Restoring depleted understory plant communities to benefit greater sage-grouse, 2022 progress report

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Report for East Cascades Audubon Society

Report prepared by Scott Harris

Institute for Applied Ecology

Institute for Applied Ecology

PREFACE

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Cover photographs: A grazing exclosure at the Brothers Study Site. Photo by Stu Garrett

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TABLE OF CONTENTS

Restoring depleted understory plant communities to benefit greater sage-grouse, 2022 progress report

EXECUTIVE SUMMARY

Despite substantial collaborative efforts to conserve greater sage-grouse (C*entrocercus urophasianus*), and their critical habitats, the dramatic decline in populations over the past 50 years has yet to be arrested. The breeding population of sage grouse in Oregon was estimated to be 15,927 in 2021, the third lowest population estimate since 1980. The habitat threats of juniper encroachment, invasion of annual grasses, and altered fire regimes receive much conservation and management attention. Combined, these threats impact the habitats that grouse depend upon. However, removing or mitigating these threats does not guarantee the restoration of critical habitat elements, in particular understory plant communities. Forbs, perennial grasses, and forb-associated arthropods in sagebrush understories are critical for chick-rearing and reproductive success. Studies have shown that annual recruitment is directly correlated to availability of grass and forb-associated arthropods. Therefore, restoration of these important understory plant communities is a high priority, as they are scarce or missing in many priority sage-grouse conservation areas.

The goal of this study is to identify best practices for restoring forb and grass understories in core sage-grouse habitat. We tested how various treatments (seeding methods, mowing, micro-irrigation, and grazing exclusion) affect restoration success in a crossed and replicated experiment near Brothers, Oregon. Research plots were installed and treatments applied in November 2021. After one growing season (November 2021 through June 2022), we found that mowing and irrigation increased total forb cover. We also found that irrigation and seeding method increased establishment of seeded species. A manual drill seeding tool was the most effective at increasing the establishment of our seeded species – yarrow (*Achillea millefolium*), Lewis' flax (*Linum lewisii*), and squirreltail grass (*Elymus elymoides*).

This study is being conducted by the Institute for Applied Ecology with funding, volunteer, and in-kind support from East Cascades Audubon Society and TerraWest Conservancy. Multiple years are needed to accurately assess the effects of restoration treatments on plant communities and establishment, particularly in arid environments and for perennial species. Therefore, our results are strictly preliminary. We will continue this study for at least one more year (and longer depending on funding).

1. INTRODUCTION

The population of greater sage-grouse (*Centrocercus urophasianus*) has declined nearly 80% across its 11-state range in the last 50-years (Coates et al. 2016). In 2015, the USFWS found that listing of greater sage-grouse as an endangered species was "warranted but precluded" – meaning that the available science justifies a listing but that other species are considered higher priority. Populations have continued to decline even following substantial collaborative efforts across the region to address conservation threats. In Oregon, the estimated sage-grouse breeding population in Oregon was estimated to be 15,927 in 2021, the third lowest population estimate since 1980, and in the Prineville District (the location of our this study) the population declined 14% in 2021 (Vold 2021). While the primary diet for adult sage-grouse is sagebrush; forbs, grasses, and the arthropods associated with forbs and grasses in sagebrush habitats are critical for hens during the brooding season and for chick survival. Chicks in particular are completely reliant on forbs and forb-associated arthropods (e.g., ants, caterpillars, grasshoppers, etc.) during the first two weeks of life (Johnson and Boyce 1990) and continue with this diet through the first four months (Dahlgren et al. 2015).

Forbs and grasses comprise the understory plant community in sagebrush steppe ecosystems. The sagebrush steppe ecosystem and associated understory plant communities have become increasingly degraded since European settlement (Davies and Bates 2014, Doherty et al. 2022). Restoration of this ecosystem has focused on the primary threats of altered wildfire regimes, invasive annual grasses, conifer expansion, and human land use and land modification. However, addressing these landscape-scale threats do not guarantee increased health of the forb and grass understory (Bates et al. 2017), and without forbs sage-grouse will never recover.

Restoring understory plant communities at landscape scales presents many operational challenges, such as very limited supplies of native seed, the need to reseed multiple times, variable plant responses due to seasonal climate variability, site access, and others. Therefore, targeting restoration efforts at forb islands in core sage grouse habitat (particularly early brood-rearing habitat) shows promise (Hulvey et al. 2017). Unlike grasses, there is a paucity of information on the best practices for restoring forbs in sagebrush steppe ecosystems. Our study will fill this knowledge gap by assessing the efficacy of four restoration practices that can be used to create forb restoration islands to benefit greater sage grouse and other sagebrush steppe species.

2. GOALS AND OBJECTIVES

The goal of this study is to identify best practices for restoring forb islands in core sage-grouse habitat. Specific study objectives are to:

1) Assess the efficacy of the following restoration treatments (alone and in combination) at restoring grass and forb understories in sagebrush steppe ecosystems
    a. Different seeding methods
    b. Mowing
    c. Micro-irrigation
    d. Livestock exclusion
2) Communicate study results with sage-grouse conservation stakeholders

3. METHODS

3.1. Site Description

Our study site is approximately four miles NNE of Brothers, Oregon in the Northern Basin and Range Ecoregion, High Lava Plains physiographic province (McClaughry et al. 2019). Soils are predominantly classified as the Ninemile-Dester Complex: shallow, well-drained soils derived from volcanic ash and weathered basalt. Typical soil profile is gravelly-sandy loam, clay, gravelly clay, then bedrock at 19-29 inches (USDA 2022b). Climatic conditions (1991-2020) were: 9.1 in of mean annual precipitation, monthly mean minimum temperatures ranging from 19 to 45 deg F, and monthly mean maximum temperatures ranging from 38 to 84 deg F (PRISM Climate Group 2022).

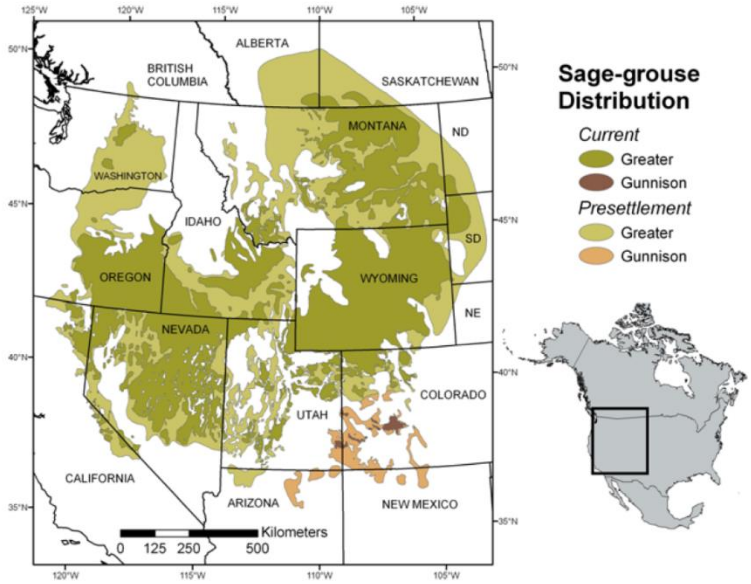

Figure 1. Historic and current distribution of sage-grouse.

Our study site is in the northwestern-most corner of the current distribution of greater sage-grouse in Oregon (Figure 1, Aldridge et al. 2008). It is in the Brothers Priority Area for Conservation (PAC, Figure 2). PAC's are identified by Oregon Dept. of Fish and Wildlife as essential for the long-term conservation of sage-grouse. The site consists of 2 pastures (named "Cody" and "West Reservoir") approximately 1.4 km apart on private land managed by TerraWest Conservancy, adjacent to public land managed by the Bureau of Land Management (Figure 3). The study area has historically been used for livestock grazing. Invasive annual grasses and juniper are uncommon in the immediate vicinity. Average shrub cover is 12% and consists of mostly of Wyoming big sagebrush (*Artemisia tridentata spp wyomingensis*) and green rabbitbrush (*Chrysothamnus viscidiflorus*). Understory graminoid and forb cover is 6% and 1%, respectively. Cover of non-native annual grass species is < 0.1%, consisting of only cheatgrass (*Bromus tectorum*) (Figure 4).

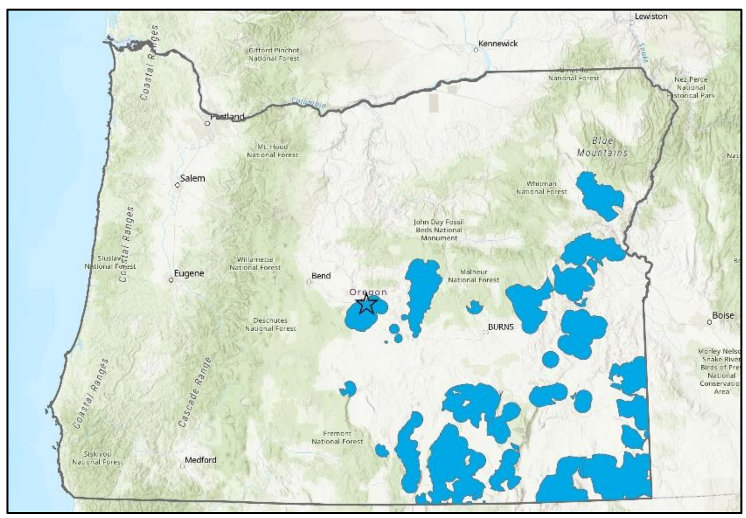

Figure 2. Priority areas for sage-grouse conservation (PACs) in Oregon shown in blue. Location of the Brothers Study site is shown by the star.

Figure 3. The Cody Pasture at the Brothers study site.

3.2. Seed Mix

Figure 4. Typical site conditions in October 2021.

We developed a seed mix specifically tailored to benefit greater sage-grouse. Prior research describes the relative values that different plant families, genera, and in some cases species contribute to the sage-grouse diet during the critical early brood-rearing stage (Rosentreter 2015). We selected species from this information that also had locally available seed. Finding locally available seed was a significant hurdle and we were unable to find most of our highest priority species. Our final seed mix (Figure 5) consisted of yarrow (*Achillea millefolium*), limestone hawksbeard (*Crepis intermedia*), Lewis' flax (*Linum lewisii*), and squirreltail grass (*Elymus elymoides*) – all perennial species. The perennial grass was added for its value as cover for nesting and brooding hens, and we wanted the proportion (by weight) of grass to be less than 10% of

Figure 5. Species in our seed mix: yarrow, limestone hawksbeard, Lewis' flax, and squirreltail grass.

the mix. The bulk seeding rate was 10 lbs/acre or 7.7 lbs/acre when converted to proportion of live seed. Specifications for each species are shown in Table 1.

Table 1. Species composition of the seed mix applied in November 2021.

Species	Scientific name	Source	Seeds per lb	PLS	lbs (bulk)
yarrow	*Achillea millefolium*	Deschutes Basin Native Plant Seedbank	3,490,791	0.92	1.00
limstone hawksbeard	*Crepis intermedia*	Oregon State University Experiment Station (Ontario)	120,039	0.30	0.77
Lewis' flax	*Linum lewisii*	Deschutes Basin Native Plant Seedbank	294,800	0.94	1.00
squirreltail grass	*Elymus elymoides*	Deschutes Basin Native Plant Seedbank	192,00	0.90	0.20

3.3. Experimental Design & Treatments

We selected four types of restoration treatments, based on prior knowledge and review of the literature, to test with a robust experimental design. Treatments are seeding method, mowing, micro-irrigation, and grazing exclusion. A no-treatment control is also included. Mowing, micro-irrigation, and grazing exclusion each have two levels (yes or no) while seeding method has three levels (seed pellets, jang seeder, or no seeding control). Therefore, a fully-crossed experiment - which would assess the efficacy of all possible combinations of treatments – would necessitate 3x2x2x2 = 24 replicates per block, or 192 replicates over eight blocks. Due to logistical constraints and limited seed supply, we eliminated some of the treatment combinations and only replicate micro-irrigation in four of the eight blocks. Grazing exclusion is accomplished with a permanent fenced exclosure and represents a split plot in our experimental design. The final experimental design includes replicates of the treatment combinations shown in Table 2.

The Jang seeder (Jang Automation Co.) is a commercially-available precision seed drill (Figure 6A) that creates a shallow furrow, drops seed at a regulated rate, and then covers the furrow. We used a manual push seeder, but this tool can be scaled-up to be pulled behind a small tractor and have up to six seed hoppers. Seed pellets (Figure 6B) were made following established methods for dry-land restoration (Gornish et al. 2019). Seed pellets were spread by hand.

Table 2. Treatment matrix. 0 = not treated or exclusion, 1 = treated, J = jang seeder, P = pelleted seeds.

	Treatment				
Label	Irrigation	Seeding	Mowing	Grazing	*Replicates*
1	1	0	0	0	4
2	1	J	0	0	4
3	1	P	0	0	4
4	1	J	1	0	4
5	1	P	1	0	4
7	0	0	0	0	8
8	0	J	0	0	8
9	0	P	0	0	8
10	0	J	1	0	8
11	0	P	1	0	8
12	0	0	1	0	4
13	1	0	0	1	4
14	1	J	0	1	4
15	1	P	0	1	4
16	1	J	1	1	4
17	1	P	1	1	3[a]
19	0	0	0	1	8
20	0	J	0	1	8
21	0	P	0	1	8
22	0	J	1	1	8
23	0	P	1	1	7[a]
24	0	0	1	1	4

a. Two plots in one of the blocks were mistakenly not mowed.

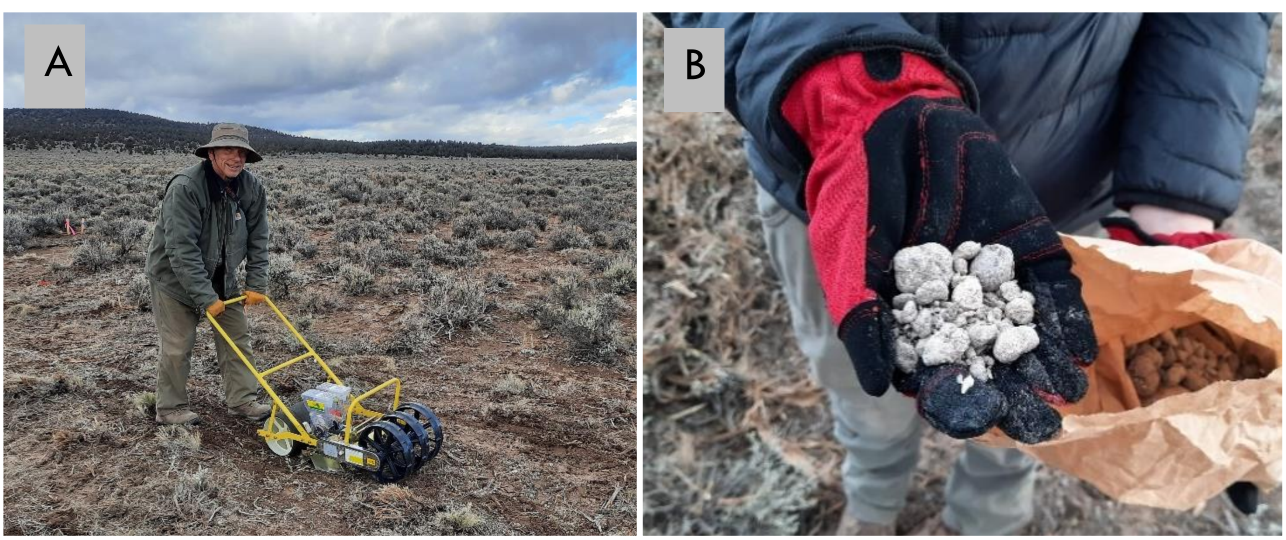

Figure 6. A) The Jang seeder. B) Seed pellets.

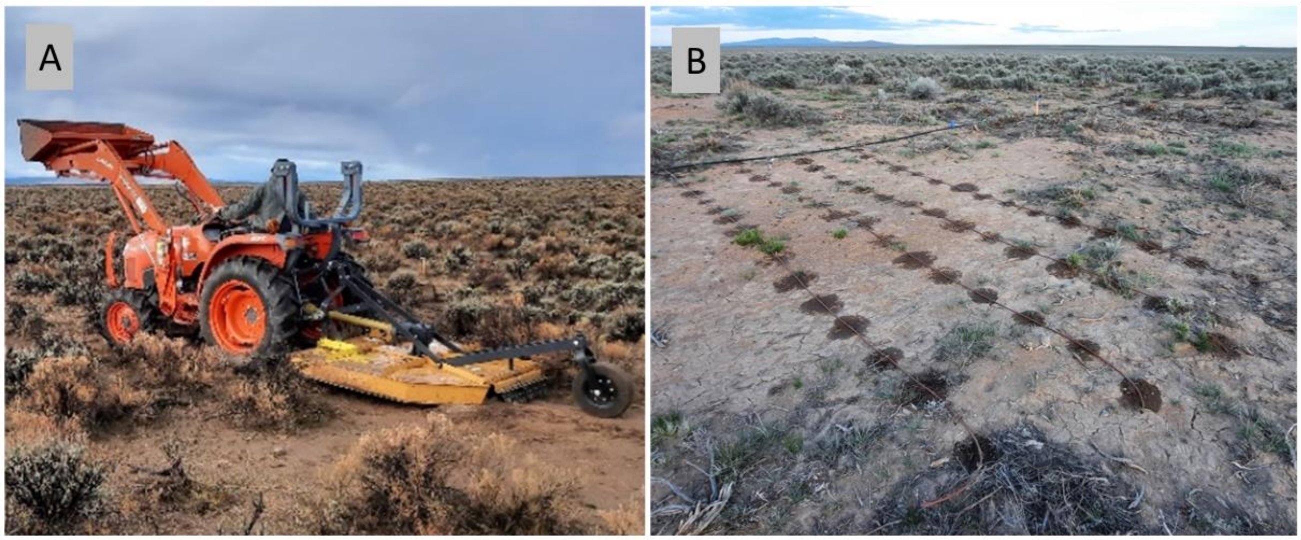

Figure 7. A) Mowing, and B) micro-irrigation treatments

Mowing was done with a brush hog pulled behind a medium-sized tractor (Figure 7A). The cutting height was set to approximately 8 inches. Micro-irrigation (Figure 7B) was done with drip irrigation tied into the existing water infrastructure on site (for livestock troughs). With irrigation, we attempted to mimic slightly above-average rainfall.

Treatment combinations are replicated in each of eight blocks, four in the Cody Pasture and 4 in the West Reservoir Pasture. All treatment plots are 5 m x 5 m with a 2 m buffer between plots. The grazed and ungrazed plots are separated by 10 m. Distance between blocks, and distance of blocks from livestock watering troughs is at least 250 m. Distance between the Cody and West Reservoir Pastures is 1.4 km. Orientation of blocks was randomly determined, but the arrangement of treatment plots within blocks were held constant to aid logistics. Appendix A shows block locations, orientation, and plot arrangement.

We installed the study plots and applied all treatments except grazing exclusion November 8-12, 2021. Exclosure fences were installed January through March 2023. The exclosures were designed to only exclude livestock. We also placed small white triangles on the fence wires to avoid injury to flying grouse. There were no managed livestock in the two pastures once the study was installed, although we were unable to monitor for “trespass” livestock (loose, unmanaged livestock).

3.4. Field Data Collection

We conducted pre-treatment surveys November 8-9, 2021. Because these surveys were outside of the growing season, for plants we only estimated the percent cover of woody species. We also estimated the percent cover of biological and physical soil crusts, and the presence of grouse scat and livestock tracks. All grouse scats observed were removed from plots.

Post-treatment surveys were conducted May 2-4 and June 22-24, 2022. The intent of the initial survey was to record any early germinants from our seed mix that might be consumed or difficult to identify by the later survey. The later survey was timed for the peak of the growing season. We counted grouse scat and livestock tracks, estimated the percent cover of each woody and forb species and graminoids by group (native annual, non-native annual, perennial), the dominant perennial graminoid species, and the counts of individual plants of our seeded species. All grouse scats observed were removed from plots.

3.5. Analysis

Each treatment plot has two 1m x 2m quadrats in which all responses were assessed. Estimates from the two quadrats were averaged to represent the response for each treatment plot. However, unique to the 2022 data is that there were no livestock in the study area – meaning that the grazing exclusion treatment cannot be assessed. Therefore, we pooled the grazed and ungrazed treatment plots in each block by calculating the average measurement values for each treatment in that block. This means that the estimates for each treatment in each block is the average of four quadrats. We could have considered the grazed and ungrazed plots as additional replicates, meaning that each treatment combination would have been replicated twice at each block. We did not do so because we felt the plots were insufficiently independent and would have represented a case of pseudo-replication (a big no-no in statistics).

All analyses were conducted in R (R Core Team 2022). We report cover estimates for all plants and counts, densities of the seeded species, and rarefied richness of forbs. Rarefied richness, which accounts for uneven sampling effort, was calculated with the vegan package in R (Oksanen and et al. 2022) with the subsampling size set at 16. Prior to statistical tests, all response variables were assessed as to whether they met appropriate assumptions. Response variables were log-transformed to meet normalcy. Homogeneity of variance was assessed with Levene's test. Residuals were visually assessed for homoscedasticity with Q-Q and residual plots. Statistical tests used 3-way ANOVA F-tests with either cover or density of seeded species as the response variable. Blocks were treated as a random effect. Post-hoc assessment of effect sizes was conducted by calculating the difference in estimated marginal means between treatments using Tukey's HSD in the emmeans package in R (Lenth 2022). Estimated marginal means adjust the mean response for each factor level by accounting for other model variables and unbalanced data. Our data set is essentially unbalanced because we replicated irrigation in 4 blocks and all other treatment combinations in 8 blocks. However, ANOVA is robust to departures from balanced data as long as the homogeneity of variance assumption is met.

4. RESULTS

4.1. Treatments

Mowing reduced shrub cover from approximately 12% to 2%. We had multiple problems with the irrigation system. In early June 2022, the irrigation pump was crushed by a vehicle and then lightning disabled the pump. These events stopped irrigation for approximately four weeks. Between May 5 and July 2, 2022 we applied the equivalent of 0.86 in of rain to the two blocks in the Cody Pasture and 1.19 in of rain to the two blocks in the West Reservoir pasture.

4.2. Livestock and grouse

We had a game camera set up on at the Cody 3 (or Cody D) block from May 5 to August 26, 2022. We saw no livestock. We saw several raptors perched on the exclosure fence and pronghorn on two occasions. Over the three surveys (November 2021, May 2022, and June 2022) we found no grouse scat in the West Reservoir blocks. At Cody, we found 6 scat in November, 13 in May, and none in June.

4.3. Plant cover

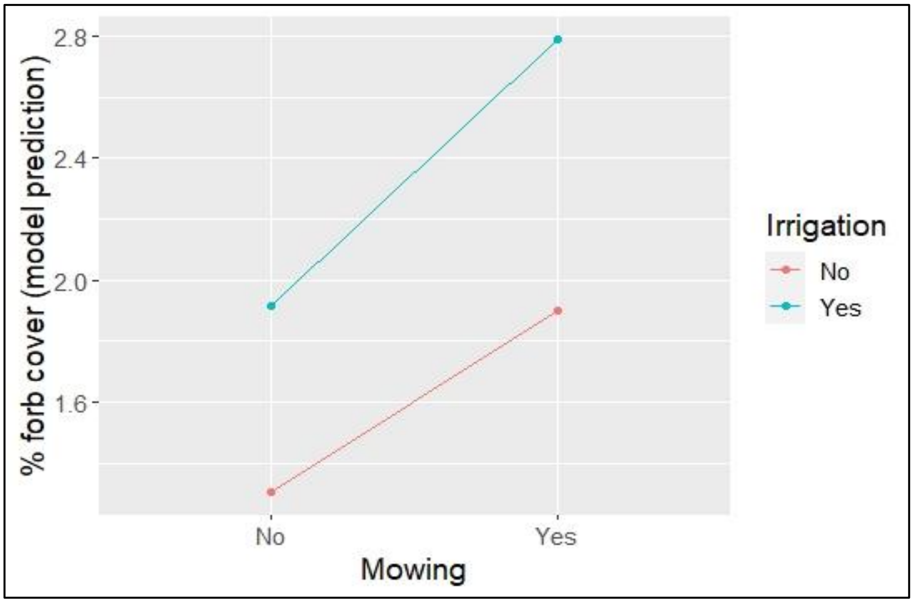

Figure 8. The response of forbs to the mowing and irrigation treatments, as predicted by the 3-way ANOVA model.

Irrigation (p = 0.052) and mowing (p=0.022) increased total forb cover. Irrigation increased total forb cover 1.5 times and mowing increased total forb cover 1.5 times. Figure 8 shows the predicted mean forb cover based on the statistical model. There were no significant interactions at the 0.10 significance level, nor did the seeding method significantly change total forb cover. Only mowing increased total graminoid cover (p=0.030), by 1.1 times. Changes to cheatgrass, the only non- native annual grass we observed, were minimal to the point where we were unable to statistically test. We were unable to test the grazing exclusion treatment because the landowner removed all livestock approximately the same time we set up the experiment in November 2021. As described earlier, we averaged the grazed and ungrazed plots for each block-treatment. Cover values and rarefied forb richness by functional group are shown in Table 3. The effects of combined treatments on total forb cover are shown in Figure 9. A list of all shrub and forb species is in Appendix B.

Figure 9. Total forb cover for each treatment combination (I = irrigated, M=mowed, J=Jang seeder, P=pelleted seeds, etc.). The red dot is the mean value and the bar in the box is the median value. The outliers are due to 2 plots in the West Reservoir Block A (also referred to as Block 2) that had high levels of thread-stalk cutleaf tansymustard (*Descurainia longipedicellata*) (see Figure 14). See Table 3 for sample sizes.

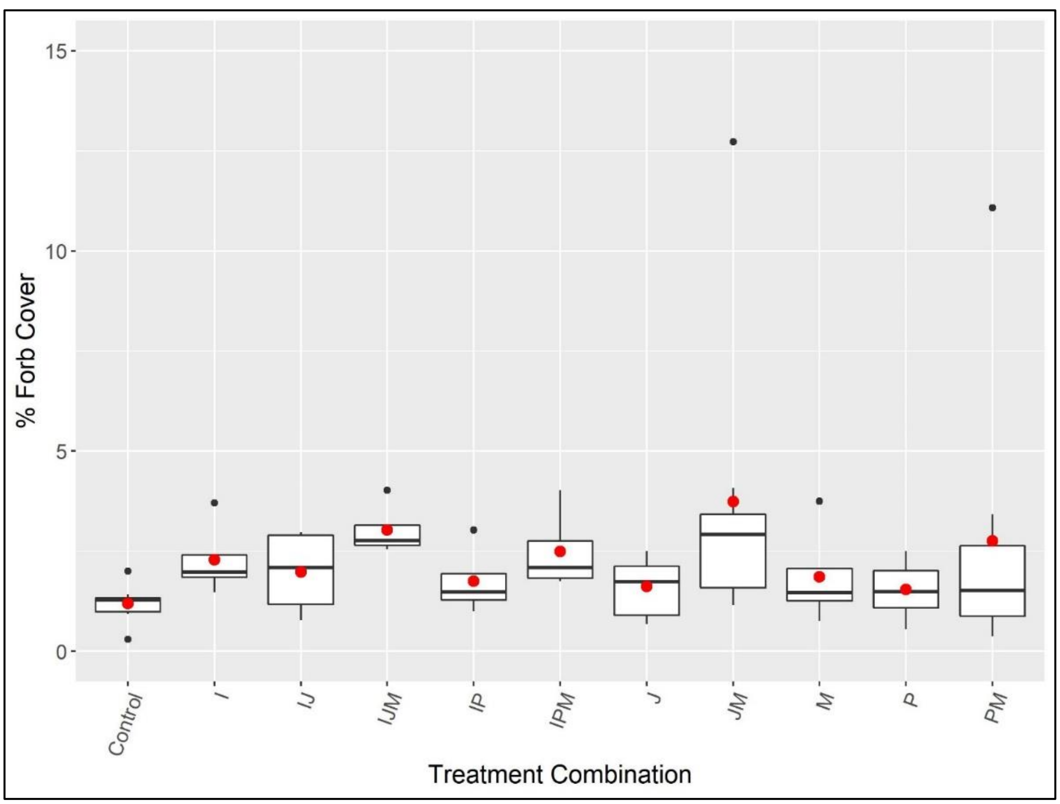

Table 3. Percent cover (and standard error) of plant functional groups by treatment in June 2022. Treatment combination codes are the same as those used in Figure 9. Richness is rarefied species richness (with subsampling set at 16).

			Forb Richness		Shrub Cover (%)		Forb Cover (%)		Graminoid Cover (%)		
Treatment	Treatment code	Replicates	Native	Non-native	Total	Sagebrush	Total	Native	Total	Native Perennial	Non-native Annual
Control	Control	8	8.4	2.0	13.7 (2.0)	11.9 (1.8)	1.2 (0.2)	1.2 (0.2)	5.5 (0.5)	5.5 (0.5)	0.0 (0.0)
Mow	M	4	8.4	1.0	5.1 (1.2)	3.7 (1.2)	1.9 (0.7)	1.8 (0.6)	7.0 (1.4)	6.8 (1.3)	0.2 (0.2)
Pellet Seed	P	8	8.3	4.0	12.7 (2.5)	10.6 (2.4)	1.5 (0.2)	1.4 (0.2)	6.0 (0.5)	6.0 (0.5)	0.0 (0.0)
Pellet Seed + Mow	PM	8	8.4	3.0	3.4 (0.8)	2.6 (0.7)	2.8 (1.2)	2.7 (1.2)	7.9 (1.7)	6.3 (0.6)	1.6 (1.5)
Jang Seed	J	8	8.6	1.0	12.1 (2.1)	10.0 (1.7)	1.6 (0.3)	1.5 (0.2)	5.6 (0.6)	5.3 (0.4)	0.3 (0.3)
Jang Seed + Mow	JM	8	9.0	4.0	3.3 (0.7)	2.2 (0.6)	3.7 (1.3)	3.7 (1.3)	7.1 (1.3)	6.2 (0.5)	0.9 (0.8)
Irrigation	I	4	8.5	1.0	11.2 (2.3)	8.9 (0.7)	2.3 (0.5)	2.2 (0.5)	4.7 (0.2)	4.7 (0.2)	0.0 (0.0)
Irrigation + Pellet Seed	IP	4	9.1	3.0	15.5 (2.0)	14.8 (2.3)	1.7 (0.4)	1.6 (0.5)	5.9 (0.8)	5.8 (0.8)	0.0 (0.0)
Irrigation + Pellet Seed + Mow	IPM	4	9.3	3.0	3.5 (0.6)	2.9 (0.6)	2.5 (0.5)	2.4 (0.5)	5.8 (0.6)	5.8 (0.6)	0.0 (0.0)
Irrigation + Jang Seed	IJ	4	9.2	3.0	14.6 (5.3)	12.5 (5.6)	2.0 (0.6)	1.8 (0.4)	6.4 (1.0)	6.4 (1.0)	0.0 (0.0)
Irrigation + Jang Seed + Mow	IJM	4	9.2	1.0	3.0 (1.5)	2.3 (1.5)	3.0 (0.3)	3.0 (0.3)	6.9 (1.2)	6.4 (1.3)	0.4 (0.3)

Figure 10. Lewis' flax seedling.

4.4. Seedlings of planted species

We found seedlings of all our seeded species except for limestone hawksbeard. All of the flax seedlings observed were very small – less than approximately 2 in tall (Figure). Therefore, we were confident that the flax seedlings germinated from our seed mix. We found both tall and short seedlings of yarrow, up to 8 in and less than 2 in respectively. Therefore, some yarrow seedlings were likely from the existing seed bank. Many of the yarrow seedlings were found under or within the sagebrush canopy. The majority of yarrow seedlings were found during the May survey while the majority of flax and squirreltail seedlings were found during the June survey (Figure 10). For the following analysis, we assessed May seedlings of yarrow and June seedlings of flax and squirreltail. The seeding method ($p < 0.001$) and irrigation ($p = 0.078$) increased the total density of seedlings of planted species. There was also some evidence for an interaction between seeding and irrigation ($p = 0.077$) – the effect of irrigation of plots seeded via pellets was stronger than on plots seeded with the Jang (Figure 11). The Jang seeder increased seedling density 1.6 times more than the density from seed pellets. Irrigation increased seedling density 1.3 times.

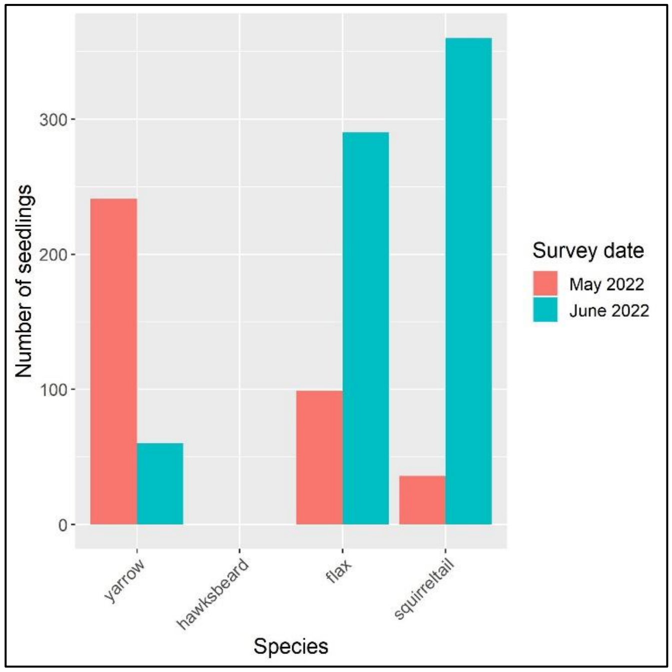

Figure 10. Number of seedlings (across all monitored plots) of the seeded forb and grass species.

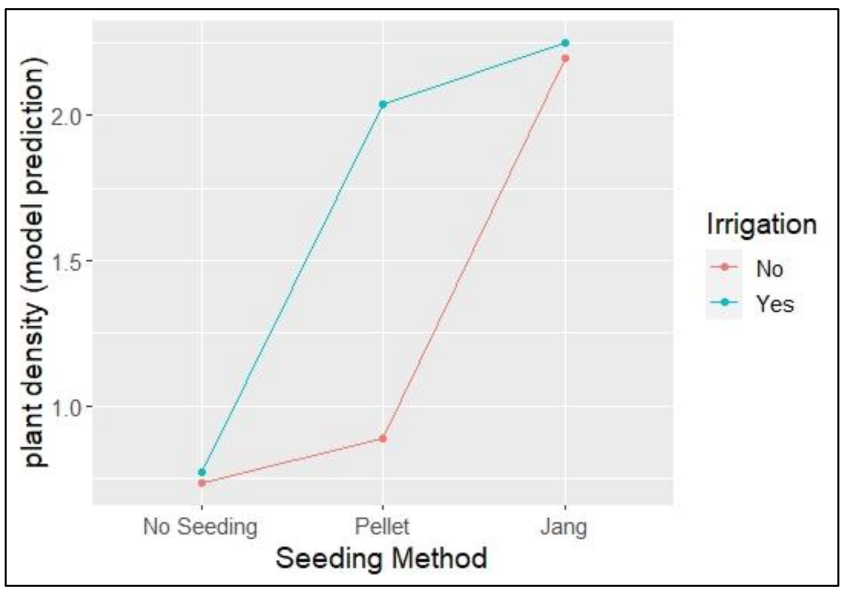

Figure 11. The response of planted species (total of yarrow, flax, and squirreltail) to the seeding method and mowing treatments. Plant density is the number of individual plants per m^2

5. DISCUSSION

After one growing season, we found that mowing and irrigation increased total forb cover. We also found that irrigation and seeding method increased establishment of seeded species. The Jang seeder was the most effective at increasing the establishment of our seeded species. While irrigation increased establishment for plots seeded with pellets, the effect of irrigation on the plots seeded with the Jang was negligible (Figure 11). For future surveys, we predict that seeding method will

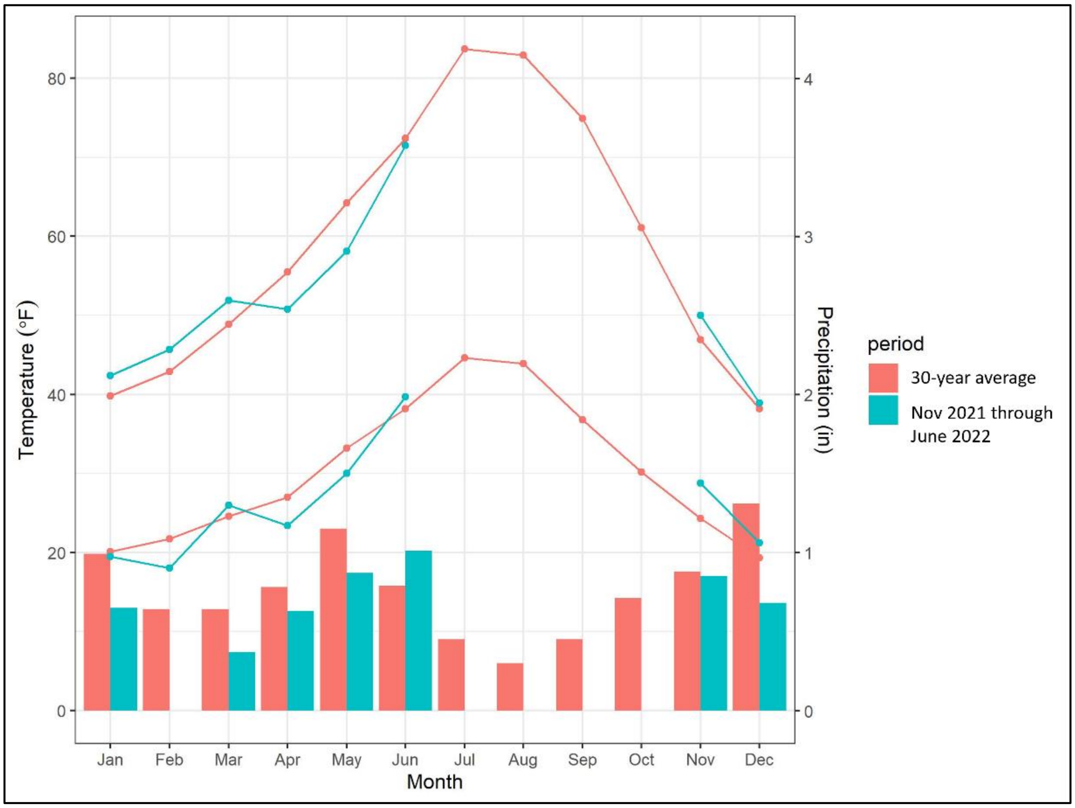

Figure 12. Precipitation, maximum temperature, and minimum temperature during the first growing season (November 2021 through June 2022) compared to 30-year average (Prism Climate Group 2022) at the Brothers study site. Precipitation July through October 2022 is not graphed.

have a stronger effect on total forb cover. It was negligible this year because the seedlings of the seeded species are quite small and minimally contribute to total forb cover.

Multiple years are needed to accurately assess the effects of restoration treatments on plant communities and establishment (Applestein et al. 2018), particularly in arid environments and for perennial species. Therefore, our results are strictly preliminary. The extreme variability in annual and inter-annual weather in the arid high desert will also greatly influence our observed responses. The Brothers area experienced an exceptional drought during the entire first growing season (USDA 2022a). Annual precipitation between November 2021 and May 2022 was 63% of the 30-year average, and there was no precipitation in February (Figure 12).

Our results were also influenced by a potential outlier the West Reservoir A block. We observed up to 20% cover of thread-stalk cutleaf tansymustard (*Descurainia longipedicellata*) in two mowed and non-irrigated plots (Figure 13), compared to an average forb cover of less than 4% across all plots. If we remove these outliers, our observed effect of mowing of total forb cover may be reduced while the effect of irrigation may increase. For now, we decided to leave these observations in the analyses based on the preliminary nature of our results.

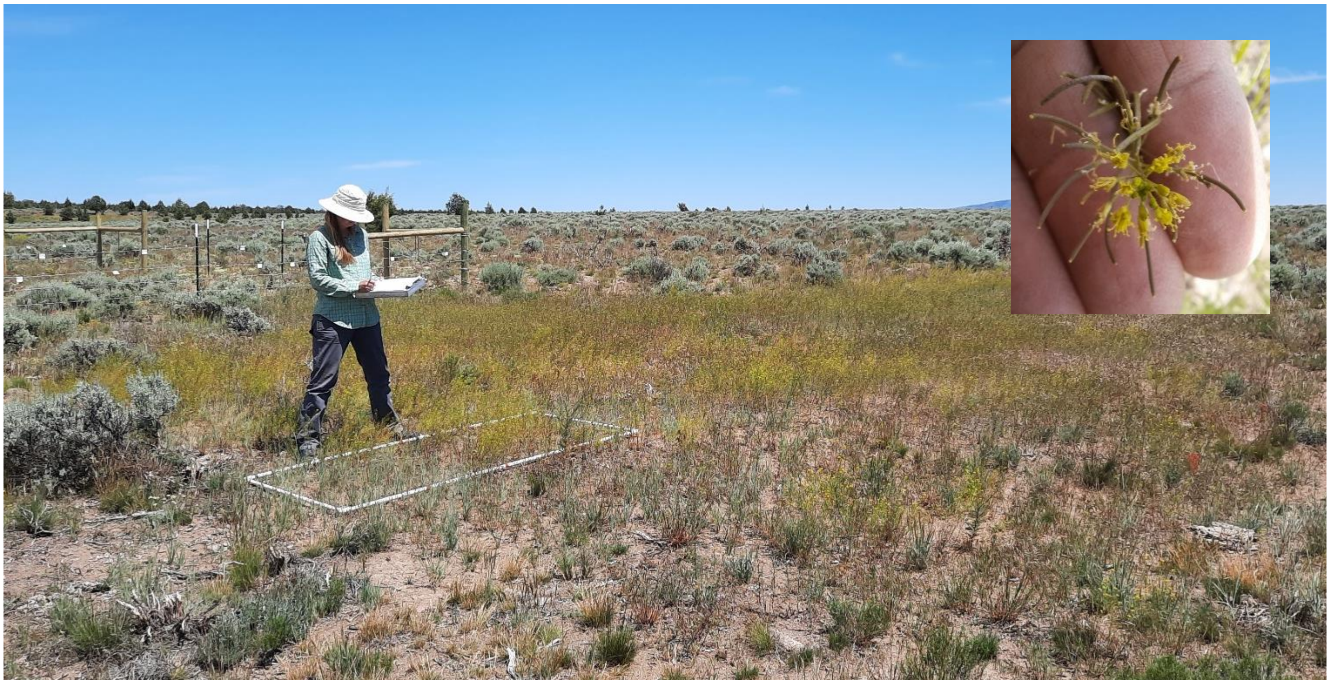

Figure 13. Thread-stalk cutleaf tansymustard (*Descurainia longipedicellata*) in two plots in the West Reservoir A block. Inset photo is the congeneric *Descurainia sophia*.

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APPENDIX A. EXPERIMENTAL LAYOUT

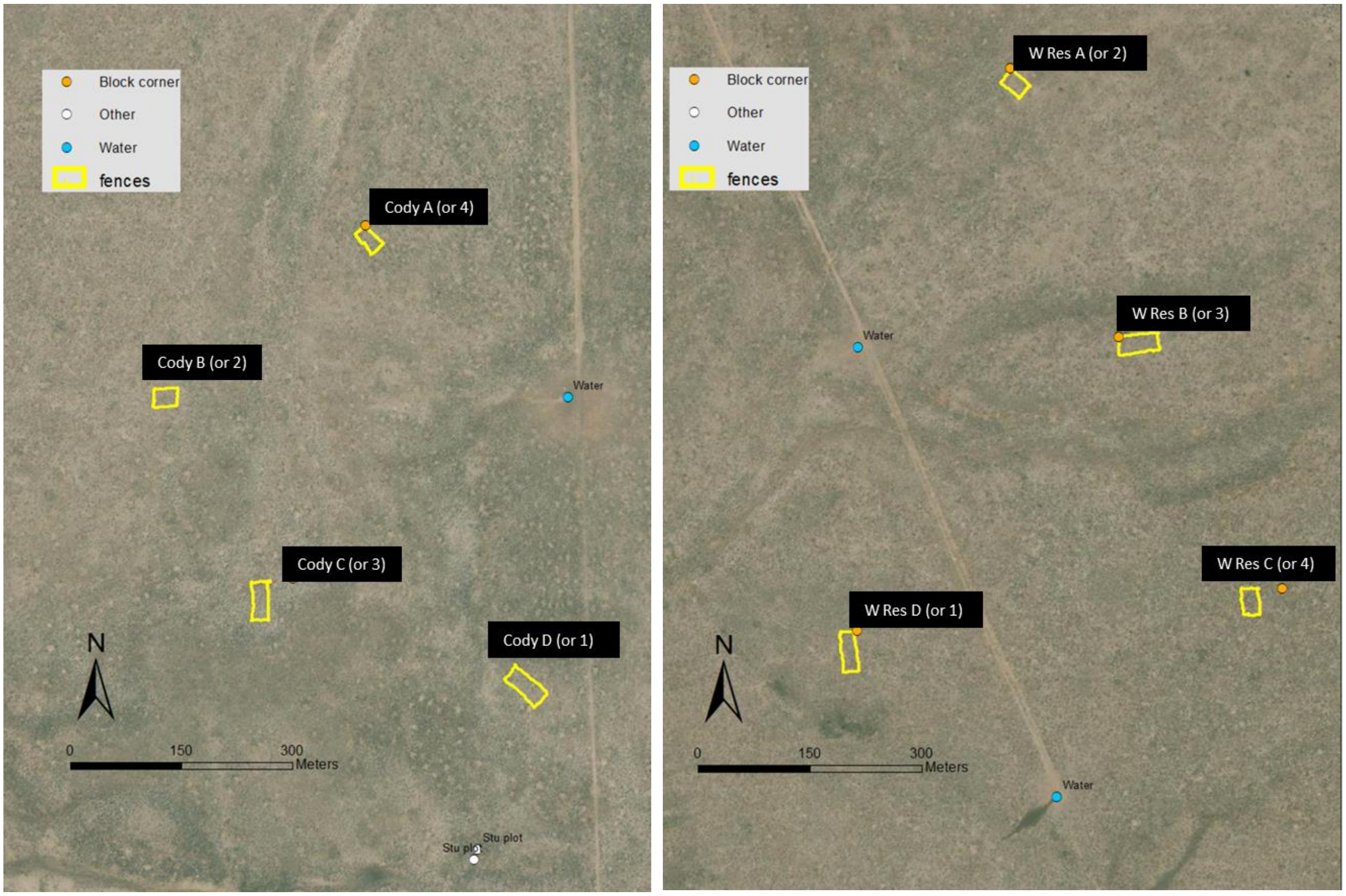

Figure A.1. Location of each block in the Cody and West Reservoir Pastures.

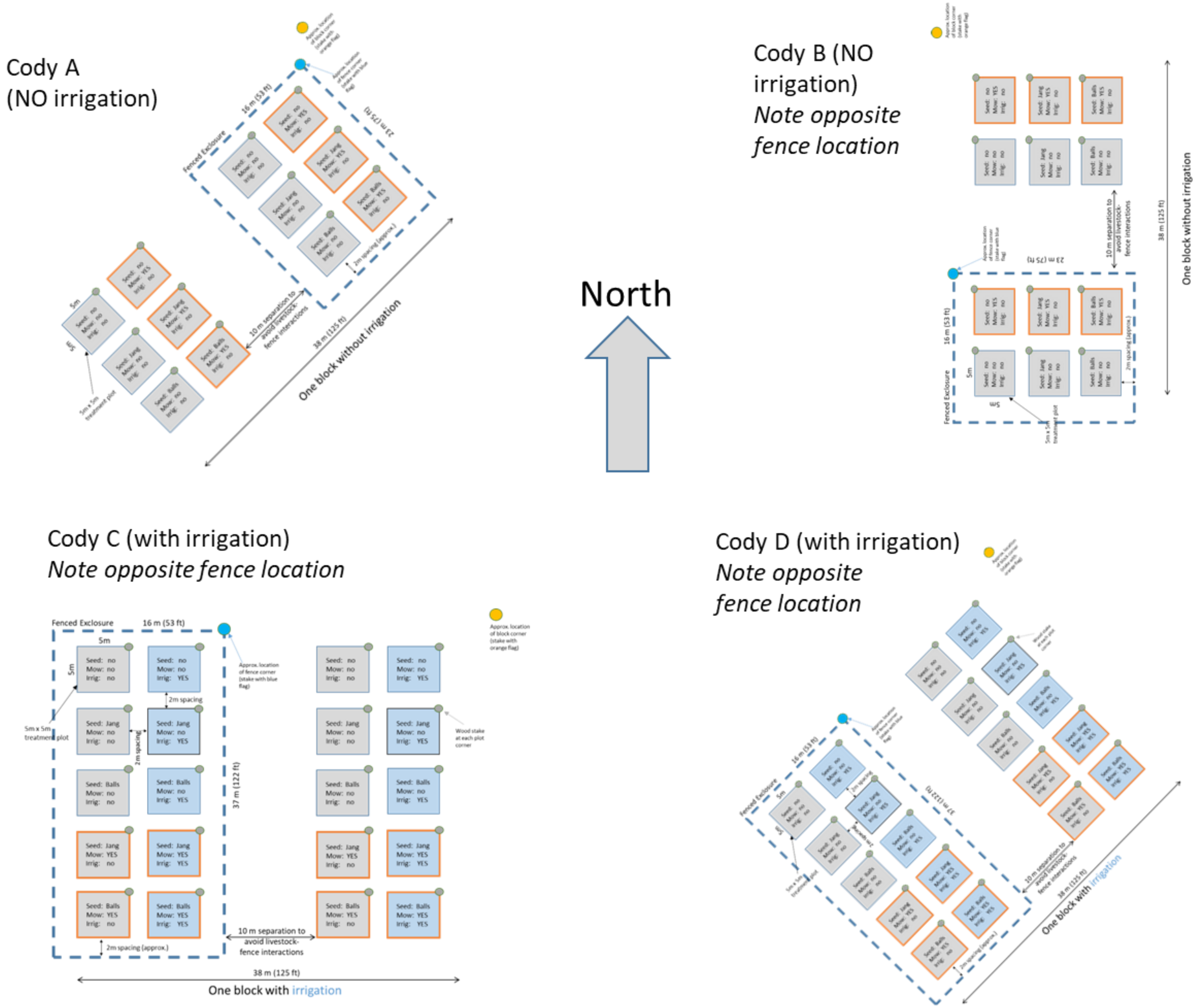

Figure A.2. Block orientation and fence positions (blue dashed line) at the Cody blocks.

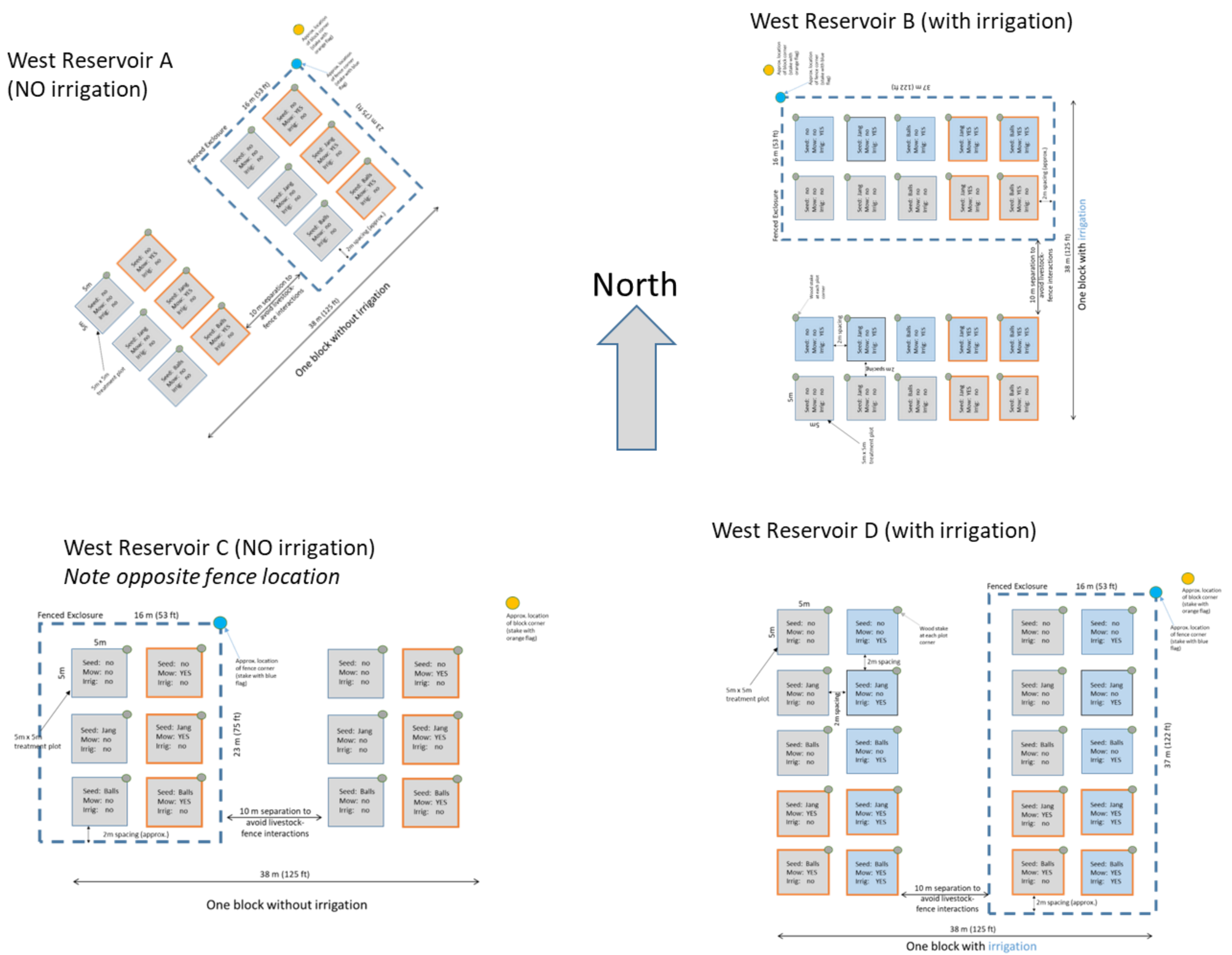

Figure A.3. Block orientation and fence positions at the West Reservoir blocks.

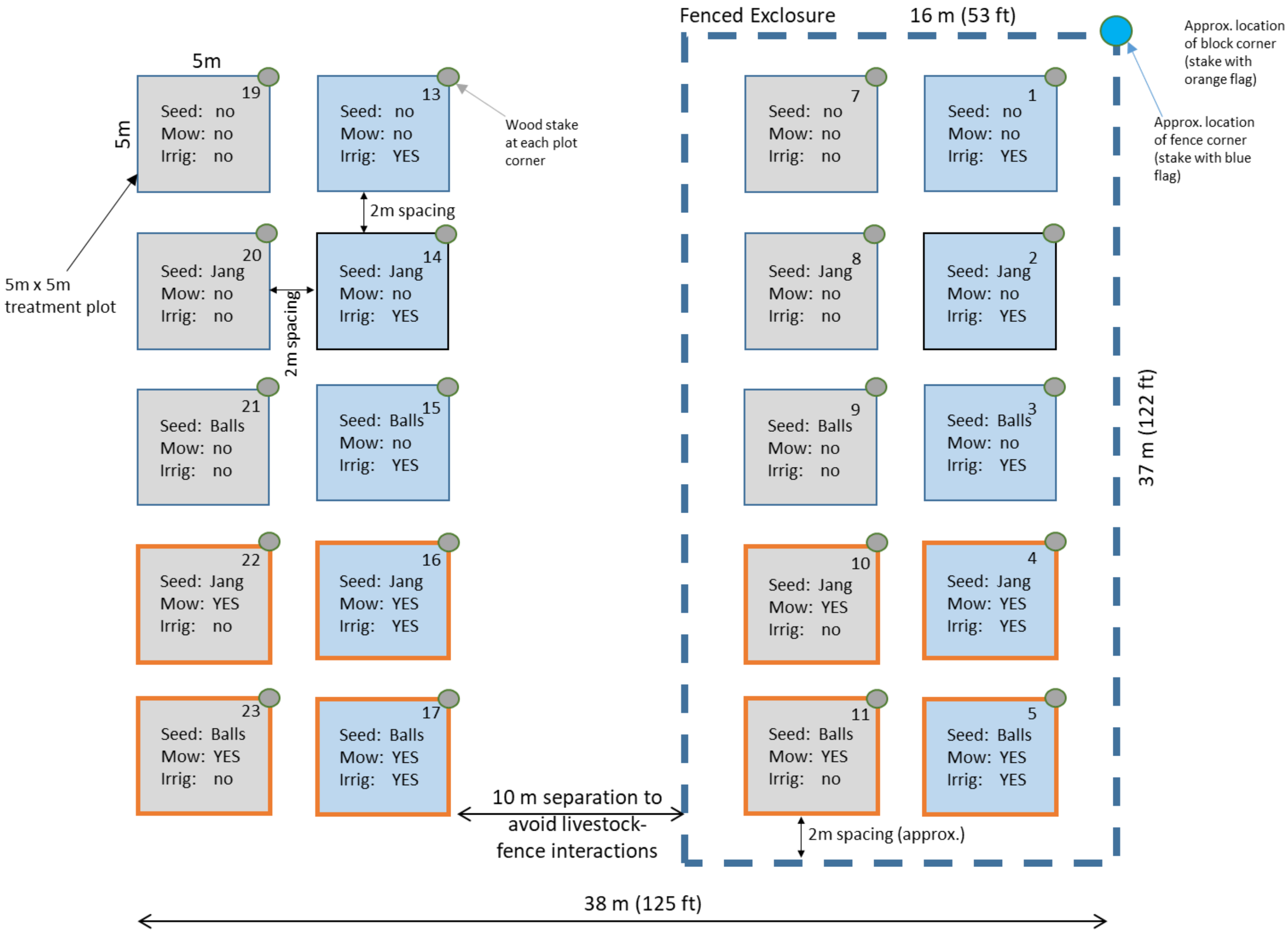

Figure A.4. Plot arrangement for a block that includes irrigation. Treatment label numbers are in the upper right corner of each plot.

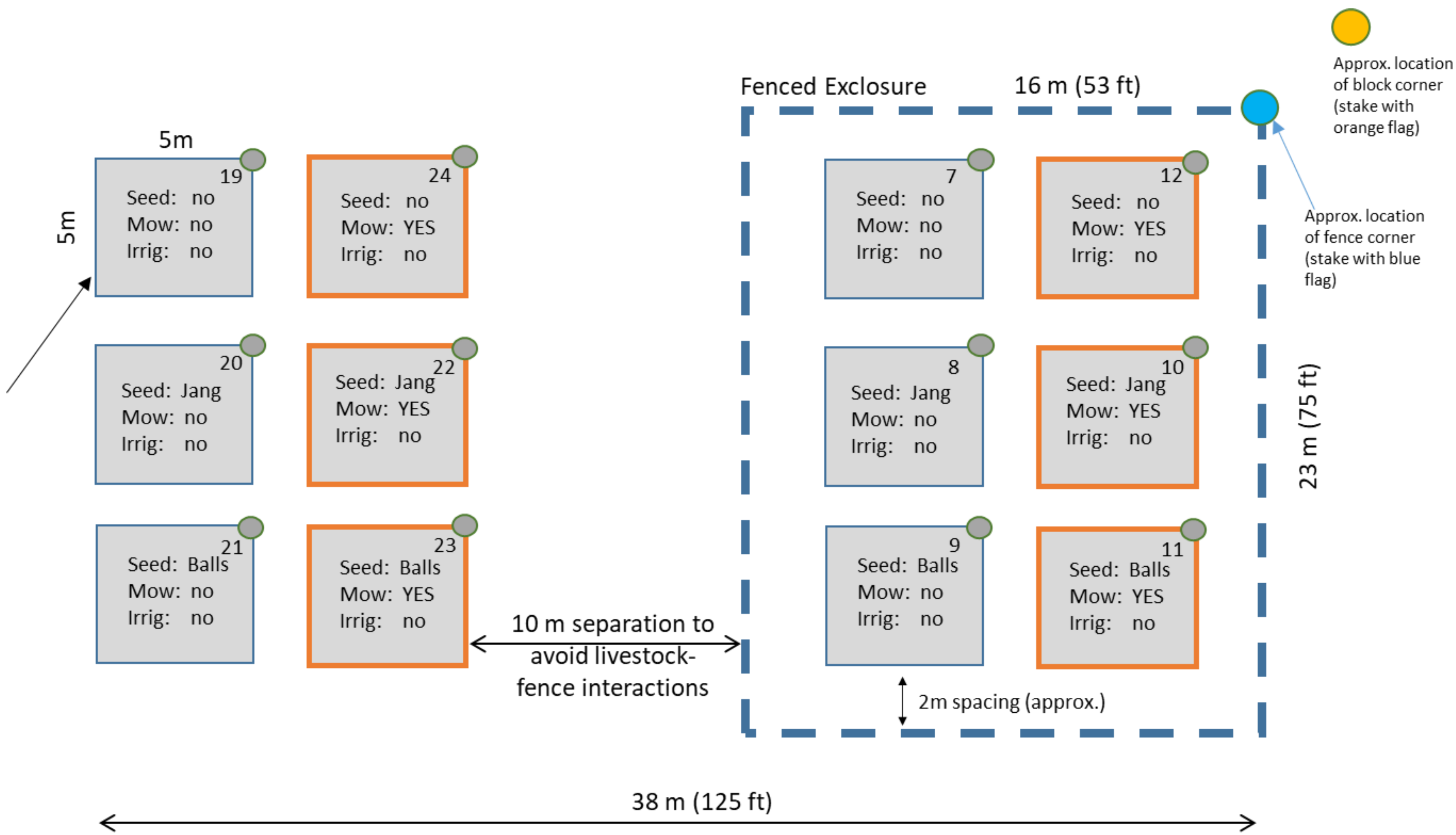

Figure A.5. Plot arrangement for a block without irrigation. Treatment label numbers are in the upper right corner of each plot.

APPENDIX B. LIST OF SHRUB AND FORB SPECIES AT THE BROTHERS STUDY SITE

	Species	Common name	Status	Duration	Species code
Shrubs	*Artemisia arbuscula*	sagebrush	Native	Perennial	ARAR
	Artemisia tridentata spp. Wyomingensis	sagebrush	Native	Perennial	ARWY
	Chrysothamnus humilis	Truckee rabbitbrush	Native	Perennial	CHHU
	Chrysothamnus viscidiflorus	rabbitbrush	Native	Perennial	CHVI
	Ericameria nauseosa	rubber rabbitbrush	Native	Perennial	ERNA
	Linanthus pungens	granite prickly-phlox	Native	Perennial	LIPU
Forbs	*Achillea millefolium*	common yarrow	Native	Perennial	ACMI
	Alyssum desertorum	desert alyssum	Non-native	Annual	ALDE
	Antennaria dimorpha	low pussytoes	Native	Perennial	ANDI
	Antennaria sp.	pussytoes	Native	Perennial	ANTEsp
	Arabis sp.	rockcress		Perennial	ARABsp
	Arabis sparsiflora	hairystem rockcress	Native	Perennial	ARSP
	Astagalus lentiginosus	freckled milkvetch	Native	Perennial	ASLE
	Astragalus misellus	pauper milkvetch	Native	Perennial	ASMI
	Astragalus newberryi	Newberry's milkvetch	Native	Perennial	ASNE
	Astragalus purshii	Pursh's milkvetch	Native	Perennial	ASPU
	Astragalus sp.	milkvetch	Native	Perennial	ASTRsp
	Blepharipappus scaber	rough eyelashweed	Native	Annual	BLSC
	Castilleja pilosa	parrothead Indian paintbrush	Native	Perennial	CAPI
	Collinsia parviflora	maiden blue eyed Mary	Native	Annual	COPA
	Crepis intermedia	intermediate hawksbeard	Native	Perennial	CRIN
	Delphinium nuttallianum	upland larkspur	Native	Perennial	DENU
	Descurainia longipedicellata	thread-stalk cutleaf tansymustard	Native	Annual	DELO
	Descurainia pinnata	intermediate tansymustard	Native	Annual	DEPI
	Diplacus nanus	dwarf monkeyflower	Native	Annual	DINA
	Draba verna	spring draba	Non-native	Annual	DRVE
	Epilobium sp.	willowherb	Native	Annual	EPILsp
	Erigeron filifolius	threadleaf fleabane	Native	Perennial	ERFI
	Erigeron sp.	fleabane			ERIGsp
	Eriogonum ovalifolium	cushion buckwheat	Native	Perennial	EROV
	Eriogonum umbellatum	sulfur-flower buckwheat	Native	Perennial	ERUM
	Gayophytum racemosum	racemed groundsmoke	Native	Annual	GARA
	Greeneocharis circumscissa	cushion cryptantha	Native	Annual	GRCI

Species list (continued)

	Species	Common name	Status	Duration	Species code
Forbs	*Holosteum umbellatum*	jagged chickweed	Non-native	Annual	HOUM
	Lepidium perfoliatum	clasping pepperweed	Non-native	Annual	LEPE
	Linum lewisii	western blue flax	Native	Perennial	LILE
	Lomatium nevadense	Nevada biscuitroot	Native	Perennial	LONE
	Lupinus argenteus	silvery lupine	Native	Perennial	LUAR
	Lupinus sp.	lupine	Native	Perennial	LUPIsp
	Microsteris gracilis	slender phlox	Native	Annual	MIGR
	Nama sp.	nama			NAMAsp
	Nothocalais troximoides	sagebrush false dandelion	Native	Perennial	NOTR
	Packera cana	woolly groundsel	Native	Perennial	PACA
	Phlox hoodii	Hood's phlox	Native	Perennial	PHHO
	Polemonium micranthum	annual polemonium	Native	Annual	POME
	Townsendia florifer	showy townsendia	Native	Biennial	TOFL
	Tragopogon dubius	yellow salsify	Non-native	Annual	TRDU