
***Astragalus mulfordiae*: Population dynamics and the effect of
cattle grazing in the Vale District, BLM**

2009 Progress Report

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***A Challenge Cost Share project funded jointly by
Bureau of Land Management, Vale District and
Institute for Applied Ecology***

PREFACE

This report is the result of a cooperative Challenge Cost Share project between the Institute for Applied Ecology (IAE) and the USDI Bureau of Land Management. IAE is a non-profit organization dedicated to natural resource conservation, research, and education. Our aim is to provide a service to public and private agencies and individuals by developing and communicating information on ecosystems, species, and effective management strategies and by conducting research, monitoring, and experiments. IAE offers educational opportunities through internships. Our current activities are concentrated on rare and endangered plants and invasive species.

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ACKNOWLEDGEMENTS

The authors gratefully acknowledge the contributions and cooperation by the Vale District Bureau of Land Management, particularly Gillian Wigglesworth and Jean Findley. Support was also provided by IAE staff and interns: Matthew Barmann, Alexis Brickner, Denise Giles, John Grotefend, Monique Leslie, Elizabeth Mathiot, and Shell Whittington. **Cover photograph:** *Astragalus mulfordiae* habitat and a caged plot including *A. mulfordiae* and *Bromus tectorum*. Photos by A.S. Thorpe.

Please cite this report as:

Massatti, R.T. and A.S. Thorpe. 2009. *Astragalus mulfordiae*: Population dynamics and the effect of cattle grazing in the Vale District, BLM. Institute for Applied Ecology, Corvallis, Oregon and USDI Bureau of Land Management, Vale District. iv + 33 pp.

TABLE OF CONTENTS

Preface	ii
Acknowledgements	ii
Table of contents	iii
List of figures	iv
List of tables	iv
Introduction	1
Methods	2
Field sites	2
Plant enclosures	3
Population and community monitoring	3
Data analysis	5
Results and Discussion	6
<i>Astragalus mulfordiae</i> enclosures	6
Population and community monitoring	7
Conclusions	9
Literature cited	14
Appendix A. Datasheet for <i>Astragalus mulfordiae</i> monitoring	15
Appendix B. <i>Astragalus mulfordiae</i> site maps	16
Appendix C. <i>Astragalus mulfordiae</i> contacts, gear list, and directions	29
Appendix D. Summary of <i>Astragalus mulfordiae</i> data from caged/uncaged plots	32

LIST OF FIGURES

- Figure 1.** Mulford's milkvetch (*Astragalus mulfordiae*).
- Figure 2.** *Astragalus mulfordiae* control (uncaged) monitoring plot.
- Figure 3.** Sampling transect at South Alkali.
- Figure 4.** Position of the quadrat and cells relative to the transect tape.
- Figure 5.** Percent change of diameter of *Astragalus mulfordiae* from 2008 to 2009.
- Figure 6.** Percent change of inflorescences per reproductive plant on *A. mulfordiae* from 2008 to 2009.

LIST OF TABLES

- Table 1.** Locations of experimental plots and site history characteristics.
- Table 2.** Cover classes used when monitoring plant species, ground cover, and surface disturbances in *A. mulfordiae* plots.
- Table 3.** Number and class of *Astragalus mulfordiae* found at each transect.
- Table 4.** Average percent cover of all vascular plant species and ground cover categories recorded at the five transects sampled in 2009.
- Table 5.** Average percent cover of ground disturbances recorded at the five transects sampled in 2009.

INTRODUCTION

Astragalus mulfordiae (Fabaceae, Mulford's milkvetch; Figure 1) is listed as a Sensitive Plant Species by the USDI Bureau of Land Management, a Species of Concern by the United States Fish and Wildlife Service, and endangered by the state of Oregon Department of Agriculture (ORNHC 2007). In 1995, there were 34 known *A. mulfordiae* populations in Idaho and 38 in Oregon (DeBolt 1995). Oregon Natural Heritage Information Center currently notes 29 occurrences scattered over 1191 km² in Oregon with a total metapopulation size of less than 12,000 (ORNHC 2009).

Astragalus mulfordiae is found from the Owyhee Uplands of Malheur County, Oregon east to the Owyhee Front and Boise Foothills of western Idaho. It primarily occurs in shrub-steppe and desert shrub communities

on sandy substrates derived from lacustrine and alluvial sediments, including old river deposits, sandy places near rivers, sandy bluffs, and dune-like talus. Primary plant associates include *Hesperostipa comata* (needle-and-thread grass), *Achnatherum hymenoides* (Indian ricegrass), *Chrysothamnus viscidiflorus* (yellow rabbitbrush), *Penstemon acuminatus* (sharp-leaf penstemon), and *Poa secunda* (Sandberg bluegrass).

Astragalus mulfordiae relies on environmental cues in late winter and early spring to initiate its regrowth and phenological stages (DeBolt 1995). In general, regrowth begins in early March, followed by flowering in April, May, and sometimes into June. The pollination mechanism is unknown; flying insects or self-pollination are likely options (DeBolt 1995). Fruits mature in June and July and plants senesce shortly thereafter. *Astragalus mulfordiae* reproduces only by seed, which is dispersed by gravity and wind (DeBolt 1995).

Monitoring studies of *A. mulfordiae* provide evidence for a drastic decline in population sizes (CPC 2009). Some populations have been extirpated through ORV use, cattle grazing, and fire. Plants were typically absent after the third year of cattle grazing (DeBolt 2001). In a study of areas seeded with *Agropyron desertorum*, fruits per inflorescence, inflorescences per plant, and adult plant survival were all lower in areas grazed by cattle (David Pyke, personal communication). However, populations appear to vary in their ability to withstand disturbances (DeBolt 1995, 2001) and there may be a genetic difference between populations that are more susceptible or more tolerant of disturbance (DeBolt 2001).



Figure 1. Mulford's milkvetch (*Astragalus mulfordiae*). Photo by A.S. Thorpe.

Competition with exotic plant species, particularly *Agropyron desertorum* (desert wheatgrass), *Chondrilla juncea* (Rush skeletonweed), and *Bromus tectorum* (cheatgrass), may also impact populations of *A. mulfordiae*. Competition with exotic species appears to be particularly problematic in areas that have recently burned and/or are heavily grazed.

This project will provide data on the population biology and long-term trends of *A. mulfordiae* in the Owyhee Uplands of eastern Oregon. In order to determine the effects of ungulates on *A. mulfordiae*, we are using small cages to protect groups of plants that experience different levels and types of grazing. Data resulting from this project will provide valuable information to assist agencies making listing decisions for the species, managing livestock grazing in various allotments, and planning conservation strategies and recovery plans. More specifically, this study is designed to:

1. Document long-term trends in population size and structure.
2. Determine the role of climatic variation (e.g., annual changes in precipitation) in observed differences in population size and reproduction.
3. Determine the effect of grazing on population size and reproduction.
4. Compare Oregon population dynamics with Idaho population dynamics.

METHODS

Field sites

All sites are located near Vale, Oregon in the Vale District, BLM. After initial site visits in 2007, six *A. mulfordiae* populations were chosen for plot establishment: Brown Butte, Double Mountain, North Harper North, North Harper South, South Alkali ACEC, and Snively (Table 1, Appendix B).

Table 1. Locations of plots and site history characteristics.

Site (location of GPS pt)	Location (Nad83, Zone11)	Fire history	Grazing	# plots
South Alkali #1 (plot 648)	0484252E 4878746N	unknown	fall cattle grazing	3 caged 3 uncaged
South Alkali #2 (plot 653)	0486054E 4878989N	unknown	fall cattle grazing	3 caged 3 uncaged
South Alkali #3 (transect start)	0485982E 4877837N	unknown	fall cattle grazing	4 caged 4 uncaged
Brown Butte (transect start)	0489997E 4842103N	Fire: late 90's	summer cattle grazing	5 caged 5 uncaged
Snively (transect start)	0484372E 4840786N	unknown	not grazed	5 caged 5 uncaged
Double Mountain (transect start)	0476635E 4853382N	Fire: 2005	sheep grazed	5 caged 5 uncaged
North Harper North (transect start)	0481055E 4857204N	unknown	cattle grazed	5 caged 5 uncaged
North Harper South (plot 675)	0481446E 4856682N	unknown	cattle grazed	5 caged 5 uncaged

Plant enclosures

In 2008, we established 10 or 20 plots at each study site to determine the effects of ungulates (primarily sheep and cattle) on *A. mulfordiae* (Table 1). Plot locations were systematically selected to maximize the number of individuals within a 1 m x 1 m area. Half of the plots were uncaged (Figure 2), the other half were caged (cover photo). We did not use a random sampling design because we wanted to ensure that there were enough plants within each plot to detect differences in growth, survival, and reproduction; we additionally wanted the caged and control plots to be well distributed throughout the population. All plots were marked in each corner with 10 inch steel nails and/or wooden stakes protruding from the soil surface. The plots were aligned with the cardinal directions; an aluminum tag noting the plot number was tied with wire around the plot marker in the southeast corner of each plot.



Figure 2. *Astragalus mulfordiae* control (uncaged) monitoring plot. The corners are marked with 10" nails. Photo by A.S. Thorpe.

Caged plots allowed us to measure the approximate effects of grazing and trampling by sheep and cattle on *A. mulfordiae* when collected data was compared to data from uncaged plots. The cage design also inhibited native ungulate grazing and trampling, but small mammals and birds could still access the space within the cages. Although we did not pair uncaged and caged plots, we attempted to locate one of each type within close proximity to control for the effects of microclimate and microtopography. Each caged plot was covered on the top and sides with hogwire. The cages stood approximately 0.3 m high and were slightly larger than 1 m². They were held in place with wire tied to wooden stakes sunk into the corners of the plots.

We divided each plots into four 0.5 m x 0.5 m subplots using a divided quadrat frame (Figure 2). Within each subplot, we mapped all *A. mulfordiae* individuals using a grid system so that recruitment, mortality, and overall trends in the plants' growth can be ascertained over time (Appendix A). We also measured the maximum diameter (cm), length of longest stem (cm), number of inflorescences, and evidence of insect and large ungulate grazing (yes/no) of every plant. Similar methods have been used to monitor the population dynamics of *A. tyghensis* in the Tygh Valley (Prineville District, BLM; Thorpe and Kaye 2008).

Population and community monitoring

This monitoring protocol follows the methods used by the Idaho Conservation Data Center to monitor populations of *A. mulfordiae* in southwestern Idaho (Mancuso 2001, Mancuso and Colket 2005, ICDC 2008). The monitoring protocol details

procedures to collect *A. mulfordiae* and other plant species abundance, ground disturbance data, plant community information, and photo points.

Five monitoring transects were established in 2009. Each transect was 20 meters long and monumented with a piece of red-painted rebar at the starting point and a large metal spike at the ending point. Sampling occurred along a meter tape running between the rebar and spike (Figure 3). A 1 m² quadrat frame was placed flush against the tape beginning at the 0 m mark.



Figure 3. Sampling transect at South Alkali.

Sampling occurred at each consecutive meter mark along the transect tape. We documented the GPS coordinates of the starting and ending point, azimuth, and side of the tape sampled for each transect (Table 3). We also completed a transect information form that included information to help relocate the transects.

Each *A. mulfordiae* individual rooted within the quadrat was counted and assigned to one of 3 life stage class categories:

- Reproductive class (R) - individuals with flowers and/or fruits
- Non-reproductive class (N) - individuals >4 cm tall without flowers or fruits
- Seedling class (S) - non-reproductive individuals <4 cm tall (or taller if cotyledons present)

Application of the size standard may inadvertently result in small plants greater than one year old being recorded as seedlings. The seedling life stage should therefore be interpreted as possibly including individuals that did not recently germinate. If two *A. mulfordiae* stems were less than 3 cm apart, they were considered one plant.

The location of each *A. mulfordiae* plant was recorded by referencing the appropriate quadrat cell in which it occurred. We divided the quadrat frame into 9 equal cells referenced by the letters “A” through “I” (Figure 4). Cell “A” was positioned at the top left corner and cell “I” at the bottom right corner, similar to reading a page of text. Cells “G”, “H”, and “I” were positioned flush against the transect tape, whether sampling started on the left or right side of the tape (Figure 4).

Each *A. mulfordiae* plant was inspected for evidence of insect/disease damage and non-insect herbivory/trampling damage. These data were recorded as yes or no values.

The canopy cover of each native and non-native plant species (shrubs, graminoids, and forbs) rooted or hanging over each quadrat was estimated and assigned a cover class (Table 2). Ground covers of basal vegetation, bare ground, biological crust, rock/gravel (≥ 2 mm), litter (< 2mm, including scat), completely dead attached shrub, and detached wood (≥ 2 mm from shrub or tree) were also estimated and assigned cover classes. These data were recorded at each quadrat along the length of the belt transect. Nomenclature followed the U.S. Department of Agriculture Plants Database (USDA 2010).

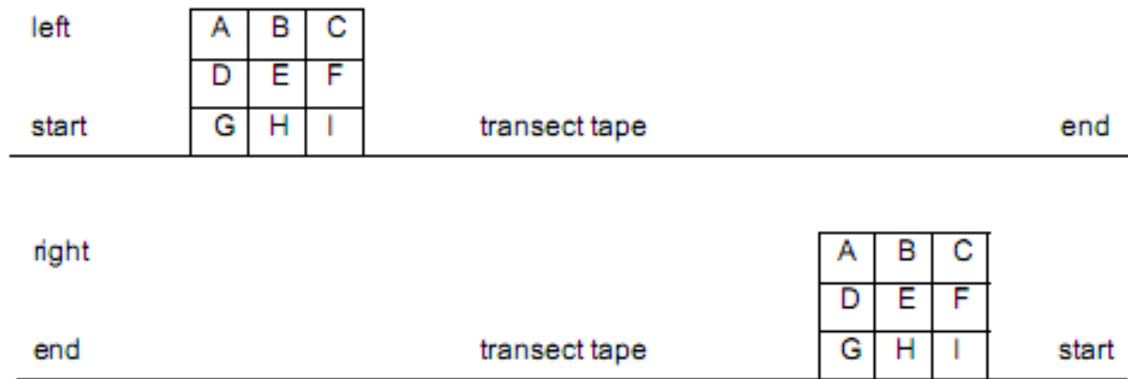


Figure 4. Position of the quadrat and cells relative to the transect tape.

The total area occupied by surface disturbances (e.g. OHV tracks, wildlife and cattle prints, gopher tunnels) within each quadrat was estimated and assigned a cover class (Table 2). Surface disturbance were additionally broken down by disturbance type; the cover class represented the percentage of ground surface within the quadrat that was clearly broken, crushed, or sloughed.

We took a minimum of 6 photos at each monitoring site. The origin rebar served as the reference point for four photos, taken at bearings of 0°, 90°, 180°, and 270°; these provided a panoramic overview of the monitoring area. We took a fifth photo standing 3 m behind the origin rebar looking towards the end spike; a sixth photo was taken standing 3 m behind the end spike looking towards the origin rebar. We took additional photos to show the plant community, disturbances, and other landscape features as needed.

Data analysis

Population and community monitoring data were summarized descriptively. All data given cover classes were converted to midpoint percent cover values (Table 2). The effect of the hogwire cages on plant performance was tested using a General Linear Model with site and treatment as fixed factors, 2009 plant diameter or mean inflorescences per reproductive plant as the dependent variables, and the 2008 data of the same categories as covariates (SPSS 17.0 2009). Plots 661 at South Alkali (uncaged), 668 at North Harper South (uncaged), and 685 at Double Mountain (caged) were either damaged or not relocated, and their corresponding 2008 data were not included in statistical analyses.

Table 2. Cover classes used when monitoring plant species, ground cover, and surface disturbances in *A. mulfordiae* plots.

Cover class	Percent cover range (%)	Midpoint to convert to (%)
0	0	0.0
1	<1 (trace)	0.5
2	1-4.9	3.0
3	5-9.9	7.5
4	10-24.9	17.5
5	25-49.9	37.5
6	50-74.9	62.5
7	75-94.9	85.0
8	95-100	97.5

RESULTS AND DISCUSSION

Astragalus mulfordiae enclosures

In 2009, 286 *A. mulfordiae* plants were sampled in 67 experimental plots, including 154 plants in caged plots and 132 plants in uncaged plots. The average diameter of plants was 28.9 cm and did not differ significantly between caged and uncaged treatments (28.6 cm and 29.1 cm, respectively; $p=0.3$; Figure 5). 251 plants (88%) were reproductive; they averaged 29.3 (caged) and 33.3 (uncaged) inflorescences per reproductive plant (Figure 6). There was a significant interaction between study site and treatment ($p=0.04$) on the number of inflorescences per reproductive plant (Figure 6). The cause of this relationship is unknown and does not appear to be related to grazing history.

Damage to *A. mulfordiae* by insects and ungulates affected 35% of the sampled population (100 plants). Insect herbivory was noted on 32 plants in both caged (20 plants) and uncaged (12 plants) plots. Grazing by cattle and/or deer occurred in plants outside of the hogwire enclosures on at most 38 plants. An additional 8 plants outside of cages and 22 plants inside of cages were marked as rodent grazed, and it is unclear if some of the grazing marked as cattle/deer may actually be a result of rodents. Only 3 plants were definitively grazed by ungulates. A summary of 2008 and 2009 *A. mulfordiae* measurements delineated by site and treatment is available in Appendix D.

Data collected from caged and uncaged plots indicated that the average size of plants increased from 2008 to 2009 (average diameter: 21.7 cm to 28.9 cm; average length of longest stem: 15.5 cm to 20.2 cm) while the number of inflorescences per reproductive plant remained similar (27.8 to 28.0) and the total number of plants decreased (338 to 286; Appendix D). A portion of the overall size increase may have resulted from the preferential loss of smaller plants; the average diameter of plants in 2008 that were gone in 2009 was 18.3 cm while that of extant plants was 22.1 cm. Similarly, the average longest stem of plants in 2008 that were gone in 2009 was 14.3 cm while that of extant plants was 15.9 cm.

Yearly population fluctuations have been documented in other parts of *A. mulfordiae*'s range (ICDC 2008) and appear to be due to several biotic and abiotic factors. Only three seedlings were recorded throughout all plots in 2009. Of the 55 plants that did not survive to 2009, 22 (40%) were located at South Alkali, 22 (40%) at Snively,

9 (16%) at Double Mountain, and 1 at each of Brown Butte and North Harper South. Many of the missing plants at Snively were associated with plots in which significant sheet erosion was noted. The cause of the erosion was unclear, but it might have been caused by ground disturbances in the surrounding microtopography. Additional missing plants at Snively were located in a plot where an ant hill was noted. At South Alkali, the dead plants were scattered throughout plots, except for one plot in which all six plants were dry and brown. The cause of this mortality is unclear, but South Alkali had the highest percent ground disturbance by cattle prints (6.1%) and total disturbance (5.9%) of all the sampling sites. Finally, plant mortality at Double Mountain seemed to be related to burial by wind-blown sand. Plants affected by the accumulation of sand deposits were much smaller on average compared to surviving plants at Double Mountain and the plants at all of the sites combined.

Table 3. Number and class of *Astragalus mulfordiae* found at each transect. All azimuth compass bearings include a 15° east declination.

Area	Transect	azimuth/side of tape monitored	# of quadrats	Reproductive	Non- reproductive	Seedling	TOTAL
Brown Butte	198	182°/east	20	13	0	3	16
Double Mountain	196	2°/east	20	3	0	0	3
North Harper North	200	354°/west	20	22	4	11	37
Snively	199	281°/south	20	21	1	3	25
South Alkali	197	24°/west	20	40	10	1	51
		TOTAL:	100	99	15	18	132

Population and community monitoring

In 2009, a total of 132 *A. mulfordiae* plants with a mean density of 1.3 plants/m² were observed within quadrats along five transects (Table 3). Reproductive plants accounted for 75% of the total observed; the remaining 25% was divided between non-reproductive plants (>4 cm tall, 11.4%) and seedlings (<4 cm tall, 13.6%).

Of the eight non-native species recorded along transects in 2009, three were graminoids and five were forbs (Table 4). Of the three graminoid species, two were annual and one (*Poa bulbosa*) was perennial. All of the five forb species were annuals. *Bromus tectorum* was the only invasive species observed at each transect and was by far the most abundant non-native plant (Table 4). Transect monitoring occurred relatively early in terms of detecting the invasive forbs *Salsola tragus* and *Sisymbrium altissimum*. Although positive identification was not possible, a seedling that occurred at four out of five sites with a mean cover of 0.4% was potentially *Sisymbrium altissimum*. Thus, non-native species cover could be significantly higher if the transects were monitored later in the growing season.

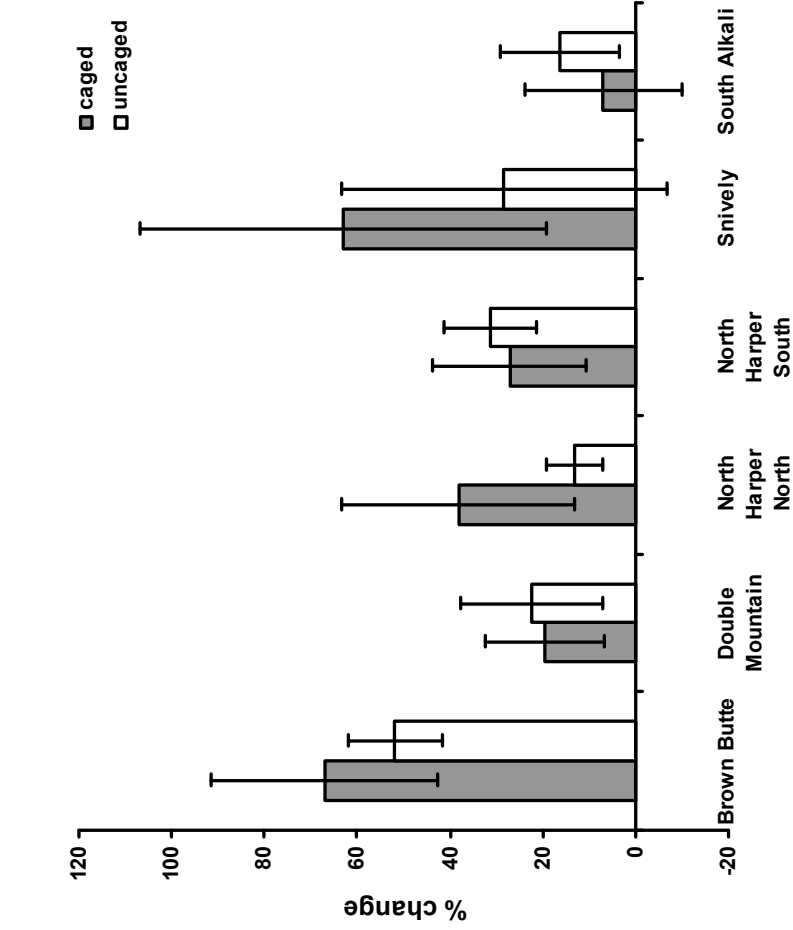


Figure 5. Percent change of diameter of *Astragalus mulfordiae* from 2008 to 2009. There was no significant effect of caging on diameter ($p=0.3$). Note that the average diameter increased regardless of site or treatment. Error bars are ± 1 SE.

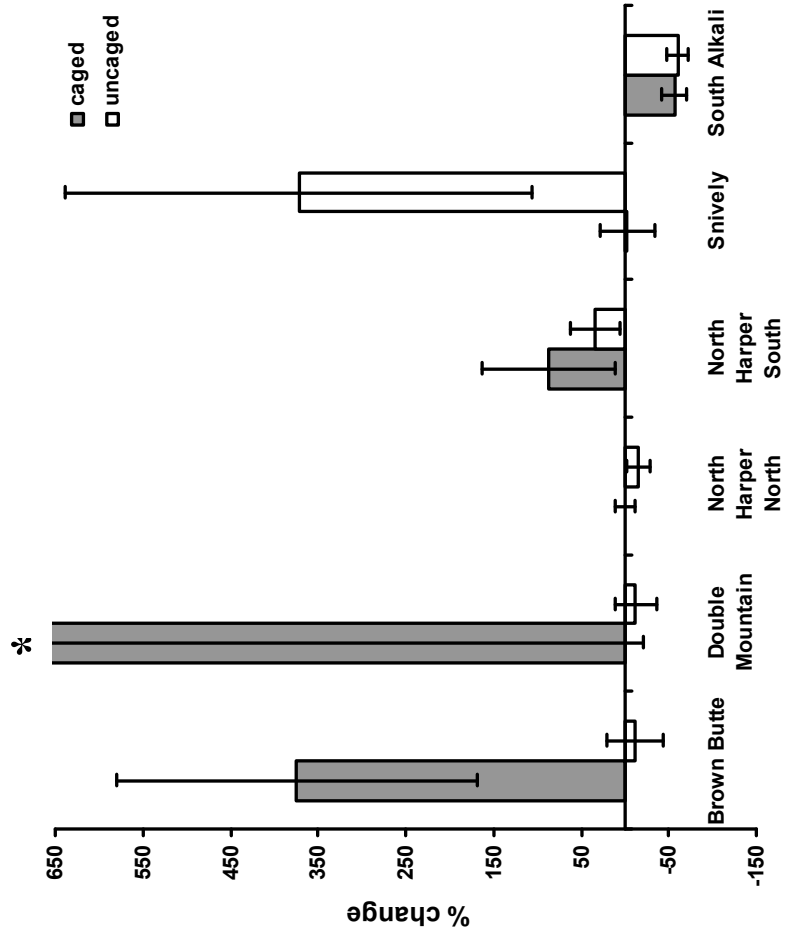


Figure 6. Percent change of inflorescences per reproductive plant on *A. mulfordiae* from 2008 to 2009. The Double Mountain caged treatment (starred) percent change is 1034%; this result is driven by one plot in which there were no inflorescences in 2008 and 43 in 2009. Excluding this plot, the overall caged trend is similar to that of the uncaged plots (slightly negative). There was no direct effect of caging on the number of inflorescences per reproductive plant ($p=0.6$), but there was a significant interaction between site and treatment ($p=0.04$). Error bars are ± 1 SE.

The loose, sandy substrate characterizing *A. mulfordiae* habitat readily leaves evidence of physical disturbances. Disturbances recorded in 2009 fell into the following categories: anthill, bird feces, burrow, cattle feces (>6 month old), cattle prints, deer feces, deer prints, divot, elk feces, game trails, human footprints (non-researcher), human footprints (researcher), insect burrow, lizard prints, medium sized rodents, rabbit feces, rills, shotgun shells/human trash, and unknown animal prints (Table 5). When the cause of the disturbance was not evident, “divot” was recorded. Among all sites, the average ground disturbance in all categories totaled 4.2%. Individual categories with the highest average covers included researcher footprints (2.8%), cattle prints (2.6%), cattle feces older than 6 months (1.7%), anthills (1.6%), divots (1.5%), and game trails (1.5%).

Insect damage, herbivory, and trampling damage to *A. mulfordiae* occurred on 31 plants (23%). Five plants were noted as having insect damage and disease. These occurrences were spread between Snively, Brown Butte, and North Harper North. At the latter transect, the damaged individual was noted to have “mottled stems.” Although herbivory and trampling were present at four of five sites (none was recorded at North Harper North), 19 out of 26 noted occurrences were recorded at South Alkali. South Alkali had the highest percent cover of cattle prints (6.1%) and total ground disturbance (5.9%). Five of the remaining six occurrences were recorded at Brown Butte, where the highest cover of game trails (7.5%) and deer prints (4.0%) were recorded. Cattle use (prints or feces) was recorded at every site in 2009.

Thirty-four species were recorded in the five transects in 2009 (Table 4). Species present in at least four transects included (with average percent cover): *Astragalus mulfordiae* (5.2%), *Balsamorhiza sagittata* (4.5%), *Penstemon acuminatus* (3%), *Phacelia linearis* (0.5%), *Achnatherum hymenoides* (4.5%), *Elymus elymoides* ssp. *elymoides* (3.5%), *Poa secunda* (3.1%), *Chrysothamnus viscidiflorus* (10.7%), *Bromus tectorum* (10.7%), *Salsola tragus* (1.9%), and cf. *Sisymbrium altissimum* (>0.4%). Other locally important species with at least 5% cover included: *Opuntia polyacantha*, *Linanthus pungens*, *Hesperostipa comata* ssp. *comata*, *Atriplex* sp, and *Poa bulbosa*. The plant community can be best described as an open shrubland with scattered graminoids and forbs. While most of the non-native taxa were annuals, all native species were perennials except for *Phacelia linearis* and *Cryptantha* sp. The non-vegetated ground surface was dominated by bare ground (average 58% cover) and litter (23.1% cover); small amounts (<2.5%) of rock/gravel, dead shrub, wood, and basal vegetation were also present (Table 4).

CONCLUSIONS

The population dynamics of *Astragalus mulfordiae* are difficult to discern from two years of data. It is evident that, while sampled populations declined from 2008 to 2009, individuals grew larger and fecundity marginally increased. Individuals that died between 2008 and 2009 were smaller on average than those that survived. The low recruitment in 2009 coupled with the large population fluctuations that were recorded in the Idaho populations (ICDC 2008) suggest that the appropriate climatic conditions for seed germination and/or seedling survival were not present from fall 2008 through spring 2009. Only continued monitoring at regular intervals will help elucidate patterns of *A. mulfordiae* population dynamics.

There was little evidence that grazing by cattle and/or sheep directly affected *Astragalus mulfordiae* population size and reproductive success. Few plants were definitely grazed by cattle; those that were grazed were extensively damaged. Cattle and sheep may affect *A. mulfordiae* populations indirectly by disturbing the ground surface either in or adjacent to plots. The loose, sandy, and exposed nature of the soil means that ground disturbance can propagate disturbance to adjacent areas. Cattle and human prints could alter surface hydrology and potentially cause some of the erosion events that led to plant mortality in plots at South Alkali and Snively. Inversely, ground disturbance at Double Mountain may have facilitated sediment deposition into plots. Limiting ground disturbance through larger fencing plots (see Massatti et al. 2009) would be one way test this hypothesis.

Invasive species were ubiquitous in *A. mulfordiae* sampling plots. *Bromus tectorum* was abundant at every site and other invasive species were locally important. These species appeared to be more abundant in areas with higher disturbance by grazing. Continued population community monitoring will determine if invasive species are becoming more abundant and what impact they are having on *A. mulfordiae* populations.

Comparison of Oregon and Idaho *A. mulfordiae* population dynamics should commence cautiously and only on a same-year basis; Idaho Conservation Data Center (ICDC) data show *A. mulfordiae* population densities can fluctuate from year-to-year. In 2009, we established and monitored population transects in Oregon using the same protocol as the ICDC (2008), which will facilitate future region-wide population comparisons.

Table 4. Average percent cover of all vascular plant species and ground cover categories recorded at the five transects sampled in 2009. Plants are organized by native status and growth habit, with the ground cover categories occurring at the end of the list. Abbreviations include: “N” = native, “I” = invasive, “F” = forb, “G” = graminoid, “S” = shrub, “P” = perennial, and “A” = annual/biennial. Continued on next page.

Species	Common Name	Native Status	Growth Habit	Life form	Average % cover					Mean
					North Harper North	Double Mtn	South Alkali	Brown Butte	Snively	
<i>Astragalus mulfordiae</i>	Mulford's milkvetch	N	F	P	5.0	4.0	6.2	4.4	6.2	5.2
<i>Balsamorhiza sagittata</i>	arrowleaf balsamroot	N	F	P	8.5	4.5	4.5	0	5.2	4.5
<i>Penstemon acuminatus</i>	sharpleaf penstemon	N	F	P	2.5	0.5	5.2	0	6.8	3.0
<i>Opuntia polyacantha</i>	plains pricklypear	N	F	P	7.5	0	0	0	0	1.5
<i>Linanthus pungens</i>	granite prickly phlox	N	F	P	6.1	0	0	0	0.5	1.3
<i>Crepis acuminata</i>	tapertip hawksbeard	N	F	P	3.3	0	2.8	0	0	1.2
<i>Comandra umbellata</i>	bastard toadflax	N	F	P	0	0	0	4.0	0	0.8
<i>Phacelia</i> sp.	phacelia	N	F	P	4.0	0	0	0	0	0.8
<i>Phacelia linearis</i>	threadleaf phacelia	N	F	A	0.5	0	0.5	0.5	0.5	0.4
<i>Leucocrinum montanum</i>	common starlily	N	F	P	0.5	0	0	0	0.5	0.2
<i>Cryptantha</i> sp.	cryptantha	N	F	A	0	0	0	0.5	0	0.1
<i>Oenothera pallida</i>	pale evening-primrose	N	F	P	0	0.5	0	0	0	0.1
<i>Sphaeralcea grossulariifolia</i>	globemallow	N	F	P	0	0	0	0.5	0	0.1
<i>Achnatherum hymenoides</i>	Indian ricegrass	N	G	P	1.7	12.3	0	2.8	5.8	4.5
<i>Elymus elymoides</i> ssp. <i>elymoides</i>	squirreltail	N	G	P	5.2	3.3	4.7	0	4.3	3.5
<i>Hesperostipa comata</i> ssp. <i>comata</i>	needle and thread	N	G	P	8.2	0	0	4.0	5.3	3.5
<i>Poa secunda</i>	Sandberg bluegrass	N	G	P	5.0	0	4.8	2.8	2.8	3.1
<i>Elymus</i> sp.	wildrye	N	G	P	0	1.6	0	0	0	0.3

Table 4 cont. Average percent cover of all vascular plant species and ground cover categories recorded at the five transects sampled in 2009. Plants are organized by native status and growth habit, with the ground cover categories occurring at the end of the list. Abbreviations include: “N” = native, “I” = invasive, “F” = forb, “G” = graminoid, “S” = shrub, “P” = perennial, and “A” = annual/biennial.

Species	Common Name	Native Status	Growth Habit	Life form	Average % cover					
					North Harper North	Double Mtn	South Alkali	Brown Butte	Snively	Mean
<i>Danthonia</i> sp.	oatgrass	N	G	P	0	0	0	0	0.5	0.1
<i>Chrysothamnus viscidiflorus</i>	yellow rabbitbrush	N	S	P	11.5	12.1	7.9	13.2	8.8	10.7
<i>Atriplex</i> sp.	saltbush	N	S	P	0	0	0	12.5	22.5	7.0
<i>Purshia tridentata</i>	antelope bitterbrush	N	S	P	0	0	0	0.5	0	0.1
<i>Salsola tragus</i>	prickly Russian thistle	I	F	A	7.5	1.0	0	0.5	0.5	1.9
<i>Sisymbrium altissimum</i>	tall tumbled mustard	I	F	A	0	0.5	7.5	0.5	0	1.7
<i>Erodium cicutarium</i>	redstem stork's bill	I	F	A	0	0	0	4.6	0	0.9
<i>Alyssum desertorum</i>	desert madwort	I	F	A	0	0	0.5	0	0	0.1
<i>Tragopogon dubius</i>	yellow salsify	I	F	A	0.5	0	0	0	0	0.1
<i>Bromus tectorum</i>	cheatgrass	I	G	A	8.0	2.4	22.5	8.8	12.0	10.7
<i>Poa bulbosa</i>	bulbous bluegrass	I	G	P	0	0	0	0	7.5	1.5
<i>Vulpia</i> sp.	annual fescue	I	G	A	0.5	0	0.5	0	0.5	0.3
cf. <i>Sisymbrium altissimum</i>		I	F	A	0.5	0	0.5	0.5	0.5	0.4
Unknown forb			F		0	0	0.5	0.5	7.5	1.7
Unknown forb (purple culm)			F		0	0	0	0.5	0.5	0.2
Asteraceae			F		0	0	0.5	0	0	0.1
Basal veg (cut off at ground)					0.7	0	0.1	0.1	0.5	0.3
Bare ground					58.6	79.4	41.0	59.6	51.4	58.0
Biological crust					0	0	0	0	0	0
Rock/gravel (≥ 2 mm)					0	2.5	1.2	2.4	6.1	2.4
Litter (<2mm), including scats					21.0	9.5	36.5	22.3	26.0	23.1
Dead shrub, attached					2.7	1.1	1.2	3.2	1.7	2.0
Wood from shrub/tree (≥ 2 mm), not attached					2.6	0.4	1.8	1.8	1.5	1.6

Table 5. Average percent cover of ground disturbances recorded at the five transects sampled in 2009. The total ground disturbance was collected in the field and is not a sum of all listed disturbances.

Disturbance Category	Average % Cover					Mean
	North Harper North	Double Mtn	South Alkali	Brown Butte	Snively	
anthill	0	0	7.5	0.5	0	1.6
bird feces (other)	0	0	0.5	0.5	0	0.2
burrow	0	0	0	3.0	0	0.6
cattle feces-older (>0.5 yr)	3.0	1.8	1.1	2.4	0	1.7
cattle prints	3.0	0	6.1	1.1	3.0	2.6
deer feces	1.3	0	0.5	0.5	0	0.5
deer prints	1.8	0	0	4.0	0	1.2
divot	3.0	0.5	0.5	2.4	1.3	1.5
elk feces	0	0.5	0	0	0	0.1
game trails	0	0	0	7.5	0	1.5
human footprints (NOT researcher)	3.0	0	0	0	0.5	0.7
human footprints (researcher)	2.2	4.8	2.2	2.0	2.9	2.8
insect burrow (diameter < 0.5 cm)	0.5	0.5	0.5	0.5	0.5	0.5
lizard prints	0	1.0	0	0	0	0.2
medium sized rodents (pocket gopher, kangaroo rat, ground squirrel)	0	0	0.5	0	0	0.1
rabbit feces	0	0.5	0	0	0	0.1
rills (erosion)	0	0.5	0	0	0	0.1
shotgun shell(s), human trash	0	0	0.5	0	0.5	0.2
unknown animal prints	0	1.3	0	0	0	0.3
Total ground disturbance	3.8	3.5	5.9	3.6	4.1	4.2

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APPENDIX B. *ASTRAGALUS MULFORDIAE* SITE MAPS



Driving route to Snively from State Route 201. Written driving directions can be found in Appendix C.

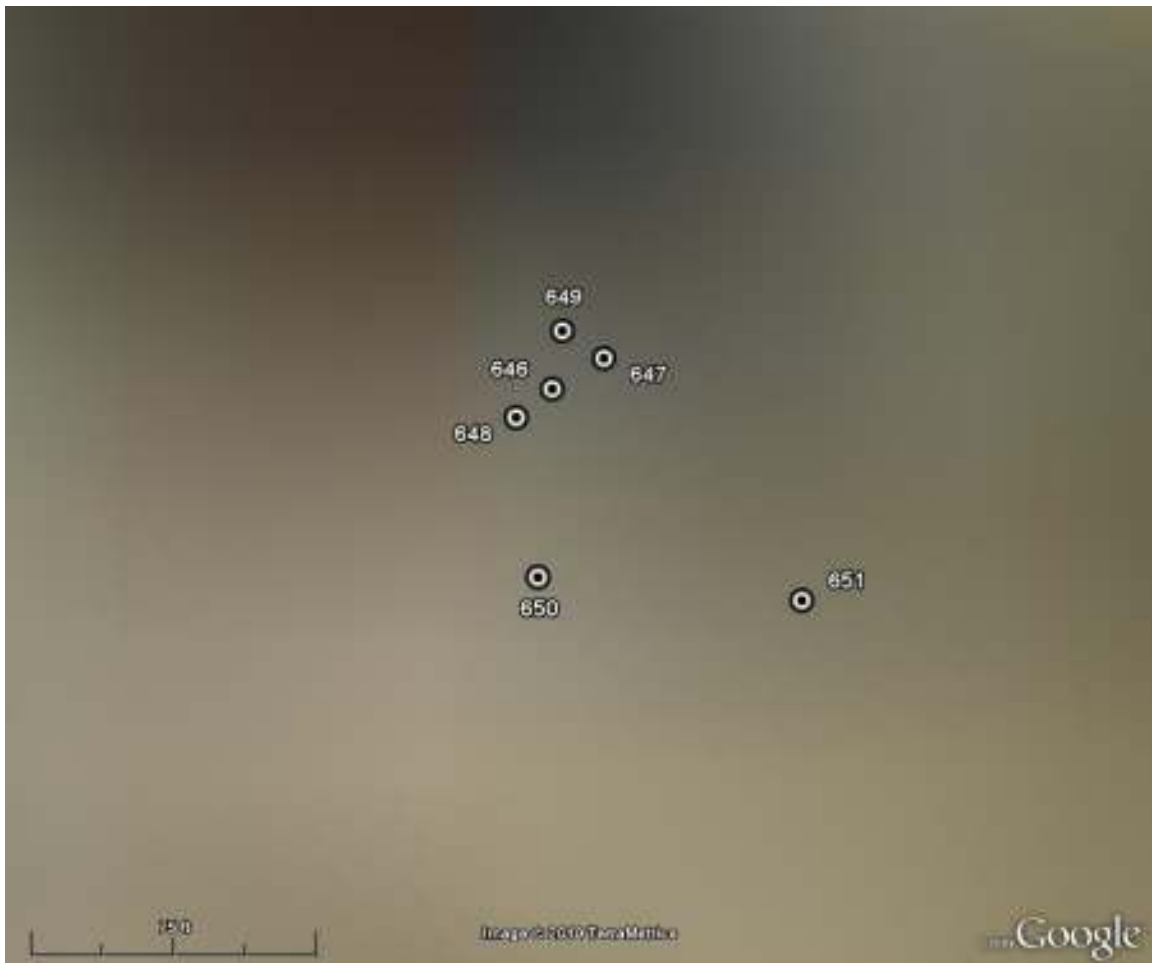


Close-up of the plot layout at Snively. Park at the river turnoff across the road. Several undeveloped campsites can be found along the river. Note scale bar at lower left corner of the photo (163 ft).

11T 0484372E 4840786N (transect start point, Nad83), GPS accuracy ± 25 ft.



Driving route to South Alkali 1, 2, and 3. From Jordan Waterhole, it is advisable to drive clockwise around the loop, visiting S. Alkali 1 first. The road basically stays on top of a ridgeline all the way around this valley. Follow the 7.5" USGS topo map and written driving directions (Appendix C) carefully, especially once you are on Valley View Road.



Close-up of the plot layout at South Alkali 1. Plots 646 – 649 are on the north side of the dirt access road, and plots 650 and 651 are on the south side of the dirt access road (road indistinguishable). Note the scale bar at the bottom left of this photo (75 ft). 11T 0484252E 4878746N (Nad83, plot 648), GPS accuracy ± 25 ft.



Close-up of the plot layout at South Alkali 2. Note the scale bar at the bottom left of this photo (181 ft). The red line represents an estimate of the dirt access road. 11T 0486054E 4878989N (Nad83, plot 653), GPS accuracy ± 25 ft.



Close-up of the plot layout at South Alkali 3. The dirt access road is to the east (right). Note the scale bar at the bottom left corner of the photo (88 ft).
11T 0485982E 4877837N (Nad83, transect start point), GPS accuracy ± 25 ft.



Driving route to North Harper from Lytle Blvd. Vale is north (up) on Lytle Blvd. If you drive past the dump, you went too far south on Lytle. Follow the 7.5" USGS topo quad and written driving directions carefully (Appendix C). An alternative route through Cow Hollow to North Harper South is marked on the Double Mountain overview map.



Close-up of the plot layout at North Harper North. Note the scale bar at the bottom left corner of the photo (89 ft).
11T 0481055E 4857204N (transect start point, Nad83), GPS accuracy ± 25 ft.



Close-up of the plot layout at North Harper South. Note the scale bar at the bottom left corner of the photo (609 ft). If area is approached from Lytle Blvd., the parking place for sampling North Harper South is marked (upper right). If area is approached from Cow Hollow, you can park at North Harper South and will have to walk up to North Harper North. The hill below the parking place is too steep to drive up. 11T 0481446E 4856682N (Plot 675, Nad83), GPS accuracy ± 25 ft.



Driving route to Double Mountain (red) and alternative route to North Harper South (green). Highway 20 is north on Russell Road. Follow the 7.5" USGS topo quad and written driving directions carefully (Appendix C).



Close-up of plot layout at the Double Mountain sampling site. The label for 677 is hidden within the group to the east (right). Plot 685 is not plotted because the cage was found rolled up in 2009. Note the scale bar in the lower left corner of the photo (199 ft).

11T 0476635E 4853382N (transect start point, Nad83), GPS accuracy ± 25 ft.



Driving route to Brown Butte sampling site from State Route 201. See Appendix C for written directions. After Clover Lane, follow the written directions carefully.



Close-up of the plot layout at Brown Butte. The faint trail bisecting the photo is the top of the ridge. Access road is 165 meters northeast of plot 545 (north is up). Note scale bar in lower left corner of photo (95ft).

11T 0489997E 4842103N (Nad83, transect starting point), GPS accuracy ± 25 ft.

APPENDIX C. *ASTRAGALUS MULFORDIAE* CONTACTS, GEAR LIST, AND DIRECTIONS

Contacts

Vale District BLM: Gillian Wigglesworth, (541) 473-3144

Gear List

Camping Box

Dry foods box

Water jug *2

Camp table

Camping chairs (one/person)

Large cooler & soft cooler

Health and Safety Box

Small trowel

Last year's report

Last year's data

Maps (USGS 7.5" topos, Gazetteer, BLM overview topo)

Datasheets

Printout of text file including GPS pts for all plots (in ASMU folder)

Clipboards (tatum + 3 extra)

Mechanical pencils

3 50m tapes

Ruler—one per person

2 pieces rebar

5 10" steel nails

5 wooden stakes

Mallet

Compasses (at least 2)

5 plot frames

string to divide frames

GPS unit

Flora (H&C, Jepson)

Plot tags

Wire

Wire cutters

Work gloves

Fencing (small amount if replacements necessary)

4 candy canes

flagging

Directions – Update directions as needed for future sampling. DO NOT assume directions, especially mileages, are precise. You can use the Google maps (above) and a compass to ensure you are always basically going in the right direction. Leave all gates as you find them (open or closed)!

South Alkali Field Site

In Vale, get onto 10th Street and go north. 10th curves to the right and turns into Lagoon Dr. Lagoon parallels railroad tracks until it dead ends, go left (north) onto Foothill Dr. At intersection, Foothill turns right, stay straight, road changes to Vale View Rd. After 0.5 -- 0.75mi, turn right onto a dirt road, it looks like a driveway. Dirt road curves to left, drive through farm fields and over an irrigation ditch, towards the hills! The irrigation ditch should be on your left on the way up. The road turns right, away from the ditch, make an immediate left. At this point you must go through a gate that has rock columns (fenced), on either side. Arrive at Jordan Water Hole (marked on USGS quad). Follow road (to left) up ridge, you should be able to look into valley to east the entire time. At the top of the ridge you must go through a second gate.

Double Mountain Field Site (from BLM office in Vale)

Turn right out of the BLM visitor's parking lot. Turn left onto 14th street. Turn right onto Hope Street. Turn left onto 17th street. Turn right onto Washington (20W). Take 20W past Vale. Turn left onto Russell Rd. Go 2 miles and turn left onto Dry Creek. Go through gate on left after a mile (it may be closed). Continue to site.

Brown Butte/Blackjack Field Site

Mendiola Road to Clover Lane (will see stand of trees); where pavement ends, turn left; cross canal and make a hard right turn (onto Road E); bear right, drive along base of butte, next to canal; cross over cattle guard, continue into pasture; at intersection/power lines, make a right turn (follow power lines for 3 mi); near gravel pit.

North Harper (North and South)

From Cow Hollow

From Vale, take 20 west. Turn left onto Russell Rd. Turn left onto Dry Creek/Twin Spring (Cow Hollow) and go through clipped gate to left. After ~4mi, turn left onto 2 track, drive fence line, go past cattle station (road goes through big thicket of Russian thistle, kind of invisible), continue to gate on left. Go through the gate on left and continue to drive the fenceline to the right. You will next come to a locked gate, follow the road to the left and up into the hills (along a drainage). This road will take you directly to the site. Do not go up the large steep hill, this is too far.

From Lytle Blvd.

Turn right onto dirt road (if coming from Vale) that cuts to northwest and goes behind ridge paralleling road. If you pass the dump, you went too far. Keep on dirt road for ~2.5 miles (always going ±NW) until you come to a triangle junction, turn left (towards water tower). Road runs ~SW for 0.9 miles before turning WNW (near the water tower). Drive 1.5 miles (total from last triangle junction), go through fence and turn left (south). Road

will follow fenceline for ~1.25 miles until it reaches another triangle junction, take right fork, which will spit you out going west on new road after 1.35 total miles from last junction. After 0.1 miles, take left fork. In 0.3 miles you will reach another fork (with a large patch of *Oenothera cespitosa*). Go left and park at top of hill to walk down and sample N. Harper South, go right, drive 0.4 miles west, and park to sample N. Harper North. Follow USGS 7.5" topo carefully.

Snively Field Site

Take 201 South past Nyssa. If you get to Adrian, you've gone too far. Turn right onto Owyhee Avenue. Turn left onto Owyhee Lake Road. Follow past Snively Hot Springs, field site is across the road from a campground with cottonwoods.

APPENDIX D. SUMMARY OF *ASTRAGALUS MULFORDIAE* DATA FROM CAGED/UNCAGED PLOTS

Astragalus mulfordiae characteristics in caged and uncaged (open) plots at six sites in the Vale District BLM in 2009. All herbivory in caged plots marked as “ungulate” was the result of rodents.

Site	Treatment	Total plants	ave.		ave. longest stem (cm)	ave. inflo	Total	
			diameter (cm)	stem (cm)			insect herbivory	ungulate herbivory
Brown Butte	caged	19	33.2	21.9	42.6	4	4	
Brown Butte	open	20	25.6	19.8	15.0	3	7	
Double Mtn	caged	16	25.7	17.9	14.4	2	5	
Double Mtn	open	25	23.9	15.2	18.9	2	11	
N. Harper North	caged	30	35.8	23.9	47.2	3	10	
N. Harper North	open	27	31.6	20.9	41.9	1	10	
N. Harper South	caged	19	26.9	18.6	26.4	5	2	
N. Harper South	open	19	26.2	17.2	33.2	0	2	
Snively	caged	27	24.4	21.1	17.9	0	0	
Snively	open	12	34.2	22.8	42.8	1	2	
South Alkali	caged	43	25.8	20.4	11.2	6	1	
South Alkali	open	29	33.0	23.0	25.0	5	14	
TOTALS:		286	28.9	20.2	28.0	32	68	

Astragalus multiflorus characteristics in caged and uncaged (open) plots at six sites in the Vale District BLM in 2008. All herbivory in caged plots marked as “ungulate” was the result of rodents.

Site	Treatment	Total plants	ave.			Total		Total	
			diameter (cm)	ave. long stem (cm)	ave. inflo	insect herbivory	ungulate herbivory		
Brown Butte	caged	19	19.4	13.2	13.8	0	0	5	
Brown Butte	open	21	16.7	12.4	14.4	0	0	2	
Double Mtn	caged	21	21.7	13.6	13.0	0	0	0	
Double Mtn	open	28	20.2	13.4	31.6	1	1	5	
N. Harper North	caged	29	27.3	18.0	44.5	1	1	11	
N. Harper North	open	27	29.0	20.4	58.6	0	0	13	
N. Harper South	caged	19	22.7	15.6	19.7	0	0	1	
N. Harper South	open	20	21.0	14.1	20.2	1	1	0	
Snively	caged	38	12.3	11.5	8.8	1	1	0	
Snively	open	22	19.7	17.3	17.5	0	0	0	
South Alkali	caged	56	21.9	17.0	35.8	0	0	2	
South Alkali	open	38	28.3	19.6	55.9	0	0	1	
TOTALS:		338	21.7	15.5	27.8	4	4	40	