

2013 Revegetation Monitoring

Introduction

The Rocky Flats Site (Site), a U.S. Department of Energy (DOE) facility, is located near Golden, Colorado. For nearly 40 years during the Cold War, the facility produced nuclear weapons components and was an integral part of the United States' nuclear weapons program. In the early 1990s, the facility was shut down, and cleanup and closure activities began. As part of the cleanup and closure, the buildings, roads, and other infrastructure in the Industrial Area were removed. Approximately 650 acres were disturbed during cleanup activities, which were completed in fall 2005. The disturbed areas were revegetated to prevent erosion and sedimentation of the Site streams and to meet water quality standards. Reestablishment of native plant species is also beneficial to wildlife and provides desirable vegetation and ground cover adjacent to the Rocky Flats National Wildlife Refuge. As part of the revegetation process, monitoring is conducted to determine whether success criteria, as stated in the *Rocky Flats, Colorado, Site Revegetation Plan* (LMS/RFS/S04513) (Revegetation Plan) (DOE 2009), are being met, as well as to determine how these revegetation areas need to be managed.

The success criteria, as stated in the Revegetation Plan, are as follows:

- A minimum of 50 percent of the seeded native species will be present at the revegetation site.
- The revegetation site will have a minimum of 70 percent total ground cover that comprises litter cover, current-year live vegetation basal cover, and rock cover.
- The revegetation site will have a minimum of 30 percent relative foliar cover of live desired species (seeded or nonseeded native species). Relative cover is defined as the percentage of cover of a given species divided by the total amount of vegetation cover present.
Example: Species A has 20 percent absolute cover, and total vegetation cover (all individual species cover values summed) is 80 percent:

$$\text{Relative cover of Species A} = (20 \div 80) \times 100 = 25 \text{ percent}$$

- No single species will contribute more than 45 percent of the relative foliar cover (except in areas where dominance by a single species is appropriate for long-term wildlife and habitat management objectives).

This report summarizes the revegetation monitoring results for 2013. Each of the locations monitored in 2013 had previously met the success criteria. As part of the long-term stewardship of the Site, revegetation locations are monitored every few years to evaluate the long-term sustainability of the vegetation and the potential successional changes in plant community composition. Thirteen revegetation units were sampled in 2013 (Figure 1¹).

¹ Although the text refers to the revegetation units with a prefix of "L," (e.g., L1), the revegetation unit numbers are shown on Figure 1 without the "L".

Methods

Semi-quantitative revegetation monitoring was conducted during the summer 2013. The monitoring method provided in the Revegetation Plan, with some modification, was used. The revegetation areas were divided into units on the basis of geographic features (e.g., roads, streams) or previous building areas (e.g., 700 Area, 400 Area). The unit boundaries were the same as had been used for previous sampling efforts.

Within each revegetation unit, sample locations were randomly generated in the Geographic Information System and located on the ground using a GPS unit. Quadrats that measured 50 centimeters by 100 centimeters were used to sample the vegetation at each location. Depending on the size of the area, the number of quadrats sampled in each area varied from 10 to 30. A total of 255 quadrats were sampled in 2013 (Table 1).

At each quadrat, both species richness and species cover were assessed. A species was listed as present for a quadrat if any part of the plant was located within or overhung inside the quadrat boundary. Species lists were generated for each revegetation unit by combining the quadrat data for that unit.

Foliar cover was estimated for each species using the following cover class system and midpoints (in parentheses): 1 = ≤ 5 percent (2.5 percent), 2 = 6–25 percent (15 percent), 3 = 26–50 percent (37.5 percent), 4 = 51–75 percent (62.5 percent), 5 = 76–95 percent (85 percent), 6 = >95 percent (97.5 percent). Basal vegetation cover, litter cover, rock cover, and bare ground cover were also estimated within each quadrat using the cover class system.

The midpoint value of each cover class was used to calculate the average absolute and relative foliar cover by species across the quadrats sampled for each revegetation unit. The percentage of absolute foliar cover was calculated as the sum of 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 species in a revegetation unit divided by the sum of cover values for all species in the same revegetation unit, multiplied by 100. The midpoint values were also used to calculate the average cover at each revegetation unit for basal vegetation, litter, and rock.

Results and Discussion

Table 2 shows the species richness (number of species), a list of species seeded, and the seeded species found growing at each revegetation location in 2013. Species richness ranged from a low of 14 species in unit L18, to a high of 40 species in unit L39. Tables 3 and 4 list the species present at each revegetation location. The wide range in the number of species present is attributable to a number of factors, including how long ago the area was revegetated, size of the location, number of quadrats sampled in the location, degree of disturbance in the area prior to revegetation, and management actions (e.g., weed control) that have been conducted in the area. Ten different seeded graminoid species had become established and were growing at some locations in 2013. These included slender wheatgrass (*Agropyron caninum* = *Agropyron trachycaulum*), western wheatgrass (*Agropyron smithii*), big bluestem (*Andropogon gerardii*), little bluestem (*Andropogon scoparius*), sideoats grama (*Bouteloua curtipendula*), blue grama (*Bouteloua gracilis*), buffalograss (*Buchloe dactyloides*), Indian grass (*Sorghastrum nutans*), sand dropseed (*Sporobolus cryptandrus*), and green needlegrass (*Stipa viridula*). Four species were established at all 13 locations in 2013: western wheatgrass, sideoats grama, blue grama, and

buffalograss. Several noxious weeds were also found at the locations monitored in 2013. These included quackgrass (*Agropyron repens*), downy brome (*Bromus tectorum*), jointed goatgrass (*Aegilops cylindrica*), filaree (*Erodium cicutarium*), diffuse knapweed (*Centaurea diffusa*), bindweed (*Convolvulus arvensis*), Dalmatian toadflax (*Linaria dalmatica*), moth mullein (*Verbascum blattaria*), common mullein (*Verbascum thapsus*), musk thistle (*Carduus nutans*), and field sow thistle (*Sonchus arvensis*). Total mean absolute foliar cover of noxious weeds at the various locations ranged from 0.9 percent to 8.4 percent (Tables 3 and 4). Weeds will continue to be managed as needed to reduce noxious weed populations in the revegetation areas and to enable the desired seeded species to become established more quickly and compete with the weeds.

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. All 13 locations met this criterion in 2013 (Tables 2 and 5). Ground cover protection from rock, litter, and current-year live vegetation varied from 80 percent to over 100 percent at the revegetation locations in 2013 (Table 6). The occasional values over 100 percent are the result of the class system used for estimating cover, which estimates cover values into a range and uses the midpoint of the cover class for analysis. The Revegetation Plan states that a minimum of 70 percent total ground cover comprising litter cover, current-year live vegetation basal cover, and rock cover is to be present to help prevent erosion. All 13 locations met this criterion in 2013 (Tables 5 and 6).

The third success criterion states that a minimum of 30 percent relative cover of desired species must be present, and the fourth criterion states that no single species should constitute more than 45 percent of the total relative cover. Tables 3 and 4 summarize the foliar cover data by location for 2013. The shaded row, titled “Total Herbaceous Native Cover,” at the bottom of each table shows the percentage of cover of desired species at each location. The values that are higher than 30 percent at each revegetation location are shaded, indicating that these locations have met this success criterion. Total relative vegetation cover of desired (native) species was greater than 50 percent at all 13 of the locations monitored in 2013. Five of the 13 monitored revegetation locations (38 percent) had a single species that constituted greater than 45 percent of the relative cover in 2013 (Tables 3 and 4). All five of these locations were dominated by western wheatgrass (one of the seeded native species) and the five locations that failed to meet all four success criteria failed solely because they each had a single species that covered greater than 45 percent of the area (Table 5).

Regarding the use of the success criteria, the Revegetation Plan states:

Success criteria and monitoring are an important component of a revegetation project . . . *These success criteria are provided as initial guidance; however, common sense combined with scientific data must be applied to final evaluations to determine whether further management actions are required* [emphasis added].

Additionally, the Revegetation Plan’s success criterion regarding dominance by a single species states that “[n]o single species will contribute more than 45 percent of the relative foliar cover (*except in areas where dominance by a single species is appropriate for long-term wildlife and habitat management objectives*)” [emphasis added].

Western wheatgrass is a desirable native species. At locations that fail only this last criterion, and that otherwise have a good stand of vegetation, several questions are worth considering:

- Is the dominance of these areas by a single species (with greater than 45 percent relative foliar cover) detrimental to long-term wildlife and habitat management?
- Is the dominance by these species likely to change in the future?
- Is it reasonable to pass these locations in 2013, even though they failed this last criterion?

As discussed in previous years, one way to answer the first question is to evaluate the dominance of relative foliar cover of native species on the undisturbed native grassland areas of the Site. Do native species account for greater than 45 percent of the cover at some locations on the native grasslands? Monitoring data for several native grassland locations at the Site are summarized in Table 7. Monitoring in 2009 at two reference locations in native grassland used for Preble's meadow jumping mouse (*Zapus hudsonius preblei*) mitigation monitoring (in the Original Landfill and A-Ponds reference areas) showed that western wheatgrass provided, respectively, 54 and 59 percent relative foliar cover. At TR06, a xeric grassland monitoring location at the Site, data collected over multiple years showed that needle-and-thread grass (*Stipa comata*), a native grassland species, consistently provided greater than 45 percent relative foliar cover. Because it is not uncommon for some of the native graminoid species to dominate the foliar cover at some locations, it is unlikely that the dominance of western wheatgrass at these revegetation areas will be detrimental to long-term wildlife and habitat management.

Relative foliar cover of different species and overall vegetation cover also commonly fluctuate in response to environmental conditions, such as temperature and the amount and timing of precipitation. Table 7 shows some of this fluctuation for western wheatgrass at TR02 and TR04 (both mesic grassland monitoring locations) and at the Original Landfill revegetation area, for needle-and-thread grass at TR06 and TR11 (mesic grassland monitoring locations), and for overall foliar cover at TR02. Annual fluctuations in species cover are common in response to changing environmental conditions. Therefore, although some of the locations monitored were dominated by individual species with greater than 45 percent cover in 2013, this may change over time as environmental conditions change. Given the evidence that dominance by a single species occurs on the native prairie, and given that annual fluctuations in foliar cover are common, there is no practical reason these locations cannot be considered to have passed all four criteria in 2013. David Buckner, an ecologist under contract with the U.S. Environmental Protection Agency (EPA), conducted revegetation monitoring for EPA at the Site in 2009, 2010, and 2011. He noted similar conditions in the revegetation areas they sampled, and he has no concerns for areas with greater than 45 percent cover by a single species. In the 2010 report, he states, "The single sample showed that western wheatgrass comprised half of the cover, and though slightly in excess of the 45% DOE criterion, it is not likely that this represents a problem situation. Many native stands on finer-textured soils 'naturally' have as much western wheatgrass as is present here, or more" (EPA 2010). Consequently, all of these locations are considered to have passed this criterion.

In summary, all 13 locations (approximately 97 acres) continued to meet all four criteria in 2013. This continues to demonstrate that the vegetation has become well established and that the vegetation should be sustainable in the long-term.

To evaluate potential successional change and trajectories in plant community composition, a comparison of past monitoring data was made with the 2013 data for each location (Table 8). Some locations have no data for a specific year because no monitoring was conducted at those locations in that year.

Changes in species richness from 2008 to 2013 varied by location. Of the eleven locations that had been previously monitored, three showed an increase in species richness from the first year of monitoring to 2013 (ranging from one to 10 species) while the other eight locations showed declines (ranging from a loss of one to 10 species). The declines are likely due to a decrease in weedy species, with two primary causes. Initially most revegetation locations tend to have a flush of weedy species at the beginning of a project, and as the seeded perennial graminoids begin to establish, some of the early successional weedy species are outcompeted and disappear from the area. An additional factor is the application of herbicides to remove the weedy competition and allow the seeded native graminoid species a better chance to establish. The percentage of seeded species that are present has increased at eight of the eleven previously monitored locations since 2008, remained the same at two locations, and declined at one location (green needlegrass declined at location L39).

Total absolute foliar cover has increased at all 13 locations from 2008 to 2013. This means the abundance of vegetation is continuing to increase across these areas and therefore providing additional soil protection and reducing the potential for surface erosion. The total relative native cover increased at 12 of 13 locations. At the one location (L39) where it decreased, it only declined by two percent, which is insignificant. These two measures suggest that a “native” prairie is establishing and is not merely weedy vegetation.

The seeded native species continue to increase in dominance at each of these revegetation locations. Table 8 lists the species that contributed more than 5 percent cover at each location from 2008 through 2013 (where data are available). The early dominance by the native, short-lived, cool-season, perennial, slender wheatgrass has given way to an increase in western wheatgrass (a long-lived, native, cool-season species). Slender wheatgrass, which is used in the seed mixes at the Site because it is a good early native colonizer, is expected to decline over time. It provides good vegetation cover for other slower establishing species such as many of the warm-season species. Examination of the dominant species listed for 2013 shows the continuing increase in warm-season, native graminoid cover as time progresses. The mix of both cool-season and warm-season graminoids is desirable for long-term sustainability.

In general, the successional trajectory of the revegetation areas is on track and should result in long-term sustainable native grassland communities in the Central Operable Unit. Continued proactive management of noxious weeds using an integrated vegetation management program will aid in that process. Future monitoring will to evaluate the sustainability of the grassland communities and successional changes.

Summary

Thirteen revegetation units, all of which had previously met the success criteria, were monitored again in 2013. The data showed that they continue to meet the success criteria and should be sustainable in the long term for stabilizing soils, providing erosion protection, and providing good habitat for wildlife.

References

DOE (U.S. Department of Energy), 2009. *Rocky Flats, Colorado, Site Revegetation Plan*, LMS/RFS/S04513, Office of Legacy Management, Grand Junction, Colorado, January.

EPA (U.S. Environmental Protection Agency), 2010. *Report of Findings Revegetation Assessment, Rocky Flats Site, Jefferson County, CO*, prepared by ESCO Associates Inc., October.

2013 Revegetation Monitoring Locations

Legend

Revegetation Monitoring Locations

Site Features

RFS COU Boundary

Lakes; Ponds

Wetland/Marsh

Stream, ditch, or other drainage feature

Road Type

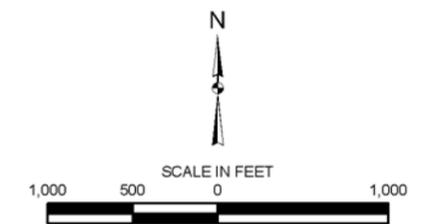
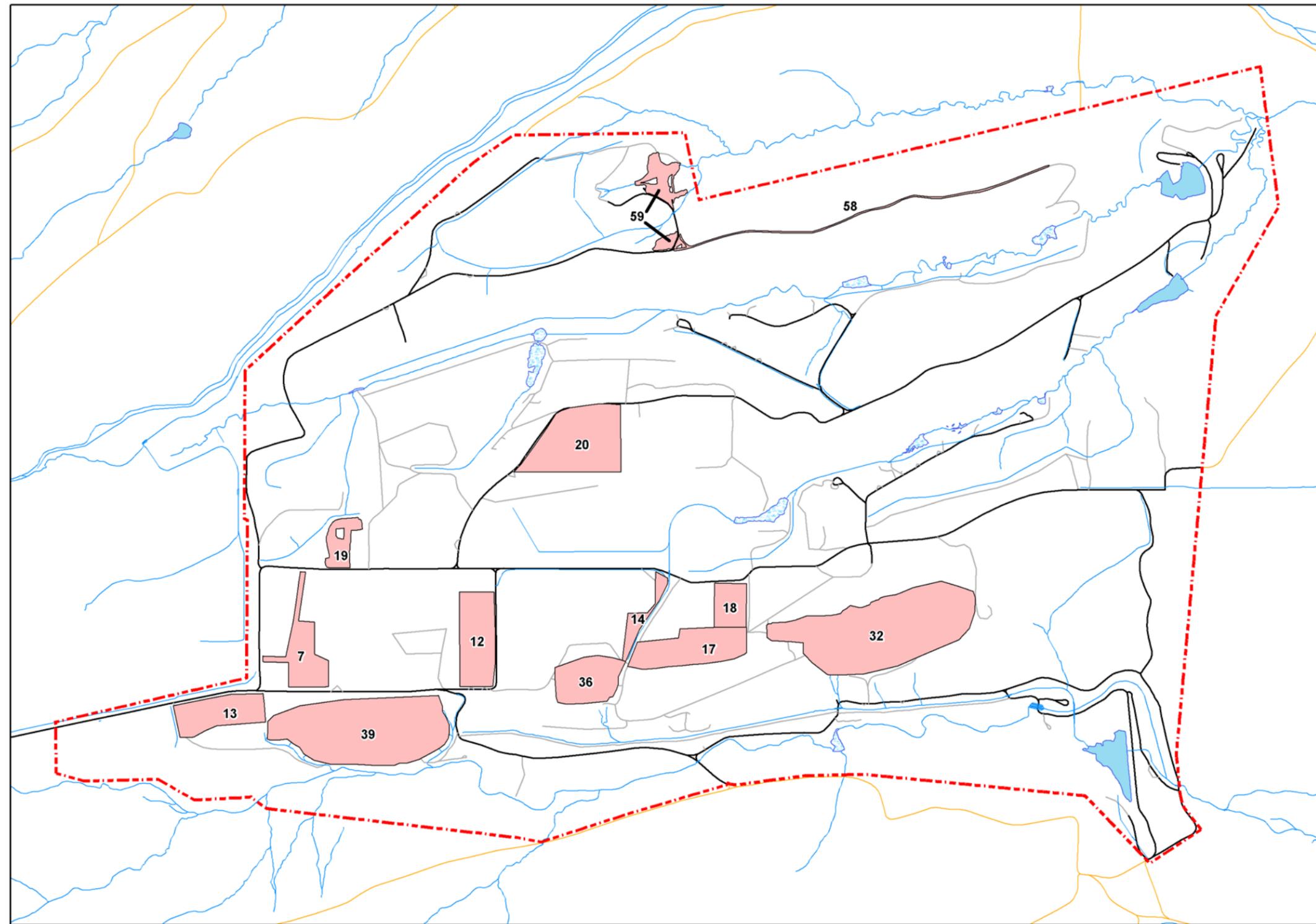
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Note:

Numbers refer to monitoring location identifiers in the report.



U.S. DEPARTMENT OF ENERGY
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Figure 1. 2013 Revegetation Monitoring Locations

Table 1. Number of Quadrats Sampled per Location in 2013

Location	# Quadrats Sampled
L7	20
L12	20
L13	20
L14	15
L17	15
L18	15
L19	20
L20	20
L32	30
L36	10
L39	30
L58	20
L59	20
Total Quadrats Sampled	255
Total Locations Sampled	13

Table 2. Species Seeded By Location and 2013 Total Species Richness Summary

	Location	L7	L12	L13	L14	L17	L18	L19	L20	L32	L36	L39	L58	L59
	Seed Mix	X	X	X	X	X	X	X	X	M	M	M	X	M
Family	Scientific Name													
Graminoids														
POACEAE	Agropyron caninum	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
POACEAE	Agropyron dasystachum									✓	✓	✓		✓
POACEAE	Agropyron smithii	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
POACEAE	Andropogon gerardii	✓	✓	✓	✓	✓	✓	✓	✓				✓	
POACEAE	Andropogon scoparius	X	X	✓	✓	X	✓	✓	✓				✓	
POACEAE	Bouteloua curtipendula	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
POACEAE	Bouteloua gracilis	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
POACEAE	Buchloe dactyloides	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
POACEAE	Koleria pyramidalis	✓	✓	✓	✓	✓	✓	✓	✓				✓	
POACEAE	Sorghastrum nutans	✓	✓	✓	✓	✓	✓	✓	✓				✓	
POACEAE	Sporobolus cryptandrus	✓	✓	✓	✓	✓	✓	✓	✓				✓	
POACEAE	Stipa viridula	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
	Total # Species Seeded	11	11	11	11	11	11	11	11	7	7	7	11	7
	# Present in 2013	8	10	7	8	8	7	7	7	6	5	5	8	6
	% Seeded Species Present in 2013	73	91	64	73	73	64	64	64	86	71	71	73	86
	Total Species Richness in 2013	15	27	26	19	18	14	16	16	37	21	40	24	33

Seed Mixes: X = Xeric Seed Mix, M = Mesic Seed Mix.

(Check marks in the columns indicate which species were included in each seed mix.)

Yellow shaded cells mean the success criterion of >50% of seeded species was met in 2013.

Blue shaded cells mean the species was present at this location in 2013.

Table 3. Revegetation Locations L7 to L19 Foliar Cover Summary 2013 (cont.)

Scientific Name	Speccode	Growth Form	Native	Cool/Warm Season	Noxious Weed	L7		L12		L13		L14		L17		L18		L19	
						Absolute Cover (%)	Relative Cover (%)												
Polypogon monspeliensis (L.) Desf.	POMO1	G	N	C															
Triticum aestivum L.	TRAE1	G	N	C															
Eragrostis cilianensis (All.) E. Mosher	ERCI2	G	N	W		0.13	0.23												
Eragrostis curvula (Schrad.) Nees	ERCU1	G	N	W						1.88	2.66								
Typha latifolia L.	TYLA1	G	Y																
Agropyron caninum (L.) Beauv. ssp. majus (Vasey) C. L. Hitchc.	AGCA1	G	Y	C		1.13	2.07	3.63	6.78			0.50	0.80	1.50	2.65	1.17	2.17	2.00	3.64
Agropyron dasystachyum (Hook.) Scribn.	AGDA1	G	Y	C															
Agropyron smithii Rydb.	AGSM1	G	Y	C		41.88	77.01	18.50	34.58	41.25	58.51	26.17	41.64	27.67	48.82	25.17	46.75	22.13	40.32
Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr	ARLO1	G	Y	C															
Carex heliophila Mack.	CAHE1	G	Y	C															
Carex nebrascensis Dew.	CANE1	G	Y	C															
Festuca ovina L. var. rydbergii St. Yves	FEOV1	G	Y	C						0.75	1.06							0.13	0.23
Hordeum jubatum L.	HOJU1	G	Y	C				0.13	0.23									0.88	1.59
Scirpus pallidus (Britt.) Fern	SCPA1	G	Y	C				0.13	0.23										
Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc.	SIHY1	G	Y	C															
Stipa comata Trin. & Rupr.	STCO1	G	Y	C						0.13	0.18								
Stipa viridula Trin.	STVI1	G	Y	C		0.88	1.61	0.38	0.70	1.88	2.66	1.17	1.86	0.33	0.59	0.50	0.93		
Andropogon gerardii Vitman	ANGE1	G	Y	W				0.25	0.47	5.25	7.45	0.17	0.27						
Andropogon scoparius Michx.	ANSC1	G	Y	W		0.75	1.38	0.38	0.70					1.00	1.76				
Bouteloua curtipendula (Michx.) Torr.	BOCU1	G	Y	W		0.13	0.23	6.75	12.62	3.38	4.79	4.67	7.43	1.17	2.06	1.83	3.41	2.50	4.56
Bouteloua gracilis (H. B. K.) Lag ex Griffiths	BOGR1	G	Y	W		0.25	0.46	1.88	3.50	1.63	2.30	5.33	8.49	6.17	10.88	7.67	14.24	12.50	22.78
Buchloe dactyloides (Nutt.) Engelm.	BUDA1	G	Y	W		3.63	6.67	7.13	13.32	4.13	5.85	14.33	22.81	10.00	17.65	6.50	12.07	1.50	2.73
Muhlenbergia montana (Nutt.) Hitchc.	MUMO1	G	Y	W															
Panicum capillare L.	PACA1	G	Y	W				0.38	0.70									0.25	0.46
Scirpus acutus Muhl.	SCAC1	G	Y	W															
Sorghastrum nutans (L.) Nash	SONU1	G	Y	W				0.75	1.40									1.88	3.42
Sporobolus asper (Michx.) Kunth	SPAS1	G	Y	W		0.38	0.69												
Sporobolus cryptandrus (Torr.) A. Gray	SPCR1	G	Y	W		0.13	0.23	1.25	2.34	0.13	0.18	3.67	5.84	0.17	0.29	0.33	0.62	2.63	4.78
Unknown Species	UNKN																	0.25	0.46
Salix exigua Nutt. ssp. interior (Rowlee) Cronq.	SAEX1	S	Y																
Yucca glauca Nutt.	YUGL1	S	Y																
Total Foliar Cover						54.38	100.00	53.50	100.00	70.50	100.00	62.83	100.00	56.67	100.00	53.83	100.00	54.88	100.00
Total Forb Cover						0.88	1.61	5.50	10.28	4.00	5.67	1.50	2.39	1.50	2.65	1.67	3.10	0.75	1.37
Total Non-Native Forb Cover						0.50	0.92	4.00	7.48	3.50	4.96	1.17	1.86	1.17	2.06	1.50	2.79	0.50	0.91
Total Native Forb Cover						0.38	0.69	1.50	2.80	0.50	0.71	0.33	0.53	0.33	0.59	0.17	0.31	0.25	0.46
Total Graminoid Cover						53.50	98.39	48.00	89.72	66.50	94.33	61.33	97.61	55.17	97.35	52.17	96.90	53.88	98.18
Total Non-Native Graminoid Cover						4.38	8.05	6.50	12.15	8.00	11.35	5.33	8.49	7.17	12.65	9.00	16.72	7.50	13.67
Total Native Graminoid Cover						49.13	90.34	41.50	77.57	58.50	82.98	56.00	89.12	48.00	84.71	43.17	80.19	46.38	84.51
Total Herbaceous Cover						54.38	100.00	53.50	100.00	70.50	100.00	62.83	100.00	56.67	100.00	53.83	100.00	54.88	100.00
Total Herbaceous Native Cover						49.50	91.03	43.00	80.37	59.00	83.69	56.33	89.66	48.33	85.29	43.33	80.50	46.63	84.97
Total Herbaceous Non-Native Cover						4.88	8.97	10.50	19.63	11.50	16.31	6.50	10.34	8.33	14.71	10.50	19.50	8.00	14.58
Total Warm-Season Graminoid Cover						5.38	9.89	18.75	35.05	16.38	23.23	28.17	44.83	18.50	32.65	16.33	30.34	21.25	38.72
Total Cool-Season Graminoid Cover						48.13	88.51	29.25	54.67	50.13	71.10	33.17	52.79	36.67	64.71	35.83	66.56	32.63	59.45
Total Noxious Weed Cover						4.25	7.82	8.38	15.65	7.63	10.82	4.67	7.43	4.00	7.06	3.00	5.57	7.63	13.90
Total Shrub Cover						0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

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, NA = Not Available

Growth Form Categories: F = Forb, G = Graminoid, S = Shrub

Cool/Warm Season Categories: C = Cool-Season Graminoid, W = Warm-Season Graminoid

Noxious Weed Category: X = Noxious Weed (listed on October 2013 Colorado State Noxious Weed List)

Yellow shaded cells indicate success criteria were met in 2013.

Blue shaded cells indicate this species provided greater than 45 percent of the relative cover in 2013.

Table 4. Revegetation Locations L20 to L59 Foliar Cover Summary 2013 (cont.)

Scientific Name	Speccode	Growth Form	Native	Cool/Warm Season	Noxious Weed	L20		L32		L36		L39		L58		L59	
						Absolute Cover (%)	Relative Cover (%)										
Polypogon monspeliensis (L.) Desf.	POMO1	G	N	C								0.08	0.14				
Triticum aestivum L.	TRAE1	G	N	C										0.13	0.46		
Eragrostis cilianensis (All.) E. Mosher	ERCI2	G	N	W													
Eragrostis curvula (Schrad.) Nees	ERCU1	G	N	W													
Typha latifolia L.	TYLA1	G	Y									0.08	0.14				
Agropyron caninum (L.) Beauv. ssp. majus (Vasey) C. L. Hitchc.	AGCA1	G	Y	C		0.75	1.55	1.17	1.80	0.75	1.15	2.08	3.51	4.00	14.68	7.88	19.33
Agropyron dasystachyum (Hook.) Scribn.	AGDA1	G	Y	C												0.13	0.31
Agropyron smithii Rydb.	AGSM1	G	Y	C		37.38	77.06	6.67	10.31	8.00	12.31	13.08	22.02	1.75	6.42	5.13	12.58
Aristida purpurea Nutt. var. robusta (Merrill) A. Holmgren & N. Holmgr	ARLO1	G	Y	C				0.58	0.90								
Carex heliophila Mack.	CAHE1	G	Y	C				0.08	0.13								
Carex nebrascensis Dew.	CANE1	G	Y	C								2.08	3.51				
Festuca ovina L. var. rydbergii St. Yves	FEOV1	G	Y	C				0.08	0.13							0.13	0.31
Hordeum jubatum L.	HOJU1	G	Y	C													
Scirpus pallidus (Britt.) Fern	SCPA1	G	Y	C													
Sitanion hystrix (Nutt.) Sm. var. brevifolium (Sm.) Hitchc.	SIHY1	G	Y	C										0.13	0.46		
Stipa comata Trin. & Rupr.	STCO1	G	Y	C													
Stipa viridula Trin.	STVI1	G	Y	C		0.38	0.77	3.67	5.67							0.25	0.61
Andropogon gerardii Vitman	ANGE1	G	Y	W				2.17	3.35	0.25	0.38	0.08	0.14	1.13	4.13		
Andropogon scoparius Michx.	ANSC1	G	Y	W				1.25	1.93	1.50	2.31	0.08	0.14	0.75	2.75		
Bouteloua curtipendula (Michx.) Torr.	BOCU1	G	Y	W		3.25	6.70	19.00	29.38	11.00	16.92	5.33	8.98	3.13	11.47	0.13	0.31
Bouteloua gracilis (H. B. K.) Lag ex Griffiths	BOGR1	G	Y	W		2.38	4.90	1.92	2.96	0.50	0.77	4.83	8.13	5.25	19.27	0.25	0.61
Buchloe dactyloides (Nutt.) Engelm.	BUDA1	G	Y	W		1.00	2.06	5.50	8.51	7.75	11.92	18.08	30.43	4.88	17.89	3.50	8.59
Muhlenbergia montana (Nutt.) Hitchc.	MUMO1	G	Y	W								0.50	0.84				
Panicum capillare L.	PACA1	G	Y	W								0.17	0.28	0.13	0.46	0.38	0.92
Scirpus acutus Muhl.	SCAC1	G	Y	W								0.50	0.84			0.13	0.31
Sorghastrum nutans (L.) Nash	SONU1	G	Y	W				0.08	0.13	1.50	2.31						
Sporobolus asper (Michx.) Kunth	SPAS1	G	Y	W													
Sporobolus cryptandrus (Torr.) A. Gray	SPCR1	G	Y	W		0.75	1.55			5.00	7.69	0.17	0.28	0.75	2.75	0.75	1.84
Unknown Species	UNKN					0.13	0.26					0.08	0.14				
Salix exigua Nutt. ssp. interior (Rowlee) Cronq.	SAEX1	S	Y									2.92	4.91				
Yucca glauca Nutt.	YUGL1	S	Y					0.58	0.90								
Total Foliar Cover						48.50	100.00	64.67	100.00	65.00	100.00	59.42	100.00	27.25	100.00	40.75	100.00
Total Forb Cover						0.75	1.55	5.17	7.99	16.25	25.00	7.92	13.32	4.38	16.06	9.25	22.70
Total Non-Native Forb Cover						0.50	1.03	2.75	4.25	9.00	13.85	5.75	9.68	3.88	14.22	7.13	17.48
Total Native Forb Cover						0.25	0.52	2.42	3.74	7.25	11.15	2.17	3.65	0.50	1.83	2.13	5.21
Total Graminoid Cover						47.63	98.20	58.92	91.11	48.75	75.00	48.50	81.63	22.88	83.94	31.50	77.30
Total Non-Native Graminoid Cover						1.75	3.61	16.75	25.90	12.50	19.23	1.42	2.38	1.00	3.67	12.88	31.60
Total Native Graminoid Cover						45.88	94.59	42.17	65.21	36.25	55.77	47.08	79.24	21.88	80.28	18.63	45.71
Total Herbaceous Cover						48.50	100.00	64.08	99.10	65.00	100.00	56.50	95.09	27.25	100.00	40.75	100.00
Total Herbaceous Native Cover						46.13	95.10	44.58	68.94	43.50	66.92	49.25	82.89	22.38	82.11	20.75	50.92
Total Herbaceous Non-Native Cover						2.25	4.64	19.50	30.15	21.50	33.08	7.17	12.06	4.88	17.89	20.00	49.08
Total Warm-Season Graminoid Cover						7.38	15.21	29.92	46.26	27.50	42.31	29.75	50.07	16.00	58.72	5.13	12.58
Total Cool-Season Graminoid Cover						40.25	82.99	29.00	44.85	21.25	32.69	18.67	31.42	6.88	25.23	26.38	64.72
Total Noxious Weed Cover						0.88	1.80	1.92	2.96	1.00	1.54	1.58	2.66	1.00	3.67	8.00	19.63
Total Shrub Cover						0.00	0.00	0.58	0.90	0.00	0.00	2.92	4.91	0.00	0.00	0.00	0.00

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, NA = Not Available

Growth Form Categories: F = Forb, G = Graminoid, S = Shrub

Cool/Warm Season Categories: C = Cool-Season Graminoid, W = Warm-Season Graminoid

Noxious Weed Category: X = Noxious Weed (listed on October 2013 Colorado State Noxious Weed List)

Yellow shaded cells indicate success criteria were met in 2013.

Blue shaded cells indicate this species provided greater than 45 percent of the relative cover in 2013.

Table 5. Success Criteria Evaluation Summary 2013

Location	>30% Relative Cover of Desired Species	>70% Total Ground Cover (Litter, Rock, and Basal Veg Cover)	50% or More of Seeded Species Present	No Single Species With >45% Relative Foliar Cover	PASS/FAIL
L7	PASS	PASS	PASS	FAIL	PASS
L12	PASS	PASS	PASS	PASS	PASS
L13	PASS	PASS	PASS	FAIL	PASS
L14	PASS	PASS	PASS	PASS	PASS
L17	PASS	PASS	PASS	FAIL	PASS
L18	PASS	PASS	PASS	FAIL	PASS
L19	PASS	PASS	PASS	PASS	PASS
L20	PASS	PASS	PASS	FAIL	PASS
L32	PASS	PASS	PASS	PASS	PASS
L36	PASS	PASS	PASS	PASS	PASS
L39	PASS	PASS	PASS	PASS	PASS
L58	PASS	PASS	PASS	PASS	PASS
L59	PASS	PASS	PASS	PASS	PASS
% Passing	100	100	100	100	100

Yellow shaded cells indicate all success criteria were met in 2013.

Blue shaded cells indicate all success criteria would be met in 2013 if >45% cover of a single species was removed as criterion.

For reasons outlined in the text, these areas are considered to have passed in 2013.

Table 6. Basal Cover Summary at Revegetation Locations 2013

Location	Basal Vegetation Cover (%)	Litter Cover (%)	Rock Cover (%)	Total Ground Cover (%)*
L7	3.1	65.8	22.4	91.3
L12	7.5	58.0	27.5	93.0
L13	5.6	81.8	13.0	100.4
L14	9.8	70.3	17.7	97.8
L17	7.5	72.5	13.8	93.8
L18	8.3	66.8	26.8	102.0
L19	7.4	68.4	21.1	96.9
L20	3.1	70.8	14.1	88.0
L32	8.8	74.0	9.3	92.1
L36	5.0	57.0	18.3	80.3
L39	7.5	58.6	23.6	89.7
L58	3.1	3.1	78.5	84.8
L59	5.0	60.0	20.5	85.5
Grand Mean	6.29	62.08	23.59	91.96

* 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.

Shaded cells indicate that the success criteria of >70% total ground cover were met in 2013.

Table 7. Relative Foliar Cover of Selected Species on Native Grasslands at Rocky Flats

Location	Species	1993	1994	1995	1998	1999	2000	2001	2007	2008	2009	2010
TR02	Agropyron smithii	40.5	33.0	31.5		23.5	23.2					
TR02	Total Foliar Cover	68.2	88.0	97.2		77.4	71.6					
TR04	Agropyron smithii	28.6	15.7	19.3		13.7	10.0					
TR06	Stipa comata	61.5	62.4	49.4	50.8			45.7				
TR11	Stipa comata	11.6	8.7	3.2		6.6	12.6					
OLF Reference Area	Agropyron smithii								21.8	33.4	59.0	33.3
A-Ponds Reference Area	Agropyron smithii										54.2	18.0

These data are from various other studies that have been conducted at Rocky Flats. The sporadic nature of the timing of some studies is a result of the purpose of the individual studies.

See the text for more information.

Table 8. Evaluation of Successional Changes in Plant Community Composition at Revegetation Locations

		Location													
		L7	L12	L13	L14	L17	L18	L19	L20	L32	L36	L39	L58	L59	
Species Richness	2008	17	26	23	26	22	23	26	17	45	25	30	ND	ND	
	2009	21	25	32	27	22	23	23	13	38	20	30	ND	ND	
	2010	13	19	26	ND	17	ND	25	23	ND	ND	23	ND	ND	
	2011	ND	ND	ND	ND	ND	ND	ND	ND	49	ND	ND	ND	ND	
	2012	ND	ND	ND	ND	ND	ND	ND	ND	24	ND	ND	ND	ND	
	2013	15	27	26	19	18	14	16	16	37	21	40	24	33	
Percent Seeded Species Present	2008	36	36	55	55	45	45	64	18	86	43	86	ND	ND	
	2009	45	45	45	55	45	55	45	36	86	71	100	ND	ND	
	2010	55	91	73	ND	73	ND	82	64	ND	ND	86	ND	ND	
	2011	ND	ND	ND	ND	ND	ND	ND	ND	86	ND	ND	ND	ND	
	2012	ND	ND	ND	ND	ND	ND	ND	ND	86	ND	ND	ND	ND	
	2013	73	91	64	73	73	64	64	64	86	71	71	73	86	
Total Absolute Foliar Cover	2008	35.6	38.6	42.9	45.3	30.3	28.2	33.8	30.6	44.5	37.3	23.7	ND	ND	
	2009	54.4	47.3	65.9	71.5	49.8	48.8	71.9	69.8	71.1	36.0	45.0	ND	ND	
	2010	60.3	59.6	57.9	ND	48.2	ND	60.0	63.1	ND	ND	36.4	ND	ND	
	2011	ND	ND	ND	ND	ND	ND	ND	ND	76.1	ND	ND	ND	ND	
	2012	ND	ND	ND	ND	ND	ND	ND	ND	63.3	ND	ND	ND	ND	
	2013	54.4	53.5	70.5	62.8	56.7	53.8	54.9	48.5	64.7	65.0	59.4	27.3	40.8	
Total Relative Native Foliar Cover	2008	45.3	31.7	65.3	44.1	35.2	39.6	36.7	26.9	50.2	61.7	84.9	ND	ND	
	2009	71.1	56.6	70.8	74.6	56.6	71.6	61.1	53.6	53.6	70.8	82.0	ND	ND	
	2010	92.5	74.2	75.4	ND	82.0	ND	66.3	65.3	ND	ND	88.1	ND	ND	
	2011	ND	ND	ND	ND	ND	ND	ND	ND	58.9	ND	ND	ND	ND	
	2012	ND	ND	ND	ND	ND	ND	ND	ND	71.8	ND	ND	ND	ND	
	2013	91.0	80.4	83.7	89.7	85.3	80.5	85.0	95.1	68.9	66.9	82.9	82.1	50.9	
Total Absolute Ground Cover * (Basal Veg, Litter, Rock)	2008	51.8	63.5	76.6	55.2	62.0	76.7	70.3	69.6	84.6	60.3	82.7	ND	ND	
	2009	82.9	76.4	93.9	69.5	76.5	86.0	101.0	71.9	88.3	82.5	78.9	ND	ND	
	2010	89.0	93.3	92.4	ND	87.3	91.4	93.3	91.4	ND	ND	83.8	ND	ND	
	2011	ND	ND	ND	ND	ND	ND	ND	ND	90.3	ND	ND	ND	ND	
	2012	ND	ND	ND	ND	ND	ND	ND	ND	94.4	ND	ND	ND	ND	
	2013	91.3	93.0	100.4	97.8	93.8	102.0	96.9	88.0	92.1	80.3	89.7	84.8	85.5	
Species with greater than 5 percent relative foliar cover	2008	Kochia scoparia (33.7%) Agropyron caninum (22.5%) Agropyron smithii (19.6%) Polygonum arenastrum (10.9%)	Lactuca serriola (22.0%) Agropyron caninum (16.2%) Triticum aestivum (12.9%) Agropyron smithii (12.0%) Erodium cicutarium (9.1%) Kochia scoparia (7.1%) Centaurea diffusa (5.2%)	Agropyron caninum (50.1%) Agropyron smithii (11.1%) Bromus tectorum (9.9%) Kochia scoparia (7.6%)	Agropyron smithii (17.3%) Erodium cicutarium (16.2%) Centaurea diffusa (15.1%) Agropyron caninum (14.3%)	Kochia scoparia (24.2%) Agropyron caninum (21.4%) Centaurea diffusa (19.2%) Lactuca serriola (6.6%) Agropyron smithii (6.0%)	Agropyron caninum (24.9%) Centaurea diffusa (18.3%) Lactuca serriola (8.9%) Kochia scoparia (7.7%) Agropyron smithii (7.1%) Agropyron cristatum (7.1%)	Agropyron smithii (23.7%) Kochia scoparia (23.0%) Bromus tectorum (19.3%) Agropyron caninum (9.6%) Alyssum minus (8.9%)	Kochia scoparia (35.9%) Triticum aestivum (14.7%) Agropyron smithii (14.3%) Agropyron caninum (9.8%) Salsola iberica (8.6%) Bromus tectorum (6.5%)	Centaurea diffusa (13.5%) Agropyron caninum (11.2%) Agropyron smithii (10.7%) Buchloe dactyloides (9.6%) Bromus inermis (9.4%) Bromus tectorum (6.0%) Bouteloua curtipendula (5.8%)	Agropyron smithii (30.9%) Grindelia squarrosa (9.4%) Agropyron caninum (7.4%) Mellilotus officinalis (6.0%) Convolvulus arvensis (6.0%) Daucus carota (5.4%)	Agropyron smithii (35.2%) Agropyron caninum (32.4%)	ND	ND	
	2009	Agropyron smithii (38.2%) Agropyron caninum (27.8%) Bromus tectorum (16.3%) Kochia scoparia (8.3%)	Agropyron caninum (27.2%) Kochia scoparia (16.1%) Agropyron smithii (15.3%) Bromus inermis (6.1%) Bromus tectorum (5.3%)	Agropyron smithii (32.1%) Agropyron caninum (28.7%) Kochia scoparia (10.4%) Bromus tectorum (9.5%)	Agropyron smithii (31.0%) Agropyron caninum (21.4%) Kochia scoparia (7.7%)	Agropyron smithii (27.1%) Agropyron caninum (19.4%) Kochia scoparia (13.0%) Bouteloua gracilis (9.4%) Buchloe dactyloides (7.4%) Bromus tectorum (5.4%)	Agropyron caninum (19.5%) Kochia scoparia (16.7%) Buchloe dactyloides (12.3%) Agropyron smithii (10.9%) Alyssum minus (7.5%) Bouteloua gracilis (6.5%) Erodium cicutarium (5.5%)	Agropyron smithii (26.8%) Kochia scoparia (25.9%) Agropyron caninum (15.3%) Bromus tectorum (8.3%) Centaurea diffusa (8.2%)	Kochia scoparia (31.0%) Agropyron smithii (27.6%) Agropyron caninum (26.5%) Mellilotus officinalis (6.3%)	Bromus inermis (28.8%) Agropyron smithii (14.0%) Bouteloua curtipendula (13.2%) Kochia scoparia (5.7%) Buchloe dactyloides (5.0%)	Agropyron smithii (27.1%) Buchloe dactyloides (13.2%) Sporobolus cryptandrus (11.1%) Agropyron caninum (10.4%)	Agropyron smithii (31.1%) Agropyron caninum (27.4%) Mellilotus officinalis (8.0%) Buchloe dactyloides (6.3%) Bouteloua curtipendula (5.7%) Bouteloua gracilis (5.2%)	ND	ND	
	2010	Agropyron smithii (62.2%) Agropyron caninum (25.5%)	Agropyron caninum (33.3%) Agropyron smithii (27.7%) Bromus tectorum (19.7%) Bouteloua curtipendula (7.1%)	Agropyron smithii (40.4%) Agropyron caninum (25.1%) Bromus tectorum (13.6%)	ND	Agropyron smithii (39.8%) Agropyron caninum (13.5%) Buchloe dactyloides (11.4%) Bromus tectorum (6.6%) Bouteloua curtipendula (5.2%)	ND	Agropyron smithii (43.8%) Bromus tectorum (22.9%) Agropyron caninum (7.1%) Buchloe dactyloides (5.6%)	Agropyron smithii (40.8%) Agropyron caninum (21.2%) Bromus tectorum (13.7%) Mellilotus officinalis (12.3%)	ND	ND	Agropyron smithii (25.5%) Agropyron caninum (25.0%) Buchloe dactyloides (13.8%) Bouteloua curtipendula (8.0%) Bouteloua gracilis (6.9%) Mellilotus officinalis (9.4%)	ND	ND	
	2011	ND	ND	ND	ND	ND	ND	ND	ND	Bromus inermis (26.2%) Bouteloua curtipendula (14.9%) Buchloe dactyloides (7.1%) Panicum virgatum (6.8%)	ND	ND	ND	ND	
	2012	ND	ND	ND	ND	ND	ND	ND	ND	Bouteloua curtipendula (32.8%) Bromus inermis (21.9%) Agropyron smithii (9.4%) Bouteloua gracilis (8.8%) Buchloe dactyloides (7.9%)	ND	ND	ND	ND	
	2013	Agropyron smithii (77.0%) Bromus tectorum (7.8%) Buchloe dactyloides (6.7%)	Agropyron smithii (34.6%) Buchloe dactyloides (13.3%) Bouteloua curtipendula (12.6%) Bromus tectorum (10.3%) Agropyron caninum (6.8%)	Agropyron smithii (58.5%) Andropogon gerardii (7.5%) Bromus tectorum (7.3%) Buchloe dactyloides (5.9%)	Agropyron smithii (41.6%) Buchloe dactyloides (22.8%) Bouteloua gracilis (8.5%) Bouteloua curtipendula (7.4%) Bromus tectorum (6.4%) Sporobolus cryptandrus (5.8%)	Agropyron smithii (48.8%) Buchloe dactyloides (17.7%) Bouteloua gracilis (10.9%) Bromus tectorum (6.5%) Bromus inermis (5.6%)	Agropyron smithii (46.8%) Bouteloua gracilis (14.2%) Buchloe dactyloides (12.1%) Agropyron intermedium (11.5%) Bromus tectorum (5.3%)	Agropyron smithii (40.3%) Bouteloua gracilis (22.8%) Bromus tectorum (13.7%)	Agropyron smithii (77.1%) Bouteloua curtipendula (6.7%)	Bouteloua curtipendula (29.4%) Bromus inermis (24.2%) Agropyron smithii (10.3%) Buchloe dactyloides (8.5%) Stipa viridula (5.7%)	Bouteloua curtipendula (16.9%) Bromus inermis (16.2%) Agropyron smithii (12.3%) Buchloe dactyloides (11.9%) Sporobolus cryptandrus (7.7%) Grindelia squarrosa (7.7%) Mellilotus officinalis (6.9%) Mellilotus alba (5.8%)	Buchloe dactyloides (30.4%) Agropyron smithii (22.0%) Bouteloua curtipendula (9.0%) Bouteloua gracilis (8.1%) Mellilotus officinalis (5.1%)	Bouteloua gracilis (19.3%) Buchloe dactyloides (17.9%) Agropyron caninum (14.7%) Bouteloua curtipendula (11.5%) Kochia scoparia (8.7%) Agropyron smithii (6.4%)	Agropyron caninum (19.3%) Agropyron intermedium (17.5%) Agropyron smithii (12.6%) Buchloe dactyloides (8.6%) Bromus tectorum (7.7%) Bromus inermis (5.2%)	

* Values greater than 100 percent are a result of the monitoring protocol that uses the midpoints of the cover class system for analysis.
ND = No Data collected at this location for this year.