

**VEGETATION MONITORING
FOR PHASE III BOND RELEASE
AT THE GORDON CREEK 2/7/8 MINES
YEAR 1: 2009**

**FOR
MOUNTAIN COAL COMPANY, LLC**



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INTRODUCTION

General Site Description

The Gordon Creek 2/7/8 Mine site is located in the Bryner Canyon and Beaver Creek area of Carbon County, Utah. Elevation of the area is about 8,000 ft above sea level. The study area is shown on the Jump Creek USGS 7.5 minute series quadrangle map in Section 18, Township 13 South, Range 8 East (Figure 1). General plant communities surrounding the area include Mountain Brush/Grass, Oak Shrubland, Sagebrush/Grass, Aspen, and Douglas Fir.

Gordon Creek 2/7/8 is an area where coal mining had been conducted for many years. More recently, the area has been reclaimed and the land restored to a condition that is consistent with the pre-mining and post-mining land uses, or primarily livestock grazing. The post-mining land use of the site following final reclamation was determined by the landowner.

Once the mine portals were sealed during reclamation activities, earthwork operations began to return the area back to its approximate original topography. Final seeding was accomplished using seeds of native and approved introduced plant species (see Figure 2). Final seedbed preparations and seeding for most of the area occurred in October 1998 with follow-up seeding on the regraded roads in October 1999.

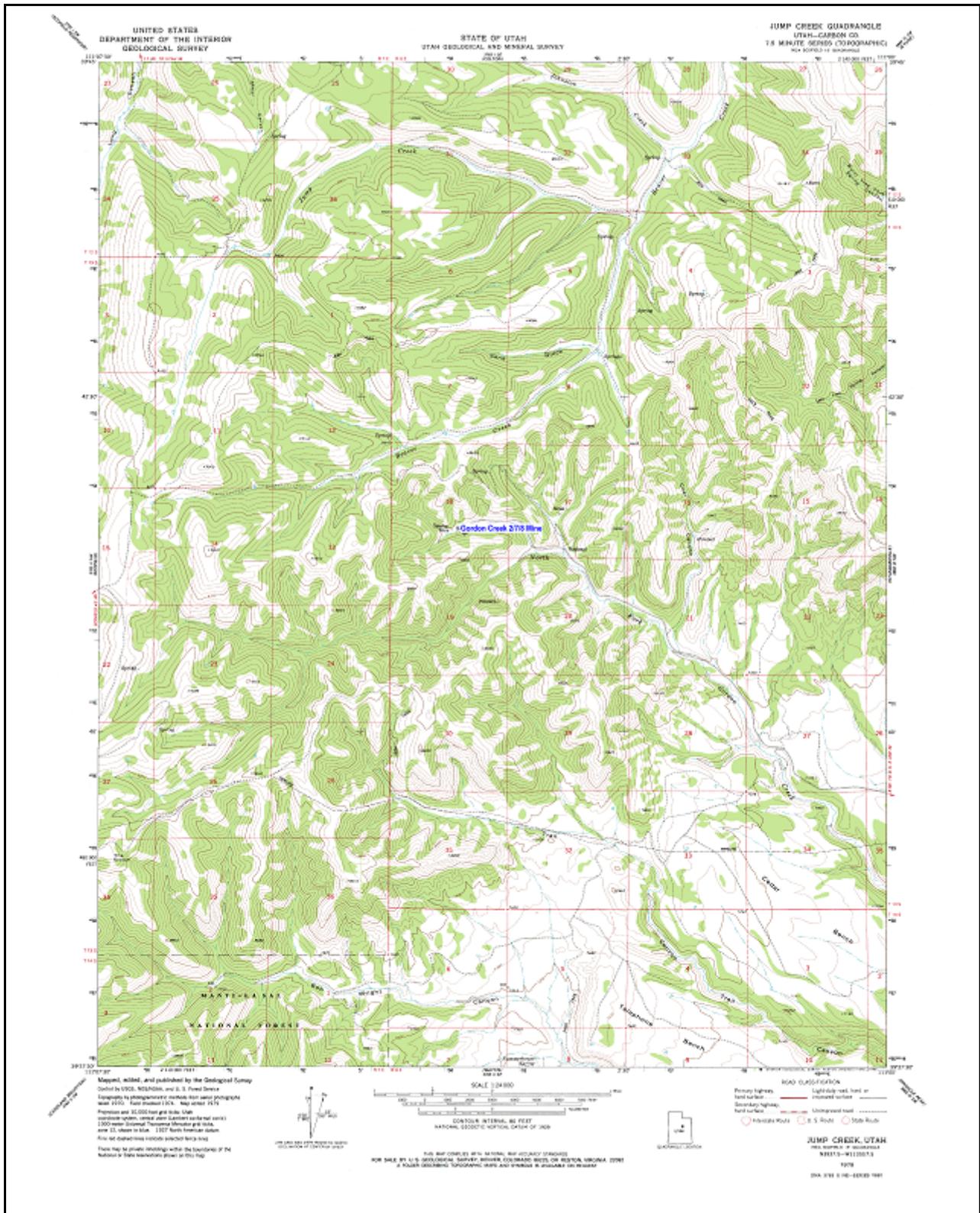


Figure 1: Gordon Creek 2/7/8 Mine Study Area

Study Objectives

This report describes the findings of quantitative sampling the vegetation at Gordon Creek 2/7/8 Mine site in 2009. The site has been reclaimed long enough that the “*Responsibility Period*” of the mine operator has passed. This means that theoretically enough time has passed for vegetation to become adequately establishment on reclaimed land.

After that time period, an application for bond release can be initiated. Thus, Mountain Coal Company may soon submit the application for *Final* or *Phase III Bond Release* through the State of Utah, Division of Oil, Gas and Mining (DOG M). Vegetation sampling in 2009 was conducted with that in mind. Because sample adequacy and statistical analyses meet the required levels, this dataset can be used as “**Year 1**” of the two consecutive years of vegetation monitoring required to apply for final bond release.

<u>COMMON NAME</u>	<u>SCIENTIFIC NAME</u>
SHRUBS	
Bitterbrush	(<i>Purshia tridentata</i>)
Mtn. Mahogany	(<i>Cercocarpus ledifolius</i>)
Rubber rabbitbrush	(<i>Chrysothamnus nauseosus</i>)
Blue elderberry	(<i>Sambucus caerulea</i>)
Snowberry	(<i>Symphoricarpos albus</i>)
Sagebrush	(<i>Artemisia tridentata</i> ssp. <i>vaseyana</i>)
FORBS	
Northern sweetvetch	(<i>Hedysarum boreale</i>)
Cicer milkvetch	(<i>Astragalus cicer</i>)
Purple daisy fleabane	(<i>Erigeron corymbosus</i>)
Little sunflower	(<i>Helianthella uniflora</i>)
Rocky Mt. penstemon	(<i>Penstemon strictus</i>)
Yellow sweet clover	(<i>Melilotus officinalis</i>)
Alfalfa (Ladak)	(<i>Medicago sativa</i>)
Pacific Aster	(<i>Aster chilensis</i>)
GRASSES	
Thickspike wheatgrass	(<i>Elymus lanceolatus</i>)
Bluebunch wheatgrass	(<i>Elymus spicatus</i>)
Slender wheatgrass	(<i>Elymus trachycaulus</i>)
Indian ricegrass	(<i>Stipa hymenoides</i>)
Gt. Basin wildrye	(<i>Elymus cinereus</i>)

Figure 2: Final Seed Mixture for the Gordon Creek 2/7/8 Mine Site

Reference Area

A reference area, or a native undisturbed Mountain Brush/Grass plant community that was previously chosen to be represent success standards for final revegetation has also been sampled. These data have been compared with the reclaimed areas of the Gordon Creek 2/7/8 Mine site.

METHODS

Quantitative and qualitative data were taken from the vegetation of the reclaimed areas at the Gordon Creek 2/7/8 Mine site as well as the Mountain Brush/Grass Reference Area. Sampling was conducted September 6-9, 2009. Methodologies used for sampling were performed in accordance with the *Vegetation Information Guidelines* supplied by DOGM.

Transect and Quadrat Placement

Random/regular placement of sample quadrats were designed in an attempt to provide unbiased accuracy of the data compiled. This was accomplished by establishing transect lines the entire length of the reclaimed and reference areas. At regular intervals along the transect lines, random numbers were generated and used to measure distances at right angles to determine sample locations. Whether these random numbers were odd or even determined which side of the transect a given quadrat was placed. The random number selected would be high enough to place quadrats to the lateral limits of the sample areas and all areas in-between. This insured that

the sample quadrats were placed randomly over the entire study area in an attempt to adequately represent the site as a whole

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).

Production

Total annual biomass production was estimated by clipping, drying and weighing current annual growth in each sample quadrat. "Double sampling" methods were employed by placing four additional quadrats around the clipped quadrat, then estimating the production of them relative to the clipped plot. Herbaceous and woody species production weights were recorded separately.

Sample Size & Adequacy

Sampling adequacy was calculated using the formula given below.

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

where,

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

The values used for “t” and “d” insured that sample adequacy was met with 90% confidence within a 10% deviation from the true mean.

Diversity Indices

MacArthur's Diversity Index is an effective diversity measurement and is computed using the following equation:

$$1/\sum pi^2$$

where,

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.

Another diversity measurement was provided that shows the average number of species encountered at each quadrat. Finally, a third measure of diversity or “richness” is simply the total number of species encountered in the quadrats.

Photographs

Color photographs of the sample areas were taken at the time of sampling and have been included within this report.

Raw Data

The raw data for total cover, cover by species, frequency and composition are available upon request from DOGM or Mountain Coal Company.

RESULTS

Reclaimed Areas

The reclaimed areas were greatly dominated by the forb species, alfalfa (*Medicago sativa*), however, there were also several grasses that were well-represented including Gt. Basin wildrye (*Elymus cinereus*), thickspike wheatgrass (*E. lanceolatus*), western wheatgrass (*E. smithii*), bluebunch wheatgrass (*E. spicatus*) and Kentucky bluegrass (*Poa pratensis*). For a list of all species present in the sample quadrats, refer to Table 1.

Table 1: Gordon Creek 2/7/8 Mine. Total cover, standard deviation and frequency by species (2009).

Reclaimed Areas (n=150)	Mean Percent	Standard Deviation	Percent Frequency
SHRUBS			
<i>Artemisia tridentata</i>	0.30	2.33	2.00
<i>Chrysothamnus nauseosus</i>	1.70	7.52	5.33
<i>Gutierrezia sarothrae</i>	0.17	1.46	1.33
<i>Purshia tridentata</i>	0.13	1.63	0.67
<i>Symphoricarpos oreophilus</i>	0.27	1.98	2.00
FORBS			
<i>Astragalus cicer</i>	2.63	10.86	12.00
<i>Cynoglossum officinale</i>	0.80	3.52	6.00
<i>Hedysarum boreale</i>	0.13	1.15	1.33
<i>Linum lewisii</i>	0.07	0.81	0.67
<i>Medicago sativa</i>	33.53	29.18	72.00
<i>Penstemon strictus</i>	1.27	4.59	9.33
GRASSES			
<i>Agropyron cristatum</i>	1.17	5.58	5.33
<i>Bromus carinatus</i>	0.13	1.15	1.33
<i>Bromus tectorum</i>	0.03	0.41	0.67
<i>Dactylis glomeratus</i>	0.27	2.37	1.33
<i>Elymus cinereus</i>	7.77	15.52	29.93
<i>Elymus lanceolatus</i>	6.53	12.83	26.67
<i>Elymus salinus</i>	1.43	6.36	6.00
<i>Elymus smithii</i>	5.55	14.13	19.33
<i>Elymus spicatus</i>	4.31	11.17	16.67
<i>Poa pratensis</i>	3.57	10.84	12.67

Total living cover of the reclaimed areas was estimated at 71.77%, all of which came from understory cover (Table 2-A). Although much the composition (51.98%) was comprised of forb species (mostly due to alfalfa), grasses were ranked close behind (44.09%). Shrubs followed at a distant 3.93% of the composition (Table 2-B).

Table 2: Gordon Creek 2/7/8 Mine. Total cover, standard deviation and sample size (2009).

Reclaimed Areas (n=150; nMIN= 6.31)	Mean Percent	Standard Deviation
A. TOTAL COVER		
Understory	71.77	10.96
Litter	9.84	5.78
Bareground	9.25	6.12
Rock	9.14	6.35
B. % COMPOSITION		
Shrubs	3.93	12.77
Forbs	51.98	34.17
Grasses	44.09	31.29
nMIN = Sample Adequacy n= Sample Size		

Total annual biomass production of the reclaimed areas was estimated at 1,164.24 pounds per acre of which 1,138.88 pounds came from herbaceous species (forbs and grasses) and only 25.26 pounds came from woody plants (Table 3).

Table 3: Production at Gordon Creek 2/7/8 (2009).		
Reclaimed Areas (n=150; nMIN=40.12)		
	Pounds/Acre	
LIFEFORM	MEAN	STD. DEV.
Herbaceous	1138.88	471.59
Woody	25.36	114.03
TOTAL	1164.24	448.29

Reference Area

The dominant plant by cover and frequency at the Mountain Brush/Grass Reference Area was the grass species Salina wildrye (*Elymus salinus*). There were four shrub species that were also

relatively common here including alder-leaf mountain-mahogany (*Cercocarpus montanus*), corymb buckwheat (*Eriogonum corymbosum*), broom snakeweed (*Gutierrezia sarothrae*) and antelope bitterbrush (*Purshia tridentata*). Forb species were relatively uncommon in the reference area (Table 4).

Table 4: Gordon Creek 2/7/8 Mine. Total cover, standard deviation and frequency by species (2009).

Mountain Brush/Grass Reference Area (n=90; nMIN= 23.37)	Mean Percent	Standard Deviation	Percent Frequency
OVERSTORY			
<i>Cercocarpus montanus</i>	0.22	2.10	1.11
UNDERSTORY			
SHRUBS			
<i>Amelanchier utahensis</i>	1.11	4.82	7.78
<i>Artemisia frigida</i>	0.11	1.05	1.11
<i>Artemisia tridentata</i> var. <i>vaseyana</i>	0.72	4.69	3.33
<i>Cercocarpus montanus</i>	3.17	7.17	20.00
<i>Eriogonum corymbosum</i>	2.83	8.43	15.56
<i>Gutierrezia sarothrae</i>	1.56	2.95	23.33
<i>Purshia tridentata</i>	1.22	4.55	11.11
<i>Symphoricarpos oreophilus</i>	0.17	1.57	1.11
FORBS			
<i>Eriogonum jamesii</i>	0.56	1.89	8.89
<i>Machaeranthera grindelioides</i>	0.11	0.74	2.22
<i>Stanleya pinnata</i>	0.17	0.90	3.33
GRASSES			
<i>Elymus salinus</i>	28.72	11.04	98.89
<i>Stipa hymenoides</i>	0.44	4.19	1.11

The total living cover for the Reference Area was 41.11% (Table 5-A). Most of this cover was understory cover (there was only 0.22% cover that consisted of overstory). The understory cover was comprised of 73.65% grasses, 24.00% shrubs and 2.35% grasses (Table 5-B).

Table 5: Gordon Creek 2/7/8 Mine. Total cover, standard deviation and sample size (2009).

Mountain Brush/Grass Reference Area (n=90 nMIN= 33.91)	Mean Percent	Standard Deviation
A. TOTAL COVER		
Overstory (o)	0.22	2.10
Understory (u)	40.89	11.73
Litter	14.33	5.44
Bareground	21.44	11.84
Rock	23.33	12.32
o + u	41.11	12.08
B. % COMPOSITION		
Shrubs	24.00	23.56
Forbs	2.35	6.17
Grasses	73.65	23.85

Total annual biomass production of the reference area was estimated at 850.05 pounds per acre of which 603.39 pounds came from herbaceous species and 246.66 came from woody plants (Table 6).

Table 6: Production at Gordon Creek 2/7/8 (2009).		
Mountain Brush/Grass Reference Area (n=90)		
	Pounds/Acre	
LIFEFORM	MEAN	STD. DEV.
Herbaceous	603.39	222.68
Woody	246.66	252.20
TOTAL	850.05	300.91

Dataset Comparisons

Comparisons were made between the datasets of the reclaimed areas at Gordon Creek 2/7/8 and the Mountain Brush/Grass Reference Area . To begin, statistical tests were implemented comparing the total living plant cover of the two areas. A Student's t-test analysis suggested that the reclaimed area's total living cover was significantly greater statistically when it was compared to the reference area (Figure 3).

FIGURE 3. STUDENT'S T TEST - A total living cover comparison between the reclaimed area at Gordon Creek 2/7/8 and its reference area (2009).

Reclaimed Area: $\bar{x}=71.77$; $s=10.96$; $n=150$

Reference Area: $\bar{x}=41.11$; $s=12.08$; $n=90$

$t = 20.186$; $df = 238$, $SL= p<0.01$

When total annual biomass production of the reclaimed area was statistically compared to that of the reference area, results also suggested there was significantly more in the former (Figure 4).

FIGURE 4. STUDENT'S T TEST - A total annual biomass production comparison between the reclaimed area at Gordon Creek 2/7/8 and its reference area (2009).

Reclaimed Area: $\bar{x}=1164.24$; $s=448.29$; $n=150$

Reference Area: $\bar{x}=850.05$; $s=300.91$; $n=90$

$t = 5.897$; $df = 238$, $SL= p<0.01$

MacArthur's Diversity Index was also employed to the datasets of the reclaimed and reference areas. A comparison of the values between these two areas suggested that the total diversity of the reclaimed area was greater than

that of the reference area by quite a wide margin (Figure 5).

Another method of comparing species diversity of the two areas was to simply calculate the mean number of species present in the sample quadrats. Results from this method also

suggested that the reclaimed area was more diverse with respect to species when compared to the reference area (Figure 6).

FIGURE 5. MacARTHUR'S INDEX - A **diversity** comparison between the reclaimed area at Gordon Creek 2/7/8 and its reference area (2009).

$$1/\sum pi^2 =$$

Reclaimed Area: 6.780

Reference Area: 3.474

FIGURE 6. AVERAGE NUMBER OF SPECIES PER SQUARE METER - A **diversity** comparison between the reclaimed area at Gordon Creek 2/7/8 and its reference area (2009).

$$\bar{x} \text{ NO. SPP/M}^2 =$$

Reclaimed Area: 2.33

Reference Area: 1.98

Finally, another diversity-type computation, the total number of species encountered in the sample quadrats, were compared. Again, the reclaimed area value was greater when compared to the reference area (Figure 7).

FIGURE 7. TOTAL SPECIES PRESENT -
A **diversity** comparison between the
reclaimed area at Gordon Creek 2/7/8 and its
reference area (2009).

Reclaimed Area: 21

Reference Area: 13

DISCUSSION & CONCLUSIONS

Subsequent to final reclamation, the primary post-mining land use as determined by the land owner, will primarily be that of grazing by domestic livestock. Consequently, Gordon Creek's Mining and Reclamation (MRP) identifies "*stock grazing*" as the post-mining land use, but it also mentions that "*reclamation is also particularly important as a means of controlling erosion and restoring disturbed areas to productive wildlife habitat*".

Because the primary post-mining land was to be focused on livestock grazing, the parameters to be used for final revegetation success standards dictated in the MRP were **total living cover** and **annual biomass productivity**. Sample results in 2009 show that the total living cover and biomass productivity of the reclaimed area exceeded that of the reference area.

Although they were not specifically called for in the MRP, other parameters were also compared herein to evaluate specific wildlife habitat qualities of the reclaimed land when compared to the reference area. These parameters were diversity indices because species and habitat diversity are important components for restoring wildlife habitat. The diversity indices employed to the datasets suggest that the reclaimed area was more diverse than the reference area in 2009.

SUMMARY

This document reports the results of quantitative sampling the vegetation of the reclaimed area at the Gordon Creek 2/7/8 Mine site. The datasets in this report represent **Year 1** of the two consecutive years required for an application for final bond release to be submitted through the State of Utah, Division of Oil, Gas & Mining (DOG M). A reference area was chosen early in the process to one day provide an area for comparison for future revegetation success standards. This Mountain Brush/Grass Reference Area was also sampled and the results were reported in this document.

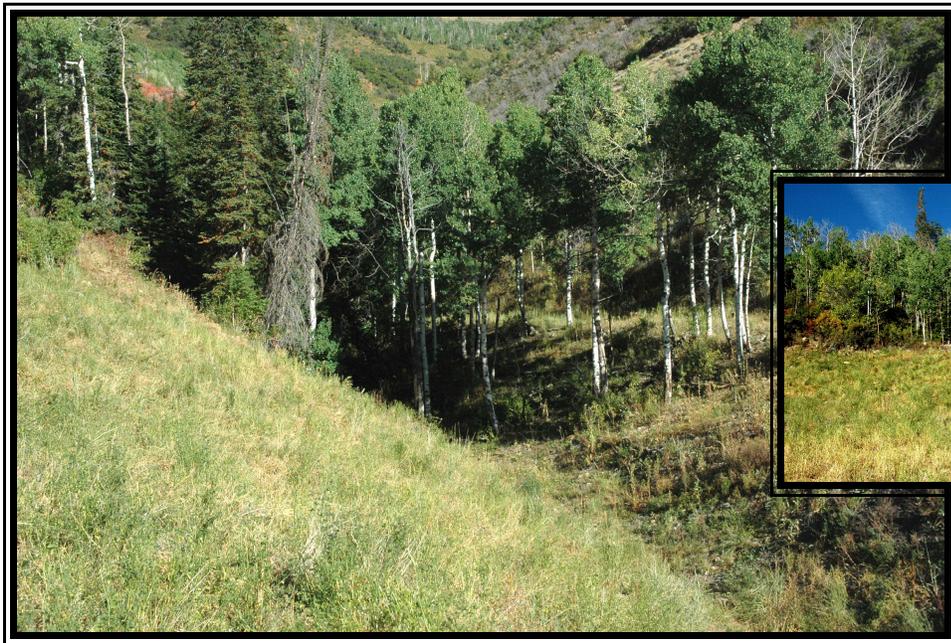
For **Year 1** (2009), when the total living cover, annual biomass production, MacArthur's Divisity Index, average number of species per quadrat and the total number of species of the reclaimed areas were compared with the reference area, all analyses suggested the reclaimed areas met or exceeded those parameters.

Year 2 (2010) sample period will be conducted to meet the required number of sample years for a Phaze III Bond Release application.

**COLOR PHOTOGRAPHS
OF THE
SAMPLE AREAS**

THE RECLAIMED AREAS









THE REFERENCE AREA

