrugata</i>	17.94	
<i>Atriplex gardneri</i>	412.58	
<i>Bassia prostrata</i>	197.32	
<i>Ceratoides lanata</i>	287.01	
<i>Chrysothamnus nauseosus</i>	125.57	
<i>Gutierrezia sarothrae</i>	125.57	
<i>Sarcobatus vermiculatus</i>	35.88	
TOTAL	2870.11	

Table 4: Des-Bee-Dove Mine Site. Total cover, standard deviation and frequency by species (2010).

Reclaimed Sediment Pond Access Road			n=80
	Mean Percent	Standard Deviation	Percent Frequency
SHRUBS			
<i>Artemisia nova</i>	1.00	4.83	5.00
<i>Atriplex canescens</i>	2.88	7.28	16.25
<i>Atriplex confertifolia</i>	1.09	4.68	6.25
<i>Atriplex gardneri</i>	3.73	10.46	13.75
<i>Bassia prostrata</i>	6.06	12.93	30.00
<i>Ceratoides lanata</i>	0.41	1.48	7.50
<i>Chrysothamnus nauseosus</i>	2.46	7.50	15.00
<i>Eriogonum corymbosum</i>	0.31	2.28	2.50
<i>Gutierrezia sarothrae</i>	2.31	5.86	17.50
<i>Sarcobatus vermiculatus</i>	1.25	5.94	5.00
FORBS			
<i>Eriogonum bicolor</i>	0.06	0.56	1.25
<i>Halogeton glomeratus</i>	4.89	10.90	26.25
<i>Linum lewisii</i>	1.06	2.70	15.00
<i>Machaeranthera canescens</i>	0.65	2.60	6.25
<i>Malcomia africana</i>	0.19	1.67	1.25
<i>Salsola tragus</i>	0.56	3.26	3.75
GRASSES			
<i>Agropyron cristatum</i>	0.25	2.22	1.25
<i>Bromus inermis</i>	0.06	0.56	1.25
<i>Elymus cinereus</i>	0.31	1.99	2.50
<i>Elymus lanceolatus</i>	2.79	5.87	26.25
<i>Elymus salinus</i>	0.56	5.00	1.25
<i>Elymus smithii</i>	2.60	5.01	27.50
<i>Stipa hymenoides</i>	0.64	2.29	10.00

Table 5: Des-Bee-Dove Mine Site. Total Cover and composition (2010).

Reclaimed Sediment Pond		n=80
Access Road		
	Mean Percent	Standard Deviation
A. TOTAL COVER		
Total Living Cover	36.13	16.09
Litter	8.80	5.07
Bareground	33.06	15.20
Rock	21.90	8.60
B. % COMPOSITION		
Shrubs	55.67	36.88
Forbs	22.37	30.95
Grasses	21.96	28.29

Table 6: Des-Bee-Dove Mine Site. Woody Species Density (2010).

Reclaimed Sediment Pond		n=80
Access Road		
SPECIES	Number/Acre	
<i>Artemisia nova</i>	65.51	
<i>Atriplex canescens</i>	216.67	
<i>Atriplex confertifolia</i>	176.36	
<i>Atriplex corrugata</i>	5.04	
<i>Atriplex gardneri</i>	196.52	
<i>Bassia prostrata</i>	251.94	
<i>Ceratoides lanata</i>	115.89	
<i>Chrysothamnus nauseosus</i>	211.63	
<i>Eriogonum corymbosum</i>	25.19	
<i>Gutierrezia sarothrae</i>	297.29	
<i>Juniperus osteosperma</i>	10.08	
<i>Pinus edulis</i>	10.08	
<i>Sarcobatus vermiculatus</i>	30.23	
TOTAL	1612.43	

Table 7: Des-Bee-Dove Mine Site. Total cover, standard deviation and frequency by species (2010).

Saltbush Shrub Reference Area			n=40
	Mean Percent	Standard Deviation	Percent Frequency
SHRUBS			
<i>Atriplex confertifolia</i>	5.00	8.94	30.00
<i>Atriplex gardneri</i>	10.25	14.77	45.00
<i>Chrysothamnus nauseosus</i>	0.38	2.34	2.50
<i>Chrysothamnus viscidiflorus</i>	0.75	3.46	5.00
<i>Eriogonum corymbosum</i>	2.45	5.88	17.50
<i>Gutierrezia sarothrae</i>	0.13	0.78	2.50
<i>Sarcobatus vermiculatus</i>	1.00	4.21	7.50
FORBS			
<i>Calochortus nuttallii</i>	0.13	0.78	2.50
<i>Stanleya pinnata</i>	0.13	0.78	2.50
GRASSES			
<i>Elymus salinus</i>	14.93	12.52	75.00

Table 8: Des-Bee-Dove Mine Site. Total Cover and composition (2010).

Saltbush Shrub Reference Area		
	Mean Percent	Standard Deviation
n=40		
A. TOTAL COVER		
Total Living Cover	35.13	11.43
Litter	9.93	4.10
Bareground	36.13	18.15
Rock	18.83	12.63
B. % COMPOSITION		
Tress & Shrubs	57.82	34.49
Forbs	0.67	3.00
Grasses	41.52	34.06

Table 9: Des-Bee-Dove Mine Site. Woody Species Density (2010).

Saltbush Shrub Reference Area	
SPECIES	Number/Acre
n=40	
<i>Atriplex confertifolia</i>	1200.87
<i>Atriplex gardneri</i>	1547.27
<i>Chrysothamnus nauseosus</i>	69.28
<i>Chrysothamnus viscidiflorus</i>	115.47
<i>Eriogonum corymbosum</i>	484.97
<i>Gutierrezia sarothrae</i>	46.19
<i>Juniperus osteosperma</i>	23.09
<i>Pinus edulis</i>	23.09
<i>Sarcobatus vermiculatus</i>	161.66
<i>Suaeda torreyana</i>	23.09
TOTAL	3694.98

TABLE 11: Statistical Summary. Student's t-test comparing **woody species density of the reclaimed areas with the reference area (2010).**

A.			
RECLAIMED SEDIMENT POND AREA			
Density	\bar{x} =2870.11	s= 2459.14	n=40
SALTBUSH SHRUB REFERENCE AREA			
Density	\bar{x} =3694.98	s=2100.63	n=40
STATISTICAL ANALYSES			
Density	t=1.6131	df=78	SL=NS
B.			
RECLAIMED SEDIMENT POND ACCESS ROAD			
Density	\bar{x} =1612.43	s=3252.08	n=80
SALTBUSH SHRUB REFERENCE AREA			
Density	\bar{x} =3694.98	s=2100.63	n=40
STATISTICAL ANALYSES			
	t=3.6803	df=118	SL=p<0.05
\bar{x} = sample mean, s = sample standard deviation, n = sample size, nMIN= minimum adequate sample (@ 90% ± .10) NS = non-significant, t = Student's t-value, df = degrees of freedom, SL = significance level, p = probability level			

COLOR PHOTOGRAPH OF THE SAMPLE AREAS

RECLAIMED SEDIMENT POND AREA





RECLAIMED SEDIMENT POND ACCESS





SALTBUSH SHRUB REFERENCE AREA



MAPS

(Add Map 1 here)

(Add Map 2 here)