

2011 Revegetation Monitoring

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 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* (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:

- 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:

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

- 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.
- A minimum of 50 percent of the seeded native species will be present at the revegetation site.
- 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 data collected during 2011.

Methods

Semi-quantitative revegetation monitoring was conducted during the summer of 2011 to evaluate the establishment of vegetation at locations across the Site. 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). Fourteen revegetation units were sampled in 2011 (Figure 1¹). Of these, nine units had yet to meet success criteria (L1, L2, L3, L21, L23, L40, L55, L56, and L57), and five others that were previously successful (L24, L25, L32, L35, and L37) were monitored again to evaluate the long-term sustainability of the vegetation and the potential successional changes in plant community composition. The 2011 monitoring efforts' results for the locations that had never before met success criteria (listed as Previously Non-Successful in the tables) and for the locations that had (listed as Previously Successful in the tables) are discussed separately.

Within each revegetation unit, sample locations were randomly generated in the Geographic Information System and located on the ground using a Global Positioning System. Quadrats that measured 50 centimeters by 100 centimeters were used to sample the vegetation at each sample location. Depending on the size of the area, the number of quadrats sampled in each area varied from 5 to 30. A total of 335 quadrats were sampled in 2011 (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. 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 = 75–95 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.

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

Results and Discussion

1.1.1 Previously Non-Successful Locations

This section discusses the results of the nine previously non-successful locations. Table 2 shows the total species richness (number of species) found at each revegetation location, a list of species seeded², and the seeded species found growing at each location in 2011. Species richness in 2011 ranged from a low of 16 species in units L23 and L57, to a high of 38 species in unit L55. Tables 3 and 4 show the list of 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, the size of the location, the number of quadrats sampled in the location, the degree of disturbance in the area prior to revegetation, and the management actions

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”.

² Slightly different seed mixes were used at the revegetation locations depending on the year they were seeded and the slope position.

(e.g., weed control) that have been conducted in the area. Twelve different seeded graminoid species had become established and were growing at some locations in 2011. 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*), junegrass (*Koleria pyramidata*), switchgrass (*Panicum virgatum*), Indian grass (*Sorghastrum nutans*), sand dropseed (*Sporobolus cryptandrus*), and green needlegrass (*Stipa viridula*). Four species were established at all nine locations in 2011: slender wheatgrass, western wheatgrass, sideoats grama, and buffalograss. Several noxious weeds were also found at these locations. These included downy brome (*Bromus tectorum*), filaree (*Erodium cicutarium*), diffuse knapweed (*Centaurea diffusa*), Canada thistle (*Cirsium arvense*), chicory (*Cichorium intybus*), bindweed (*Convolvulus arvensis*), field sow thistle (*Sonchus arvensis*), moth mullein (*Verbascum blattaria*), and common mullein (*Verbascum thapsus*). Weeds will continue to be managed as needed to keep noxious weed populations down in the revegetation areas and 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. Table 2 also lists the percentage of seeded species present at the locations in 2011. Eight of nine locations (89 percent) had 50 percent or more seeded species present in 2011 based solely on the quadrat monitoring data (Tables 2 and 5). Location L40 failed to meet this criterion based on quadrat monitoring data. However, only five quadrats were sampled at this location. As discussed in previous annual reports, the monitoring method may contribute to the lack of seeded species present, because the measure is based solely on the species list generated from the quadrat sampling. Given the small size of the total area measured on the ground through the quadrat method, it is possible that more of the seeded species are present at the revegetation locations but are simply outside the “footprint” of the randomly located quadrats in 2011. Therefore, in December 2011, location L40 was traversed on foot to determine if other species were present. Based on this survey, four more seeded species were observed growing in the revegetation area, in addition to those found only within the quadrats. The additional species included big bluestem, sideoats grama, Indian grass, and sand dropseed. Based on this extra evaluation, location L40 has met this success criterion (82 percent).

Table 6 summarizes the timing and revegetation techniques used for revegetation at each location. Ground cover protection from rock, litter, and current-year live vegetation varied from 74 percent to over 100 percent at the revegetation locations in 2011 (Table 7). 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 nine locations (100 percent) met this criterion in 2011 (Tables 5 and 7).

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 2011. 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

30 percent at 100 percent (nine) of the locations monitored in 2011 (Table 5). Seven of the nine revegetation locations (78 percent) had a single species that constituted greater than 45 percent of the relative cover in 2011 (Tables 3 and 4). Five of these locations were dominated by western wheatgrass (one of the seeded native species), and the other two locations were dominated by slender wheatgrass. All seven locations failed to meet all four success criteria 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 and slender wheatgrass are desirable native species. At locations that fail only this last criterion, and 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 there any other reason not to pass these locations in 2011, just because 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 grasslands is summarized in Table 8. Monitoring in 2009 at two reference locations in native grassland used for Preble's meadow jumping mouse mitigation monitoring (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 or slender 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 8 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 these locations were dominated by

species with greater than 45 percent cover in 2011, 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 2011.

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, based on this reasoning.

Table 5 and Figure 1 show which previously non-successful revegetation locations monitored in 2011 met each of the success criteria listed. In summary, all nine locations (approximately 74 acres) met all four criteria in 2011 (some for the specific reasons described above). These areas have established good stands of vegetation that should be sustainable in the future.

1.1.2 Previously Successful Locations

Five locations that met success criteria previously (L24, L25, L32, L35, and L37) were monitored in 2011 to evaluate the long-term sustainability of the vegetation and the successional changes in plant community composition.

Table 9 shows a comparison of the 2008, 2009, and 2011 summary data for total species richness (number of species) found at each revegetation location, percentage of seeded species present, total absolute foliar cover, total native relative foliar cover, total absolute ground cover, and the list of species that had 5 percent or more of total relative foliar cover at each location. Changes in species richness from 2008 to 2011 varied by location. The greatest decline in species richness occurred at locations L25 and L37 from 2009 to 2011. At both locations, most of the decline in species richness was from a loss of forb species that resulted from the broadleaf herbicide that was used for weed control at these locations. Location L32 saw a large increase in species richness from 2009 to 2011 from both forbs and graminoids. Some of this increase may be attributable to the lack of herbicide applications at this location. The last time this area was sprayed was in 2009, so the effect of the application may have worn off by 2011, resulting in an increase in species richness. The other two locations, L24 and L35, showed little change in species richness over the years.

The percentage of seeded species present has generally increased or remained the same at all locations except L35, where Indian grass, a species present in 2009, was not observed (within the quadrats) in 2011. Most likely Indian grass was present in the revegetation area but was just not captured within the quadrats evaluated for this monitoring. The 2011 values continue to meet the success criterion for the percentage of seeded species.

Annual variation in total foliar cover can vary considerably in response to herbicide applications or environmental factors. Herbicide applications at revegetation locations are targeted primarily at noxious forb species. With the loss of forb cover, declines in overall foliar cover the following year are not uncommon. Over time, some loss would be made up by increases in graminoid cover. Foliar cover responses to other environmental factors (i.e., spatial and temporal

distribution of precipitation) are also common. Past vegetation monitoring studies on the grasslands at the Site have shown that total foliar cover can fluctuate up to 20 percent or more annually (K-H 2001).

At each location, total native foliar cover was greater in 2011 than in 2008. All locations were well above the success criterion of 30 percent. Total ground cover (composed of basal vegetation cover, litter cover, and rock cover) also increased at all locations from 2008 to 2011. All locations continued to remain well above the success criterion of 70 percent. At two locations, L24 and L35, western wheatgrass provided approximately 60 percent of the relative foliar cover. This exceeds the 45 percent relative foliar cover for a single species success criterion; however, as discussed in the previous section of the report, it is not uncommon for native species on the undisturbed native grassland areas to provide more than 45 percent of the relative foliar cover. Also, given the annual variability in cover by individual species, an abundance of this species is not a problem. Therefore, each of these areas continues to meet the success criterion.

The seeded native species continue to increase in dominance at each of these revegetation locations. Table 9 shows the species that provided more than 5 percent cover at each location during 2008, 2009, and 2011. The early dominance by the native, short-lived, cool-season, perennial, slender wheatgrass has begun to give way to an increase in western wheatgrass (a long-lived, native, cool-season species) and warm-season, native perennials such as blue grama and sideoats grama. This mix of cool-season and warm-season graminoids is desirable for long-term sustainability. Western wheatgrass is the dominant species at each of the locations except L32, where smooth brome, a nonnative perennial grass dominant before the revegetation activities, has reestablished. Early successional weedy species such as kochia (*Kochia scoparia*), filaree, and alyssum (*Alyssum minus*) have all but disappeared as the native species have increased across the revegetation locations. Cover of diffuse knapweed, a noxious weed, and yellow sweet clover (*Melilotus officinalis*), a common nonnative forb species seeded at the Site years ago, have been reduced in cover primarily through herbicide applications. Downy brome only remained a problem at location L25 in 2011 and will hopefully decrease as the perennial desirable grasses further establish and crowd it out.

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 weeds using an integrated vegetation management program will aid in that process.

Summary

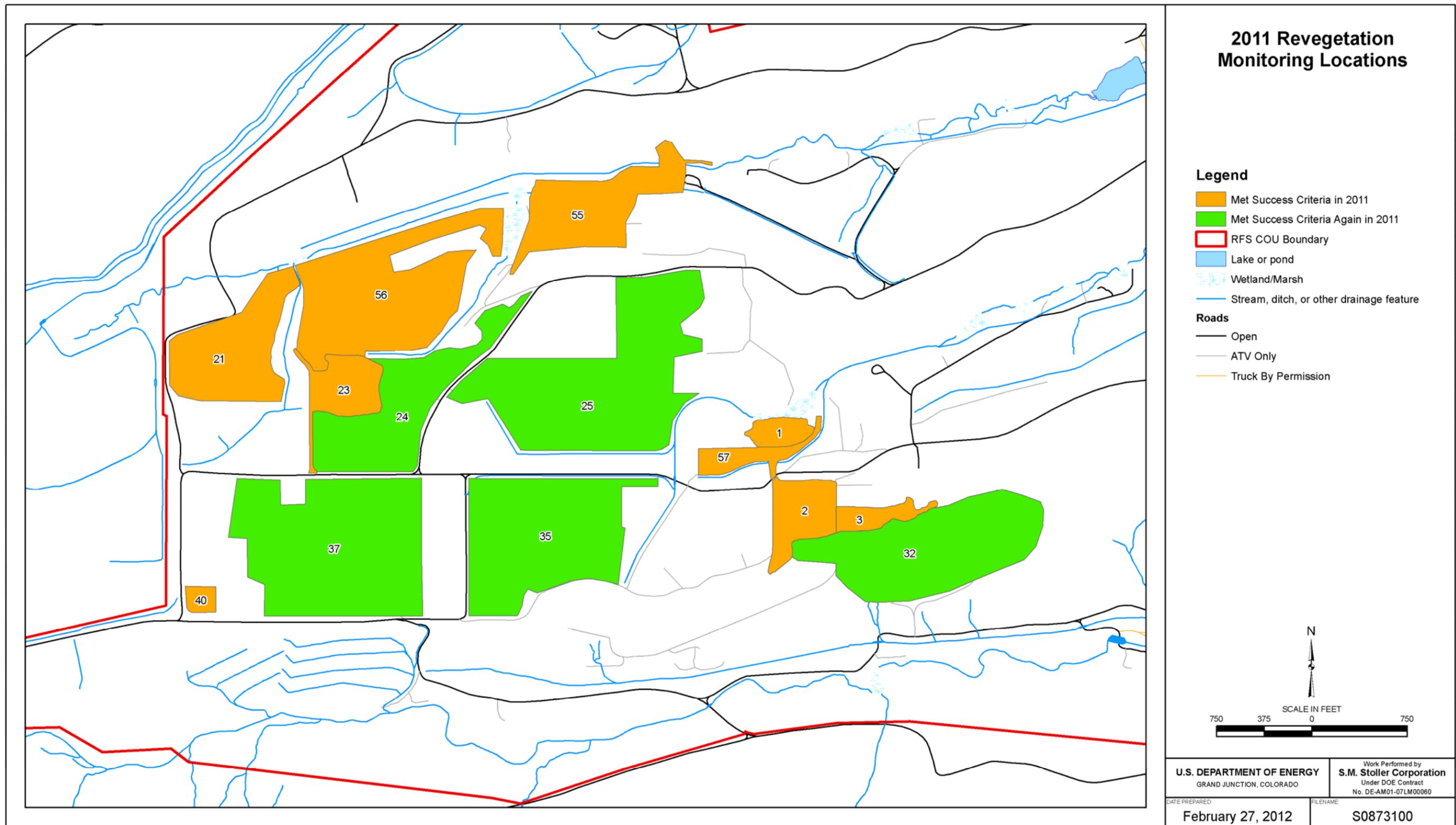
Fourteen revegetation units were monitored in 2011. The nine units that had yet to meet success criteria based on the 2010 monitoring (L1, L2, L3, L21, L23, L40, L55, L56, and L57) each met success criteria in 2011. All of the revegetation units from Site closure have successfully established stands of vegetation. A reevaluation of five other locations that had met success criteria previously (L24, L25, L32, L35, and L37) showed that they continue to meet the success criteria and should be sustainable in the long term to stabilize the soils and provide erosion protection.

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.

K-H (Kaiser-Hill Company, L.L.C.), 2001. *2000 Annual Vegetation Report for the Rocky Flats Environmental Technology Site*, prepared by Kaiser-Hill Company, L.L.C. for the U.S. Department of Energy, Rocky Flats Field Office, Golden, Colorado, June.

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



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Figure 1. 2011 Revegetation Monitoring Locations.

Table 1. Number of Quadrats Sampled per Location in 2011

Location	# Quadrats Sampled
L1	20
L2	20
L3	15
L21	30
L23	20
L24	30
L25	30
L32	30
L35	30
L37	30
L40	5
L55	30
L56	30
L57	15
Total Quadrats Sampled	335
Total Locations Sampled	14

Table 2. Species Seeded by Location and 2011 Total Species Richness Summary

	Location	L1	L2	L3	L21	L23	L24	L25	L32	L35	L37	L40	L55	L56	L57
	Seed Mix	M	X	X	X1	X	X	X	M	X	X	X	M	X	X
Family	Scientific Name														
Graminoids															
POACEAE	Agropyron caninum	X	X	X	X	X	X	X	X	X	X	X	X	X	X
POACEAE	Agropyron dasystachum	X							X				X		
POACEAE	Agropyron smithii	X	X	X	X	X	X	X	X	X	X	X	X	X	X
POACEAE	Andropogon gerardii		X	X	X	X	X	X		X	X	X		X	X
POACEAE	Andropogon scoparius		X	X	X	X	X	X		X	X	X		X	X
POACEAE	Bouteloua curtipendula	X	X	X	X	X	X	X	X	X	X	X	X	X	X
POACEAE	Bouteloua gracilis	X	X	X	X	X	X	X	X	X	X	X	X	X	X
POACEAE	Buchloe dactyloides	X	X	X	X	X	X	X	X	X	X	X	X	X	X
POACEAE	Elymus canadensis				X										
POACEAE	Koleria pyrimidata		X	X	X	X	X	X		X	X	X		X	X
POACEAE	Panicum virgatum				X										
POACEAE	Sorghastrum nutans		X	X	X	X	X	X		X	X	X		X	X
POACEAE	Sporobolus cryptandrus		X	X	X	X	X	X		X	X	X		X	X
POACEAE	Stipa viridula	X	X	X	X	X	X	X	X	X	X	X	X	X	X
	Total # Species Seeded	7	11	11	13	11	11	11	7	11	11	11 (12)	7	11	11
	# Present in 2011	6	7	8	8	7	10	11	6	9	10	5 (9)	6	8	7
	% Seeded Species Present in 2011	86	64	73	62	64	91	100	86	82	91	45 (82)	86	73	64
	Total Species Richness in 2011	18	19	21	29	16	27	30	49	25	33	18 (20)	38	20	16

Seed Mixes: X = Xeric Seed Mix, X1 = Variation on Xeric Seed Mix, M = Mesic Seed Mix.

Yellow shaded cells mean the success criterion of >50% of seeded species was met in 2011.

Blue shaded cells mean the species was present at this location in 2011.

Green shaded cells are results based on observations outside the quadrats but within the revegetation area. The numbers in parentheses represent the recalculated values based on the additional species observed. Based on these observations this location passes the criterion.

Table 3. Revegetation Locations L1 to L25 - Foliar Cover Summary 2011 (cont.)

Scientific Name	Speccode	Growth Form	Native	Cool/Warm Season	Noxious Weed	L1		L2		L3		L21		L23		L24		L25	
						Absolute Cover (%)	Relative Cover (%)												
<i>Festuca ovina</i> L. var. <i>rydbergii</i> St. Yves	FEOV1	G	Y	C								0.1	0.3						
<i>Hordeum brachyantherum</i> Nevski	HOBR1	G	Y	C		0.3	0.4												
<i>Hordeum jubatum</i> L.	HOJU1	G	Y	C				0.1	0.2	0.2	0.4			1.0	1.7	0.2	0.3	0.1	0.2
<i>Juncus balticus</i> Willd.	JUBA1	G	Y	C		0.1	0.2					2.6	8.7						
<i>Koeleria pyramidata</i> (Lam.) Beauv.	KOPY1	G	Y	C										0.1	0.2			0.4	0.9
<i>Scirpus pungens</i> Vahl	SCPU1	G	Y	C								0.1	0.3						
<i>Sitanion hystrix</i> (Nutt.) Sm. var. <i>brevifolium</i> (Sm.) Hitchc.	SIHY1	G	Y	C															
<i>Stipa viridula</i> Trin.	STVI1	G	Y	C		1.8	3.0	6.6	12.6	1.2	2.7					0.1	0.2	0.5	1.0
<i>Andropogon gerardii</i> Vitman	ANGE1	G	Y	W						1.0	2.3	1.6	5.4			0.1	0.2	0.6	1.2
<i>Andropogon scoparius</i> Michx.	ANSC1	G	Y	W				0.1	0.2			1.3	4.2			0.2	0.3	0.3	0.7
<i>Bouteloua curtipendula</i> (Michx.) Torr.	BOCU1	G	Y	W		0.5	0.9	1.9	3.6	3.0	6.9	2.8	9.6	0.1	0.2	2.6	5.2	1.2	2.4
<i>Bouteloua gracilis</i> (H. B. K.) Lag ex Griffiths	BOGR1	G	Y	W		1.1	1.9	0.8	1.4	0.3	0.8	1.7	5.6	0.3	0.4	3.3	6.6	0.7	1.4
<i>Buchloe dactyloides</i> (Nutt.) Engelm.	BUDA1	G	Y	W		1.3	2.2	2.6	5.0	5.8	13.5	2.3	7.9	0.1	0.2	3.8	7.8	9.9	20.3
<i>Cenchrus longispinus</i> (Hack.) Fern	CELO1	G	Y	W				0.1	0.2										
<i>Juncus torreyi</i> Cov.	JUTO1	G	Y	W		0.8	1.3					0.1	0.3						
<i>Panicum capillare</i> L.	PACA1	G	Y	W				0.1	0.2					0.1	0.2	0.3	0.7	0.1	0.2
<i>Panicum virgatum</i> L.	PAVI1	G	Y	W								2.1	7.0						
<i>Scirpus acutus</i> Muhl.	SCAC1	G	Y	W								0.1	0.3						
<i>Sorghastrum nutans</i> (L.) Nash	SONU1	G	Y	W												0.1	0.2	0.7	1.4
<i>Sporobolus cryptandrus</i> (Torr.) A. Gray	SPCR1	G	Y	W						0.2	0.4			0.1	0.2	0.3	0.7	0.3	0.7
<i>Sporobolus neglectus</i> Nash	SPNE1	G	Y	W												0.5	1.0		
<i>Spartina pectinata</i> Link	SPPE1	G	Y	W		0.9	1.5												
<i>Rosa arkansana</i> Porter	ROAR1	S	Y																
<i>Salix exigua</i> Nutt. ssp. <i>interior</i> (Rowlee) Cronq.	SAEX1	S	Y									0.6	2.0						
<i>Yucca glauca</i> Nutt.	YUGL1	S	Y									0.1	0.3						
Total Foliar Cover						57.8	100.0	52.5	100.0	43.3	100.0	29.6	100.0	60.4	100.0	49.4	100.0	48.8	100.0
Total Forb Cover						1.8	3.0	1.0	1.9	6.0	13.8	1.9	6.5	1.1	1.9	2.2	4.4	6.4	13.2
Total Non-Native Forb Cover						0.8	1.3	0.8	1.4	5.8	13.5	1.5	5.1	1.1	1.9	1.8	3.5	5.9	12.1
Total Native Forb Cover						1.0	1.7	0.3	0.5	0.2	0.4	0.4	1.4	0.0	0.0	0.4	0.8	0.5	1.0
Total Graminoid Cover						56.0	97.0	51.5	98.1	37.3	86.2	27.0	91.3	59.3	98.1	47.3	95.6	42.3	86.8
Total Non-Native Graminoid Cover						11.1	19.3	2.0	3.8	6.7	15.4	0.3	0.8	2.9	4.8	1.6	3.2	6.3	13.0
Total Native Graminoid Cover						44.9	77.7	49.5	94.3	30.7	70.8	26.8	90.4	56.4	93.4	45.7	92.4	36.0	73.8
Total Herbaceous Cover						57.8	100.0	52.5	100.0	43.3	100.0	28.9	97.7	60.4	100.0	49.4	100.0	48.8	100.0
Total Herbaceous Native Cover						45.9	79.4	49.8	94.8	30.8	71.2	27.2	91.8	56.4	93.4	46.1	93.3	36.5	74.9
Total Herbaceous Non-Native Cover						11.9	20.6	2.8	5.2	12.5	28.8	1.8	5.9	4.0	6.6	3.3	6.7	12.3	25.1
Total Warm-Season Graminoid Cover						4.5	7.8	5.6	10.7	10.3	23.8	11.9	40.3	0.9	1.4	11.3	22.8	13.8	28.2
Total Cool-Season Graminoid Cover						51.5	89.2	45.9	87.4	27.0	62.3	15.1	51.0	58.4	96.7	36.0	72.8	28.6	58.6
Total Noxious Weed Cover						0.5	0.9	2.0	3.8	4.5	10.4	0.4	1.4	2.5	4.1	2.0	4.0	7.6	15.6
Total Shrub Cover						0.0	0.0	0.0	0.0	0.0	0.0	0.7	2.3	0.0	0.0	0.0	0.0	0.0	0.0

Absolute Cover = The sum of all cover values for a species in a revegetation unit divided by the number of quadrats sampled in that unit.

Relative Cover = The sum of all cover values for a species in a revegetation unit divided by the sum of all cover values for all species in the same revegetation unit, multiplied by 100.

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 December 2011 Colorado State Noxious Weed List)

Yellow shaded cells indicate success criteria were met in 2011.

Blue shaded cells indicate this species provided greater than 45 percent of the relative cover in 2011.

Table 4. Revegetation Locations L32 to L57 - Foliar Cover Summary 2011 (cont.)

Scientific Name	Speccode	Growth Form	Native	Cool/Warm Season	Noxious Weed	L32		L35		L37		L40		L55		L56		L57	
						Absolute Cover (%)	Relative Cover (%)												
<i>Festuca ovina</i> L. var. <i>rydbergii</i> St. Yves	FEOV1	G	Y	C						0.1	0.2	0.5	0.8						
<i>Hordeum brachyantherum</i> Nevski	HOBR1	G	Y	C															
<i>Hordeum jubatum</i> L.	HOJU1	G	Y	C		0.1	0.1			0.6	1.3			2.2	3.4			0.3	0.5
<i>Juncus balticus</i> Willd.	JUBA1	G	Y	C										0.1	0.1				
<i>Koeleria pyramidata</i> (Lam.) Beauv.	KOPY1	G	Y	C				0.1	0.2					0.1	0.1				
<i>Scirpus pungens</i> Vahl	SCPU1	G	Y	C										2.1	3.3				
<i>Sitanion hystrix</i> (Nutt.) Sm. var. <i>brevifolium</i> (Sm.) Hitchc.	SIHY1	G	Y	C		0.1	0.1												
<i>Stipa viridula</i> Trin.	STVI1	G	Y	C		0.9	1.2	0.2	0.3	0.2	0.4			1.8	2.8	0.2	0.4	1.0	1.6
<i>Andropogon gerardii</i> Vitman	ANGE1	G	Y	W		0.2	0.2	0.3	0.5	0.8	1.7			1.3	2.0	0.5	1.1		
<i>Andropogon scoparius</i> Michx.	ANSC1	G	Y	W		2.1	2.7			0.8	1.7	1.0	1.6	0.2	0.3	0.2	0.4	0.2	0.3
<i>Bouteloua curtipendula</i> (Michx.) Torr.	BOCU1	G	Y	W		11.3	14.9	6.8	13.2	2.1	4.7	0.5	0.8	1.4	2.2	2.5	5.4	0.7	1.0
<i>Bouteloua gracilis</i> (H. B. K.) Lag ex Griffiths	BOGR1	G	Y	W		2.0	2.6	3.3	6.3	2.6	5.9			3.2	5.0	3.4	7.4	0.2	0.3
<i>Buchloe dactyloides</i> (Nutt.) Engelm.	BUDA1	G	Y	W		5.4	7.1	2.2	4.2	9.1	20.6	6.5	10.5	4.8	7.6	2.3	4.9	1.7	2.6
<i>Cenchrus longispinus</i> (Hack.) Fern	CEDA1	G	Y	W															
<i>Juncus torreyi</i> Cov.	JUTO1	G	Y	W		0.1	0.1												
<i>Panicum capillare</i> L.	PACA1	G	Y	W		0.1	0.1	0.1	0.2					0.1	0.1				
<i>Panicum virgatum</i> L.	PAVI1	G	Y	W		5.2	6.8									0.1	0.2		
<i>Scirpus acutus</i> Muhl.	SCAC1	G	Y	W															
<i>Sorghastrum nutans</i> (L.) Nash	SONU1	G	Y	W		0.1	0.1			0.3	0.8			0.5	0.8				
<i>Sporobolus cryptandrus</i> (Torr.) A. Gray	SPCR1	G	Y	W		3.3	4.3	0.6	1.1	1.5	3.4								
<i>Sporobolus neglectus</i> Nash	SPNE1	G	Y	W						0.1	0.2								
<i>Spartina pectinata</i> Link	SPPE1	G	Y	W										0.1	0.1				
<i>Rosa arkansana</i> Porter	ROAR1	S	Y			0.1	0.1												
<i>Salix exigua</i> Nutt. ssp. <i>interior</i> (Rowlee) Cronq.	SAEX1	S	Y											0.1	0.1				
<i>Yucca glauca</i> Nutt.	YUGL1	S	Y			0.1	0.1												
Total Foliar Cover						76.1	100.0	51.7	100.0	44.1	100.0	62.0	100.0	63.5	100.0	46.2	100.0	63.7	100.0
Total Forb Cover						16.3	21.5	3.8	7.4	3.2	7.2	11.0	17.7	3.8	6.0	1.9	4.2	3.7	5.8
Total Non-Native Forb Cover						7.9	10.4	1.5	2.9	2.3	5.3	6.0	9.7	2.2	3.4	0.5	1.1	3.3	5.2
Total Native Forb Cover						8.4	11.1	2.3	4.5	0.8	1.9	5.0	8.1	1.7	2.6	1.4	3.1	0.3	0.5
Total Graminoid Cover						59.6	78.3	47.8	92.6	40.9	92.8	51.0	82.3	59.6	93.8	44.3	95.8	60.0	94.2
Total Non-Native Graminoid Cover						23.2	30.4	0.7	1.3	1.8	4.2	4.0	6.5	4.0	6.3	3.2	6.9	1.7	2.6
Total Native Graminoid Cover						36.4	47.9	47.2	91.3	39.1	88.7	47.0	75.8	55.6	87.5	41.1	89.0	58.3	91.6
Total Herbaceous Cover						75.9	99.8	51.7	100.0	44.1	100.0	62.0	100.0	63.4	99.9	46.2	100.0	63.7	100.0
Total Herbaceous Native Cover						44.8	58.9	49.5	95.8	39.9	90.5	52.0	83.9	57.3	90.2	42.5	92.1	58.7	92.1
Total Herbaceous Non-Native Cover						31.1	40.9	2.2	4.2	4.2	9.5	10.0	16.1	6.2	9.7	3.7	7.9	5.0	7.9
Total Warm-Season Graminoid Cover						29.8	39.1	13.7	26.5	17.6	39.9	8.5	13.7	11.5	18.1	8.9	19.3	2.8	4.5
Total Cool-Season Graminoid Cover						29.8	39.2	34.2	66.1	23.3	52.9	42.5	68.5	48.1	75.7	35.3	76.5	57.2	89.8
Total Noxious Weed Cover						7.0	9.2	0.9	1.8	2.2	4.9	1.0	1.6	3.7	5.8	1.2	2.5	4.7	7.3
Total Shrub Cover						0.2	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.1	0.0	0.0	0.0	0.0

Absolute Cover = The sum of all cover values for a species in a revegetation unit divided by the number of quadrats sampled in that unit.

Relative Cover = The sum of all cover values for a species in a revegetation unit divided by the sum of all cover values for all species in the same revegetation unit, multiplied by 100.

Native Categories: Y = Native, N = Non-Native, NA = Not Available

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

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Noxious Weed Category: X = Noxious Weed (listed on December 2011 Colorado State Noxious Weed List)

Yellow shaded cells indicate success criteria were met in 2011.

Blue shaded cells indicate this species provided greater than 45 percent of the relative cover in 2011.

Table 5. Success Criteria Evaluation Summary 2011

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
L1	PASS	PASS	PASS	FAIL	PASS
L2	PASS	PASS	PASS	FAIL	PASS
L3	PASS	PASS	PASS	PASS	PASS
L21	PASS	PASS	PASS	PASS	PASS
L23	PASS	PASS	PASS	FAIL	PASS
L24	PASS	PASS	PASS	FAIL	PASS
L25	PASS	PASS	PASS	PASS	PASS
L32	PASS	PASS	PASS	PASS	PASS
L35	PASS	PASS	PASS	FAIL	PASS
L37	PASS	PASS	PASS	PASS	PASS
L40	PASS	PASS	FAIL	FAIL	PASS
L55	PASS	PASS	PASS	FAIL	PASS
L56	PASS	PASS	PASS	FAIL	PASS
L57	PASS	PASS	PASS	FAIL	PASS
% Passing	100	100	100	100	100

Yellow shaded cells indicate all success criteria were met in 2011.

Blue shaded cells indicate all success criteria would be met in 2011 if >45% cover of a single species was removed as criteria.

For reasons outlined in the text, these areas are considered to have passed as of 2011.

Green shaded cells indicate the success criteria was met when a survey was conducted for seeded species outside the quadrat boundaries for reasons outlined in the text.

Table 6. Revegetation Location Information Table

Location	Original Revegetation Date	Seed Mix*	Original Erosion Control	Additional Revegetation Effort Date	Amendments Added	New Erosion Control
1	Fall 2007	M	Flexterra		Biosol, Mycorrhizal Inoculent	
2	Summer 2004	X	Erosion Matting	Fall 2007	soil (from 991 slump), Biosol, Mycorrhizal Inoculent	Flexterra
3	Summer 2004	X	Erosion Matting	Fall 2007	soil (from 991 slump), Biosol, Mycorrhizal Inoculent	Flexterra
21	Summer/Fall 2005	X1	Flexterra/Crimped Straw			
23	Summer/Fall 2005	X	Crimped Straw	Summer/Fall 2007	Compost, Sustane, Mycorrhizal Inoculent	Flexterra
24	Summer/Fall 2005	X	Crimped Straw			
25	Summer/Fall 2005	X	Crimped Straw			
32	Summer 2004	M	Erosion Matting			
35	Summer 2005	X	Flexterra/Hydromulch			
37	Summer/Fall 2005	X	Crimped Straw/Flexterra			
40	Summer/Fall 2005	X	Crimped Straw			
55	Summer 2005	M	Crimped Straw/Flexterra			
56	Summer/Fall 2005	X	Crimped Straw/Hydromulch			
57	Summer 2005	X	Flexterra	Summer 2008	Compost, Sustane, Mycorrhizal Inoculent	Flexterra/Erosion Blankets

* See Table 2 for specific species in seed mix.

Table 7. Basal Cover Summary at Revegetation Locations 2011

Location	Basal Vegetation Cover (%)	Litter Cover (%)	Rock Cover (%)	Total Ground Cover (%)*
L1	4.4	63.0	6.9	74.3
L2	9.4	56.0	11.1	76.5
L3	8.3	50.7	15.3	74.3
L21	5.4	21.8	49.9	77.2
L23	4.4	69.5	9.3	83.1
L24	10.0	50.4	35.6	96.0
L25	9.2	53.0	39.6	101.8
L32	8.3	73.2	8.8	90.3
L35	6.3	51.4	32.0	89.7
L37	8.8	43.3	38.2	90.2
L40	5.0	54.5	36.0	95.5
L55	6.7	67.0	9.5	83.2
L56	6.7	48.2	25.9	80.8
L57	4.2	58.0	14.5	76.7
Grand Mean	6.9	54.3	23.8	85.0

* 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 2011.

Table 8. 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 9. Revegetation Summary Data for Previously Successful Areas (L24-L37)

		Location				
		L24	L25	L32	L35	L37
Species Richness	2008	28	31	45	28	24
	2009	27	38	38	28	43
	2011	27	30	49	25	33
Percent Seeded Species Present	2008	64	73	86	73	73
	2009	64	82	86	91	82
	2011	91	100	86	82	91
Total Absolute Foliar Cover	2008	57.0	49.8	76.5	74.8	61.8
	2009	60.7	45.3	71.1	54.8	46.8
	2011	49.4	48.8	76.1	51.7	44.1
Total Relative Native Foliar Cover	2008	75.0	72.7	50.2	75.7	76.4
	2009	79.3	78.1	53.6	81.8	54.8
	2011	93.3	74.9	58.9	95.8	90.5
Total Absolute Ground Cover (Basal Veg, Litter, Rock)	2008	64.2	61.4	84.6	67.1	69.1
	2009	86.8	87.8	88.3	93.9	81.8
	2011	96	101.8*	90.3	89.7	90.2
Species with greater than 5 percent relative foliar cover	2008	Slender wheatgrass (50.5%) Western wheatgrass (17.7%) Filaree (6.1%) Kochia (5.6%) Diffuse knapweed (5.6%)	Slender wheatgrass (36.7%) Western wheatgrass (23.9%) Kochia (7.4%) Blue grama (7.1%) Alyssum (6.1%)	Diffuse knapweed (13.5%) Slender wheatgrass (11.2%) Western wheatgrass (10.7%) Buffalograss (9.6%) Smooth brome (9.4%) Downy brome (6.0%) Sideoats grama (5.8%)	Western wheatgrass (33.9%) Slender wheatgrass (28.7%) Yellow sweet clover (6.5%) Sideoats grama (5.6%)	Slender wheatgrass (31.6%) Western wheatgrass (27.6%) Buffalograss (9.1%) Kochia (6.4%)
	2009	Western wheatgrass (33.2%) Slender wheatgrass (21.6%) Kochia (7.4%) Buffalograss (5.9%)	Western wheatgrass (25.4%) Slender wheatgrass (19.5%) Buffalograss (11.6%) Yellow sweet clover (6.3%)	Smooth brome (28.8%) Western wheatgrass (14.0%) Sideoats grama (13.2%) Kochia (5.7%) Buffalograss (5.0%)	Western wheatgrass (42.1%) Slender wheatgrass (17.8%) Sideoats grama (10.0%) Blue grama (7.9%)	Slender wheatgrass (18.1%) Western wheatgrass (12.8%) Buffalograss (8.7%) Crested wheatgrass (6.8%) Diffuse knapweed (6.2%) Downy brome (5.9%) Alyssum (5.0%)
	2011	Western wheatgrass (60%) Slender wheatgrass (9.3%) Buffalograss (7.8%) Blue grama (6.6%) Sideoats grama (5.2%)	Western wheatgrass (25.1%) Buffalograss (20.3%) Slender wheatgrass (18.3%) Downy brome (8.2%) Diffuse knapweed (5.5%)	Smooth brome (26.2%) Sideoats grama (14.9%) Buffalograss (7.1%) Switchgrass (6.8%)	Western wheatgrass (60.3%) Sideoats grama (13.2%) Blue grama (6.3%) Slender wheatgrass (5.0%)	Western wheatgrass (34.0%) Buffalograss (20.6%) Slender wheatgrass (13.8%) Blue grama (5.9%)

* Values greater than 100 percent are a result of the monitoring protocol that uses the midpoints of the cover class system for analysis.