REPORT:
STEPTOE VALLEY SAGE-GROUSE
HABITAT MOSAIC RESTORATION PROJECT

Spring 2005 tour of field site. From left: Janet Bair, TNC Nevada, Jason Williams, Nevada Dept. of Wildlife, Lee Turner, Eastern Nevada Landscape Coalition, Paul Podborny, BLM, Steve Foree, Nevada Dept. of Wildlife, Alan Sands, TNC Idaho, Tara Forbis, TNC Nevada, Elaine York, TNC Utah.

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Summary
Two levels of mosaic pattern treatments were compared to each other and to control areas to determine the effectiveness of using sagebrush disturbance/seeding treatments to improve Sage-grouse habitat. Native grasses were seeded into treated areas. Hand-collected forb seeds were seeded into experimental plots. Preliminary results indicate that the treatments reduced shrub cover, but did not affect grass cover. Forb cover increased, however, so did the cover of cheatgrass. Biological crust cover was also reduced by the treatments. Forb seedling plots indicated that particular species were more successful during the first year of monitoring, and survival was higher in disturbed than undisturbed areas. There was no increase in Sage-grouse site use.

These preliminary results indicate that this kind of treatment might increase native herbaceous cover, however, the increase in cheatgrass and decrease in biological soil crusts suggest that a method that results in less soil disturbance would be preferable. Longer-term monitoring on this project provide better information to guide management.

Background
The Greater Sage-grouse (hereafter, "Sage-grouse") has experienced population declines resulting from loss and degradation of sagebrush ecosystems. These systems have experienced conversion to agriculture, loss of herbaceous understory, invasion of non-native plant species, and fragmentation by roads and other human structures. A range-wide assessment of the status of the Sage-grouse concluded that "we are not optimistic about the future of sage-grouse because of long-term population declines coupled with continued loss and degradation of habitat and other factors" (Connelly et al. 2004).

The Sage-grouse's habitat requirements are somewhat correlated with those of other sagebrush obligates (Rowland et al. 2006) and Sage-grouse are sometimes thought of as an umbrella species (Rich and Allen 2001). Sage-grouse habitat indicators (such as native herbaceous cover) are correlated with ecosystem resilience, the ability of the ecosystem to recover from disturbances such as wildfire. Additionally, forbs and insects, which are critical to Sage-grouse diets, are key components of system biodiversity.

Nevada contains more sagebrush than any other state (10 million hectares). Seventy-two percent of this sagebrush is managed by BLM (Rowland et al. 2003). BLM's Great Basin Restoration Initiative (Great Basin Restoration Initiative; Pellant 2003) and the draft Ely BLM Resource Management Plan call for restoration activities to increase resilience in sagebrush ecosystems.

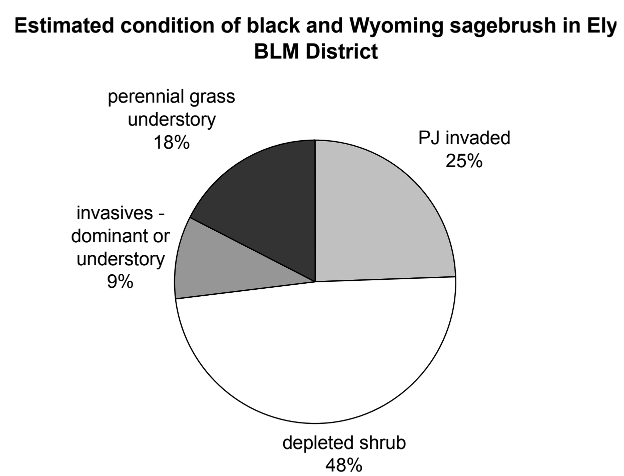


Fig. 1. Current condition of black and Wyoming sagebrush in the Ely District. These data are taken from the six watersheds with available vegetation data. "Depleted shrub" refers to sagebrush with little or no herbaceous understory. "PJ invaded" refers to sagebrush sites (as defined by soil type) that have been invaded by single-leaf pinyon pine and Utah juniper. "Perennial grass understory" refers to sagebrush with a native herbaceous understory. "Invasives – dominant or understory" refers to sites either dominated by invasives or sites with sagebrush and an understory of invasives.

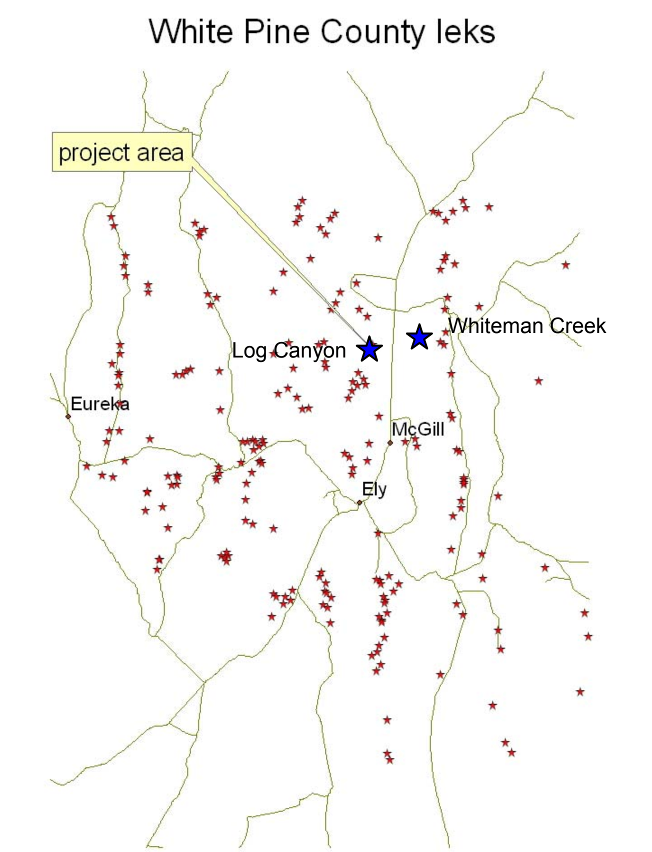


Fig. 2. Log Canyon, the project area, and Whiteman Creek, the reference area, in relation to Ely and McGill, Nevada.

Planned restoration treatments include mechanical treatments and seeding to increase the diversity of successional stages in sagebrush ecosystems. These treatments are needed to restore the function of sagebrush ecosystems (Fig. 1) but there is concern that large-scale application of these treatments could harm Sage-grouse populations at the local level (Pedersen et al. 2003). Therefore, data on the effects of these treatments are needed to ensure that future restoration treatments are carried out in an adaptive management context, with monitoring and research informing management.

Partners involved in this project included the National Fish and Wildlife Foundation, The Nature Conservancy of Nevada, the Nevada Department of Wildlife (NDOW), Need More Sheep Co., the Eastern Nevada Landscape Coalition and Delamar Valley Cattle (a welfare production project of the Church of Jesus Christ of Latter-Day Saints), which donated a tractor and Lawson pasture aerator as well as an equipment operator.

Methods

Treatment area

The project was carried out adjacent to a Sage-grouse lek at Log Canyon, approximately 30 miles north of Ely (Fig. 2), Nevada. The initial project site was adjacent to the Whiteman Creek lek, 9.25 km to the WNW of Log Canyon, a site with much higher lek counts. However, consultation with NDOW and BLM biologists revealed that there is heavy elk and deer use of the Whiteman area, which would be expected to adversely impact the success of any seeding done there. Therefore, the project was moved to Log Canyon and Whiteman Creek was used as a reference site for lek counts and breeding bird surveys.

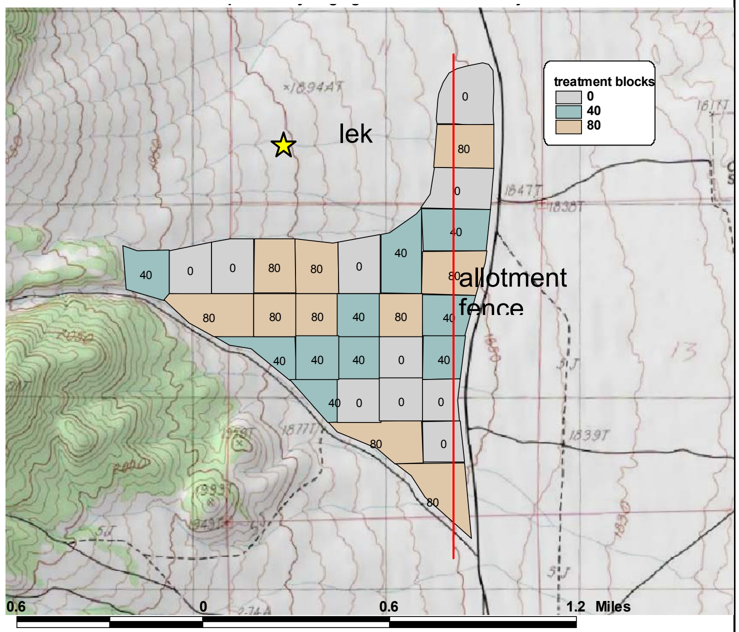


Fig. 3. Treatment blocks of 0 (control), 40%, and 80% sagebrush

Species	lbs/ac
Thickspike Wheatgrass	1
Western Wheatgrass	1
Bluebunch Wheatgrass	1
Basin Wildrye	1.14
Sandberg Bluegrass	1
Squirreltail	0.8
Needle and Thread Grass	0.15
Indian Ricegrass	3
Globemallow	0.2

Table 1. Seed mixture.

Restoration treatments

Mosaic-pattern disturbances were applied in treatment blocks, which made up an experimental design (Figure 3). There are 10 blocks each of 0 (control), 40%, and 80% treatment. Each block was between 5 and 15 acres in size.

Fig. 4. Lawson pasture aerator with seed boxes applying disturbance and seeding treatment, Oct. 2005.

Sagebrush cover reduction and seeding were accomplished with an aerator, a toothed drum pulled behind a tractor. The tractor was driven in a curvilinear pattern to create a 12-foot wide pattern that disturbed and seeded either approximately 40% or approximately 80% of each 10-acre block. The seed was broadcast behind the drum and fell into the depressions created by the teeth. Treatments were applied in the October of 2005 (Fig. 4). Composition of the seed mixture is shown in Table 1.

Implementation of the treatments was successful. We found that we were unable to cover the westernmost 40% block due to the rockiness of the terrain, and parts of the westernmost 80% block were also inaccessible. Additionally, it was impractical to carry out treatments on the east side of the allotment fence (Fig. 3), which reduced the acreage treated.

Species	% Viable
Arabis holboellii	100
Arenaria kingii	95
Astragalus lentiginosus	83
Astragalus newberryi	99
Castilleja chromosa	68
Caulanthus crassicaulis	83
Chaenactis douglasii	87
Crepis acuminata	4
Delphinium andersonii	68
Erigeron argentatus	not tested
Eriogonum caespitosum	75
Eriogonum ovalifolium	82
Frasera albomarginata	97
Haplopappus acaulis	54
Penstemon confusus	not tested
Physaria chambersii	95
Senecio multilobatus	68

Table 2. Hand-collected forb seeds with viability estimates. Numbers represent mean values. Species in blue were seeded into experimental plots. Species in black were not due to insufficient numbers.

Forb seeds

We hired a seed collector, who monitored the phenology of the seeds on our list of desired species. She was able to collect usable amounts (we neglected to weigh the total collections between collecting and planting) of the species shown in Table 2.
We then sent these seeds for viability testing to the U.S. Forest Service Shrub Lab in Provo, Utah. The results of this viability testing are in Table 2.

Collected forb seeds were seeded into experimental plots as follows: we created 20 small, haphazardly-located test plots, 10 each within the treated and untreated areas. These plots were all located in proximity, so they do not represent the total range of conditions across the site. However, they were situated this way to allow for repeated, efficient monitoring. Each plot contained fifteen subplots of 20 by 20 cm, each containing one of the species shown in blue in Table 3. In October of 2005, we sowed 50 seeds of one species into each of these subplots. The plots were covered with window screen, which was staked down to protect the seed from granivores over the winter (Fig. 5).

The remainder of the forb seed was mixed, and was raked into haphazardly located "seed islands" throughout the project area. These seed islands were monitored September of 2006 to determine whether seedlings were present.

Livestock

We obtained an agreement with the livestock permittee to keep the sheep (this allotment is exclusively sheep grazing) out of the area for three years. However, this fall we learned that he will be selling the allotment, so we have been in contact with the responsible range conservationist to ensure that the new permittee will honor this agreement.

Experimental design

Treatments at the site were designed to allow us to answer the following questions:

- Does a mosaic of mechanical treatment with seeding increase the cover of native grass species relative to the control?
- Does a mosaic of mechanical treatment with seeding increase the cover of native forb species relative to the control?
- Does a mosaic of mechanical treatment with seeding increase Sage-grouse utilization of treated sites?
- Which forb species will germinate and survive in treated

Fig. 5. Newly planted forb seed plot covered with window screening covering.

sites?

Because the funding used so far was for a one-year project, we obtained only preliminary answers to our research/adaptive management questions. However, we have since sought funding to be able to continue monitoring on this project, and have received private funding that will allow us to continue monitoring over a 10-year period.

Monitoring was designed to quantify three indicators of success:

- vegetation percent cover and diversity in treated and control sites
- native forb seed success
- Sage-grouse site utilization

Vegetation percent cover and diversity

Vegetation percent cover was measured in summer 2005 and summer 2006. The vegetation monitoring follows protocols in Herrick et al. (2002). Sampling plots were randomly located within strata (0, 40%, and 80% treatment blocks). Each sampling plot included 4 parallel 50-meter transects 10 meters apart. Each treatment block contained 2 sampling plots.

Point-intercept sampling was used to estimate vegetative cover of all species and ground cover. Along each transect, 50 points were sampled for a total of 200 data points per plot. The overstory and understory species touched by the pin were recorded as well as the ground cover (bare, litter, lichen, moss, rock, plant). Following the conclusion of sampling at each plot, the botanist walked randomly throughout the plot or 10 minutes and recorded the presence of species not encountered during sampling.

In 2005, 60 vegetation plots were sampled. Using power analysis (Elzinga et al. 1998, Appendix 1), we determined that only 30 plots were necessary in 2006.

Fig. 6. Seedling monitoring in forb experimental plots.

Fig. 7. Seedling point frame with seedlings of *Chaenactis douglasii.*

Native forb seed success monitoring

Seed success monitoring has been ongoing during summer 2006 in the native forb seed experimental plots (Fig. 6). Plots were monitored monthly May through October. Seedlings were assigned coordinates that located them to within 2 cm^2 and a point frame anchored to permanent corner markers was used so that individuals can be relocated in successive years (Fig. 7). Dates of germination and mortality and species identity were recorded for each individual.

Sage-grouse site utilization

To detect potential changes in Sage-grouse site utilization, a belt transect was conducted along all transects in each plot. The belt transect was two meters wide. All Sage-grouse scat was counted along all four vegetation transects. At Log Canyon, 60 plots were sampled in 2005, and again in 2006. Sixty plots were also sampled at the reference site, Whiteman Creek, in both years. Power analysis suggested that due to the high level of variability among plots, 60 plots was not enough to be able to expected to detect relatively small changes.

Data analysis

Vegetation cover data was divided into functional groups including shrub, native perennial grass, native annual forb, native perennial forb, dead shrub cover, invasives cover, and total herbaceous cover. Ground cover types analyzed included biological crusts (including moss and lichen), bare ground, and litter. Wildlife scat counts analyzed included ungulates (deer, elk, and antelope), and Sage-grouse.

Normal quantile-quantile plots were used to examine residuals using a variety of standard transformations. The log transformation most effectively normalized residuals for herbaceous and grass vegetation cover groups. To normalize residuals for annual forbs, invasive species, biotic crust, wild ungulate scat counts, rank transformation was used. The square-root transformation normalized residuals for perennial forbs. Sage-grouse scat counts were not normalized by any transformation due to the high proportion of zeroes in the dataset, therefore, we used a Mann-Whitney U test to analyze these data.

Treatment effects on the plant functional groups as well as ground cover types were tested using analysis of covariance with 2005 cover estimates as the covariate, and treatment level as the main effect. Bonferroni post-hoc tests were used to examine differences among the three treatment levels. Differences in wildlife use between the control (Log Canyon) and reference (Whiteman Creek) sites were also tested using analysis of variance. Differences among treatment levels at Log Canyon were similarly tested. All analyses were performed in Statistica 6.0 (StatSoft, Inc. 2003)

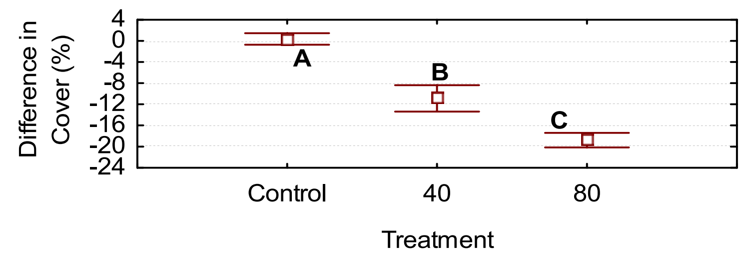


Fig. 8. Means and Standard Errors of Post- minus Pre-treatment Shrub Cover

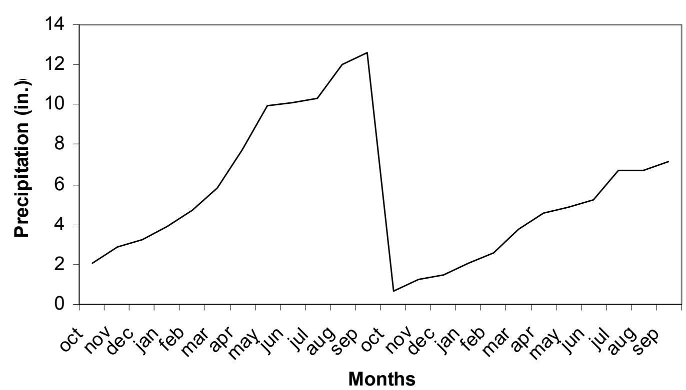


Fig. 9. Cumulative precipitation at Ely Airport, water years 2005 and 2006

Results and Discussion

All figures represent shows means and standard errors of raw data. Analysis was performed on transformed data as indicated in the Methods section.

Shrub cover

Data and field observations indicate that the aerator killed some shrubs and hedged others.

The treatment had a highly significant effect on shrub cover when the treatment effect was analyzed in the context of pre-treatment shrub cover for each plot ($F_{23,2}$=33.85, P<0.000001; Figure 8).

The Bonferroni comparison (between MS = 15.17, df = 20) indicated that shrub cover was significantly reduced in the 80% treated blocks versus the 40% treated blocks (p=0.0002) and the control blocks (p<0.000001; Fig. 8). Shrub cover was also significantly diminished in the 40% treated blocks compared to the control (p=0.0073).

Therefore, our treatments successfully reduced shrub cover, although cover was reduced less than anticipated. When the aerator treated approximately 40% of the block, shrub cover was reduced 11%; when 80% was treated, cover was reduced 19%.

Grass cover

There was a substantial between-year difference in precipitation; the water year 2005 had 12.6 inches of precipitation at the Ely airport (Fig. 9; data from NRCS) while 2006 had only 7.5 inches, and this was mirrored in differences between years in grass cover.

The treatments did not have a significant effect on grass cover after one year ($F_{23,2}$=0.41, P=0.67; Fig. 10). The action of the aerator did not appear to kill individual clumps, and most appeared to have survived. Grass seedlings from the seeding treatment were small at the time of monitoring (Fig. 11) and their cover was not measurable with point-intercept in 2006. However, seedlings were abundant (see below, "Grass seedling density estimates"), and vegetation monitoring during subsequent years should begin to reflect changes in grass cover due to seeding success and subsequent seedling survival.

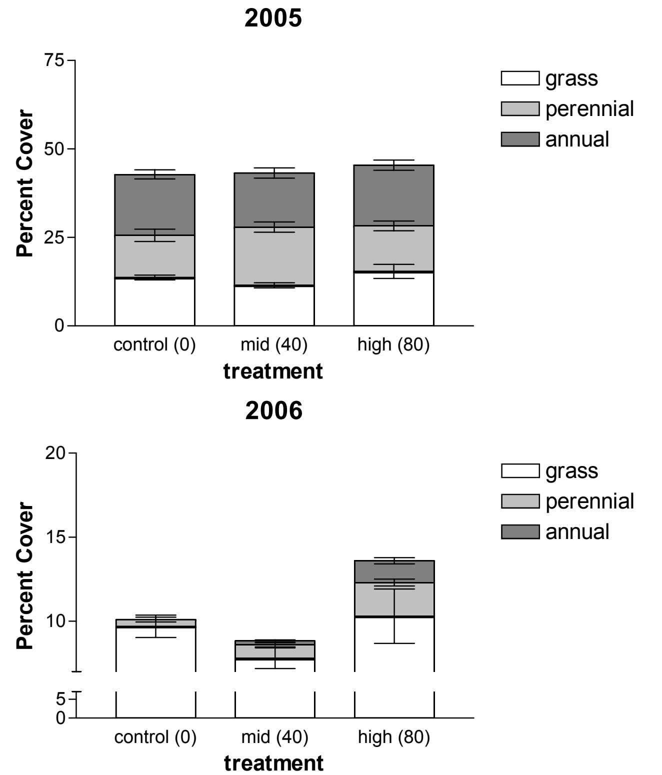


Fig. 10. Native grass, and perennial and annual forb cover, 2005 and 2006.

Fig. 11. Grass seedling in treated area.

Perennial forb cover

There was a considerable decrease in native perennial forb cover throughout the project area from years 2005 to 2006 (average decrease across treatment types was 12.84%; Fig. 10), likely due to decreased precipitation between 2005 and 2006 (Fig. 9). However, forb cover decreased less in treated than untreated plots (ANCOVA $F_{23,2}$=9.23, P=0.0014; Fig. 10). The Bonferroni comparison (between MS = 0.18, df = 20) indicated that forb cover decreased significantly less between years in the 80% treated plots compared to both the control (p=0.0012) and 40% treated blocks (p=0.0442). There was no significant difference between the control and 40% treated plots (p=0.2789).

The only forb seed included in the seed mix was globemallow (*Spheralcea ambigua*), but it was present in only trace amounts. The differences among treatment groups in forb cover are due to the establishment of on-site seeds.

Native annual forbs

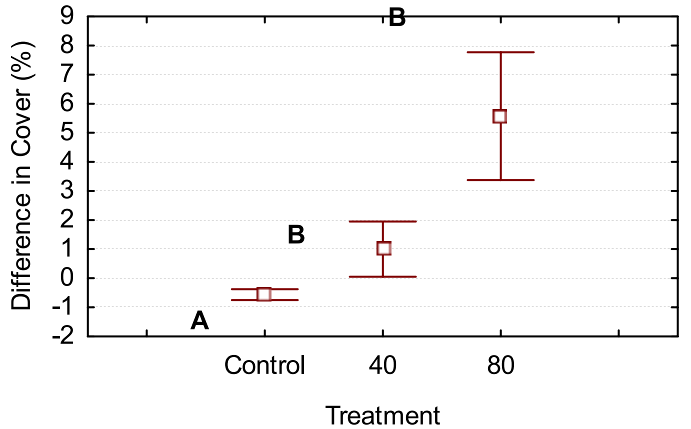
The interannual, precipitation-caused decrease in native annual forb cover was significantly less in the treated blocks compared to the control blocks ($F_{23,2}$=25.7, P=0.000003; Fig. 10). Also, there was significantly greater native annual forb cover in the 40 percent treatment blocks than the 80 percent treatment blocks (p=0.0072).

The aerator creates small "pockets" on the soil surface which can capture seeds, moisture, and soil particles. These pockets create a beneficial microhabitat for seed germination and seedling establishment, which likely led to the greater number of annual forbs in the treated vs. control plots in 2006.

Invasive species

The treatments resulted in significant increases in invasives (ANCOVA $F_{23,2}$=6.57, P=0.00639; Fig. 12). Cheatgrass, nearly exclusively, comprised the invasives category. Where it was present prior to treatment, it increased after the aerator's disturbance. Analysis of the rank transformed data showed significant differences between the control and 40 percent treated (between MS = 21.28, df = 20; p=0.0018) and the control and 80 percent treated areas (p=0.007; Fig. 12).

Figure 12. Means and Standard Errors of Post- minus Pre-treatment invasive species cover



The increase in cheatgrass occurred mostly in the 80% treated block at the south end of the project area (Fig. 13).

This ~10 acre area had the lowest perennial grass cover to begin with. Figure 14 represents the vegetation plots sampled in the southern end of the project. Each dot represents a plot, and each label represents the percent cover of native grasses in that plot. In the two plots located in the southern end of the project area, grass cover was lower than in any of the other plots. The southern end of the project area also had deeper soil than much of the rest of the treatment area. It was also close to a former sheep camp south of the project area, where sagebrush had been removed and replaced by cheatgrass, providing a seed source.

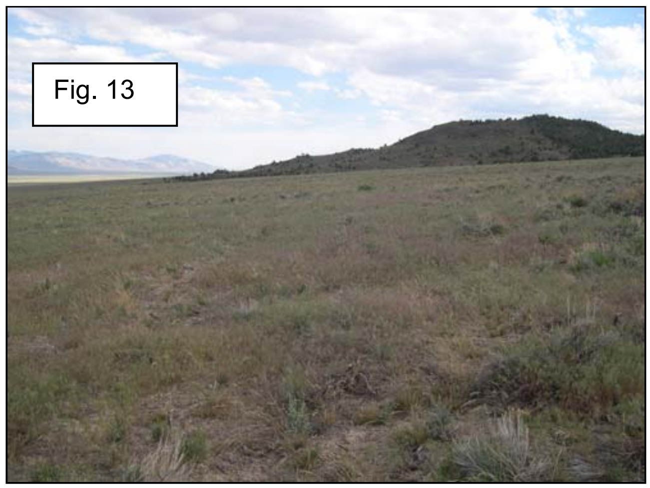


Fig. 13

However, throughout most of the treatment area, cheatgrass cover was low post-treatment. These results suggest that a soil-disturbing treatment like aeration should be used cautiously at low elevations, with particular care being used in deep-soil sites, and sites in proximity to cheatgrass seed sources. In such sites, a no-till seeder is likely a better restoration tool.

These seeders are just beginning to become available www.truaxcomp.com/rangeland.html), and have been developed with input from the Great Basin Restoration Initiative.

Despite the heavy cheatgrass presence in the southern end of the project area, there are also abundant native grass seedlings present in this area. This site, in the 10" precipitation zone, could experience a recovery due to success of these

Perennial grass percent cover, south end

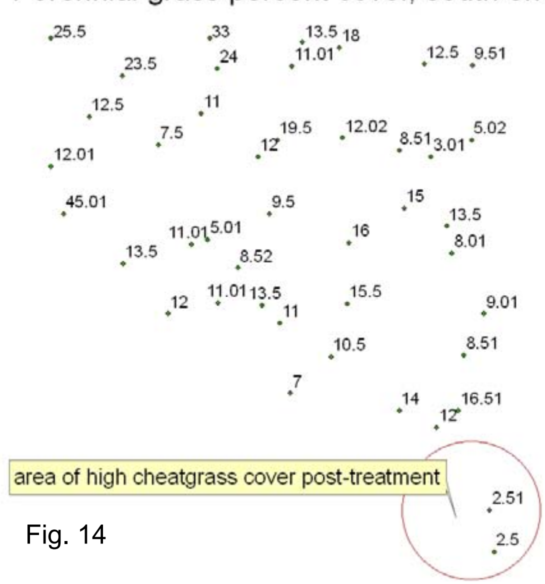
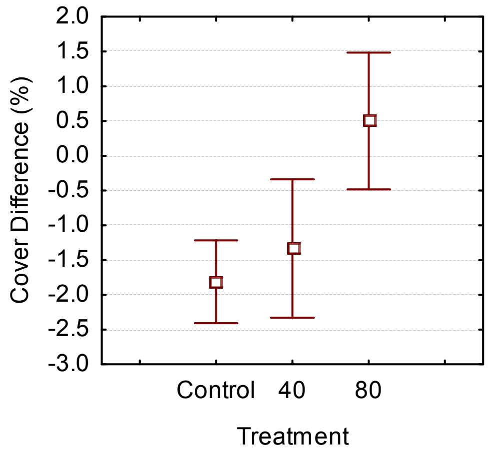


Fig. 14

Figure 15. Means and Standard Errors of Post- minus Pre- treatment dead shrub cover



seedlings if precipitation is sufficient. Future monitoring will determine the outcome of this competition between native and invasive species.

Dead Shrubs

One might expect an increase in dead shrub cover in the 40 and 80 percent treated blocks because the aerator killed some of the shrubs. However, there was not a significant difference in dead shrub cover among treatments (ANCOVA $F_{23,2}$=1.73, p=0.2030, Fig. 15). This may be attributed to the observation that the branches of killed shrubs were generally completely detached from the stem and so were recorded as litter if intercepted during monitoring. Dead stems are comparatively narrow and vertical and so would be encountered infrequently with point-intercept monitoring.

Biological soil crusts

The biological soil crust category consists of moss, lichen, and biological soil crusts. Analysis of the rank transformed data showed a significant difference between the control and 80 percent treated plots (Bonferroni between MS = 36.65, df = 20, p=0.0054; Fig. 16), but no difference between the control and 40 (p=0.2187) nor between the 40 and 80 percent treated plots (p=0.2296). This suggests that the aerator's disturbance removed some of the biological surfaces, but only significantly so in the 80 percent treated plots.

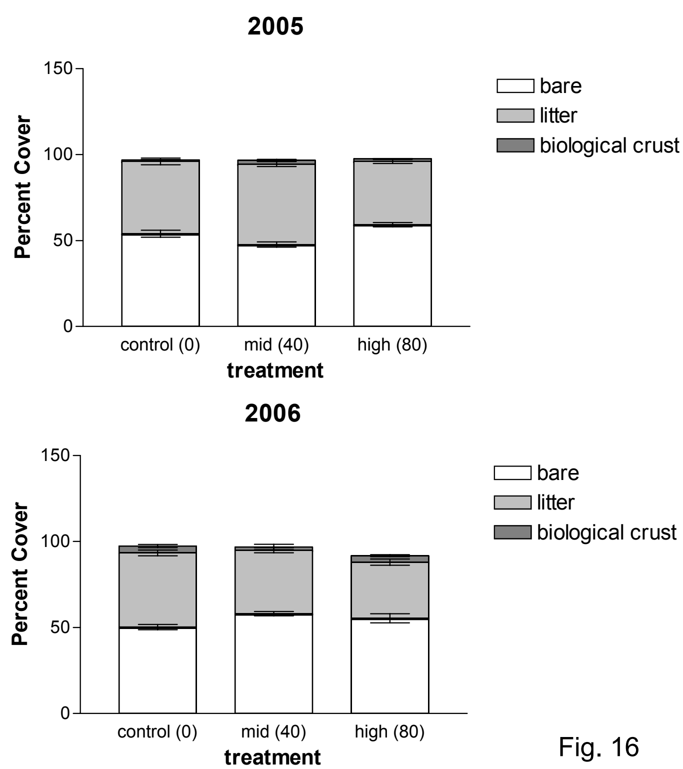


Fig. 16

Therefore, a major downside of this kind of treatment is in the removal of biological soil crusts, which are important for soil stability, hydrologic function, and resistance to invasive species. It is likely that in a more intact system, smaller levels of treatment could be shown to decrease crust cover, but the initial cover at this site was only ~1%. Prescriptions for potential crust cover for a site of this kind are not known, but would likely be much higher than 1%.

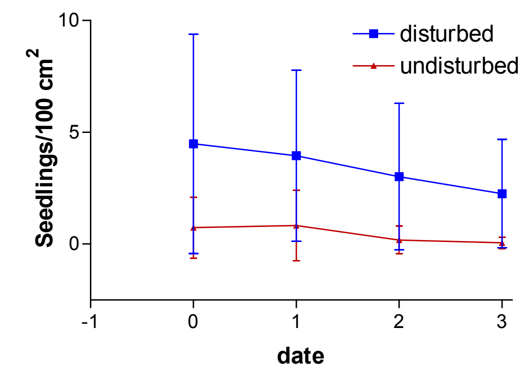


Fig. 17

Litter

There was no significant difference in litter cover among treatments (ANCOVA $F_{23,2}=1.39$, $p=0.2724$; Fig. 16). We anticipated that the treatments would add a considerable amount of litter to the soil surface because of the aerator's crushing of the shrubs, but the data do not show this.

Grass seedling density estimates

We did not estimate grass seedling germination or survival rates; rather, we estimated density of grass seedlings at each sampling date in our forb seedling plots. Data are shown in Figure 17. Densities were significantly higher on disturbed than undisturbed plots (Repeated Measures ANOVA $F_{4,15}=$, $p<0.001$). We will continue to follow grass seedlings next year to get more meaningful estimates of treatment effect on germination and survival.

Hand-collected forb seed germination and survival

We tracked the germination and survival of our hand-collected forb seeds in the experimental plots described above. Germination did not differ among treatments (ANOVA $F_{1,13}=0.22$, $p=0.643$; Fig. 18) but rates did differ among species (ANOVA $F_{13,14}=40.65$, $p<0.0001$). The species with the highest germination rates were *Chaenactis douglasi*, followed by *Eriogonum ovalifolium* and *Eriogonum caespitosum*. However, it should be noted that many of these species

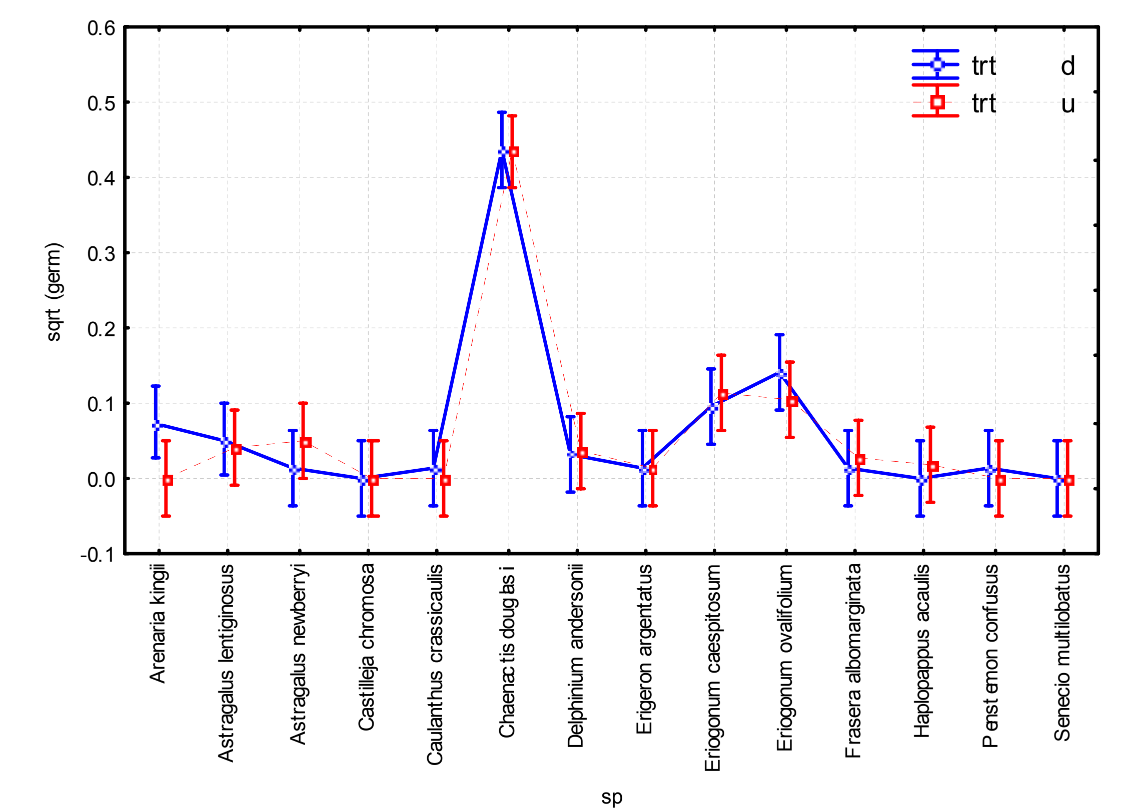


Fig. 18

showed significant dormancy. Data from the lab seed germinations, which involved germination trials at alternating temperatures of 10/20ºC for 4 weeks, combined with viability analysis, indicated that after spending the winter buried in seed bags, many of the species (*Astragalus lentiginosus, Astragalus newberryi, Castilleja chromosa, Caulanthus crassicaulis, Chaenactis douglasii, Crepis acuminate, Delphinium andersonii, Erigeron argentatus, Eriogonum caespitosum, Eriogonum ovalifolium, Frasera albomarginata, Haplopappus acaulis,*and *Senecio multilobatus*) showed significant dormancy. Therefore, we will continue to monitor these plots next year to get better estimates of germination and survival of these species.

Although germination rates didn't differ between disturbed and undisturbed plots, seedling survival did (Kaplan-Meyer: Z = 2.42541 p = .01529; Fig. 19). Survival was higher on disturbed plots, suggesting that overall establishment (the product of germination and survival) should be higher in the treated area. These first-year results are promising, however, we will continue to monitor these plots to get more meaningful, long-term results.

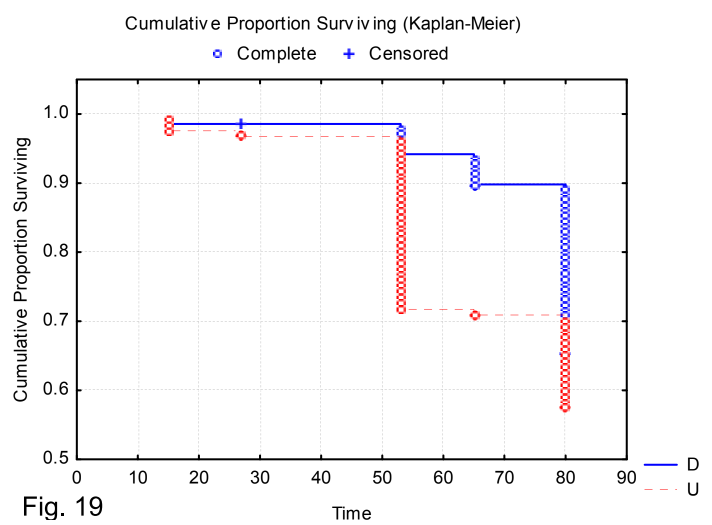


Fig. 19

Seed islands

43% of the 136 seed islands were monitored for success. Of the monitored points, 41% had seeded species growing in them. The most common species were *Chaenactis douglasi*, followed by *Caulanthus crassiculis* and *Astragalus lentiginosus*.

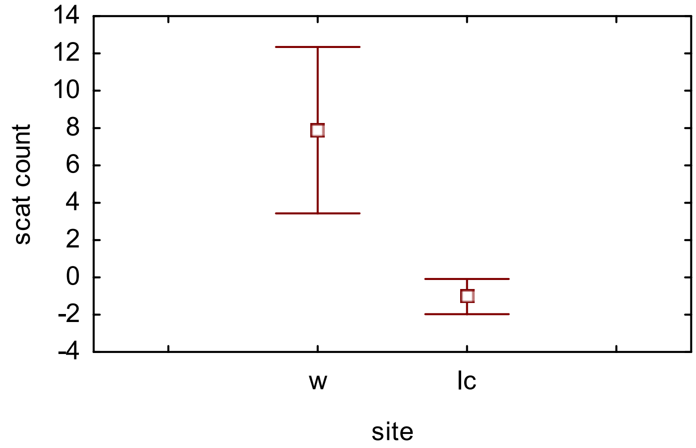
Sage-grouse site use

We wanted to examine the effects of the treatment on Sage-grouse site use, but because our treatment blocks at Log Canyon are certainly smaller than the range of a grouse, we had to compare our site to a reference site, Whiteman Creek. The difference between pre- and post-treatment Sage-grouse site use, as measured by scat counts, was significant (Mann-Whitney U=240, P<0.0002; Fig. 20). However, it was at Whiteman Creek, the reference area, rather than at Log Canyon that site use increased. Therefore, there was no evidence that the treatments improved Sage-grouse habitat within one year. However, we would expect that this kind of change would happen over a longer time period, and the two sites began with very different populations (Log Canyon 2005 lek count = 8; Whiteman 2005 lek count = 57).

We also found that ungulate use increased more at Whiteman than Log Canyon (ANCOVA $F_{23,1}$=10.84, P=0.0016).

We also analyzed scat count data to determine whether grouse were using control versus treatment blocks at Log Canyon differentially. A Chi-square test comparing before and after-treatment scat counts found no difference (Chi-square = 1.95, df = 2, p = 0.378).

Fig. 20. Means and standard errors of post- minus pre-treatment Sage-grouse scat counts



<u>Public outreach and communication of results</u>

Public outreach activities on this project include the following:

- Organized and conducted field tour of Sage-grouse restoration sites at Log Canyon. Attendees from The Nature Conservancy of Idaho, Utah and Nevada, the Nevada Department of Wildlife, the Ely Field Office of the Bureau of Land Management, and the local nonprofit Eastern Nevada Landscape Coalition.
- Did a press release to the Ely Daily Times which resulted in an article on the project. This article can be viewed at: http://elynews.com/articles/2005/11/18/lifestyles/import-23538.txt
- Involved volunteers in data collection.
- Presented poster, "Steptoe Valley Sage-grouse Restoration Project" at Pinyon Juniper and Sagebrush Management Conference held in Montrose, Colorado.
- Presented talk, "Steptoe Valley Sage-grouse Restoration Project" at the Eastern Nevada Range Research Days in Ely, Nevada.
- Presented talk "Progress on the Eastern Nevada Landscape Restoration Project" which included a section on the Steptoe Valley Sage-grouse Project to Northern Nevada Stewardship Group as keynote speaker at their annual meeting in Elko.
- Presented talk, "Steptoe Valley Sage-grouse Restoration Project" at the Eastern Nevada Landscape Coalition Annual Meeting on June 16 in Ely, Nevada.
- Solicited and received a private donation of $30,000 to continue monitoring on the Steptoe Valley Sage-grouse Project over the next 10 years.

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