Final Project Report

Brome Reduction Study 2019

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1.1 Introduction

The Clark County Desert Conservation Program provided funding to Utah State University (USU) to evaluate herbicide treatments for controlling invasive annual grasses in order to reduce fire risks to critical desert habitat. Red brome (*Bromus rubens*) and common Mediterranean grass (*Schismus barbatus*) are non-native invasive annual grass (IAG) species with wide distribution in the blackbrush communities of the southwestern United States Mojave Desert. While many preemergence and postemergence herbicides are labeled for control of IAG, their effectiveness, impact to non-target species, and overall longevity are not well understood in an arid, southwest desert climate.

1.2 Background and Overview

The Greater Trout Canyon translocation site is an approximately 59,000-acre site located in Clark County, Nevada. This site has been designated as a protective area designed to augment the population of desert tortoise (*Gopherus agassizii*) residing in the Eastern Mojave Recovery Unit. Red brome is present at Trout Canyon and has been implicated in increased fire susceptibility of the area (Van Linn et al. 2015) as well as poor juvenile tortoise growth and survival in Trout Canyon and other translocation sites (Drake et al. 2018). The goal of this project was to increase understanding of which herbicides and their respective rate and application timing would result in the greatest IAG reduction at Trout Canyon.

1.3 Project Location

Potential study locations were identified within the Trout Canyon translocation site in Clark County, NV. Six one-acre plots were pre-selected as potential study plot locations by the DCP in 2019 (Figure 1.1) The proposed sites underwent an Environmental Assessment (EA) DOI-BLM-NV-S010-0117-EA and a Finding of No Significant Impact was issued for the six potential sites. USU made a site visit March 31, 2022, and determined that Site 2 had the highest density of red brome and selected it for conducting the herbicide trial.

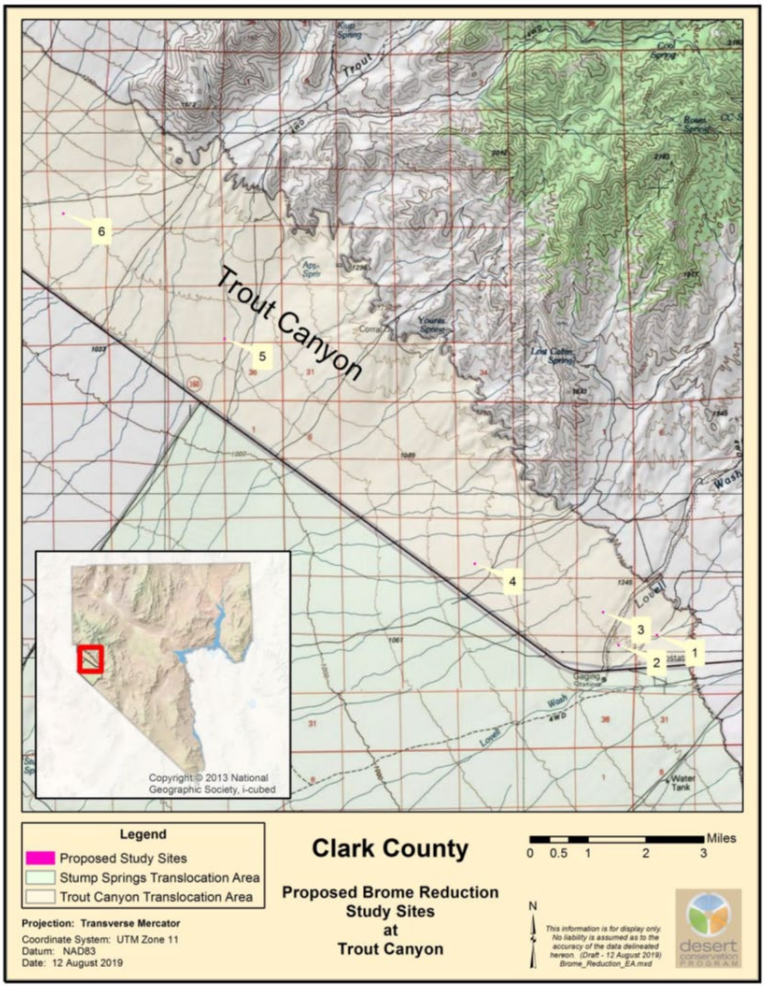

Figure 1.1 - Six proposed study sites for the red brome reduction trial within the Trout Canyon Desert Tortoise translocation area.

1.4 Project Goals and Objectives

The goal of this project is to determine the most effective materials and methods to reduce the abundance of brome and other non-native annual grasses at Trout Canyon. Reducing the amount of brome at these locations will decrease the risk of wildfires, increase the success of native plant establishment, and provide opportunities for better nutrition to the desert tortoises which depend upon these habitats.

Specific objectives include:

1. Compare the success of non-native annual grass reduction using two kinds of herbicides.
2. Compare the effects of these herbicides on native vegetation within the treated areas.

2.1 Materials and Methods

2.2 Site Description and Trial Placement

The location selected for the trials by USU in Spring 2022 based on red brome densities was site 2. However, the trial was not initiated until November 2023 due to ingoing drought conditions. The trial was placed just inside the North boundary of site 2. Topography and species composition and density varied across the site and the plots were arranged to reduce variation in red brome cover and perennial species composition (Figure 2.1 – plots on the site). The first replication was located on a south facing slope, while replications two and three varied, but were mostly on flat topography and the fourth replication had variable topography with plots ranging from southern to northern exposures and a ravine passing through some of the plots. At the time of trial establishment, plots were marked with wire flags in all four corners. Later, the research trial boundary was collected into ArcGIS online using the ArcGIS Collector application running on a Samsung Tab E 8.0 (SM377V) tablet using a Geode GNS3S (Model#: GNS3S-CFG-13817) (Juniper Systems, Logan UT, 84321) mounted on a pole at 1.7-meter height, providing sub-meter accuracy. Individual plot coordinates were collected by walking to each corner of the plot and dropping a point to complete the polygons. Data were exported as a shapefile and are included with the final data.

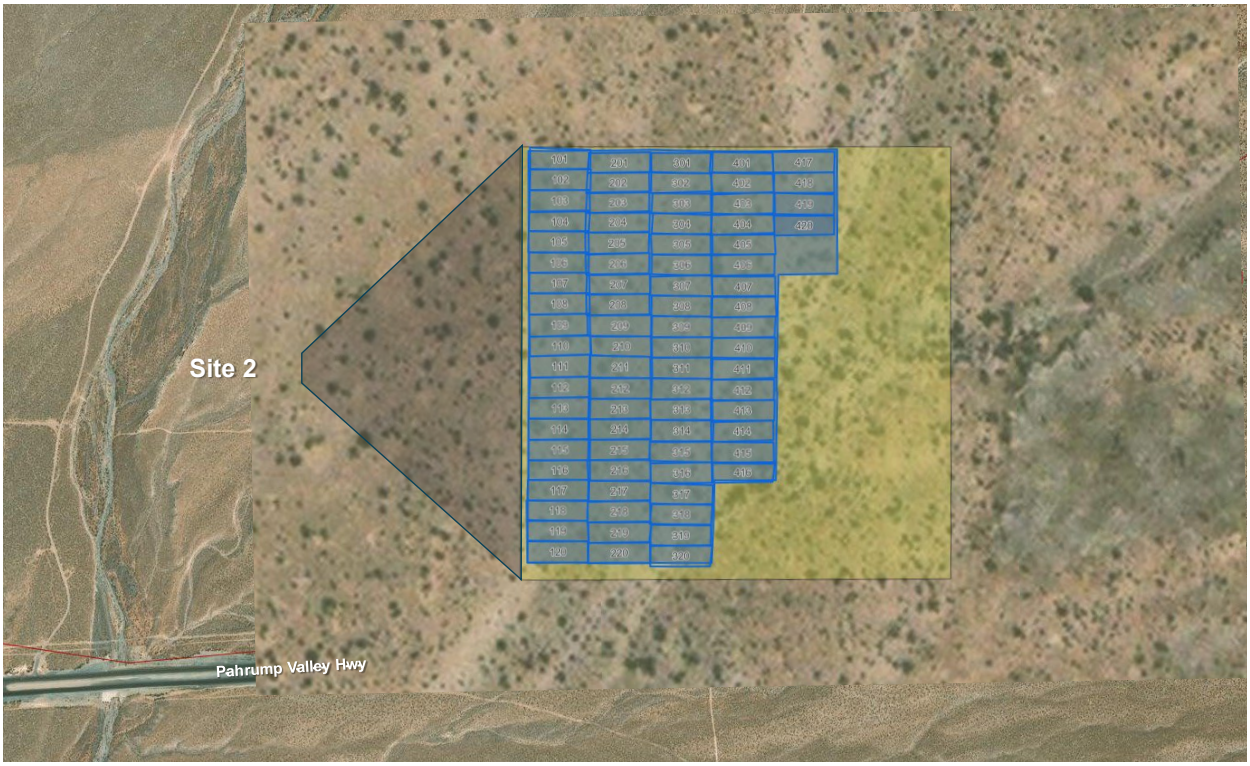

Figure 2.1. Individual plot location and layout within Site 2 of the Trout Canyon Desert Tortoise Relocation Area.

2.3 Soil Description

The soil on the site is an Irongold-Weiser Association (NRCS 2004) which is an extremely gravelly loam alluvium with a petrocalcic hardpan 10 to 14 inches below the surface. This association also includes areas of extremely gravelly fine sandy loam soils.

2.4 Environmental Conditions During the Trial

Annual precipitation in the region of the trial is low on average, with extreme variation experienced both prior to and during the research period (Figure 2.2). After extreme drought in fall of 2020 and into summer of 2021, above average rainfall was received in Fall 2021. Spring 2022 rainfall was below average but cumulative rainfall after June 1, 2022, tracked closely to the 30-year average. Rainfall in Spring and Fall 2023 was above average as was rainfall in the Spring of 2024. However, drought conditions were severe at the site with rainfall from June 1, 2024, to June 1, 2025, barely 25% of the 30-year average.

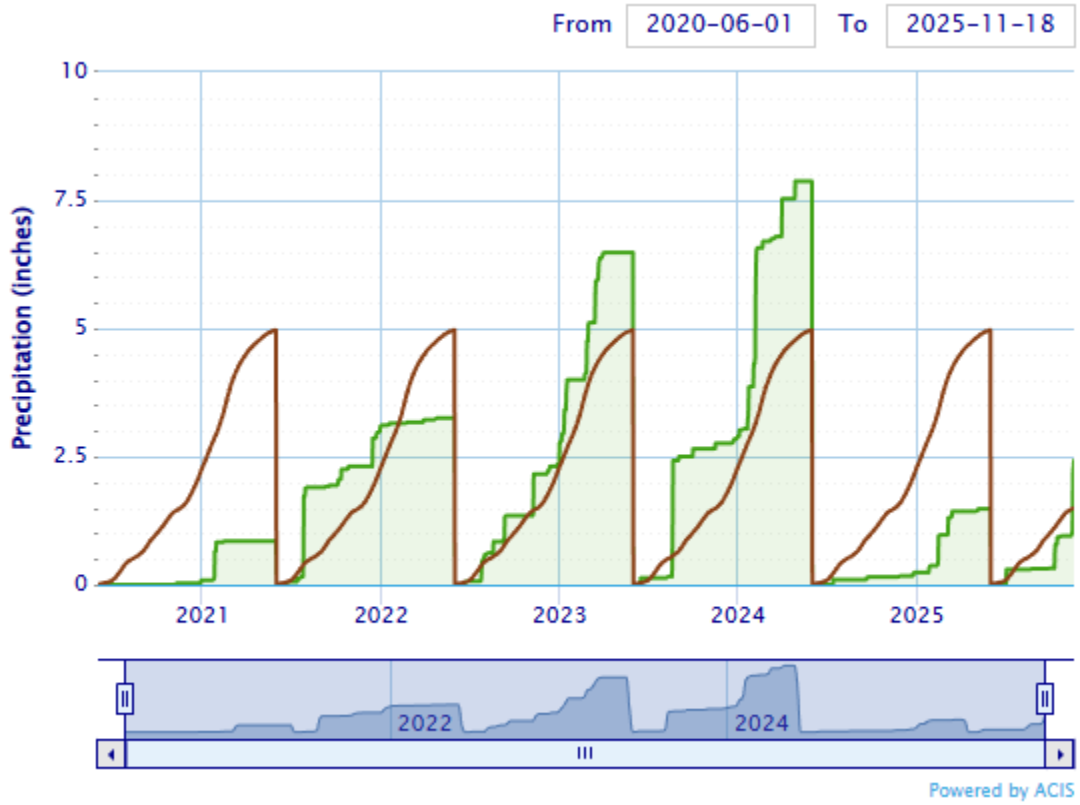

Figure 2.2 Cumulative rainfall from Fall 2020 to Fall 2025 restarting every June 1, near the Trout Canyon Desert Tortoise Translocation Area where the red brome reduction trial was located (Pahrump 2.9 SSW weather station, NOAA-ACIS). The red line represents the 30-year average, while the green line represents the annual cumulative precipitation. The Red Brome Reduction Trial was established on November 2, 2023.

2.5 Species on the site

Dominant native species within the plot area included creosote, white bursage, and desert trumpet (Table 2.1). Dominant non-native annual species included filaree, red brome and Mediterranean grass.

Table 2.1. Weedy and native species observed at the location of the Red Brome Reduction trial at the Trout Canyon Desert Tortoise Translocation Area.

Common name	Scientific name	Common name	Scientific name
Filaree*	*Erodium cicutarium*	Desert trumpet	*Eriogonum inflatum*
Red Brome*	*Bromus rubens*	Ephedra	*Ephedra californica*
Mediterranean grass*	*Schismus barbatus*	Fluff grass	*Dasyochloa pulchella*
Anderson's desert thorn	*Lycium andersonii*	Indigo Bush	*Psorothamnus fremontii*
Bladder sage	*Salazaria mexicana*	Littleleaf ratany	*Krameria erecta*
Brittlebush	*Encelia virginensis*	Manybristle chinchweed	*Pectis papposa*
Burrobush	*Hymenoclea salsola*	Rabbitbrush	*Chrysothamnus*
Cooper's dogweed	*Adenophyllum cooperi*	White bursage	*Ambrosia dumosa*
Creosote bush	*Larrea tridentata*	Whitestem paper flower	*Psilostrophe cooperi*
Desert marigold	*Baileya multiradiata*	Winterfat	*Krascheninnikova lanata*

*Annual weed species.

2.6 Trial Design and Treatment Application

The trial consisted of 20 treatments arranged in a randomized complete block design with four replications. Individual main plots measured 10 by 30 feet. Treatment included Rejuvra (indaziflam) and Plateau (imazapic) applied alone and in combinations. Other factors included preemergence (PRE) compared to postemergence (POST) application timings and a comparison between Non-Ionic Surfactant (NIS) and Methylated Seed Oil (MSO) added only to postemergence treatments. Preemergence treatments were applied November 6, 2023, and postemergence treatments were applied January 29, 2024. All treatments were applied with a CO^2-pressurized backpack sprayer calibrated to deliver 18 gallons per acre at 30 psi spray pressure. The spray was delivered through a 10-foot boom with six Teejet8002 VS nozzles spaced 20 inches apart. Excess herbicide spray used to charge the boom prior to spraying plots and any spray remaining in the boom after all plots were treated was collected in cups placed under each nozzle, poured into a container and removed from the site during applications. This ensured the only herbicide on the site was within specified treated plots.

2.7 Data Collection

Data collection included visual cover of all species and density counts of all plants in a plot for perennial species with easily identifiable stems. For annual weeds, including red brome, Mediterranean grass, and filaree only visual cover was recorded. Even though it is listed as a perennial, desert trumpet behaved like an annual within the plots with large flushes of plants

occurring in the spring. Because of the high density of plants, only cover was recorded for desert trumpet. For the annual weeds and desert trumpet, cover in the spring was for actively growing plants and cover in the fall was recorded for the dry biomass left after these plants matured. In November 2024, filaree biomass from the spring was not discernable and therefore cover was not estimated for that evaluation date. For perennial plants, cover and densities were only recorded for plants that were either actively growing or showed evidence of growth during the current year's growing season (i.e. dried leaves, dried flowers, or fruits). Two species (littleleaf ratany, *Krameria erecta* and manybristle chinchweed, *Pectis papposa*), were recorded in November 2023 and not observed actively growing at subsequent evaluation dates, likely due to dry conditions. Evaluations took place November 8, 2023 (collected the day after treatment but considered as our pre-treatment evaluation), March 26, 2024, November 13, 2024, and April 3, 2025. The pretreatment evaluation was done after the PRE-treatment application due to an unfavorable weather forecast for the next day. This was determined to be okay as the preemergence indaziflam treatments would not be expected to cause any plant response until months later. At the postemergence treatment timing on January 29, 2024, density counts of germinated species were taken with small frames ($0.25m^2$) placed on open areas and under canopy of shrubs within each plot. These density counts were highly variable and were used to describe relative densities of annual grasses prior to application but are not included in the analysis. An estimate of bare ground was calculated by combining cover ratings for all species in each plot and subtracting from 100%.

2.8 Data Analysis

Due to the scattered nature of woody and other perennials across the site, it was not possible to evaluate individual treatments on individual woody and perennial species. However, cover and density numbers for each species were graphed to see if any changes could be visualized. Except for desert trumpet, perennial species cover and density ratings were grouped together for statistical analysis. Cover data were transformed with an arcsin square root transformation prior to analysis to address unequal variance between data means. As discussed above, red brome, Mediterranean grass, filaree, and desert trumpet cover were analyzed individually by species. Combined perennial species count data were square-root transformed prior to analysis.

Data were analyzed as a repeated measures analysis of variance and means were separated using Fisher's Protected LSD at p=0.05. March 2025 cover data for red brome, Mediterranean grass, and desert trumpet cover were not included in the analysis of these species due to large numbers of zeroes in the data. For filaree, cover ratings were not collected in November 2024 and so spring 2024 and 2025 data were included in the time analysis.

2.9 Trial Removal

A last visit to the research site was made October 28, 2025. Extreme drought conditions were evident as much of the vegetation was brown with minimal evidence of plant growth during the previous year. Overview pictures were taken of each plot for archival purposes. All trial site corner markers and plot flags were removed.

3.1 Results

At the pre-treatment evaluation, cover of annual weedy species was around 14%, while native cover averages were around 18% and bare ground was close to 69% (Figure 3.1).

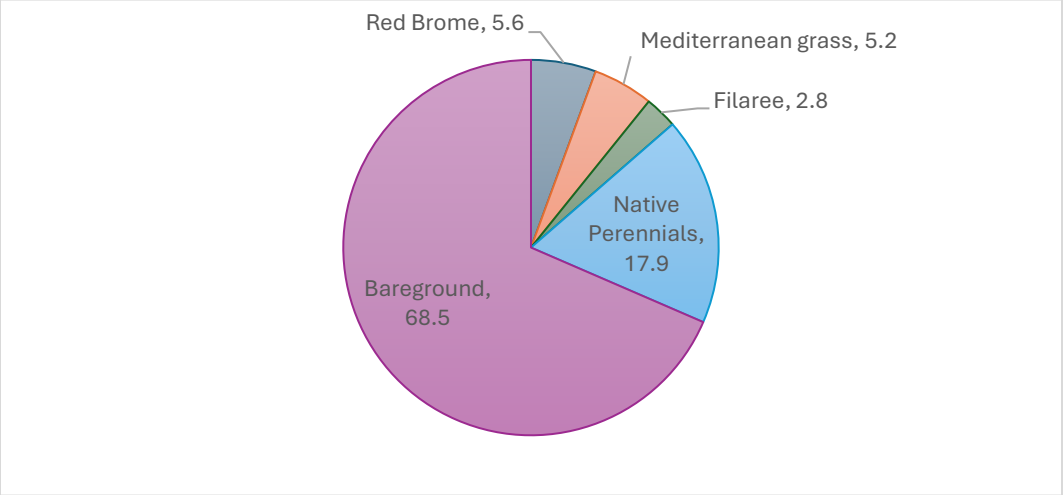

Figure 3.1 Average pretreatment cover of weedy species, native species, and bare ground at the Brome Reduction Trial in the Trout Canyon Desert Tortoise Relocation Area, November 7, 2023.

Species cover was significantly impacted by changes in rainfall during the trial period as well as the time of year the evaluations were taken. Some plants were actively growing in the Spring, and others were actively growing in the Fall.

3.2 Treatment Impact on Annual Weeds

Red Brome

Red brome cover was variable across the trial and ranged from 3 to 9% across all treatments prior to treatment application (Table 3.1). Cover of red brome increased significantly by 3 to 4 times in the two untreated plots between November 2023 and March 2024. At the March 2024 evaluation, Rejuvra at 1 and 3 oz applied PRE or at 1 oz or 3 oz applied POST with either NIS or MSO did not reduce red brome cover compared to the untreated plots. All other treatments significantly reduced red brome cover compared to both untreated checks. Similar results were observed at the November 2024 evaluation date with the exception that Rejuvra applied POST at the 5 oz rates, regardless of adjuvant, no longer had lower red brome cover than the untreated plots, nor did Plateau alone with NIS. Plateau alone plus MSO had similar red brome cover to Plateau plus NIS but remained less than the untreated plots. Rejuvra at 5 oz PRE had similar control to Plateau + Rejuvra at any rate PRE or with combinations of Plateau + Rejuvra applied POST regardless of adjuvant. Due to drought conditions, red brome cover was less than 3% regardless of treatment at the April 2025 evaluation.

Table 3.1. Red brome (Bromus rubens) cover over time in response to preemergence and postemergence herbicide applications made at the Trout Canyon desert tortoise relocation area.

			Visual cover[†]							
Treatment	Rate	Timing*	7 Nov 2023		26 Mar 2024		13 Nov 2024		3 Apr 2025[‡]	
	fl oz/acre		%							
Untreated Check	-	PRE	5.5	c-m	21.8	a	10.0	bc	0.2	
Rejuvra	1	PRE	6.8	c-l	11.1	bcde	4.8	c-o	1.6	
Rejuvra	3	PRE	7.0	b-k	15.5	ab	7.4	c-k	0.03	
Rejuvra	5	PRE	3.3	i-q	5.3	c-o	2.1	l-q	0.3	
Rejuvra + Plateau	1 + 5	PRE	4.0	c-p	7.5	c-l	2.5	l-q	0	
Rejuvra + Plateau	3 + 5	PRE	4.5	c-o	4.5	e-p	1.5	nopq	0	
Rejuvra + Plateau	5 + 5	PRE	7.0	c-k	3.5	j-q	4.0	j-q	0	
Untreated Check	-	POST	5.5	c-l	16.0	ab	9.3	b-f	2.8	
Rejuvra + NIS	1 + 0.25%	POST	5.8	c-m	9.3	b-g	6.8	c-k	0.7	
Rejuvra + NIS	3 + 0.25%	POST	3.0	j-q	7.5	b-k	4.8	c-p	0	
Rejuvra + NIS	5 + 0.25%	POST	7.8	b-j	7.8	c-k	4.3	c-o	0	
Plateau + NIS	5 + 0.25%	POST	8.8	b-h	4.8	c-o	3.8	e-p	1.6	
Rejuvra + MSO	3 + 2 pt	POST	3.5	g-q	9.8	bcd	6.0	c-l	0.08	
Rejuvra + MSO	5 + 2 pt	POST	3.8	f-p	4.5	c-p	4.0	d-p	0.05	
Plateau + MSO	5 + 2 pt	POST	5.3	c-m	3.3	j-q	1.3	opq	0.4	
Rejuvra + Plateau + NIS	1 + 5 + 0.25%	POST	5.5	c-l	8.3	c-l	2.9	j-q	0	
Rejuvra + Plateau + NIS	3 + 5 + 0.25%	POST	5.0	c-n	4.1	h-q	1.4	m-q	0	
Rejuvra + Plateau + NIS	5 + 5 + 0.25%	POST	6.5	c-k	7.0	c-k	1.4	m-q	0	
Rejuvra + Plateau + MSO	3 + 5 + 2.0 pt	POST	8.3	b-i	3.0	k-q	0.8	pq	0	
Rejuvra + Plateau + MSO	5 + 5 + 2.0 pt	POST	4.8	c-o	1.3	opq	0.4	q	0	

*Timing: PRE = preemergence applications made November 6, 2023. POST = postemergence applications made January 29, 2024.

[†]Means within the table followed by the same letters are not significantly different according to Fisher's LSD at p=0.05.

[‡]April 2025 cover data for red brome were excluded from analysis due to low cover caused by drought conditions, resulting in too many zero values for statistical analysis. Actual numbers are shown for reference.

Mediterranean grass

Mediterranean grass also had low cover in the pretreatment evaluation in November 2023, ranging from 3 to 8% (Table 3.2). By the March 2024 evaluation date, cover was 5 times higher is the untreated plots compared to the previous November. All treatments except Rejuvra at 1 fl oz/acre PRE reduced Mediterranean grass cover compared to the untreated checks. Some combinations of Rejuvra + Plateau had less Mediterranean grass cover than Rejuvra alone at 1 or 3 fl oz/acre or Plateau + NIS alone. On November 13, 2024, all treatments except Rejuvra at 1 and 3 fl oz/acre PRE and Rejuvra at 1 oz/acre POST reduced Mediterranean grass cover compared to the untreated plots. In general, combination of Rejuvra + Plateau had some of the largest reductions in Mediterranean grass cover. Interestingly, Plateau or Rejuvra at 3 fl oz/acre alone POST with NIS had more Mediterranean grass cover compared to the same treatments with MSO. On April 3, 2025, the highest cover in any treatment was less than 2%.

Table 3.2. Common Mediterranean grass (*Schismus barbatus*) cover over time in response to preemergence and postemergence herbicide applications made at the Trout Canyon desert tortoise relocation area.

			Visual cover†							
Treatment	Rate	Timing*	7 Nov 2023		26 Mar 2024		13 Nov 2024		3 Apr 2025‡	
	fl oz/acre		%							
Untreated Check	-	PRE	5.75	j-s	27.5	a	23.8	abc	1.7	
Rejuvra	1	PRE	5.5	j-s	21.3	abcd	20.5	bcd	1.0	
Rejuvra	3	PRE	6	i-s	17.5	def	20.8	abcd	0.03	
Rejuvra	5	PRE	3.25	rstu	8.8	g-m	11.0	ghi	0.03	
Rejuvra + Plateau	1 + 5	PRE	3.5	q-u	5.8	k-s	5.3	k-s	0	
Rejuvra + Plateau	3 + 5	PRE	4.25	n-t	5.0	m-s	5.6	m-s	0	
Rejuvra + Plateau	5 + 5	PRE	6.5	i-s	7.0	i-s	4.5	n-t	0.03	
Untreated Check	-	POST	5.25	j-s	26.3	ab	26.8	ab	1.1	
Rejuvra + NIS	1 + 0.25%	POST	6.25	i-s	18.8	cde	20.0	bcd	0	
Rejuvra + NIS	3 + 0.25%	POST	3.25	rstu	10.0	g-k	12.0	fgh	0	
Rejuvra + NIS	5 + 0.25%	POST	6	j-s	8.0	g-n	9.3	g-l	0	
Plateau + NIS	5 + 0.25%	POST	7.25	h-q	13.5	efg	18.5	cde	1.6	
Rejuvra + MSO	3 + 2 pt	POST	3.5	q-u	10.0	ghij	9.8	ghij	0.05	
Rejuvra + MSO	5 + 2 pt	POST	3.75	o-u	8.0	h-p	8.3	g-o	0	
Plateau + MSO	5 + 2 pt	POST	5	l-s	7.0	i-s	7.3	h-r	0.8	
Rejuvra + Plateau + NIS	1 + 5 + 0.25%	POST	5.5	j-s	7.0	i-r	9.5	ghij	0	
Rejuvra + Plateau + NIS	3 + 5 + 0.25%	POST	4.75	k-s	6.5	i-s	7.0	i-r	0	
Rejuvra + Plateau + NIS	5 + 5 + 0.25%	POST	5.25	j-s	3.8	q-u	3.8	p-u	0	
Rejuvra + Plateau + MSO	3 + 5 + 2.0 pt	POST	7.75	g-n	4.3	n-t	3.0	stu	0	
Rejuvra + Plateau + MSO	5 + 5 + 2.0 pt	POST	5.75	j-s	1.3	u	1.4	tu	0	

*Timing: PRE = preemergence applications made November 6, 2023. POST = postemergence applications made January 29, 2024.

†Means within the table followed by the same letters are not significantly different according to Fisher's LSD at p=0.05.

‡April 2025 cover data for Mediterranean grass were excluded from analysis due to low cover caused by drought conditions, resulting in too many zero values for statistical analysis. Actual numbers are shown for reference.

Filaree

Filaree cover doubled in untreated plots from the November 7, 2023, to March 26, 2024 (Table 3.3). Rejuvra applied PRE or POST did not reduce filaree cover, possibly due to the filaree already being emerged prior to treatment and Rejuvra only having preemergence activity. In general, treatments containing Plateau reduced filaree cover. There were a few exceptions such as Plateau alone plus MSO and a few combinations of Rejuvra + Plateau with NIS. These anomalies may be related to variable filaree pressure across the site. However, the PRE combination of Rejuvra + Plateau all significantly reduced filaree cover, regardless of Rejuvra rate. Unfortunately, we did not have a treatment of Plateau alone PRE to confirm that it was providing most of the suppression. Interestingly, by April 3, 2025, all combination of Rejuvra + Plateau regardless of application timing reduced filaree cover. In addition, Rejuvra at 5 fl oz/acre POST with either NIS or MSO provided significant reductions in filaree, while Plateau alone POST with either NIS or MSO did not provide significant reductions. Rejuvra at 5 fl oz/acre PRE although not lower than the untreated plots, was also not significantly different from the most effective treatments.

Table 3.3. Filaree (*Erodium cicutarium*) cover over time in response to preemergence and postemergence herbicide applications made at the Trout Canyon desert tortoise relocation area.

			Visual cover†					
Treatment	Rate	Timing*	7 Nov 2023		26 Mar 2024		3 Apr 2025	
	fl oz/acre		%					
Untreated Check	-	PRE	4.0	g-l	7.8	abc	4.0	e-j
Rejuvra	1	PRE	3.0	h- n	7.5	a-e	4.0	e-j
Rejuvra	3	PRE	3.5	h-m	8.8	ab	3.0	h-n
Rejuvra	5	PRE	1.8	j-q	6.0	d-i	0.9	n-r
Rejuvra + Plateau	1 + 5	PRE	2.0	i-o	3.0	j-p	0.4	opqr
Rejuvra + Plateau	3 + 5	PRE	3.3	h-n	2.8	h-n	0.03	or
Rejuvra + Plateau	5 + 5	PRE	3.8	g-k	0.8	j-r	0	r
Untreated Check	-	POST	3.3	h-n	6.8	a-g	3.0	h-n
Rejuvra + NIS	1 + 0.25%	POST	2.5	h-n	8.5	abcd	4.8	c-h
Rejuvra + NIS	3 + 0.25%	POST	3.0	h-n	11.3	a	1.5	k-r
Rejuvra + NIS	5 + 0.25%	POST	1.3	l-r	11.8	a	0.3	opqr
Plateau + NIS	5 + 0.25%	POST	3.8	g-k	2.1	h-n	2.3	h-n
Rejuvra + MSO	3 + 2 pt	POST	1.5	j-r	9.0	a-f	0.9	n-r
Rejuvra + MSO	5 + 2 pt	POST	2.0	i-p	6.8	b-h	0.2	pqr
Plateau + MSO	5 + 2 pt	POST	2.5	h-n	4.8	e-j	1.2	m-r
Rejuvra + Plateau + NIS	1 + 5 + 0.25%	POST	2.3	h-o	4.0	g-l	0.3	opqr
Rejuvra + Plateau + NIS	3 + 5 + 0.25%	POST	3.0	h-n	4.0	f-j	0.2	pqr
Rejuvra + Plateau + NIS	5 + 5 + 0.25%	POST	3.3	h-m	2.5	h-n	0.03	qr
Rejuvra + Plateau + MSO	3 + 5 + 2.0 pt	POST	3.0	h-n	2.3	h-n	0	r
Rejuvra + Plateau + MSO	5 + 5 + 2.0 pt	POST	3.3	h-n	1.3	j-p	0	r

*Timing: PRE = preemergence applications made November 6, 2023. POST = postemergence applications made January 29, 2024.
†Means within the table followed by the same letters are not significantly different according to Fisher's LSD at p=0.05. Data for filaree was not collected November 2024 and is not included in the analysis.

3.3 Treatment Impacts on Native Plants

Desert Trumpet

Desert trumpet appears to be sensitive to Plateau as all treatment that included Plateau had significant reduction in desert trumpet cover at both the March 2024 and November 2024 evaluation dates (Table 3.4). Interestingly, Rejuvra at 5 fl oz/acre with MSO applied POST had slightly reduced cover compared to the untreated plots at the November 13, 2025, evaluation. As with the annual weed species, desert trumpet cover on April 3, 2025, was less than 2% in the untreated plots. While no statistical analysis is possible on the 2025 data, none of the treated plots except for the lowest rate of Rejuvra PRE averaged close to 0.5 percent cover of desert trumpet. This suggests that longer term research is needed to observe treatment effects on desirable species through cycles of drought and normal rainfall patterns.

Table 3.4. Desert trumpet (*Eriogonum inflatum*) cover over time in response to preemergence and postemergence herbicide applications made at the Trout Canyon desert tortoise relocation area.

Treatment	Rate	Timing*	Visual cover†							
			7 Nov 2023		26 Mar 2024		13 Nov 2024		3 Apr 2025‡	
	fl oz/acre		%							
Untreated Check	-	PRE	7.5	f-n	11.3	b-i	15.3	ab	1.6	
Rejuvra	1	PRE	5.8	h-p	10.5	b-i	11.3	bcdef	1.3	
Rejuvra	3	PRE	6.5	h-p	10.8	b-i	12.0	bcdefgh	0.4	
Rejuvra	5	PRE	9.0	c-l	12.8	bcde	20.5	a	0.3	
Rejuvra + Plateau	1 + 5	PRE	6.5	i-p	2.5	p-v	1.4	rstuv	0.05	
Rejuvra + Plateau	3 + 5	PRE	8.0	d-m	3.0	n-u	1.1	stuv	0.1	
Rejuvra + Plateau	5 + 5	PRE	4.8	j-r	2.5	o-v	0.5	uv	0	
Untreated Check	-	POST	9.0	c-k	15.0	abc	13.5	bcd	1.8	
Rejuvra + NIS	1 + 0.25%	POST	5.3	i-p	7.8	g-p	10.3	bcdefghi	0.4	
Rejuvra + NIS	3 + 0.25%	POST	5.8	h-p	14.3	ab	12.3	bcdefg	0.05	
Rejuvra + NIS	5 + 0.25%	POST	4.0	k-s	9.8	b-i	11.0	bcdefghi	0.1	
Plateau + NIS	5 + 0.25%	POST	4.0	l-t	1.3	r-v	0.9	tuv	0	
Rejuvra + MSO	3 + 2 pt	POST	4.5	m-t	6.3	i-q	10.8	cdefghijk	0.03	
Rejuvra + MSO	5 + 2 pt	POST	4.8	j-r	7.5	d-m	6.8	fghijklmn	0.3	
Plateau + MSO	5 + 2 pt	POST	7.8	e-n	1.4	r-v	0.5	uv	0.03	
Rejuvra + Plateau + NIS	1 + 5 + 0.25%	POST	3.5	l-t	1.5	q-v	0.8	tuv	0.1	
Rejuvra + Plateau + NIS	3 + 5 + 0.25%	POST	8.5	b-j	1.5	q-v	0.9	tuv	0	
Rejuvra + Plateau + NIS	5 + 5 + 0.25%	POST	2.5	o-v	0.8	tuv	0.3	v	0	
Rejuvra + Plateau + MSO	3 + 5 + 2.0 pt	POST	7.8	e-n	1.3	r-v	0.5	uv	0	
Rejuvra + Plateau + MSO	5 + 5 + 2.0 pt	POST	6.5	f-o	1.0	tuv	0.5	uv	0	

*Timing: PRE = preemergence applications made November 6, 2023. POST = postemergence applications made January 29, 2024.

†Means within the table followed by the same letters are not significantly different according to Fisher's LSD at p=0.05.

‡April 2025 cover data for desert trumpet were excluded from analysis due to low cover caused by drought conditions, resulting in too many zero values for statistical analysis. Actual numbers are shown for reference.

Combined Perennial Plant Cover and Densities

As described above, the random distribution of various plant species across the trial precludes analysis by individual species. Significant changes between evaluation dates were observed but are most likely due to the time of year that different species demonstrated signs of active growth (fall vs spring), with some weedy species actively growing at the March evaluation dates, but dormant in November. No significant treatment effects or treatment by observation date interactions were observed for either perennial plant cover or densities, suggesting little impact from the tested herbicides on well-established plants. While this is encouraging, the responses of specific species found in the trial at low densities would not be captured in our overall analysis. Species of critical importance should be evaluated in trials conducted in areas that have uniform populations and high densities of the species of interest to make conclusive determinations of herbicide safety. While we did not see any specific injury to perennial plants on the site, extreme drought stress across the entire area could have easily masked any subtle injury symptoms. While individual species response could not be evaluated individually, responses were examined visually in case any single plot responses could yield useful information. It appeared that densities of native plants in treated plots followed the same trends of those in untreated plots.

Table 3.5. Combined perennial plant cover and densities over time in response to preemergence and postemergence herbicide applications made at the Trout Canyon desert tortoise relocation area.

			Visual cover†				Plant density†			
Treatment	Rate	Timing*	7 Nov 2023	26 Mar 2024	13 Nov 2024	3 Apr 2025	7 Nov 2023	26 Mar 2024	13 Nov 2024	3 Apr 2025
	fl oz/acre		%				no/300ft^2			
Untreated Check	-	PRE	15.0	17.8	17.5	20.0	6.3	4.8	9.5	6.5
Rejuvra	1	PRE	10.6	25.3	15.0	17.3	8.5	7.8	8.3	17.1
Rejuvra	3	PRE	18.0	31.5	24.3	21.0	7.5	7.0	8.3	15.8
Rejuvra	5	PRE	21.0	26.0	21.4	21.1	10.3	8.3	12.5	15.4
Rejuvra + Plateau	1 + 5	PRE	9.1	16.0	11.0	8.4	7.75	7.3	21.5	15.1
Rejuvra + Plateau	3 + 5	PRE	14.5	20.8	13.8	19.8	6.25	6.5	9.8	11.5
Rejuvra + Plateau	5 + 5	PRE	7.8	19.5	8.1	14.0	4.6	7.3	6.8	9.3
Untreated Check	-	POST	12.3	18.5	14.8	23.5	7.5	10.8	12.3	7.6
Rejuvra + NIS	1 + 0.25%	POST	15.4	28.8	20.1	19.8	7.3	7.8	10.0	12.8
Rejuvra + NIS	3 + 0.25%	POST	10.0	20.0	14.8	14.1	6.8	4.5	6.3	15.7
Rejuvra + NIS	5 + 0.25%	POST	18.3	30.8	18.4	29.5	13.8	13.8	17.0	16.7
Plateau + NIS	5 + 0.25%	POST	10.3	16.5	14.9	17.2	5.8	7.8	7.3	10.2
Rejuvra + MSO	3 + 2 pt	POST	9.4	13.0	13.9	12.4	8.5	4.8	10.0	18.0
Rejuvra + MSO	5 + 2 pt	POST	12.3	15.0	16.0	28.3	12.0	7.0	12.8	13.8
Plateau + MSO	5 + 2 pt	POST	8.6	20.0	10.4	13.6	8.0	6.3	4.5	6.5
Rejuvra + Plateau + NIS	1 + 5 + 0.25%	POST	12.8	28.3	23.3	18.1	11.3	13.0	20.0	11.5
Rejuvra + Plateau + NIS	3 + 5 + 0.25%	POST	5.3	14.8	11.1	9.3	4.3	5.0	4.5	6.0
Rejuvra + Plateau + NIS	5 + 5 + 0.25%	POST	10.8	21.5	17.4	14.5	7.5	6.0	8.3	12.0
Rejuvra + Plateau + MSO	3 + 5 + 2.0 pt	POST	7.3	15.5	10.4	12.3	4.5	7.3	8.3	7.6
Rejuvra + Plateau + MSO	5 + 5 + 2.0 pt	POST	8.3	18.3	11.3	14.6	7.1	6.0	12.5	8.8

*Timing: PRE = preemergence applications made November 6, 2023. POST = postemergence applications made January 29, 2024.
†There were no significant treatment effects on either percent cover or plant density for desirable perennial plants, except for desert trumpet presented separately.

3.4 Treatment Impacts on Bare Ground

Bare ground was estimated by subtracting the combined cover for all species within a plot and subtracting it from 100%. With increasing precipitation and germination of annual and perennial plants, bare ground fell from 59% or greater pre-treatment to less than 20% in untreated plots on March 26, 2024 (Table 3.5). Treatments of Rejuvra at 1 or 3 fl oz/acre PRE or Rejuvra plus NIS at all rates applied POST did not increase bare ground compared to the untreated plots. However, all other treatments, including Rejuvra plus MSO applied POST significantly increased bare ground. Some of the highest levels of bare ground were with treatments combining Rejuvra + Plateau or Plateau alone. By November 13, 2024, bare ground increased across all plots with all the POST treatments with Rejuvra at 3 fl oz/acre or above having higher bare ground than the untreated plots. However, most of the Rejuvra + Plateau combination still maintained the highest bare ground estimates. It is important to remember that some of the increase in bare ground with Plateau treatments is due to reductions in desert trumpet cover. At the April 3, 2025, evaluation, even the untreated plots had nearly 70% estimated bare ground. With a few anomalies, treatments containing Rejuvra + Plateau PRE or POST had among the highest level of bare ground. This was somewhat dependent on Rejuvra rate within those combinations. Plateau with MSO alone POST also maintained a high level of bare ground.

Table 3.6. Calculated bare ground over time in response to preemergence and postemergence herbicide applications made at the Trout Canyon desert tortoise relocation area.

			Estimated bare ground[†]							
Treatment	Rate	Timing*	7 Nov 2023		13 Nov 2024		13 Nov 2024		3 Apr 2025[‡]	
	fl oz/acre		%							
Rejuvra	1	PRE	68.4	h-r	24.1	ABC	48.5	t-y	74.9	d-p
Rejuvra	3	PRE	59.0	p-v	15.8	CD	35.6	yzA	75.5	c-o
Rejuvra	5	PRE	61.8	m-t	42.3	vxyz	45.0	u-z	77.5	c-n
Untreated Check	-	PRE	62.3	l-t	13.8	D	33.5	yzA	69.9	h-q
Rejuvra + Plateau	1 + 5	PRE	74.9	d-p	66.0	h-s	79.9	b-h	91.2	a
Rejuvra + Plateau	3 + 5	PRE	65.5	i-s	63.5	k-t	78.0	b-k	80.1	b-h
Rejuvra + Plateau	5 + 5	PRE	70.3	h-q	65.7	i-s	82.9	b-g	86.0	b-e
Untreated Check	-	POST	64.8	i-t	17.0	BCD	35.8	xyzA	67.9	h-r
Rejuvra + NIS	1 + 0.25%	POST	64.9	i-t	29.0	ABC	42.9	vxyz	74.4	d-p
Rejuvra + NIS	3 + 0.25%	POST	75.0	d-p	36.8	xyzA	56.3	q-v	84.3	b-g
Rejuvra + NIS	5 + 0.25%	POST	62.8	l-t	33.8	zAB	57.1	q-v	70.0	g-q
Plateau + NIS	5 + 0.25%	POST	66.0	i-s	61.0	o-u	62.0	n-t	77.4	c-m
Rejuvra + MSO	3 + 2 pt	POST	77.6	c-l	53.3	r-v	59.6	o-u	86.6	abc
Rejuvra + MSO	5 + 2 pt	POST	73.5	e-p	59.0	p-u	65.0	i-s	71.2	d-p
Plateau + MSO	5 + 2 pt	POST	70.9	g-q	63.9	k-t	79.6	b-i	84.1	b-g
Rejuvra + Plateau + NIS	1 + 5 + 0.25%	POST	70.5	h-q	51.5	s-x	63.6	k-t	81.5	b-h
Rejuvra + Plateau + NIS	3 + 5 + 0.25%	POST	73.5	f-p	68.9	h-r	79.6	b-j	90.6	ab
Rejuvra + Plateau + NIS	5 + 5 + 0.25%	POST	71.7	g-q	64.0	j-t	77.3	c-m	85.5	b-f
Rejuvra + Plateau + MSO	3 + 5 + 2.0 pt	POST	66.0	i-s	73.5	e-p	85.4	b-f	87.7	abc
Rejuvra + Plateau + MSO	5 + 5 + 2.0 pt	POST	71.5	f-q	76.5	c-k	86.5	abcd	85.4	a-e

*Timing: PRE = preemergence applications made November 6, 2023. POST = postemergence applications made January 29, 2024.

[†]Means within the table followed by the same letter and case are not significantly different according to Fisher's LSD at p=0.05.

4.1 Discussion

While reducing fire risk is important, understanding impacts on native plants utilized by desert tortoise is also critical. Invasive annual grasses have been shown to increase wildfire frequency and severity. Especially when fuel loads are high. A large amount of research has shown that herbicides can be used to effectively manage invasive annual grasses and reduce the impacts of fire as well as competitive effects on native plant communities. However, it is also critical to understand potential negative effects of herbicide treatments on native vegetation, especially if those plants are a valuable resource for native animal and insect species.

This research provided a unique opportunity to test specific herbicide treatment for efficacy in controlling annual invasive weeds as well as determine native plant response to specific treatments within the moisture limited condition of the Mojave Desert ecosystem.

The results of this trial are different from results carried out in numerous environments across the Western US and likely differ based on the extremely dry conditions at the Trout Canyon site. In higher rainfall areas in Utah, invasive annual grass species, including downy brome, Japanese brome, and medusahead have exhibited variable response to Plateau, often requiring rates as high as 11 fl oz/acre to provide acceptable control (Buell 2021, Olsen 2013). This is more than double the 5 fl oz/acre rate of Plateau used in the Trout Canyon trial. In addition, research with Rejuvra at similar sites mentioned above has provided significantly higher and more persistent control of invasive annual grasses compared to Plateau (Sebastian et al. 2016). In this trial, it appeared that Plateau was much more active in controlling red brome and Mediterranean grass compared to Rejuvra. One reason may be that the site had so little precipitation, that it was not enough to activate or move the Rejuvra into position, as indaziflam, the active ingredient in Rejuvra has extremely low water solubility (Sebastian 2017). Plateau on the other hand has remarkably high water solubility and may have been more available to control seedling annual grasses under the dry conditions. Additionally, the lack of moisture may have reduced any movement of the Plateau, allowing it to remain in top layer of soil where annual plants are germinating. However, it is interesting that the combinations of Rejuvra + Plateau maintained higher control of the annual grasses than the products alone, suggesting that both are playing a role in the longer term suppression of these annuals.

Lack of filaree control with Rejuvra treatments was expected as it has not been shown to be effective on that species in other research. This can be an advantage if filaree is a species that is useful as a food source for species like the desert tortoise. It is also unclear whether filaree produces enough thatch to be considered a factor in carrying fire.

As far as injury to desirable vegetation, this trial clearly demonstrated that desert trumpet is extremely sensitive to Plateau. For perennial/woody plant species, there were no obvious negative effects from the herbicide treatments, although as discussed in the results, the populations were too variable to make definitive conclusions.

Given the low populations of annual grasses on the site, at least during the trial period, it is questionable if treatments would be warranted for fire suppression.

5.1 Recommendations

This research demonstrates the complexity of weed management within variable climatic conditions. It also highlights the necessity to conduct research under localized conditions as treatment effects are highly influenced by specific edaphic and climatic conditions.

Based on the results the following recommendations are included below:

1. Herbicide treatments for invasive annual grass management and wildfire suppression should be targeted at areas producing enough thatch to increase wildfire risk. This may include higher elevation areas within the Trout Mountain Translocation site as well as other areas of critical desert tortoise habitat.
2. In areas specifically targeted for fire prevention (ie roadsides, industrial sites, etc) a combination of Rejuvra + Plateau will likely provide the most consistent control of invasive annual grasses and other annual species like filaree.
3. When applying herbicides for invasive annual grass management, determining the importance of desert trumpet on the site should be considered and used to determine products and or rates of application.
4. Specific plant species of critical importance to desert tortoise should be considered for additional research to determine potential herbicide treatment effects.

6.1 Literature Cited

Buell, Hailey L., (2021) Control of Three Invasive Annual Grasses in Utah Using Herbicides Including Indaziflam, MS Thesis, Utah State University, 8397. https://digitalcommons.usu.edu/etd/8397

Elwood, Heather, (2013) Integrated Management of Downy Brome (Bromus tectorum L.) Infested Rangeland, MS Thesis, Utah State University, https://digitalcommons.usu.edu/etd/2019

Natural Resources Conservation Service, USDA. 2004. Nye County Order III Soil Survey. Reno, Nevada.

Sebastian, D. J., Fleming, M. B., Patterson, E. L., Sebastian, J. R. & Nissen, S. J. 2017 Indaziflam: a new cellulose-biosynthesis-inhibiting herbicide provides long-term control of invasive winter annual grasses. Pest Manag. Sci. 73, 2149–2162.

Sebastian DJ, Nissen SJ and De Souza Rodrigues J, (2016) Pre-emergence control of six invasive winter annual grasses with imazapic and indaziflam. Invas Plant Sci Manag 9: 308–316.