

# 2007 Present Landfill and Original Landfill Revegetation Monitoring

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## Introduction

The Rocky Flats Site (Site), a U.S. Department of Energy facility, is located near Golden, Colorado. For nearly 40 years during the Cold War, the Site produced nuclear weapons components and was an integral part of the United States' nuclear weapons program. In the early 1990s the Site was shut down, and cleanup and closure activities began. As part of the cleanup and closure of the Site, the buildings, roads, and other infrastructure in the Industrial Area were removed. At the conclusion of the Present Landfill (PLF) and Original Landfill (OLF) projects, both areas were revegetated with native plant species to provide a vegetation cover on each landfill. As part of the revegetation process, monitoring is conducted to evaluate the status of the vegetation. The *Rocky Flats, Colorado, Site Revegetation Plan* (Revegetation Plan; DOE 2005) provides initial success criteria for revegetation areas at the Site. As stated in the plan, the success criteria are simply initial guidance and may be modified using professional judgment, scientific data, and common sense to determine whether the vegetation establishment at a given location is acceptable. This report summarizes the revegetation monitoring results for data collected at the PLF and OLF during 2007.

## Methods

Semiquantitative revegetation monitoring was conducted during late summer to evaluate the establishment of vegetation at the PLF and OLF in 2007. The PLF was divided into three revegetation sampling units—two on the cover and one on the east face (Figure 1). The OLF was sampled as one unit (Figure 1). Within each revegetation unit, sample locations were randomly generated in the Geographic Information System and then located on the ground for monitoring. Quadrats of 50 centimeters  $\times$  100 centimeters were used to sample the vegetation. Fifteen quadrats were sampled on each half of the cover at the PLF, and an additional 10 quadrats were sampled on the east face of the PLF. The top of the cover was divided approximately in half because the eastern and western areas differed somewhat in the soil materials that were placed on each half. The sampling was designed to see if there was a difference in the vegetation as a result of the soil differences. The OLF had a total of 29 quadrats sampled across the face of the cover in 2007. At each quadrat, both species richness and species cover were sampled. A species was listed as present for a quadrat if any part of the plant was located within or overhung inside the quadrat boundary. Cover was estimated for each species using the following cover class system and midpoints (in parentheses): 1 = <5% (2.5%), 2 = 6–25% (15%), 3 = 26–50% (37.5%), 4 = 51–75% (62.5%), 5 = 75–95% (85%), 6 = >95% (97.5%).

Species lists were generated for each revegetation unit by combining all the quadrat data for that unit. Foliar cover by species was averaged across all the quadrats sampled for each revegetation unit. Midpoints of each cover class were used for analysis. Foliar cover data are reported as the percent absolute cover and percent relative cover for each species encountered. The percent absolute foliar cover was calculated as the sum of all cover values for a species in a revegetation unit divided by the number of quadrats sampled in that unit. Relative foliar cover was calculated

as the sum of all cover values for a particular species in a revegetation unit divided by the sum of all cover values for all species in the same revegetation unit, multiplied by 100.

## Results and Discussion

Table 1 presents the species richness in 2007 at both the PLF and OLF. Total species richness was 34 species at the PLF and 25 species at the OLF. The difference in numbers between the PLF and OLF is largely related to the environmental conditions at each location. The OLF is on a south-facing hillside, where soil is much drier than soil at the PLF. The 2006 drought also affected the OLF more than the PLF as a result of the slope aspect. Therefore, germination and vegetation establishment has been less because of the harsher conditions. Also, the overabundance of erosion control materials initially installed on the OLF (straw with Flexterra applied on top) has hindered germination and establishment of the seeded species. Several locations still remain where the thickness of the erosion controls inhibits germination. Until this material breaks down, little growth is expected. Table 2 lists the species that were seeded at each landfill. At the PLF and OLF, a total of 8 and 5 seed species were present, respectively, in 2007. One of the success criteria in the Revegetation Plan states that at least 50 percent of the seeded species must be present in an area for it to be considered successful. Based on an evaluation by sampling location, only the western portion of the PLF cover did not meet this criterion in 2007 (Table 2).

Ground cover protection from rock, litter, and current-year live vegetation was above 95 percent at both the PLF and OLF (Table 3). The occasional value over 100 percent is a result of the cover class system used for estimating cover, which estimates cover values into a range and uses the midpoint of the cover class for analysis. Another success criterion outlined in the Revegetation Plan states that a minimum of 70 percent total ground cover consisting of litter cover, current-year live vegetation basal cover, and rock cover is to be present to help prevent erosion. At each of the locations on the PLF and OLF, most of the ground cover came from litter, of which a portion is represented by the erosion matting. In time, the litter cover will continue to remain the dominant ground cover, but it will come from dead plant material that becomes matted down, rather than from the erosion matting. The conclusion is that the covers at both landfills have substantial protection on the soil surface to prevent erosion.

A third success criterion outlined in the Revegetation Plan states that a minimum of 30 percent relative cover of desired species must be present. Table 1 summarizes the foliar cover data for the PLF and OLF by location for 2007. The shaded row titled Total Herbaceous Native Cover represents the percentage of desired species at each location. The relative cover values at individual locations that are higher than 30 percent are shaded, indicating that these locations have met this success criterion. This criterion was met at both the PLF and OLF in 2007. The dominant species on the cover of the PLF in 2007 were slender wheatgrass (*Agropyron caninum* [= *Agropyron trachycaulum*]), western wheatgrass (*Agropyron smithii*), buffalo grass (*Buchloe dactyloides*), and Canada bluegrass (*Poa compressa*). The east face of the PLF was dominated by slender wheatgrass, western wheatgrass, side-oats grama (*Bouteloua curtipendula*), and wild lettuce (*Lactuca serriola*). Weed cover from forbs on the PLF cover was not very high in 2007 because portions had been treated with Milestone (aminopyralid) in spring of 2006 and 2007 to keep the weeds down to allow for better establishment of the graminoids. Small amounts of diffuse knapweed (*Centaurea diffusa*), Canada thistle (*Cirsium arvense*), filaree (*Erodium cicutarium*), and downy brome (*Bromus tectorum*), all noxious weeds, were present on the landfill cover in 2007. On the east face of the PLF, diffuse knapweed was the only noxious weed

present. At the OLF, the dominant species were slender wheatgrass, western wheatgrass, and diffuse knapweed. Both the east face of the PLF and the face of the OLF are scheduled for weed control efforts in 2008.

A fourth success criterion outlined in the Revegetation Plan states that no single species shall comprise more than 45 percent of the total relative cover. The relative cover of slender wheatgrass on the west PLF area was 60 percent, and this area did not meet the success criterion in 2007 (Table 1). No other species comprised greater than 45 percent of the relative cover at either the PLF or OLF.

Table 4 presents a summary of the pass/fail criteria for each revegetation areas at the PLF and OLF monitored in 2007. Three of the four locations passed all four criteria in 2007. The only area that did not pass was the western portion of the PLF, which lacked the presence of greater than 50 percent of seeded species and had greater than 45 percent cover of slender wheatgrass. However, the criteria listed in the Revegetation Plan are an initial set of criteria established primarily for erosion protection. As stated in the Revegetation Plan, these "...criteria are provided as initial guidance; however, common sense combined with scientific data will need to be applied to final evaluations to determine whether further management actions are required at specific locations." The fact that three of the areas passed each of the criteria listed in the Revegetation Plan does not mean that the vegetation has established to a desirable level at either landfill as of 2007. A good, healthy stand of vegetation is desirable on both landfills to protect the covers and provide good erosion control. Proactive management of the revegetation areas is critical to success. These data are useful for making management decisions and they provide documentation of the successional changes at the revegetation locations. This documentation can be used to help improve revegetation techniques at the Site.

## Summary

Monitoring was conducted at PLF and OLF during 2007. Results indicate that the vegetation is in the early stages of establishment. Ground cover from vegetation, rock, and litter (including erosion controls) is protecting the soil from erosion. The drought in 2006 limited some vegetation establishment and growth, but additional growth was observed in 2007. Although three of the four locations monitored on the landfills met all four success criteria listed in the Revegetation Plan, vegetation has not established to the extent desired on either landfill as of 2007. Proactive management of the revegetation areas will be conducted to establish a good stand of vegetation on the landfills and help control undesirable species.

## References

DOE (U.S. Department of Energy), 2005. *Rocky Flats, Colorado, Site Revegetation Plan*, Office of Legacy Management, Grand Junction, Colorado, December.

USFWS (U.S. Fish and Wildlife Service), 1999. *Rocky Mountain Arsenal (RMA) National Wildlife Refuge Habitat Restoration Plan*, Rocky Mountain Arsenal National Wildlife Refuge, U.S. Department of the Interior, Commerce City, Colorado.

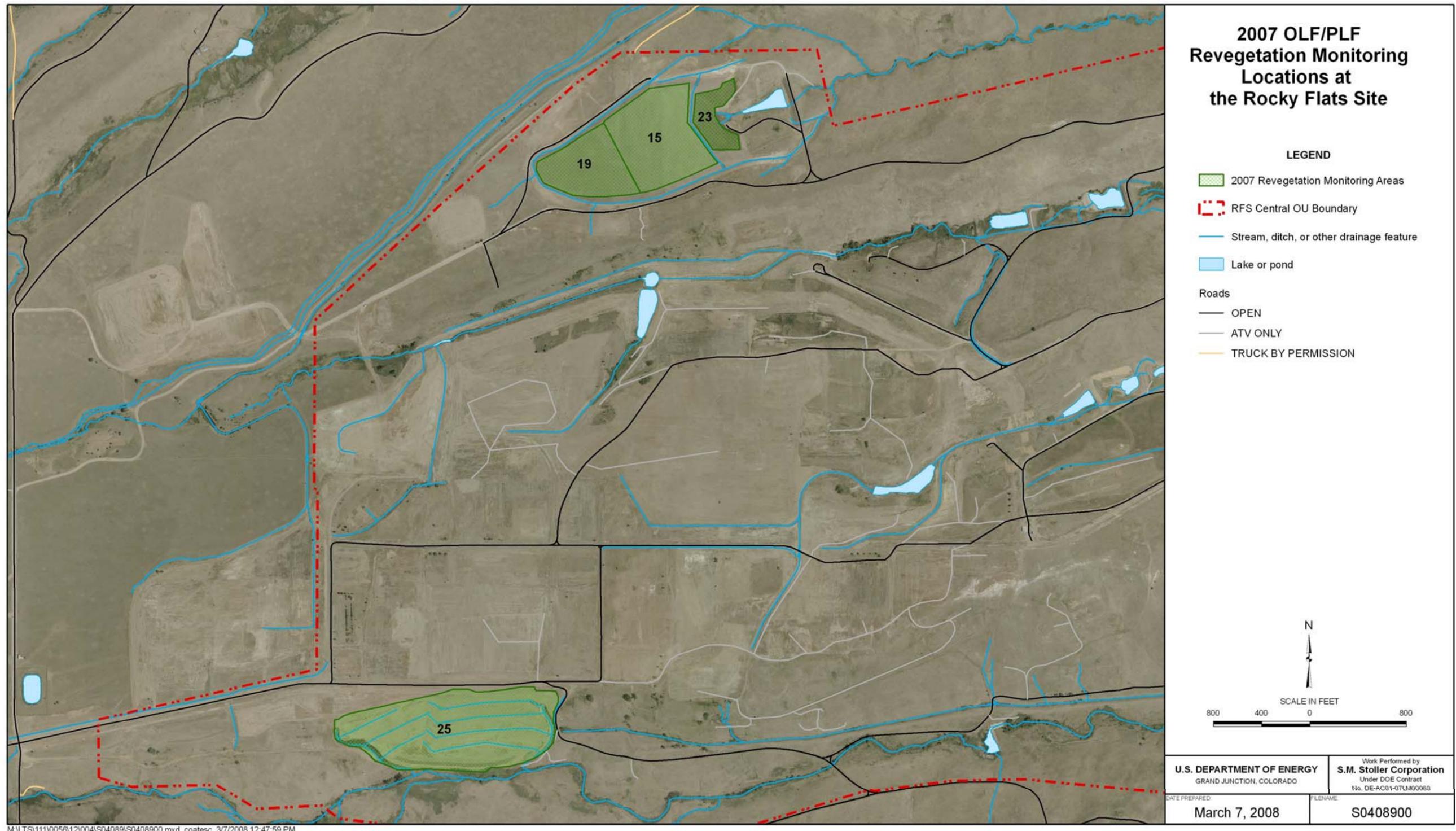


Figure 1. 2007 OLF/PLF Revegetation Monitoring Locations at the Rocky Flats Site.

Table 1. 2007 Species Richness and Foliar Cover Summary at PLF and OLF

Scientific Name	Speccode	Growth Form	Native	Cool/ Warm Season	Noxious Weed	East PLF Cover		West PLF Cover		East Face PLF		OLF Cover	
						A15		A19		A23		A25	
						Absolute Cover (%)	Relative Cover (%)						
Alyssum minus (L.) Rothmaler var. micranthus (C. A. Mey.) Dudley	ALMI1	F	N					0.2	0.3			0.6	1.7
Centaurea diffusa Lam.	CEDI1	F	N		X	0.3	1.0			1.8	7.8	3.9	10.8
Cirsium arvense (L.) Scop.	CIAR1	F	N		X	1.0	2.9						
Erodium cicutarium (L.) L'Her.	ERCI1	F	N		X			0.2	0.3			0.1	0.2
Kochia scoparia (L.) Schrad.	KOSC1	F	N									1.9	5.3
Lactuca serriola L.	LASE1	F	N			0.3	1.0			4.3	18.9	1.6	4.3
Melilotus alba Medic.	MEAL1	F	N									1.8	5.0
Melilotus officinalis (L.) Pall.	MEOF1	F	N			0.7	1.9					1.2	3.4
Salsola iberica Senn. & Pau.	SAIB1	F	N							1.5	6.7	1.6	4.6
Taraxacum officinale Weber	TAOF1	F	N			0.2	0.5					0.1	0.2
Thlaspi arvense L.	THAR1	F	N			0.2	0.5						
Tragopogon dubius Scop.	TRDU1	F	N			0.3	1.0						
Ambrosia psilostachya DC.	AMPS1	F	Y			0.5	1.4					0.1	0.2
Conyza canadensis (L.) Cronq.	COCA1	F	Y									0.2	0.5
Erigeron divergens T. & G.	ERDI1	F	Y			0.2	0.5						
Euphorbia serpyllifolia Pers.	EUSE1	F	Y							0.3	1.1		
Grindelia squarrosa (Pursh.) Dun.	GRSQ1	F	Y			0.2	0.5			1.5	6.7	0.2	0.5
Helianthus annuus L.	HEAN1	F	Y					0.2	0.3				
Verbena bracteata Lag. & Rodr.	VEBR1	F	Y			0.2	0.5						
Agropyron desertorum (Fisch.) Schult.	AGDE1	G	N	C				0.2	0.3				
Agrostis stolonifera L.	AGST1	G	N	C								0.1	0.2
Bromus japonicus Thunb. ex Murr.	BRJA1	G	N	C		1.2	3.4					0.2	0.5
Bromus tectorum L.	BRTE1	G	N	C	X	0.3	1.0	0.2	0.3			0.4	1.2
Dactylis glomerata L.	DAGL1	G	N	C				0.2	0.3				
Festuca pratensis Huds.	FEPR1	G	N	C		0.2	0.5						
Poa compressa L.	POCO1	G	N	C		2.2	6.3	7.3	12.9			0.5	1.4
Poa pratensis L.	POPR1	G	N	C				0.2	0.3				
Triticum aestivum L.	TRAE1	G	N	C								1.4	3.8
Setaria viridis (L.) Beauv.	SEVI1	G	N	W								0.2	0.5
Agropyron caninum (L.) Beauv. ssp. majus (Vasey) C. L. Hitchc.	AGCA1	G	Y	C		14.5	42.0	34.2	60.3	5.8	25.6	10.6	29.5
Agropyron griffithsii Scribn. & Smith	AGGR1	G	Y	C				2.3	4.1				
Agropyron smithii Rydb.	AGSM1	G	Y	C		5.5	15.9	4.5	7.9	4.3	18.9	7.0	19.4
Elymus canadensis L.	ELCA1	G	Y	C				1.0	1.8				
Hordeum jubatum L.	HOJU1	G	Y	C				1.3	2.4				
Koeleria pyramidata (Lam.) Beauv.	KOPY1	G	Y	C		0.3	1.0	2.2	3.8				
Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc.	SIHY1	G	Y	C								0.1	0.2
Stipa viridula Trin.	STVI1	G	Y	C		0.2	0.5	0.2	0.3				
Andropogon gerardii Vitman	ANGE1	G	Y	W		1.3	3.9	0.5	0.9				
Andropogon scoparius Michx.	ANSC1	G	Y	W								0.2	0.5
Bouteloua curtipendula (Michx.) Torr.	BOCU1	G	Y	W		1.2	3.4			3.0	13.3	1.6	4.3
Bouteloua gracilis (H. B. K.) Lag ex Griffiths	BOGR1	G	Y	W		0.2	0.5					0.2	0.5
Buchloe dactyloides (Nutt.) Engelm.	BUDA1	G	Y	W		3.5	10.1	2.0	3.5	0.3	1.1	0.4	1.2
Total Foliar Cover						34.5	100.0	56.7	100.0	22.5	100.0	35.9	100.0
Total Forb Cover						4.0	11.6	0.5	0.9	9.3	41.1	13.2	36.7
Total Non-Native Forb Cover						3.0	8.7	0.3	0.6	7.5	33.3	12.8	35.5
Total Native Forb Cover						1.0	2.9	0.2	0.3	1.8	7.8	0.4	1.2
Total Graminoid Cover						30.5	88.4	56.2	99.1	13.3	58.9	22.8	63.3
Total Non-Native Graminoid Cover						3.8	11.1	8.0	14.1	0.0	0.0	2.8	7.7
Total Native Graminoid Cover						26.7	77.3	48.2	85.0	13.3	58.9	20.0	55.6
Total Herbaceous Native Cover						27.7	80.2	48.3	85.3	15.0	66.7	20.4	56.8
Total Herbaceous Non-Native Cover						6.8	19.8	8.3	14.7	7.5	33.3	15.5	43.2
Total Warm-Season Graminoid Cover						6.2	17.9	2.5	4.4	3.3	14.4	2.5	7.0
Total Cool-Season Graminoid Cover						24.3	70.5	53.7	94.7	10.0	44.4	20.3	56.4
Total Noxious Weed Cover						1.7	4.8	0.3	0.6	1.8	7.8	4.4	12.2

Absolute Cover = The percentage of the number of hits on a species out of the total number of hits possible.  
Relative Cover = The percentage of the number of hits on a species out of the total number of vegetation hits.  
Native Categories: Y = Native, N = Non-Native  
Growth Form Categories: F = Forb, G = Graminoid  
Cool/Warm Season Categories: C = Cool-Season Graminoid, W = Warm-Season Graminoid  
Noxious Weed Category: X = Noxious Weed (listed on May 2006 Colorado State Noxious Weed List)  
Shaded cells indicate success criteria were met in 2007.

**Table 2. PLF and OLF Species Seeded By Location and 2007 Total Species Richness Summary**

Family	Scientific Name	East PLF Cover	West PLF Cover	East Face PLF	OLF Cover
		A15	A19	A23	A25
<b>Graminoids</b>					
POACEAE	Agropyron caninum	X	X	X	X
POACEAE	Agropyron dasystachum	X	X	X	X
POACEAE	Agropyron lanceolatus	X	X		
POACEAE	Agropyron smithii	X	X	X	X
POACEAE	Andropogon gerardii	X	X		
POACEAE	Andropogon scoparius				
POACEAE	Bouteloua curtipendula	X	X	X	X
POACEAE	Bouteloua gracilis	X	X	X	X
POACEAE	Buchloe dactyloides	X	X	X	X
POACEAE	Koleria pyrimidata	X	X		
POACEAE	Poa canbyi	X	X		
POACEAE	Sorghastrum nutans	X	X		
POACEAE	Sporobolus cryptandrus	X	X		
POACEAE	Stipa viridula	X	X	X	X
	Total # Species Seeded	13	13	7	7
	# Present in 2007	8	6	4	5
	% Seeded Species Present in 2007	62	46	57	71
	Total Species Richness in 2007	23	17	9	26

**Table 3. PLF and OLF Basal Cover Summary at Revegetation Locations**

<b>Location</b>	<b>Basal Vegetation Cover (%)</b>	<b>Litter Cover (%)</b>	<b>Rock Cover (%)</b>	<b>Total Ground Cover (%)*</b>	<b>Bare Ground (%)</b>
A15	12.3	49.2	45.0	106.5	0.0
A19	13.3	68.8	14.8	97.0	3.0
A23	3.5	87.8	11.0	102.3	0.0
A25	3.9	63.9	30.4	98.2	1.8

\* Numbers greater than 100 are an artifact of the sampling method using a cover class system and midpoints for analysis.  
The Total Ground Cover value is the sum of the Basal Vegetation Cover, Litter Cover, and Rock Cover.

**Table 4. 2007 PLF and OLF Success Criteria Evaluation Summary**

<b>Location</b>	<b>&gt;30% Relative Cover of Desired Species</b>	<b>&gt;70% Total Ground Cover (Litter, Rock, and Basal Veg Cover)</b>	<b>50% or More of Seeded Species Present</b>	<b>No Single Species With &gt;45% Relative Foliar Cover</b>	<b>PASS/FAIL</b>
A15	PASS	PASS	PASS	PASS	PASS
A19	PASS	PASS	FAIL	FAIL	FAIL
A23	PASS	PASS	PASS	PASS	PASS
A25	PASS	PASS	PASS	PASS	PASS