

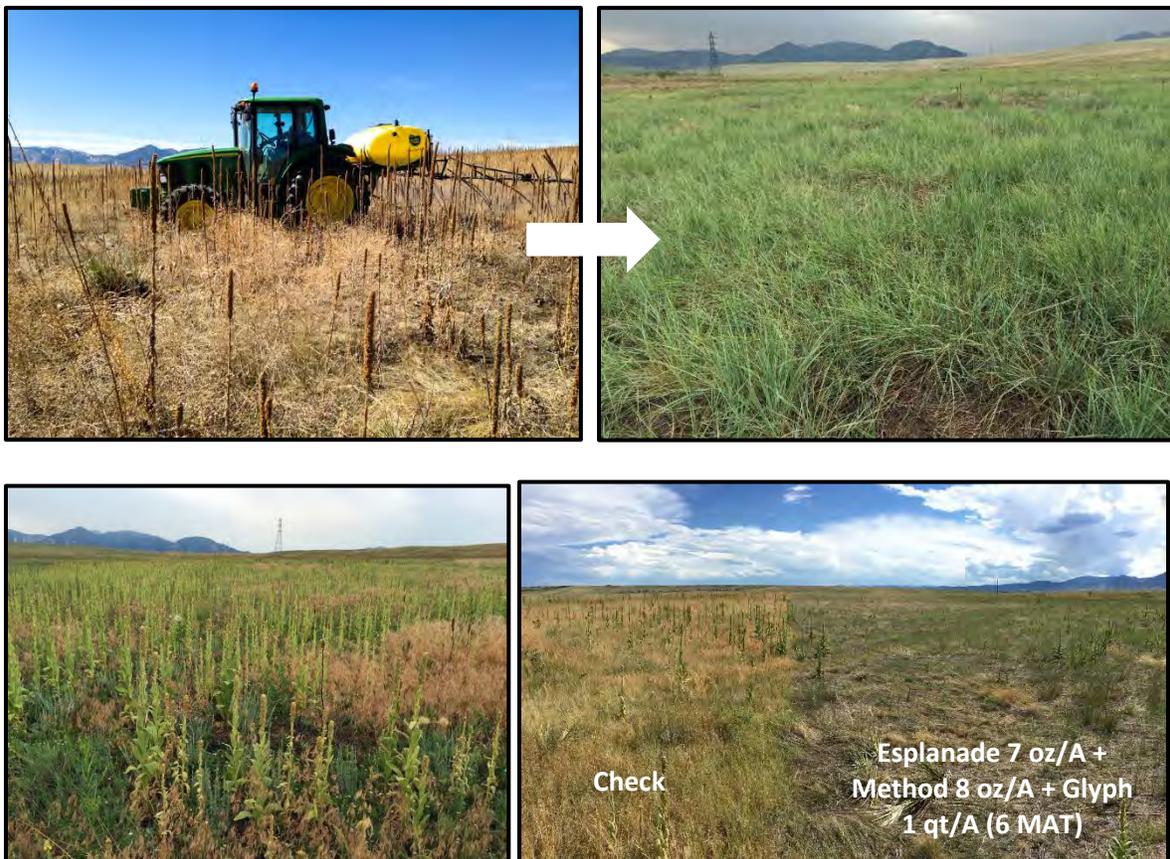
**Extending the Duration of Annual, Biennial, and Perennial Weed Control
with Esplanade Tank Mixes**
Final Report December 9, 2016

Submitted by:

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Section 1: Abstract

Abstract:

Invasive species management on non-crop and rangeland remains a constant challenge throughout many regions of the United States. While there are over 300 rangeland weeds, downy brome (*Bromus tectorum* L.), Dalmatian toadflax (*Linaria dalmatica*), musk thistle (*Carduus nutans*), Scotch thistle (*Onopordum acanthium*), diffuse knapweed (*Centaurea diffusa*), and moth mullein (*Verbascum blattaria*) have emerged as some of the most invasive and problematic on Boulder County Open Space properties. Downy brome (*Bromus tectorum* L.) is a competitive winter annual grass that is considered one of the most problematic invasive species in rangeland. It has been estimated the western United States rangeland is infested with over 22 million hectares of downy brome. While glyphosate, imazapic, and rimsulfuron are the current industry standards for annual grass control, all of these restoration options provide inconsistent control or cause injury to desirable perennial species. In addition, Dalmatian toadflax, musk thistle, moth mullein, and diffuse knapweed infest over 2.8 million ha alone, and are all Colorado Noxious Weed List B species. The increasing spread of biennial species is a result of their adaptability, life cycle, and prolific seed production. Weeds compete for moisture and can spread by seed or vegetatively into undisturbed areas, outcompeting native grass, forb and shrub species. Herbicides with both foliar and soil-residual activity (2,4-D, aminocyclopyrachlor, aminopyralid, chlorsulfuron, clopyralid, dicamba, fluroxypyr, picloram, and triclopyr) are most commonly used, yet these control options lack residual seedling control resulting in rapid re-invasions. An experiment is proposed to evaluate the efficacy of indaziflam, a new herbicide that has the potential to extend the duration of annual, biennial, and perennial invasive weed control by eliminating re-establishment from the soil seed bank. Our proposed experiment will evaluate the efficacy of currently recommended herbicides alone and in combination with indaziflam. Research at Colorado State University has shown that treatments including indaziflam resulted in significantly longer downy brome (88-94%) and Dalmatian toadflax control (84-91%) four years after treatment. Cover and control of weed species and desirable perennial grass cover evaluations will be collected after treatments are applied. All data will be analyzed in SAS by analysis of variance and by regression, to determine optimum treatments. This research could ultimately provide a new, long-term control option for controlling noxious weed species on Boulder County Parks and Open Space properties. Educational opportunities including field tours will be made available to Boulder County Parks and Open Space employees during completion of the experiment.

Section 2: Introduction

Objectives:

Objective 1: To determine if indaziflam (Esplanade™, Bayer CropScience) tank mixes provide extended annual, biennial, and perennial weed species control as compared to currently recommended herbicides.

Objective 2: To evaluate desirable native grass, forb, and shrub species response to herbicide treatments.

Hypothesis:

Research Hypothesis: Treatments including indaziflam provide significantly longer annual, biennial, and perennial residual seedling control as compared to treatments alone or excluding indaziflam.

Null Hypothesis: Treatments including indaziflam will not provide significantly longer annual, biennial, and perennial residual seedling control.

Anticipated Value of the Proposed Research/Contribution to Management Needs:

Annual, biennial, and perennial weeds including downy brome, Dalmatian toadflax, musk thistle, Scotch thistle, diffuse knapweed, and moth mullein are often present on similar rangeland, roadside, and

disturbed sites along the Front Range of Colorado. All of these species are found on Boulder County Parks and Open Space properties (Mayhoffer, Hillside, and Kenosha). These highly invasive species compete with desirable native species for early spring moisture and have the capability to spread from disturbed to undisturbed areas. Downy brome also germinates in the fall and early spring, exploiting moisture and nutrients before native plant communities begin active growth in the spring. Downy brome seeds are tolerant to temperature and moisture stress and can remain viable for up to 5 years. Land managers have been faced with the problem of selectively controlling biennial and perennial invasive species with broadleaf herbicides, and current chemical control options for downy brome include imazapic, rimsulfuron, and glyphosate; however, these herbicides lack consistency beyond the initial year of application and have been shown to injure desirable plant communities.

Indaziflam (Esplanade™, Bayer CropScience) is a relatively new herbicide that is currently registered for annual weed control in turf, orchards, and noncropland. Indaziflam is used at rates between 3.5 and 7 oz/A and has excellent preemergence activity on many annual weed species (Fig. A1). Indaziflam has several attributes that make it an ideal candidate to control non-crop weeds that reproduce primarily by seed production, 1) long soil-residual activity and 2) no injury to perennial grasses, forbs, and shrubs (Figs. A2-6). This combination would increase the opportunity for successful restoration of Boulder County Open Space properties. Because indaziflam is a root inhibiting herbicide this allows for increased safety on desirable perennial plants, that have roots below the layer where the herbicide is active (Fig. A1). The emerged plants at the time of application would be initially controlled by the tank mix partner (picloram, aminocyclopyrachlor, etc.), while indaziflam would provide the long-term control of subsequent seedlings (Fig. A7). Field studies at CSU have demonstrated that indaziflam has excellent long term downy brome control (3+ years) with minimal injury to native perennial species (Figs. A2-6). A greenhouse study has shown indaziflam can control downy brome, diffuse knapweed, common mullein, and Scotch thistle seedlings at rates as low as 1 oz/A (Fig. A7).

Our proposed research will ultimately provide additional management options for long-term control of invasive annual, biennial, and perennial species, where treatments in the past have provided inconsistent, short-term control. Applying this knowledge will be especially important to land managers and county agencies throughout the western United States who have had difficulties controlling these species in the past. Fewer herbicide applications would mean additional years for native species to respond and recover, a lighter load of herbicides sprayed on managed properties, and the financial/labor savings from yearly herbicide treatments or mowing operations. This research will also provide an insight into the effect of herbicide treatments used for invasive weed control, on desirable grass, forb, and shrub species.

Section 3: Methods (2 Separate Studies with 2 Sites Each)

1) Invasive Annual, Biennial, and Perennial Control (Mayhoffer Property 2 Sites)

We conducted an experiment to test the hypothesis that herbicide treatments that include Esplanade will provide increased residual control compared to treatments without Esplanade. Within this study we also evaluated herbicide treatments effect on desirable grass, forb, and shrub species. Treatments were applied to 1 acre plots and repeated at **two research sites (120' x 450')**. All treatments were applied with a 25' boom at 30 gal/A, 2.5 mph, and 30 psi. The experiment had 12 total treatments with one early spring application timing (**March 2016**). Visual estimates of cover and control of individual weed species were conducted, as well as visual cover and injury estimates of the desirable perennial grass, forb, and shrub species. This experiment is designed to be conducted for 2-3 years with additional long-term evaluations in following years; however, current data on weed control and response of the native plant community to herbicide treatments can be seen below.



Mayhoffer Lower Site Spray Information

Application Information

Application Date	March 11 and 12, 2016
Time of Day	10:00 AM
Application Method	Tractor
Application Timing	POST
Air Temp (F)	60
Relative Humidity (%)	33%
Wind Velocity (mph)	0 to 2

Application Equipment

Sprayer Type	Speed (mph)	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	PSI
Back Pack	2.5	Flat Fan?	11002	18"	20"	25'	30	30

Summary Comments

The site is located on the Mayhoffer property of Boulder county. It has been overrun by several invasive noxious weeds and has restoration has been attempted in the past but failed. This site is on a hillside with a dense stand of common mullein, knapweed, and several others listed below.

Application March 11, 2015:

- Downy Brome: 1-2 tiller, 0.5-1" tall
- Fringed Sage: thick, 1-2" tall, 50% green
- Mullein: Dried and Post seed set, 3-8" rosettes
- Gumweed: Post Seedset
- Moth Mullein: Post Seedset, 2-5" rosettes
- Diffuse Knapweed: Post Seedset, Rosettes 1-4:
- Salsify: 2-4" tall green
- Yellow Alyssum: 0.5-1" tall
- Filare: 0.5-1" tall
- Louisiana Sage: 1-2" tall
- Blue Grama: Dormant
- Buffalo Grass: Dormant
- Dalmatian: 1-2" tall

Western: 2-4" tall just breaking dormancy
 Curly Dock: 2-3" tall
 Prickly lettuce: 0.5" tall
 Yucca: green
 Knotweed?
 Grey wormwood? Porter Aster? 1" tall
 Musk: 2-4" rosettes, few plants
 Wild tarragon: Post Seed, sparse
 Parsley: 2" tall

Table 1. Mayhoffer Lower Hillside Site Protocol

Trt	Treatment	Rate
1	Esplanade	7 oz/A
2	Method	8 oz/A
3	Method + Esplanade	8 oz/A + 7 oz/A
4	Untreated	1 qt/A
5	Method+ Telar	8 oz/A + 1 oz/A
6	Method+ Telar + Esplanade	8 oz/A + 1 oz/A + 7 oz/A
7	Tordon	1 qt/A
8	Tordon + Esplanade	1 qt/A + 7 oz/A
9	Tordon + Telar (Boulder Std)	1 qt/A + 1 oz/A
10	Tordon + Telar + Esplanade (reduced rates)	1 qt/A + 1 oz/A + 7 oz/A
11	Tordon + Telar + Esplanade (reduced rates)	16 oz/A + 2 oz/A + 7 oz/A
12	Method+ Telar + Esplanade (reduced rates)	5 oz/A + 2 oz/A + 7 oz/A

*All treatments included 24 oz/A glyphosate and 24 oz/A NIS except Trts 11 and 12

**Trts 11 and 12 had 12 oz/A glyphosate and 24 oz/A NIS

***Chemical and product names found in Table A8 (Pg. 37)

Mayhoffer Upper Site Spray Information

Application Information

Application Date	March 9, 2016
Time of Day	10:00 AM
Application Method	Tractor
Application Timing	POST
Air Temp (F)	60
Relative Humidity (%)	33%
Wind Velocity (mph)	0 to 2

Application Equipment

Sprayer Type	Speed (mph)	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	PSI
Back Pack	2.5	Flat Fan?	11002?	18"?	20"	25'	30	30

Summary Comments

The site is located on the Mayhoffer property of Boulder county. It has been overrun by several invasive noxious weeds and has restoration has been attempted in the past but failed. This site is on flat piece of land close to several recreational trails. The site was mowed July 2015.

Application March 9, 2015:

Western wheatgrass: just breaking dormancy, 1-2" tall, 1-2 leaf

Mullein: 3-6" rosettes

Dalmatian Toadflax: 0.5-2" tall

Fringed Sage" 0.5-1" tall

Sideoats: dormant

Blue Gramma: dormant

Diffuse: 2-4" rosettes

Salsify: 2-6" tall

Curly Cup: dormant

Table 2. Mayhoffer Upper Hilltop Site Protocol

Trt No.	Treatment	Rate
1	Esplanade	7 oz/A
2	Method	8 oz/A
3	Method + Telar	8 oz/A + 1 oz/A
4	Tordon	1 qt/A
5	Tordon + Telar (Boulder Standard)	1 qt/A + 1 oz/A
6	Method + Esplanade	8 oz/A + 7 oz/A
7	Non-treated	
8	Method+ Telar + Esplanade	8 oz/A + 1 oz/A + 7 oz/A
9	Tordon + Esplanade	1 qt/A + 7 oz/A
10	Tordon + Telar + Esplanade (reduced rates)	1 qt/A + 1 oz/A + 7 oz/A
11	Tordon + Telar + Esplanade (reduced rates)	16 oz/A + 2 oz/A + 7 oz/A
12	Method+ Telar + Esplanade (reduced rates)	5 oz/A + 2 oz/A + 7 oz/A

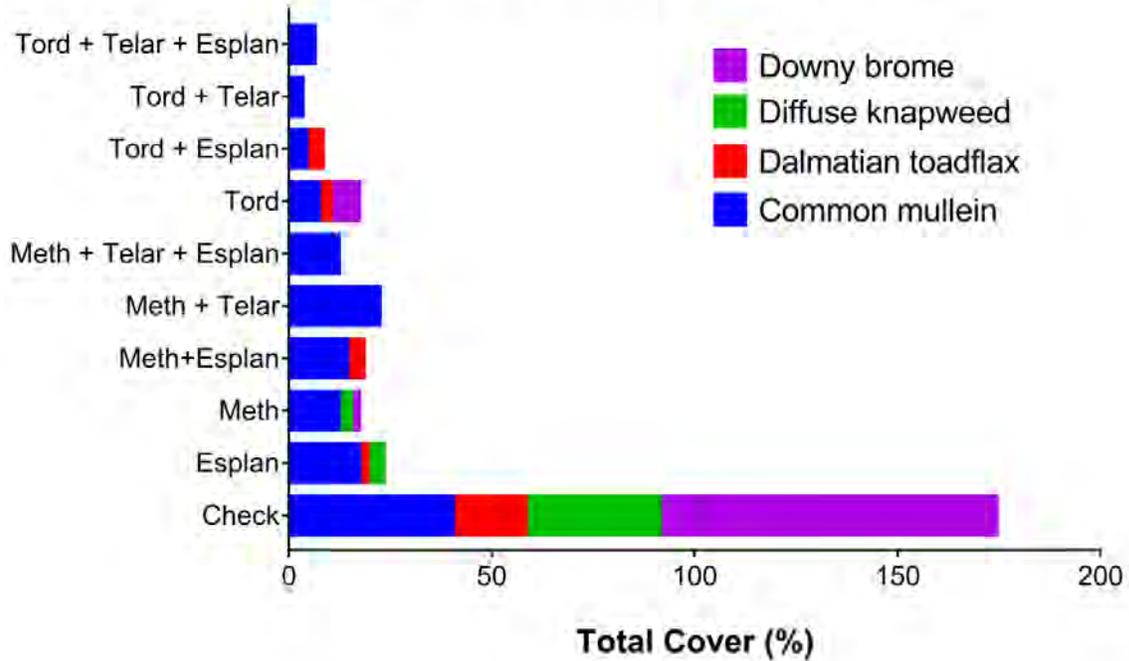
*All treatments included 24 oz/A glyphosate and 24 oz/A NIS except Trts 11 and 12

**Trts 11 and 12 had 12 oz/A glyphosate and 24 oz/A NIS

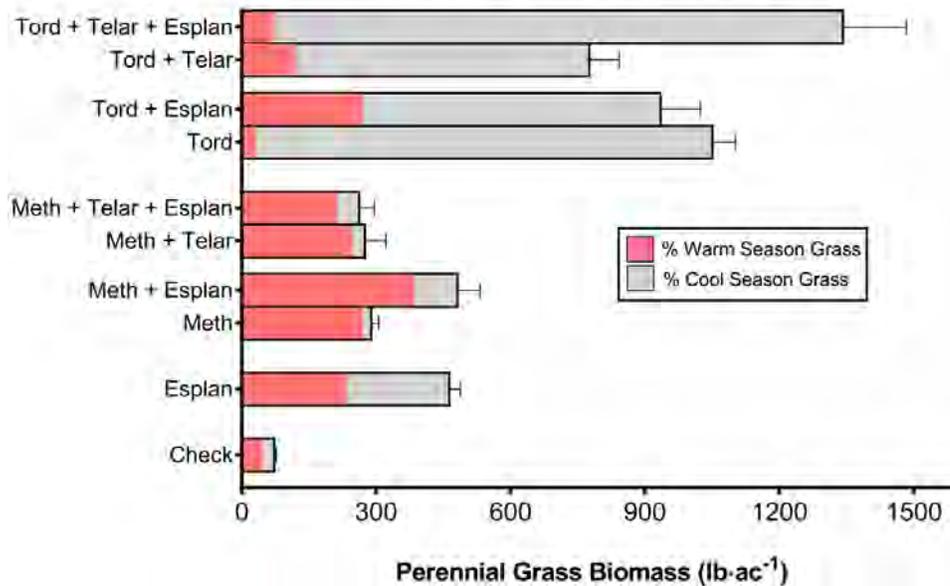
***Chemical and product names found in Table A8 (Pg. 37)

Data (Weed Control and Native Response)

Weed Control (Sites Combined)



Perennial Grass Response (Site 2)

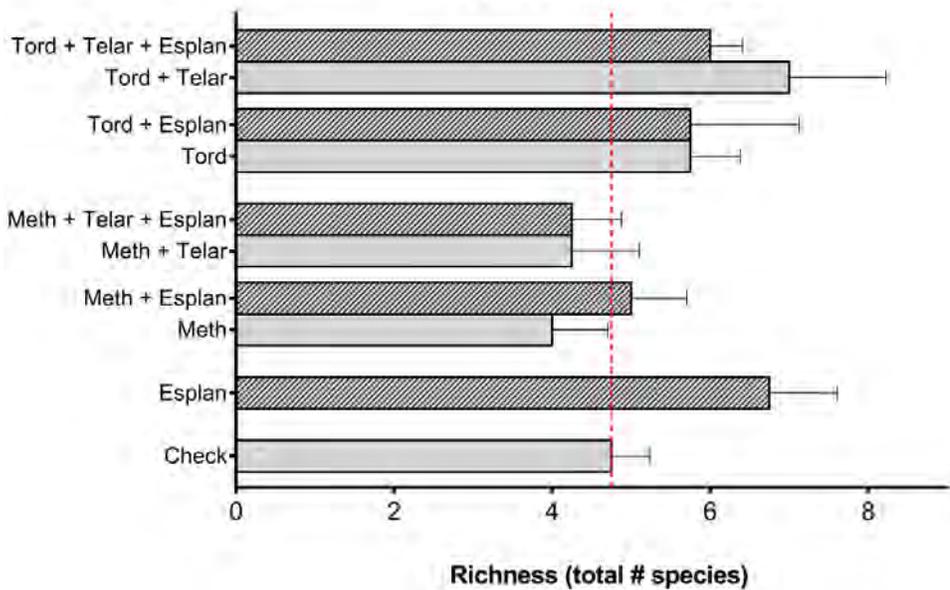


* Esplanade (7oz), Method (8oz), Telar (1oz), Tordon (1qt)

** All included 24oz glyphosate + 24oz NIS

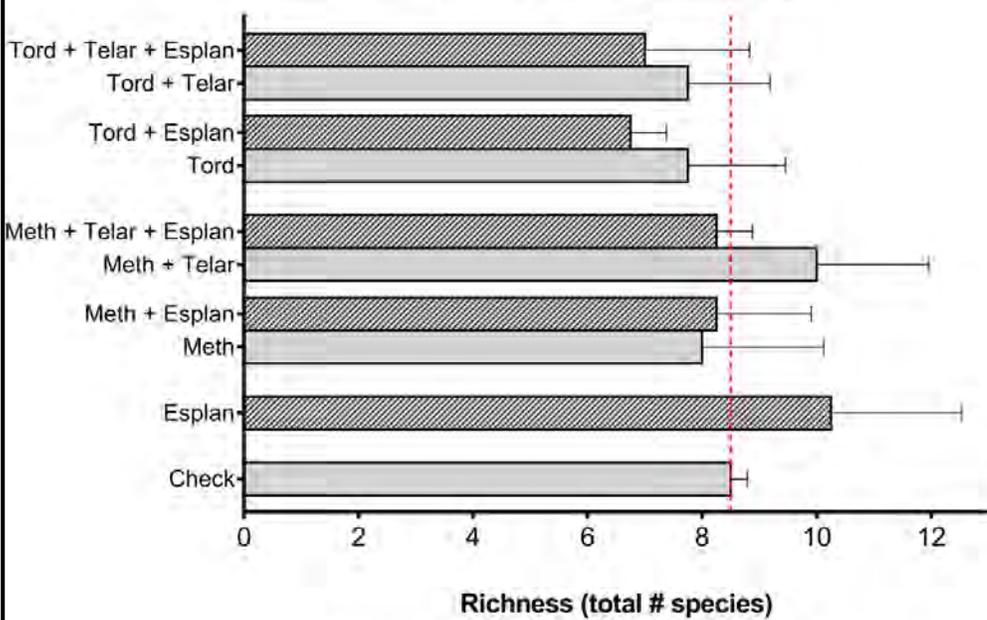
*** Treated March 2015, Biomass Harvest December 2016

Native Forb Response (Site 1) Lower Site



* Esplanade (7oz), Method (8oz), Telar (1oz), Tordon (1qt)
 ** All included 24oz glyphosate + 24oz NIS
 *** Treated March 2015, Evaluated July 2016

Native Forb Response (Site 2) Upper Site



* Esplanade (7oz), Method (8oz), Telar (1oz), Tordon (1qt)
 ** All included 24oz glyphosate + 24oz NIS
 *** Treated March 2015, Evaluated July 2016

2. Downy Brome Control and Desirable Plant Community Response (2 Sites)

An additional two studies were conducted on the Hillside and Kenosha properties of Boulder County. These two studies evaluated downy brome control and desirable plant community response to currently recommended herbicide treatments compared to treatments with indaziflam. Two application timings were evaluated. Data for visual downy brome control and response of the native plant community can be seen below.



*Site images in appendix (Pg. 27)

Table 3:

Trt	Treatment	Rate	Unit	Growth Stage
1	Non-treated			
2	Olympus	0.9	OZ/A	Fall 2015
	NIS	0.25	% V/V	Fall 2015
3	Olympus	1.2	OZ/A	Fall 2015
	NIS	0.25	% V/V	Fall 2015
4	Olympus	0.9	OZ/A	Fall 2015
	Esplanade	5	OZ/A	Fall 2015
	NIS	0.25	% V/V	Fall 2015
5	Olympus	1.2	OZ/A	Fall 2015
	Esplanade	5	OZ/A	Fall 2015
	NIS	0.25	% V/V	Fall 2015
6	Matrix	3	OZ/A	Fall 2015
	NIS	0.25	% V/V	Fall 2015
7	Matrix	4	OZ/A	Fall 2015
	NIS	0.25	% V/V	Fall 2015
8	Matrix	3	OZ/A	Fall 2015
	Esplanade	5	OZ/A	Fall 2015
	NIS	0.25	% V/V	Fall 2015
9	Matrix	4	OZ/A	Fall 2015
	Esplanade	6.8	OZ/A	Fall 2015
	NIS	0.25	% V/V	Fall 2015
10	Plateau	7	OZ/A	Fall 2015
	Accord XRT II	12	OZ/A	Fall 2015
	NIS	0.25	% V/V	Fall 2015
11	Accord XRT II	12	OZ/A	Fall 2015
	NIS	0.25	% V/V	Fall 2015
12	Esplanade	5	OZ/A	Fall 2015
	NIS	0.25	% V/V	Fall 2015
13	Esplanade	6.8	OZ/A	Fall 2015

Trt	Treatment	Rate	Unit	Growth Stage
16	Olympus	0.9	OZ/A	Spring 2016
	NIS	0.25	% V/V	Spring 2016
17	Olympus	1.2	OZ/A	Spring 2016
	NIS	0.25	% V/V	Spring 2016
18	Matrix	3	OZ/A	Spring 2016
	NIS	0.25	% V/V	Spring 2016
19	Matrix	4	OZ/A	Spring 2016
	NIS	0.25	% V/V	Spring 2016
20	Matrix	3	OZ/A	Spring 2016
	Esplanade	5	OZ/A	Spring 2016
	NIS	0.25	% V/V	Spring 2016
21	Matrix	4	OZ/A	Spring 2016
	Esplanade	6.8	OZ/A	Spring 2016
	NIS	0.25	% V/V	Spring 2016
22	Plateau	7	OZ/A	Spring 2016
	Accord XRT II	12	OZ/A	Spring 2016
	NIS	0.25	% V/V	Spring 2016
23	Accord XRT II	12	OZ/A	Spring 2016
	NIS	0.25	% V/V	Spring 2016
24	Esplanade	6.8	OZ/A	Spring 2016
	Piper	10	OZ/A	Spring 2016
	Accord XRT II	12	OZ/A	Spring 2016
	NIS	0.25	% V/V	Spring 2016

	NIS	0.25	% V/V	Fall 2015
14	Accord XRT II	12	OZ/A	Fall 2015
	Esplanade	5	OZ/A	Fall 2015
	NIS	0.25	% V/V	Fall 2015
15	Esplanade	6.8	OZ/A	Fall 2015
	Piper	10	OZ/A	Fall 2015
	Accord XRT II	12	OZ/A	Fall 2015
	NIS	0.25	% V/V	Fall 2015

Hillside Site 1 Spray Information

Application Date	December 10, 2015	March 3, 2016
Time of Day	2:00 PM	10:00 AM
Application Method	Broadcast/backpack	Broadcast/backpack
Application Timing	Winter Application Timing	Spring
Air Temp (F)	47	54.8
Relative Humidity (%)	23	33.1
Wind Velocity (mph)	1-3 mph	1-3 mph

Application Equipment

Sprayer Type	Speed (mph)	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	PSI
Back Pack	3.0	Flat Fan	11002	18"	20"	10'	20	40

Summary Comments

Study site is in the Front Range in Colorado on Boulder County Property. There is a nice native stand of western wheatgrass and several other shrub species. Downy brome has invaded this area and is threatening to outcompete the native plant community. This study was established to monitor downy brome control as well as native species tolerance to herbicide applications. The following day after treatment there was a big snow storm and received another storm in mid-December as well. Excellent moisture after application.

Application December 10, 2015:

Downy brome – 1 to 2 leaf, 1-2" tall
 Western- dormant
 Rabbit Brush- dried, post seed set
 Wild Tarragon- dried, post seed set
 Prickly Lettuce- dried, post seed set
 Yucca- green
 Fringed Sage- dried, post seed set

Application March 3, 2016:

Fringed sage green
 All other species dormant
 Downy Brome – 1-3 leaf, 1 tiller 1-2" tall, very dense, 25% red and 75% green
 Have received very good moisture following up to this application. Looks dry for a couple days but March should be wet

Description				Downy Brome 5/12/2016 Control %		Downy Brome 5/12/2016 Cover %		DB Control 7/15/2016 Control %		DB Cover 7/15/2016 Cover %	
Rating Date											
Rating Type											
Rating Unit											
Trt	Treatment	Rate	Rate								
No.	Name	Rate	Unit								
December Timing											
1	UNTREATED			0	i	88.5	a	7.5	d	87.8	a
2	OLYMPUS	0.9	OZ/A	7.5	hi	83	a	6.3	d	87.5	a
	INDUCE	0.25	% V/V								
3	OLYMPUS	1.2	OZ/A	8.8	ghi	75.8	abc	15.3	d	78.3	ab
	INDUCE	0.25	% V/V								
4	OLYMPUS	0.9	OZ/A	13.8	ghi	79.3	ab	20	d	71.3	abc
	ESPLANADE	5	OZ/A								
	INDUCE	0.25	% V/V								
5	OLYMPUS	1.2	OZ/A	12.5	ghi	73.8	abc	18.8	d	64.5	bc
	ESPLANADE	5	OZ/A								
	INDUCE	0.25	% V/V								
6	MATRIX	3	OZ/A	97.5	ab	2.5	f	97.5	a	5	g
	INDUCE	0.25	% V/V								
7	MATRIX	4	OZ/A	100	a	0	f	98.3	a	1.8	g
	INDUCE	0.25	% V/V								
8	MATRIX	3	OZ/A	99.8	a	0.3	f	99.8	a	0.3	g
	ESPLANADE	5	OZ/A								
	INDUCE	0.25	% V/V								
9	MATRIX	4	OZ/A	100	a	0	f	100	a	0	g
	ESPLANADE	6.8	OZ/A								
	INDUCE	0.25	% V/V								
10	PLATEAU 2L	7	OZ/A	96.5	ab	3.5	f	95.3	a	4.3	g
	ACCORD XRT II	12	OZ/A								
	INDUCE	0.25	% V/V								

11	ACCORD XRT II	12	OZ/A	82	bcd	15	ef		66.3	bc	32.5	ef
	INDUCE	0.25	% V/V									
12	ESPLANADE	5	OZ/A	20	gh	67.5	bc		23.8	d	72.5	abc
	INDUCE	0.25	% V/V									
13	ESPLANADE	6.8	OZ/A	23.8	fg	65.5	bc		25	d	68.8	abc
	INDUCE	0.25	% V/V									
14	ACCORD XRT II	12	OZ/A	99.3	a	0.8	f		97.3	a	2.8	g
	ESPLANADE	5	OZ/A									
	INDUCE	0.25	% V/V									
15	ESPLANADE	6.8	OZ/A	99.8	a	0.3	f		96.8	a	3.3	g
	Piper	10	OZ/A									
	ACCORD XRT II	12	OZ/A									
	INDUCE	0.25	% V/V									
March Spring Application												
16	OLYMPUS	0.9	OZ/A	12.5	ghi	77.5	abc		23.8	d	70	abc
	INDUCE	0.25	% V/V									
17	OLYMPUS	1.2	OZ/A	13.8	ghi	80	ab		22.5	d	54.3	cd
	INDUCE	0.25	% V/V									
18	MATRIX	3	OZ/A	36.3	ef	62.5	cd		69.3	bc	30.8	ef
	INDUCE	0.25	% V/V									
19	MATRIX	4	OZ/A	75	cd	22.5	e		95.5	a	4.5	g
	INDUCE	0.25	% V/V									
20	MATRIX	3	OZ/A	89	abc	9.8	ef		94.3	a	5.8	g
	ESPLANADE	5	OZ/A									
	INDUCE	0.25	% V/V									
21	MATRIX	4	OZ/A	100	a	0	f		99.3	a	0.8	g
	ESPLANADE	6.8	OZ/A									
	INDUCE	0.25	% V/V									

22	PLATEAU 2L	7	OZ/A	72.5	d	23.5	e		82	ab	18	fg
	INDUCE	0.25	% V/V									
23	ACCORD XRT II	12	OZ/A	48.8	e	48.8	d		56.3	c	41.3	de
	INDUCE	0.25	% V/V									
24	ESPLANADE	6.8	OZ/A	95	ab	3.8	f		95.3	a	4.8	g
	Piper	10	OZ/A									
	ACCORD XRT II	12	OZ/A									
	INDUCE	0.25	% V/V									

Native Grass and Forb Response to Herbicides

				Hillside Perennial Grass	Hillside Perennial Grass	Hillside Species Richness
				7/15/2016	7/15/2016	7/15/2016
				Injury %	Cover %	Species/trt #
January Application						
1	UNTREATED			0	0	3
				0	0	
				0	2	
				60	15	
Mean =				15	4.3	
2	OLYMPUS	0.9	OZ/A	0	0	5
	INDUCE	0.25	% V/V	0	0	
				0	15	
				0	5	
Mean =				0	5	
3	OLYMPUS	1.2	OZ/A	0	0	6
	INDUCE	0.25	% V/V	0	0	
				90	10	
				0	55	
Mean =				22.5	16.3	
4	OLYMPUS	0.9	OZ/A	0	0	6
	ESPLANADE	5	OZ/A	0	0	
	INDUCE	0.25	% V/V	0	25	

				0	30	
Mean =				0	13.8	
5	OLYMPUS	1.2	OZ/A	0	0	6
	ESPLANADE	5	OZ/A	0	0	
	INDUCE	0.25	% V/V	0	15	
				0	75	
Mean =				0	22.5	
6	MATRIX	3	OZ/A	0	0	7
	INDUCE	0.25	% V/V	0	0	
				0	65	
				0	75	
Mean =				0	35	
7	MATRIX	4	OZ/A	0	0	6
	INDUCE	0.25	% V/V	0	0	
				20	25	
				40	10	
Mean =				15	8.8	
8	MATRIX	3	OZ/A	0	0	4
	ESPLANADE	5	OZ/A	0	0	
	INDUCE	0.25	% V/V	0	0	
				0	0	
Mean =				0	0	
9	MATRIX	4	OZ/A	0	0	6
	ESPLANADE	6.8	OZ/A	50	15	
	INDUCE	0.25	% V/V	25	0	
				0	65	
Mean =				18.8	20	
10	PLATEAU 2L	7	OZ/A	0	0	4
	INDUCE	0.25	% V/V	0	0	
				0	25	
				20	15	
Mean =				5	10	
11	ACCORD XRT II	12	OZ/A	0	0	6
	INDUCE	0.25	% V/V	0	8	
				20	20	
				0	25	
Mean =				5	13.3	
12	ESPLANADE	5	OZ/A	0	0	6
	INDUCE	0.25	% V/V	0	0	
				30	10	

				0	0	
Mean =				7.5	2.5	
13	ESPLANADE	6.8	OZ/A	0	0	5
	INDUCE	0.25	% V/V	0	0	
				0	5	
				40	50	
Mean =				10	13.8	
14	ACCORD XRT II	12	OZ/A	0	0	5
	ESPLANADE	5	OZ/A	0	0	
	INDUCE	0.25	% V/V	0	45	
				0	8	
Mean =				0	13.3	
15	ESPLANADE	6.8	OZ/A	0	0	4
	Piper	10	OZ/A	25	70	
	ACCORD XRT II	12	OZ/A	0	75	
	INDUCE	0.25	% V/V	0	55	
Mean =				6.3	50	
March Spring Application						
16	OLYMPUS	0.9	OZ/A	0	0	6
	INDUCE	0.25	% V/V	0	0	
				40	15	
				50	25	
Mean =				22.5	10	
17	OLYMPUS	1.2	OZ/A	0	0	5
	INDUCE	0.25	% V/V	0	5	
				0	10	
				0	10	
Mean =				0	6.3	
18	MATRIX	3	OZ/A	0	0	7
	INDUCE	0.25	% V/V	15	40	
				0	10	
				0	0	
Mean =				3.8	12.5	
19	MATRIX	4	OZ/A	0	0	6
	INDUCE	0.25	% V/V	0	6	
				0	0	
				50	40	

Mean =				12.5	11.5	
20	MATRIX	3	OZ/A	0	0	6
	ESPLANADE	5	OZ/A	0	0	
	INDUCE	0.25	% V/V	0	8	
				15	30	
Mean =				3.8	9.5	
21	MATRIX	4	OZ/A	0	0	6
	ESPLANADE	6.8	OZ/A	0	0	
	INDUCE	0.25	% V/V	0	5	
				0	10	
Mean =				0	3.8	
22	PLATEAU 2L	7	OZ/A	0	0	5
	INDUCE	0.25	% V/V	0	0	
				0	0	
				0	70	
Mean =				0	17.5	
23	ACCORD XRT II	12	OZ/A	0	0	6
	INDUCE	0.25	% V/V	0	0	
				0	0	
				30	15	
Mean =				7.5	3.8	
24	ESPLANADE	6.8	OZ/A	0	0	5
	Piper	10	OZ/A	30	50	
	ACCORD XRT II	12	OZ/A	0	65	
	INDUCE	0.25	% V/V	0	55	
Mean =				7.5	42.5	

Kenosha Site 2 Spray Information

Application Date	January 28, 2016	March 3, 2016
Time of Day	1:00 PM	10:00 AM
Application Method	Broadcast/backpack	Broadcast/backpack
Application Timing	Winter Application Timing	Spring
Air Temp (F)	70	54.8
Relative Humidity (%)	26.7rainy	33.1
Wind Velocity (mph)	2-4	1-3 mph

Application Equipment

Sprayer Type	Speed (mph)	Nozzle Type	Nozzle Size	Nozzle Height	Nozzle Spacing	Boom Width	GPA	PSI
Back Pack	3.0	Flat Fan	11002	18"	20"	10'	20	40

Summary Comments

This site is located in Longmont Colorado on a space that appears to have been a crop field at some point. There is a dense stand of downy brome with approximately 10-20% perennial grass understory cover. There was snow on the ground most of December so the initial application was applied in late January immediately after snow-melt. Three days after treatment 10-12" of snow accumulated at this site.

Application January 28, 2016:

Perennial grasses-100% dormant

Prickly Lettuce- post seedset 100% dry

Downy Brome- 1 tiller, 1-3 leaf, 1-3" tall, 50% green and 50% purple/red

Application March 3, 2016:

Western Wheatgrass just breaking dormancy, some green and about 1-4" tall. May see some injury

Downy Brome – 1-3 leaf, 1 tiller, 1-2" tall, very dense, 25% red and 75% green

Have received very good moisture following up to this application. Looks dry for a couple days but March should be wet

Rating Type				Control % 5/12/16		Control % 7/15/16	
Rating Unit							
Trt	Treatment	Rate	Unit				
No.	Name	Rate	Unit				
January Application							
1	UNTREATED			0	i	0	e
2	OLYMPUS	0.9	OZ/A	5	hi	1.3	e
	INDUCE	0.25	% V/V				

3	OLYMPUS	1.2	OZ/A	10	ghi	12.5	de
	INDUCE	0.25	% V/V				
4	OLYMPUS	0.9	OZ/A	31.3	ef	30	c
	ESPLANADE	5	OZ/A				
	INDUCE	0.25	% V/V				
5	OLYMPUS	1.2	OZ/A	46.3	de	33.8	c
	ESPLANADE	5	OZ/A				
	INDUCE	0.25	% V/V				
6	MATRIX	3	OZ/A	100	a	99.5	a
	INDUCE	0.25	% V/V				
7	MATRIX	4	OZ/A	100	a	100	a
	INDUCE	0.25	% V/V				
8	MATRIX	3	OZ/A	100	a	100	a
	ESPLANADE	5	OZ/A				
	INDUCE	0.25	% V/V				
9	MATRIX	4	OZ/A	100	a	100	a
	ESPLANADE	6.8	OZ/A				
	INDUCE	0.25	% V/V				
10	PLATEAU 2L	7	OZ/A	98.3	a	95.5	a
	INDUCE	0.25	% V/V				
11	ACCORD XRT II	12	OZ/A	71.3	bc	33.8	c
	INDUCE	0.25	% V/V				
12	ESPLANADE	5	OZ/A	17.5	fgh	23.8	cd
	INDUCE	0.25	% V/V				
13	ESPLANADE	6.8	OZ/A	26.3	fg	22.5	cd
	INDUCE	0.25	% V/V				
14	ACCORD XRT II	12	OZ/A	100	a	93	a

	ESPLANADE	5	OZ/A					
	INDUCE	0.25	% V/V					
15	ESPLANADE	6.8	OZ/A	96.3	a		91.8	ab
	Piper	10	OZ/A					
	ACCORD XRT II	12	OZ/A					
	INDUCE	0.25	% V/V					
March Spring Application								
16	OLYMPUS	0.9	OZ/A	16.3	f-i		5	e
	INDUCE	0.25	% V/V					
17	OLYMPUS	1.2	OZ/A	11.3	ghi		2.5	e
	INDUCE	0.25	% V/V					
18	MATRIX	3	OZ/A	55	cd		75.8	b
	INDUCE	0.25	% V/V					
19	MATRIX	4	OZ/A	85.8	ab		95	a
	INDUCE	0.25	% V/V					
20	MATRIX	3	OZ/A	91.5	a		96.3	a
	ESPLANADE	5	OZ/A					
	INDUCE	0.25	% V/V					
21	MATRIX	4	OZ/A	94.5	a		97.5	a
	ESPLANADE	6.8	OZ/A					
	INDUCE	0.25	% V/V					
22	PLATEAU 2L (scratch treatment)	7	OZ/A	0	i		2.5	e
	INDUCE	0.25	% V/V					
23	ACCORD XRT II	12	OZ/A	68.8	bc		33.8	c
	INDUCE	0.25	% V/V					
24	ESPLANADE	6.8	OZ/A	96.3	a		90.3	ab

	Piper	10	OZ/A					
	ACCORD XRT II	12	OZ/A					
	INDUCE	0.25	% V/V					

Perennial Grass Response to Herbicide Treatments

				Kenosha PG Injury	Kenosha PG Cover
				7/15/2016 Injury %	7/15/2016 Cover %
January Application	Treatment	Rate			
1	UNTREATED			0	20
				0	20
				0	5
				0	3
Mean =				0	12
2	OLYMPUS	0.9	OZ/A	0	18
	INDUCE	0.25	% V/V	0	15
				0	10
				0	7
Mean =				0	12.5
3	OLYMPUS	1.2	OZ/A	0	8
	INDUCE	0.25	% V/V	0	15
				0	15
				0	70
Mean =				0	27
4	OLYMPUS	0.9	OZ/A	0	10
	ESPLANADE	5	OZ/A	0	10
	INDUCE	0.25	% V/V	0	10
				0	80
Mean =				0	27.5
5	OLYMPUS	1.2	OZ/A	50	6
	ESPLANADE	5	OZ/A	0	40
	INDUCE	0.25	% V/V	5	30
				50	50
Mean =				26.3	31.5
6	MATRIX	3	OZ/A	80	10
	INDUCE	0.25	% V/V	60	25

				10	18
				35	65
Mean =				46.3	29.5
7	MATRIX	4	OZ/A	80	5
	INDUCE	0.25	% V/V	50	45
				50	20
				75	3
Mean =				63.8	18.3
8	MATRIX	3	OZ/A	40	20
	ESPLANADE	5	OZ/A	15	60
	INDUCE	0.25	% V/V	0	70
				50	50
Mean =				26.3	50
9	MATRIX	4	OZ/A	50	18
	ESPLANADE	6.8	OZ/A	25	15
	INDUCE	0.25	% V/V	40	18
				0	70
Mean =				28.8	30.3
10	PLATEAU 2L	7	OZ/A	30	25
	INDUCE	0.25	% V/V	50	18
				50	30
				75	5
Mean =				51.3	19.5
11	ACCORD XRT II	12	OZ/A	0	8
	INDUCE	0.25	% V/V	0	20
				0	20
				0	3
Mean =				0	12.8
12	ESPLANADE	5	OZ/A	0	25
	INDUCE	0.25	% V/V	0	12
				0	15
				0	20
Mean =				0	18
13	ESPLANADE	6.8	OZ/A	0	40
	INDUCE	0.25	% V/V	0	35
				0	20
				0	5
Mean =				0	25
14	ACCORD XRT II	12	OZ/A	0	60
	ESPLANADE	5	OZ/A	40	10

	INDUCE	0.25	% V/V	0	10
				40	50
Mean =				20	32.5
15	ESPLANADE	6.8	OZ/A	0	10
	Piper	10	OZ/A	0	18
	ACCORD XRT II	12	OZ/A	0	20
	INDUCE	0.25	% V/V	10	50
Mean =				2.5	24.5
March Spring Application					
16	OLYMPUS	0.9	OZ/A	0	18
	INDUCE	0.25	% V/V	0	35
				0	8
				0	10
Mean =				0	17.8
17	OLYMPUS	1.2	OZ/A	0	20
	INDUCE	0.25	% V/V	0	25
				0	3
				0	2
Mean =				0	12.5
18	MATRIX	3	OZ/A	45	50
	INDUCE	0.25	% V/V	25	45
				40	25
				60	40
Mean =				42.5	40
19	MATRIX	4	OZ/A	40	65
	INDUCE	0.25	% V/V	65	8
				40	40
				60	70
Mean =				51.3	45.8
20	MATRIX	3	OZ/A	25	60
	ESPLANADE	5	OZ/A	25	15
	INDUCE	0.25	% V/V	45	25
				0	7
Mean =				23.8	26.8
21	MATRIX	4	OZ/A	50	35
	ESPLANADE	6.8	OZ/A	15	60
	INDUCE	0.25	% V/V	25	50
				60	65

Mean =				37.5	52.5
22	PLATEAU 2L (Wasn't Sprayed)	7	OZ/A	0	8
	INDUCE	0.25	% V/V	0	10
				0	10
				0	35
Mean =				0	15.8
23	ACCORD XRT II	12	OZ/A	20	10
	INDUCE	0.25	% V/V	0	5
				0	15
				0	5
Mean =				5	8.8
24	ESPLANADE	6.8	OZ/A	0	15
	Piper	10	OZ/A	0	18
	ACCORD XRT II	12	OZ/A	0	15
	INDUCE	0.25	% V/V	30	45
Mean =				7.5	23.3

Year 1 Conclusions (2016)

The studies conducted in 2016 were a great success for the Boulder County Open Space Program, and the objectives of the grant proposal have been met. This initial year we treated the two sites at the Mayhoffer property, in addition to the two downy brome sites. All studies were evaluated for herbicide efficacy on target weeds, and injury to desirable perennial grasses and forbs. At the Mayhoffer property, herbicide treatments were all successful at controlling 90 to 99% of weeds, with common mullein appearing in low densities in all plots. As expected, all treatments including Esplanade resulted in 100% downy brome control for this first growing season after treatment. Across all treatments, it appeared as though tank-mix combinations with Esplanade provided a slight increase in weed control as compared to treatments excluding Esplanade. Data collections in 2017 will provide additional evidence for whether these tank-mix treatments with Esplanade are in fact, able to reduce the biennial re-infestations occurring from seed. In terms of species richness at the lower and upper site, Esplanade applied alone resulted in a significant increase in species richness as compared to the non-treated control. All treatments did not significantly reduce species richness at both sites; however, at Site 1 the Tordon treatments increased richness more than Method treatments, and at Site 2 Method treatments increased richness more than Tordon treatments. From the perennial grass biomass harvest we found it interesting that all treatments significantly increased biomass compared to the non-treated control. Another observation was that Tordon treatments increased perennial grass biomass more than all other treatments. A majority of the Tordon treatments had a significant amount of western wheatgrass, whereas Method seemed to injure the western and warm season grasses filled in. That is shown in the biomass harvest diagram, with more cool season grasses in Tordon treatments and more warm season grasses in Method treatments. We

expect the cool season grasses to recover in 2017. Esplanade did not injure any native grasses or forbs in the studies.

The downy brome studies at the hillside and Kenosha properties provided insight into the efficacy of multiple herbicides for downy brome control (glyphosate, indaziflam, imazapic, and rimsulfuron). Summarizing the studies, we see that Olympus treatments resulted in very little downy brome control at both application timings. Matrix treatments resulted in 90-100% control at the December-January timing; however, Matrix at the March timing showed minimal downy brome control. This is evidence that Matrix likely requires significant moisture for activation. Glyphosate alone (Accord XRTII) treatments did not provide significant downy brome control through the July timing and will likely revert back to non-treated densities in year 2 (2017). Treatments including Esplanade, at both timings, resulted in 96-100% downy brome control at the July 2016 evaluation. This was the level of control that was expected and should be evaluated in 2017 for residual control. Plateau treatments provided excellent control (95-99%) supporting other research, but control has consistently been shown to decrease for Plateau by year two. This should also be evaluated in 2017 and compared to the level of control of Esplanade treatments. In addition, treatments including Esplanade significantly increased perennial grass biomass and forb/shrub richness as compared to treatments excluding Esplanade. In 2017, visual and biomass evaluations will provide further evidence for the utility of Esplanade on Boulder County Open Space properties. We look forward to further collaboration this next year.

