

**2012-13 VEGETATION DATA SUMMARY
GREATER SAGE-GROUSE RESPONSE TO SEASON-LONG AND
PRESCRIBED GRAZING (NRCS CONSERVATION PRACTICE 528)
ON PAIRED ECOLOGICAL SITES**



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November 2013**

ABSTRACT

This report summarizes vegetation data collected to date for the ongoing greater sage-grouse (*Centrocercus urophasianus*) research project in Rich County, Utah. The objective of this research is to compare the effects of season-long and prescribed rotational grazing practices on greater sage-grouse vital rates, population trends, and habitat quality.

Vegetation data were collected on 2 study areas that varied by grazing management practices. At each study area, vegetation characteristics were recorded at nesting and brood locations that were then paired with random sites in the same pasture or grazing treatment.

Table of Contents

Table of Figures	4
Introduction.....	5
Background	5
Study Area.....	6
Methods.....	10
Experimental Design	10
Vegetation and Habitat Monitoring	10
Data Analysis	11
Results and Discussion	11
Literature Cited	12
Appendix A.....	16
Appendix B.....	24

Table of Figures

Figure 1. Average 2010-12 monthly precipitation (mm) for Woodruff, Utah..... 7

Figure 2. Sage-grouse nesting and brooding areas for Three Creeks Allotment based on sage-grouse known locations 2012-13. 8

Figure 3. Sage-grouse nesting and brooding areas for Deseret Land and Livestock based on sage-grouse known locations 2012-13..... 9

Table 1. Mean percent cover for greater sage-grouse nest and brood sites and paired random sites, Deseret Land and Livestock and Three Creeks Allotment, Rich County, USA, 2012-2013. 11

Introduction

Background

Compared to most other galliforms, sage-grouse (*Centrocercus* spp.) are longer lived and have lower reproductive output resulting from smaller clutch sizes and lower re-nesting rates (Schroeder et al. 1999). Adult female survival, chick survival, and nest success are important to population growth and changes in any of these vital rates drive fluctuations within a population (Schroeder et al. 1999, Moynahan et al. 2006, Taylor et al. 2012). Vital rates are influenced by site-specific events such as disease, predation, and weather and can vary by year, season, and geographic location (Johnson and Braun 1999, Naugle et al. 2004, Holloran et al. 2005, Moynahan et al. 2006, Taylor et al. 2012). Survival rates in some populations vary little, while survival in others may vary dramatically by season and year (Zablan et al. 2003, Beck et al. 2006, Moynahan et al. 2006). Range-wide annual survival rates of hens are documented to vary 37 – 78% depending on the study population, with winter survival rates being typically highest (Connelly et al. 2011a). Survival in long distance migratory populations has been reported to be lower than for more sedentary or non-migratory populations in Idaho (Beck et al. 2006). Nest success is also variable by year and location ranging from 15-86% (Connelly et al. 2004). Stable populations typically have higher nest success than declining populations (Dalke et al. 1963, Schroeder et al. 1999).

Higher survival rates and nest success in some studies have been linked to habitat characteristics and vegetation cover. Shrub canopy cover and herbaceous understory are important vegetation parameters which may directly influence survival and nest success (Aldridge and Brigham 2002, Holloran et al. 2005, Aldridge and Boyce 2007, Robinson 2007, Kolada et al. 2009, Guttery 2011). Low survival and reproductive rates could be an indication of poor habitat conditions. Invasive species, change in fire regimes, drought, encroachment of unsuitable native vegetation, and overgrazing can all lead to unsuitable habitat conditions for sage-grouse (Connelly et al. 2000, 2004). Wildlife biologists recognize that protecting large expanses of viable sagebrush (*Artemisia* spp.) habitat is necessary to conserve sage-grouse populations (Connelly et al. 2011). Wildlife managers strive to enhance population growth by maintaining or improving key sagebrush habitat components that positively influence sage-grouse survival and reproductive success. Core areas are identified and habitat projects are implemented to achieve optimal sagebrush cover while increasing beneficial grass and forb cover (Pyke 2011, Connelly et al. 2011b).

Additionally, lekking, nesting, and brooding-rearing periods are influenced by annual variation in weather. During dry winters, lekking and subsequent nesting can be up to three weeks earlier than during normal precipitation years (Robinson 2007).

The Utah Division of Wildlife Resources (UDWR) reported that sage-grouse were historically found in all 29 Utah counties (UDWR 2009). In 2009, sage-grouse occupied habitats in 26 of Utah's counties. The UDWR estimated that 13.6% or 11,514 mi² (29,821 km²) of Utah provides habitat for sage-grouse. Beck et al. (2003) reported that sage-grouse in Utah occupy 41% of historical habitats.

Declines in sage-grouse populations appear to parallel the loss and fragmentation of sagebrush habitats (UDWR 2009). The cause of this habitat loss and fragmentation include wildfire, urban expansion, development, agricultural conversion, herbicide treatments, rangeland seeding, noxious weeds/invasive species expansion, conifer encroachment, drought, and improper livestock grazing management (UDWR 2009). The primary land use in sage-grouse habitats in Utah is grazing by domestic livestock.

Reported effects of grazing on sage-grouse and sagebrush steppe habitats differ (Beck and Mitchell 2000). The reason for this is that no before-after-control-impact (BACI) studies (Underwood 1994) have been conducted to specifically document the long-term impacts on greater sage-grouse vital rates and the effects specific grazing strategies on ecological site condition and trends. The current research project will scientifically document greater sage-grouse (*C. urophasianus*; sage-grouse) individual and population responses to vegetation changes that may occur under differing grazing practices of paired ecological sites located in Rich County, Utah. This report focuses on the vegetation data summaries that have been completed to date.

Study Area

The study area is located in Rich County, Utah, in the western United States. Rich County is located in northeastern Utah and constitutes the southwestern portion of the Wyoming Basin Sage-grouse Management Zone II (Stiver 2011). The research is being conducted on 2 study sites within Rich County. The first study site is located on Deseret Land and Livestock (DLL), an 86,900 ha privately-owned ranch comprised of roughly 80,600 ha of private lands and 6,300 ha of BLM managed lands at lower elevations. The DLL is managed as a cohesive unit and land managers there have used rotational prescribed grazing practices since 1979. Preliminary data of landscape-level grouse response (multi-year lek and brood counts) and vegetation attributes through time (35 years) on this site, suggested that prescribed grazing practices were positively correlated with decreased bare ground, increased herbaceous cover and increased lek and brood counts (Danvir 2002). The DLL grazing plan calls for 20-25% of the pastures rested on an annual basis (21,000 ha). However better information regarding greater sage-grouse vital rates and habitat use is needed to fully assess and contrast the effects of DLL prescribed grazing strategies and traditional BLM allotment season-long grazing on the species.

The second site, Three Creeks, is a 56,900 ha collection of private lands and 27 BLM and USFS grazing allotments managed under season-long grazing practices. Under the season-long grazing plan, the entire allotment is grazed during the grazing season. Under this type of grazing plan, livestock may spend more time in mesic areas as the vegetation desiccates. These areas are important late season brood-rearing area (Connelly et al. 2011a).

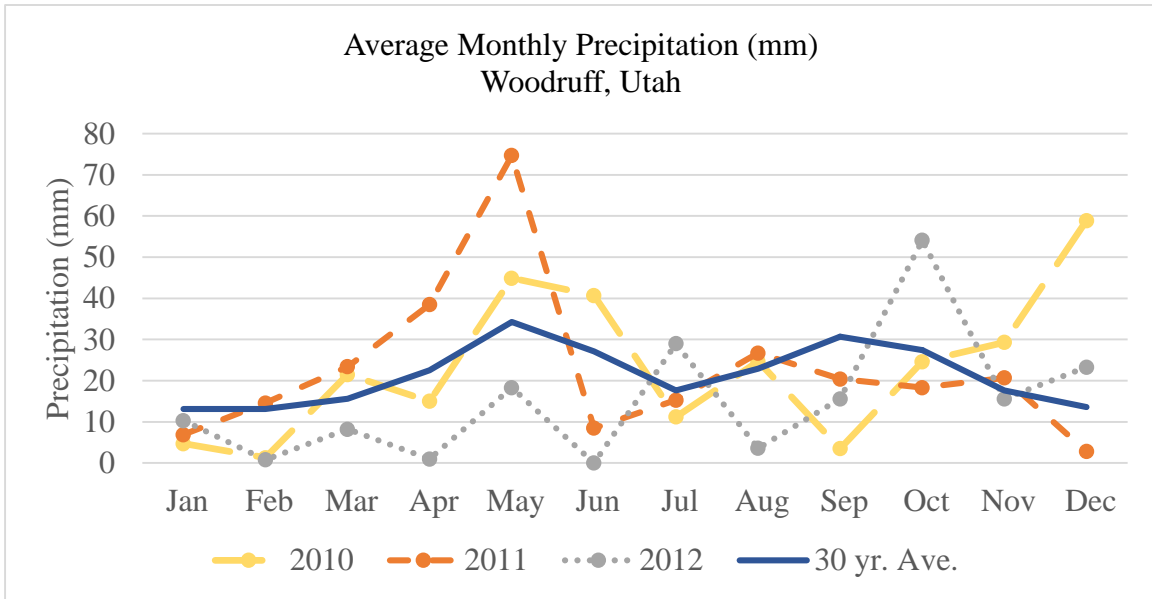
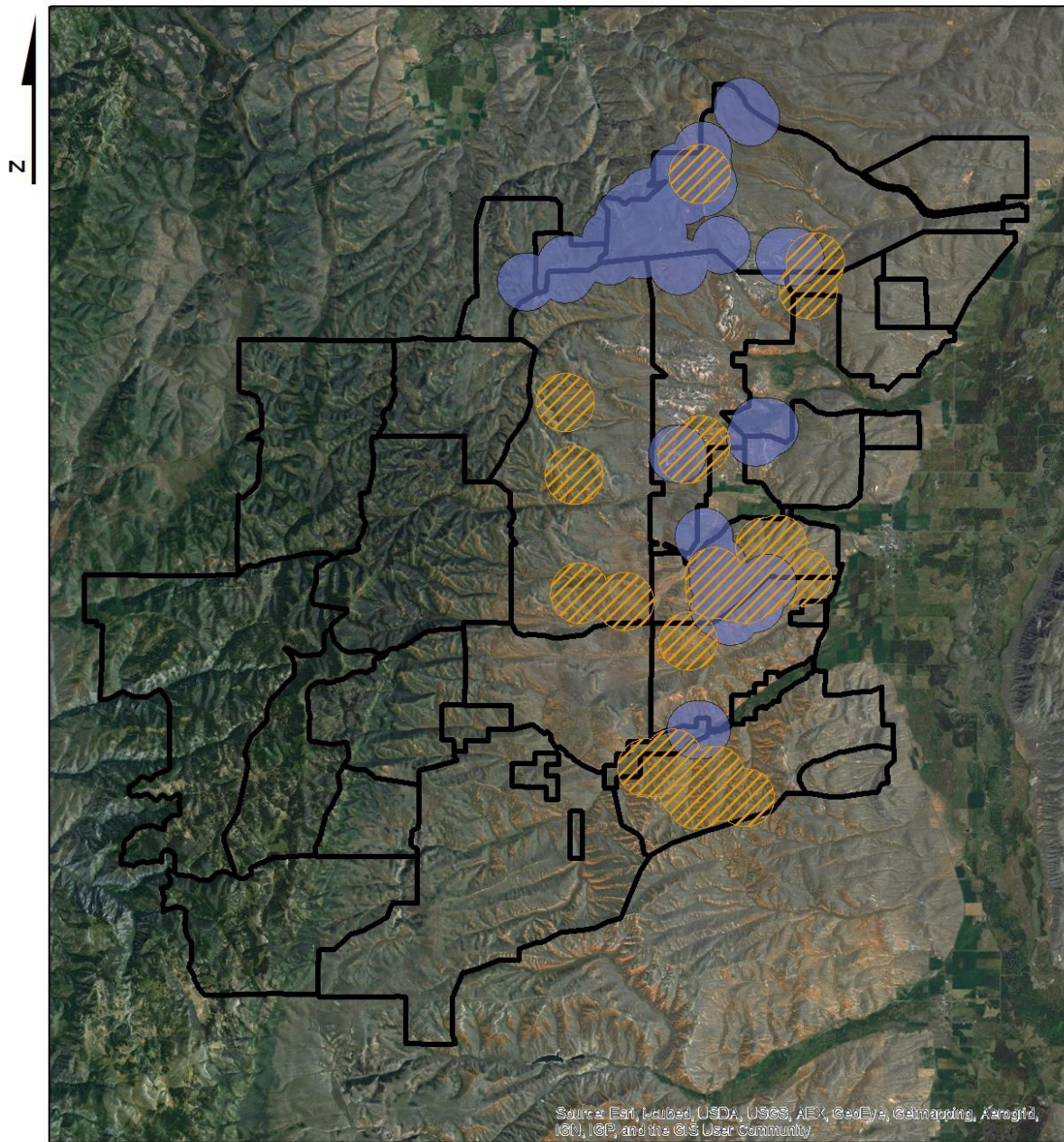


Figure 1. Average 2010-12 monthly precipitation (mm) for Woodruff, Utah.

Both sites exhibit characteristic sagebrush steppe habitats dominated by Wyoming big sagebrush (*A. tridentata wyomingensis*) and an understory of bunchgrass species. Stands of aspen (*Populus tremuloides*), fir (*Abies* spp.), and pine (*Pinus* spp.) are found at higher elevations. Elevation ranges from 1900 to 2600 m. Mean annual precipitation ranges from 250 mm in the lower elevations to 457 mm at higher elevation. Roughly half of this precipitation occurs from December to March (Johnson 1989; Figure 1). Mean temperatures ranged from 28.7° C in July to -6° C in January (Western Regional Climate Center 2012).

The two sites exhibit similar ecological sites and provide nesting, breeding, and wintering habitat for sage-grouse. Approximately, 50% of each study sites affords sage-grouse nesting and breeding habits (Figures 2 and 3).



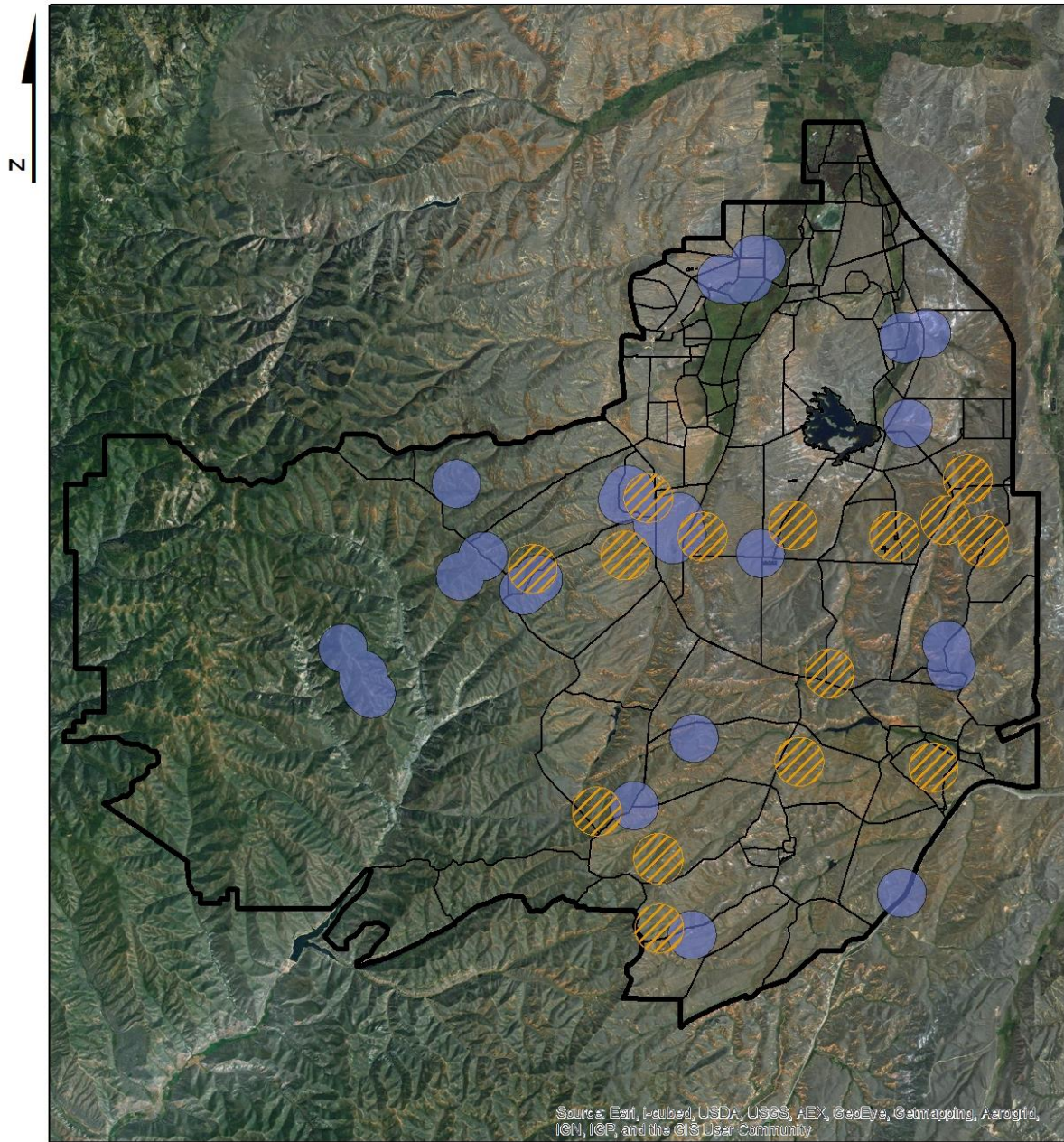
Three Creeks Greater Sage-Grouse Brood and Nesting Habitat

Sage-Grouse Habitat

Nest
 Brood

0 2.5 5 10 Miles

Figure 2. Sage-grouse nesting and brooding areas for Three Creeks Allotment based on sage-grouse known locations 2012-13.



Deseret Greater Sage-Grouse Brood and Nesting Habitat

Sage-Grouse Habitat

-  Nest
-  Brood

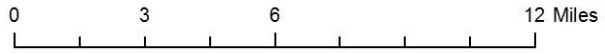


Figure 3. Sage-grouse nesting and brooding areas for Deseret Land and Livestock based on sage-grouse known locations 2012-13.

Methods

Experimental Design

The research project consists of a paired site study. Data on sage-grouse habitat use and vital rates are being collected on the two study sites under current grazing management practices.

Vegetation and Habitat Monitoring

Sage-grouse habitat quality in response to grazing as influenced by environmental conditions in 2012-2013 were assessed using standard vegetation sampling techniques (Robel 1970, Connelly et al. 2003). Because the research focus is hens and their reproductive success, vegetation surveys were based on the location of nesting sites and subsequent brood locations of collared hens. Each vegetation survey location was paired with a random site generated using the 'genconrandompnts' command builder in Geospatial Modeling Environment (GME; Beyer 2012). Each paired random site was located in the same grazing pasture as the nest or brood site. Thus, both sites were exposed similar grazing pressures.

Vegetation surveys were conducted along 4 transects laid out in the cardinal directions. Transect length varied by location type. Nest location transects were 15 m and transects at brood sites were 25 m. The longer transect length at brood sites reflected the larger area of use by broods (Connelly et al. 2003).

We determined canopy cover for all shrub species at each site using measurement techniques based on the canopy line intercept method described by Canfield (1941). The ability of the line intercept method to converge on the actual shrub cover at lower sample sizes when compared to Daubenmire plots makes it a better choice for our sites (Hanley 1978). Measurements included both length of vegetation intercept and height. Because of the open nature of shrub canopies in sagebrush steppe, gaps in foliage that are <5 cm were considered continuous. On transects where 2 species intersect at the same position, only the taller of the 2 species was recorded to avoid overestimation of shrub canopy cover.

We estimated percent forb cover using methods outlined by Daubenmire (1959). Plots were read at 3, 6, 9, 12, and 15 m along each transect at nest sites (n=20/site). Longer transect lengths for brood sites included additional plots at 18 and 21 m (n=28/site). When possible all forbs and grasses within the plot were identified to species level. Specimens that are unidentifiable to species level in the field were recorded as A=annual or P=perennial, G=grass or F=forb and assigned a number based on the sample order (e.g., PF1, PF2). Samples of unidentified species were collected for later identification. The percent cover for each species was assigned using Daubenmire's class system. The use of classes in cover estimations reduces bias and error between observers to a point lower than the normal variation within the site (Daubenmire 1959). Height for each species in the plot was measured using the individual of that species closest to the bottom right corner of the plot. Bare ground, rock, and litter cover was also estimated for each plot.

The mean percentage of cover for species in each plot was calculated using the cover class midpoint (Daubenmire 1959). Percentages for each species was summed for all plots at each

site then divided by total number of plots. The resulting value is used as the estimation of total percentage of cover for each species at that site. Forb mean height was also calculated for each site.

Data Analysis

Vegetation characteristics for use and paired random sites for 2012-13 were summarized by site using Microsoft Access®. Summaries were exported to .csv format for more complex analysis in R. Because the data includes multiple dependent variables a multivariate analysis of variance (MANOVA) test was selected. We tested all measures of vegetation response based on variations of study area, site type, random and actual sites. General summaries were then calculated using the summary function.

Results and Discussion

Overall, mean grass height was higher and total shrub cover lower on DLL at both nest and brood and random sites than Three Creeks (Table 1). Gregg et al. (1995), Guttery (2011) reported that increased grass height was an important habitat parameter affecting nest and brood success. Percent forb, grass, litter and bareground did not differ. Percent forb cover at random nest sites was slightly higher in Three Creeks (7.3%) than DLL (5.3%). However, mean grass height was higher at DLL sites (11.9 cm) than Three Creeks (9.8 cm).

Table 1. Mean percent cover for greater sage-grouse nest and brood sites and paired random sites, Deseret Land and Livestock and Three Creeks Allotment, Rich County, USA, 2012-2013.

	Deseret Land & Livestock				Three Creeks			
	Nest	Paired	Brood	Paired	Nest	Paired	Brood	Paired
%Cover								
Shrub	30.0	26.8	17.7	20.4	29.0	29.8	32.4	28.5
Grass	16.5	13.0	21.8	14.2	16.0	15.5	18.7	12.3
Forb	5.4	5.3	9.3	7.4	7.2	7.3	9.4	8.2
Litter	73.0	70.0	75.0	74.5	70.4	72.8	72.9	65.5
Bare Ground	21.3	24.2	19.4	22.3	16.5	19.2	17.7	22.4
Height (cm)								
Shrub								
Grass	11.8	11.8	12.2	12.5	9.5	9.7	11.5	10.6
Forb	4.6	4.5	5.8	6.0	4.2	4.6	5.6	5.0
Robel (cm)	57.2	49.4			58.1	49.0		

Random and actual nest sites within respective study areas did not differ for the other vegetation parameter measured. We applied the same test using brood sites and found that in DLL grass height was slightly lower (12.2cm vs. 12.5cm) at actual brood sites compared to random brood sites, but higher than Three Creeks. In Three Creeks brood sites varied by grass cover with actual sites having higher grass cover (18.7% vs. 12.3%) than random sites.

Differences between study areas in grass heights at both random and actual nesting sites suggests that DLL has greater grass heights overall compared to Three Creeks. However, there was no evidence that sage-grouse are selecting areas with greater grass heights for nesting. Greater grass heights may provide more nesting cover for hens. But when we compared Robel measurements, a measure of visual obstruction, no significant differences were apparent between study areas. Looking at brood locations on DLL did show that grass height was significantly greater in areas that broods were located. For Three Creeks this was true for grass and litter cover.

Actual brood locations showed differences in total shrub cover between sites. Shrub cover in DLL was near 18% while cover at similar sites in Three Creeks were nearer 32%. Analysis between random and actual brood sites within DLL found no difference in shrub cover. This might suggest that shrub cover is generally less in DLL compared to Three Creeks but that broods aren't necessarily selecting for those areas of lower shrub cover.

With 2 more years of data collection planned for the study sample size will increase and help us illuminate potential differences in sage-grouse vital rates in response to vegetation conditions currently not possible with our current data.

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Appendix A.

2012-13 VEGETATION DATA ANALYSIS RESULTS

-- MANOVA Results for Actual Nest Sites by Study Area --

Response ShrubCover :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	1.9	1.911	0.0112	0.9164
Residuals	43	7365.1	171.282		

Response ForbHeight :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	2.417	2.4169	1.0289	0.3161
Residuals	43	101.002	2.3489		

Response ForbCover :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	25.226	25.2261	3.9169	0.05423 .
Residuals	43	276.931	6.4403		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Response GrassHeight :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	56.88	56.877	6.7476	0.0128 *
Residuals	43	362.45	8.429		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Response GrassCover :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	0.9	0.887	0.0048	0.9449
Residuals	43	7906.5	183.873		

Response Litter :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	114.3	114.32	0.3576	0.553
Residuals	43	13747.1	319.70		

Response Bare :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	193.6	193.61	1.0811	0.3043
Residuals	43	7700.8	179.09		

Response Rock :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	21.87	21.869	0.3145	0.5778
Residuals	43	2990.08	69.537		

Response RobelAve :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	9.2	9.17	0.0228	0.8807
Residuals	44	17713.3	402.57		

-- MANOVA Results for Actual Brood Sites by Study Area --

Response ShrubCover :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	4687.2	4687.2	27.546	9.472e-07 ***
Residuals	94	15994.9	170.2		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Response ForbHeight :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	1.06	1.0630	0.1996	0.6561
Residuals	94	500.72	5.3268		

Response ForbCover :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	0.23	0.2302	0.0113	0.9155
Residuals	94	1910.52	20.3247		

Response GrassHeight :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	10.47	10.470	0.7627	0.3847
Residuals	94	1290.53	13.729		

Response GrassCover :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	205.9	205.95	0.9197	0.34
Residuals	94	21049.5	223.93		

Response Litter :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	147.6	147.59	0.5207	0.4723
Residuals	94	26642.6	283.43		

Response Bare :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	32.7	32.662	0.1933	0.6612
Residuals	94	15881.6	168.953		

Response Rock :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	30.4	30.427	0.505	0.4791
Residuals	94	5663.7	60.252		

-- MANOVA Results for Random/Actual Nest Sites in Deseret --

Response ShrubCover :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Rand_Act	1	103.9	103.92	0.5904	0.4473
Residuals	36	6336.1	176.00		

Response ForbHeight :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Rand_Act	1	0.186	0.1862	0.0782	0.7814
Residuals	36	85.723	2.3812		

Response ForbCover :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Rand_Act	1	0.055	0.05457	0.0211	0.8852
Residuals	36	92.910	2.58083		

Response GrassHeight :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Rand_Act	1	0.00	0.0002	0	0.9969
Residuals	36	391.26	10.8683		

Response GrassCover :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Rand_Act	1	111.8	111.83	0.5368	0.4685
Residuals	36	7500.5	208.35		

Response Litter :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Rand_Act	1	65.1	65.133	0.2886	0.5944
Residuals	36	8123.5	225.651		

Response Bare :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Rand_Act	1	80.3	80.302	0.4695	0.4976
Residuals	36	6157.0	171.029		

Response Rock :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Rand_Act	1	0.39	0.3921	0.0194	0.89
Residuals	36	727.97	20.2215		

-- MANOVA Results for Random/Actual Nest Sites in Three Creeks --

Response ShrubCover :
Df Sum Sq Mean Sq F value Pr(>F)
Rand_Act 1 4.7 4.692 0.0372 0.8479
Residuals 50 6311.3 126.226

Response ForbHeight :
Df Sum Sq Mean Sq F value Pr(>F)
Rand_Act 1 2.024 2.0244 0.8229 0.3687
Residuals 50 123.008 2.4602

Response ForbCover :
Df Sum Sq Mean Sq F value Pr(>F)
Rand_Act 1 1.25 1.2493 0.1153 0.7356
Residuals 50 541.90 10.8380

Response GrassHeight :
Df Sum Sq Mean Sq F value Pr(>F)
Rand_Act 1 0.79 0.7926 0.125 0.7252
Residuals 50 317.04 6.3409

Response GrassCover :
Df Sum Sq Mean Sq F value Pr(>F)
Rand_Act 1 8.9 8.856 0.1176 0.7331
Residuals 50 3765.6 75.313

Response Litter :
Df Sum Sq Mean Sq F value Pr(>F)
Rand_Act 1 108.6 108.58 0.3391 0.563
Residuals 50 16008.3 320.17

Response Bare :
Df Sum Sq Mean Sq F value Pr(>F)
Rand_Act 1 75.3 75.264 0.4099 0.525
Residuals 50 9181.3 183.626

Response Rock :
Df Sum Sq Mean Sq F value Pr(>F)
Rand_Act 1 33.3 33.296 0.4299 0.5151
Residuals 50 3872.8 77.456

-- MANOVA Results for Random/Actual Brood Sites in Deseret --

Response ShrubCover :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Rand_Act	1	85.3	85.308	0.5208	0.4725
Residuals	85	13921.9	163.787		

Response ForbHeight :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Rand_Act	1	1.47	1.4748	0.1812	0.6714
Residuals	85	691.66	8.1371		

Response ForbCover :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Rand_Act	1	83.12	83.121	3.7988	0.05459 .
Residuals	85	1859.85	21.881		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Response GrassHeight :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Rand_Act	1	2.08	2.0772	0.1335	0.7158
Residuals	85	1322.86	15.5630		

Response GrassCover :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Rand_Act	1	1220.4	1220.41	8.4735	0.0046 **
Residuals	85	12242.3	144.03		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Response Litter :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Rand_Act	1	17.7	17.73	0.1135	0.737
Residuals	85	13275.4	156.18		

Response Bare :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Rand_Act	1	247.7	247.75	1.6391	0.2039
Residuals	85	12847.7	151.15		

Response Rock :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Rand_Act	1	108.5	108.486	2.3297	0.1306
Residuals	85	3958.2	46.567		

-- MANOVA Results for Random/Actual Brood Sites in Three Creeks --

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Response ShrubCover :
      Df  Sum Sq Mean Sq F value Pr(>F)
Rand_Act  1   413.1  413.09  1.8369 0.1783
Residuals 103 23163.0  224.88

Response ForbHeight :
      Df  Sum Sq Mean Sq F value Pr(>F)
Rand_Act  1    9.75  9.7465  2.5506 0.1133
Residuals 103 393.59  3.8213

Response ForbCover :
      Df  Sum Sq Mean Sq F value Pr(>F)
Rand_Act  1   38.12  38.120  2.7245 0.1019
Residuals 103 1441.17  13.992

Response GrassHeight :
      Df  Sum Sq Mean Sq F value Pr(>F)
Rand_Act  1   24.07  24.073  2.3089 0.1317
Residuals 103 1073.89  10.426

Response GrassCover :
      Df  Sum Sq Mean Sq F value Pr(>F)
Rand_Act  1  1097.1 1097.08  7.4843 0.007331 **
Residuals 103 15098.1  146.58
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Response Litter :
      Df  Sum Sq Mean Sq F value Pr(>F)
Rand_Act  1  1425 1424.93  4.4043 0.03829 *
Residuals 103  33324  323.53
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Response Bare :
      Df  Sum Sq Mean Sq F value Pr(>F)
Rand_Act  1   577.8  577.83  2.5661 0.1122
Residuals 103 23193.7  225.18

Response Rock :
      Df  Sum Sq Mean Sq F value Pr(>F)
Rand_Act  1    935  935.02  9.0838 0.003247 **
Residuals 103 10602  102.93
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

-- Random Brood Sites by Study Area --

Response ShrubCover :
Df Sum Sq Mean Sq F value Pr(>F)
Rand_Act 1 413.1 413.09 1.8369 0.1783
Residuals 103 23163.0 224.88

Response ForbHeight :
Df Sum Sq Mean Sq F value Pr(>F)
Rand_Act 1 9.75 9.7465 2.5506 0.1133
Residuals 103 393.59 3.8213

Response ForbCover :
Df Sum Sq Mean Sq F value Pr(>F)
Rand_Act 1 38.12 38.120 2.7245 0.1019
Residuals 103 1441.17 13.992

Response GrassHeight :
Df Sum Sq Mean Sq F value Pr(>F)
Rand_Act 1 24.07 24.073 2.3089 0.1317
Residuals 103 1073.89 10.426

Response GrassCover :
Df Sum Sq Mean Sq F value Pr(>F)
Rand_Act 1 1097.1 1097.08 7.4843 0.007331 **
Residuals 103 15098.1 146.58

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Response Litter :
Df Sum Sq Mean Sq F value Pr(>F)
Rand_Act 1 1425 1424.93 4.4043 0.03829 *
Residuals 103 33324 323.53

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Response Bare :
Df Sum Sq Mean Sq F value Pr(>F)
Rand_Act 1 577.8 577.83 2.5661 0.1122
Residuals 103 23193.7 225.18

Response Rock :
Df Sum Sq Mean Sq F value Pr(>F)
Rand_Act 1 935 935.02 9.0838 0.003247 **
Residuals 103 10602 102.93

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

-- Random Nest Sites by Study Area --

Response ShrubCover :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	57.5	57.536	0.4684	0.4974
Residuals	43	5282.3	122.845		

Response ForbHeight :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	0.047	0.04696	0.0187	0.8917
Residuals	43	107.730	2.50534		

Response ForbCover :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	39.70	39.700	4.77	0.03446 *
Residuals	43	357.88	8.323		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Response GrassHeight :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	45.02	45.018	5.5972	0.02257 *
Residuals	43	345.85	8.043		

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Response GrassCover :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	59.2	59.157	0.7572	0.3891
Residuals	43	3359.6	78.130		

Response Litter :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	57.1	57.133	0.2366	0.6292
Residuals	43	10384.7	241.505		

Response Bare :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	242.6	242.59	1.3658	0.249
Residuals	43	7637.6	177.62		

Response Rock :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	0.0	0.002	1e-04	0.9939
Residuals	43	1610.7	37.458		

Response RobelAve :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
StudyArea	1	1.5	1.54	0.0025	0.9605
Residuals	42	26038.9	619.97		

Appendix B.

Summary Results Random Nest Sites Deseret

	ShrubCover	ForbHeight	ForbCover	GrassHeight	GrassCover	Litter	Bare	Rock
Min.	:14.35	:2.320	:2.890	:6.680	:3.83	:41.75	:5.75	:0.000
1st Qu.	:18.95	:3.420	:3.880	:9.105	:7.28	:59.75	:14.44	:0.620
Median	:24.80	:4.650	:5.090	:11.820	:9.65	:69.37	:26.37	:2.500
Mean	:26.76	:4.494	:5.289	:11.777	:13.07	:70.25	:24.23	:3.946
3rd Qu.	:33.20	:5.355	:5.930	:13.645	:17.18	:79.75	:31.62	:4.000
Max.	:47.33	:6.600	:9.730	:17.030	:42.87	:91.37	:47.00	:17.500

Summary Results Random Nest Sites Three Creeks

	ShrubCover	ForbHeight	ForbCover	GrassHeight	GrassCover	Litter	Bare	Rock
Min.	:4.33	:2.160	:3.000	:5.870	:4.95	:43.50	:0.62	:0.000
1st Qu.	:23.07	:3.422	:4.705	:8.102	:10.00	:60.31	:5.81	:0.560
Median	:29.25	:3.830	:6.760	:9.085	:13.62	:71.62	:14.25	:2.500
Mean	:29.81	:4.560	:7.334	:9.752	:15.47	:72.81	:19.22	:3.832
3rd Qu.	:38.47	:5.043	:9.435	:11.180	:17.18	:88.38	:28.38	:3.435
Max.	:57.46	:10.520	:18.500	:17.190	:35.00	:97.50	:46.37	:34.120

Summary Results Actual Nest Sites Deseret

	ShrubCover	ForbHeight	ForbCover	GrassHeight	GrassCover	Litter	Bare	Rock	Robel
Min.	:12.86	:2.040	:2.500	:6.22	:2.500	:45.25	:5.62	:0.00	:10.0
1st Qu.	:16.62	:3.585	:4.520	:9.33	:5.465	:56.19	:9.81	:2.13	:32.5
Median	:28.90	:4.080	:5.380	:12.52	:9.310	:80.12	:13.50	:2.50	:56.3
Mean	:30.06	:4.634	:5.365	:11.78	:16.497	:72.87	:21.32	:4.15	:53.2
3rd Qu.	:39.56	:5.680	:6.385	:14.26	:14.705	:85.81	:33.88	:5.75	:68.8
Max.	:70.98	:8.370	:7.800	:16.57	:67.120	:94.37	:48.25	:14.37	:101

Summary Results Actual Nest Sites Three Creeks

	ShrubCover	ForbHeight	ForbCover	GrassHeight	GrassCover	Litter	Bare	Rock	Robel
Min.	:8.05	:2.030	:2.500	:4.950	:3.15	:27.62	:0.250	:0.00	:16.3
1st Qu.	:22.27	:3.192	:4.215	:7.640	:10.74	:54.75	:6.185	:1.19	:36.3
Median	:29.40	:3.890	:6.530	:8.895	:13.47	:71.61	:13.750	:2.50	:51.3
Mean	:29.08	:4.165	:7.151	:9.505	:16.06	:70.43	:16.496	:5.35	:53.8
3rd Qu.	:36.13	:5.065	:9.355	:11.105	:19.57	:85.44	:26.185	:3.81	:66.3
Max.	:57.50	:6.820	:16.190	:14.760	:46.07	:95.62	:43.370	:52.1	:107

Summary Results Random Brood Sites Deseret

	ShrubCover	ForbHeight	ForbCover	GrassHeight	GrassCover	Litter	Bare	Rock
Min.	:0.00	:1.710	:2.500	:3.00	:2.500	:41.07	:2.94	:0.000
1st Qu.	:10.78	:3.955	:4.220	:9.89	:6.715	:67.28	:13.74	:1.380
Median	:20.57	:5.080	:6.320	:12.37	:12.810	:75.62	:20.17	:2.500
Mean	:20.40	:6.038	:7.359	:12.48	:14.177	:74.49	:22.25	:3.676
3rd Qu.	:27.73	:7.845	:8.965	:15.18	:20.330	:83.03	:29.59	:4.460
Max.	:55.80	:14.680	:24.680	:19.74	:30.370	:96.60	:56.51	:21.690

Summary Results Random Brood Sites Three Creeks

	ShrubCover	ForbHeight	ForbCover	GrassHeight	GrassCover	Litter	Bare	Rock
Min.	:0.18	:1.640	:2.500	:3.59	:2.50	:32.14	:0.62	:0.26
1st Qu.	:16.66	:3.680	:6.120	:8.27	:6.21	:54.37	:7.94	:2.50
Median	:29.55	:4.890	:7.740	:11.15	:8.55	:64.28	:19.01	:5.08
Mean	:28.47	:4.957	:8.207	:10.55	:12.26	:65.54	:22.40	:10.75
3rd Qu.	:39.78	:6.000	:10.160	:12.69	:18.51	:79.10	:32.32	:13.12
Max.	:69.59	:10.090	:18.020	:19.85	:30.98	:93.57	:54.46	:52.32

Summary Results Actual Brood Sites Deseret

	ShrubCover	ForbHeight	ForbCover	GrassHeight	GrassCover	Litter	Bare	Rock
Min.	:0.00	:1.500	:2.500	:6.61	:5.23	:45.08	:0.350	:0.000
1st Qu.	:7.64	:3.900	:5.710	:9.64	:12.16	:67.69	:8.943	:0.080
Median	:17.49	:5.020	:8.750	:11.16	:19.43	:73.28	:15.975	:2.500
Mean	:17.72	:5.778	:9.314	:12.16	:21.84	:75.04	:19.396	:5.825
3rd Qu.	:27.05	:7.558	:11.852	:13.89	:27.43	:86.76	:27.117	:9.260
Max.	:61.69	:13.770	:21.960	:27.37	:74.00	:97.50	:49.010	:49.910

Summary Results Actual Brood Sites Three Creeks

	ShrubCover	ForbHeight	ForbCover	GrassHeight	GrassCover	Litter	Bare	Rock
Min.	:0.00	:2.580	:2.860	:5.330	:4.060	:30.17	:0.00	:0.000
1st Qu.	:25.17	:4.098	:6.235	:9.398	:7.567	:58.28	:6.94	:1.333
Median	:35.02	:5.210	:8.855	:11.695	:12.870	:79.91	:13.88	:2.500
Mean	:32.44	:5.567	:9.412	:11.507	:18.729	:72.91	:17.70	:4.779
3rd Qu.	:42.08	:7.115	:12.113	:13.420	:23.260	:90.10	:26.53	:4.730
Max.	:56.98	:10.060	:21.390	:19.700	:65.260	:97.50	:50.89	:36.070