C/025/005 Incoming
CC! Lisa #5356

Alton Coal Development, LLC
463 North 100 West, Suite 1
Cedar City, Utah 84720
Phone (435) 867-5331 • Fax (435) 867-1192

January 18, 2017

Daron R. Haddock
Coal Program Manager
Oil, Gas & Mining
1594 West North Temple, Suite 1210
Salt Lake City, UT 84114-5801

Subject: **ACD 2016 Progress Report, Alton Coal Development, LLC, Coal Hollow Mine, Kane County, Utah, C/025/0005,**

Dear Mr. Haddock,

Alton Coal Development, LLC is submitting the Annual 2016 "Greater Sage-grouse Population Monitoring and Habitat Improvement" report.

Changes to the MRP associated with this amendment have been uploaded to the DOGM's server for review. Upon approval, 2 (two) clean hard copies of the text for insertion into the MRP will be submitted. Please do not hesitate to contact me if you have any questions 435-691-1551.

Sincerely

B. Kirk Nicholes

B. Kirk Nicholes
Environmental Specialist

RECEIVED
FEB 02 2017
DIV. OF OIL, GAS & MINING

APPLICATION FOR COAL PERMIT PROCESSING

Permit Change ☒ New Permit ☐ Renewal ☐ Exploration ☐ Bond Release ☐ Transfer ☐

Permittee: Alton Coal Development, LLC
Mine: Coal Hollow Mine **Permit Number:** C/025/0005
Title: 2016 Greater Sage-grouse Population Monitoring and Habitat Improvement
Description, Include reason for application and timing required to implement:

Instructions: If you answer yes to any of the first eight questions, this application may require Public Notice publication.

☐ Yes ☒ No 1. Change in the size of the Permit Area? Acres: _____ Disturbed Area: _____ ☐ increase ☐ decrease.
☐ Yes ☒ No 2. Is the application submitted as a result of a Division Order? DO# _____
☐ Yes ☒ No 3. Does the application include operations outside a previously identified Cumulative Hydrologic Impact Area?
☐ Yes ☒ No 4. Does the application include operations in hydrologic basins other than as currently approved?
☐ Yes ☒ No 5. Does the application result from cancellation, reduction or increase of insurance or reclamation bond?
☐ Yes ☒ No 6. Does the application require or include public notice publication?
☐ Yes ☒ No 7. Does the application require or include ownership, control, right-of-entry, or compliance information?
☐ Yes ☒ No 8. Is proposed activity within 100 feet of a public road or cemetery or 300 feet of an occupied dwelling?
☐ Yes ☒ No 9. Is the application submitted as a result of a Violation? NOV # _____
☐ Yes ☒ No 10. Is the application submitted as a result of other laws or regulations or policies?
Explain: _____
☐ Yes ☒ No 11. Does the application affect the surface landowner or change the post mining land use?
☐ Yes ☒ No 12. Does the application require or include underground design or mine sequence and timing? (Modification of R2P2)
☐ Yes ☒ No 13. Does the application require or include collection and reporting of any baseline information?
☐ Yes ☒ No 14. Could the application have any effect on wildlife or vegetation outside the current disturbed area?
☐ Yes ☒ No 15. Does the application require or include soil removal, storage or placement?
☐ Yes ☒ No 16. Does the application require or include vegetation monitoring, removal or revegetation activities?
☐ Yes ☒ No 17. Does the application require or include construction, modification, or removal of surface facilities?
☐ Yes ☒ No 18. Does the application require or include water monitoring, sediment or drainage control measures?
☐ Yes ☒ No 19. Does the application require or include certified designs, maps or calculation?
☐ Yes ☒ No 20. Does the application require or include subsidence control or monitoring?
☐ Yes ☒ No 21. Have reclamation costs for bonding been provided?
☐ Yes ☒ No 22. Does the application involve a perennial stream, a stream buffer zone or discharges to a stream?
☐ Yes ☒ No 23. Does the application affect permits issued by other agencies or permits issued to other entities?
☐ Yes ☒ No 24. Does the application include confidential information and is it clearly marked and separated in the plan?

Please attach three (3) review copies of the application. If the mine is on or adjacent to Forest Service land please submit four (4) copies, thank you. (These numbers include a copy for the Price Field Office)

I hereby certify that I am a responsible official of the applicant and that the information contained in this application is true and correct to the best of my information and belief in all respects with the laws of Utah in reference to commitments, undertakings, and obligations, herein.

B. Kirk Nicholes	Environmental Specialist	01/18/2016	B. Kirk Nicholes
Print Name	Position	Date	Signature (Right-click above choose certify then have notary sign below)

Subscribed and sworn to before me this 19 day of Jan, 2017

Notary Public: Marty Nicholes, state of Utah.

My commission Expires: 9-11-2017
Commission Number: 670359
Address: 1670 E Millstone Cir
City: Enoch State: UT Zip: 84721

Notary Public
MARTY NICHOLES
Commission #670359
My Commission Expires
Sept 11, 2017
State of Utah

For Office Use Only:	Assigned Tracking Number:	Received by Oil, Gas & Mining
		RECEIVED FEB 02 2017 DIV. OF OIL, GAS & MINING

APPLICATION FOR COAL PERMIT PROCESSING
Detailed Schedule Of Changes to the Mining And Reclamation Plan

Permittee: Alton Coal Development, LLC
Mine: Coal Hollow Mine
Title: 2016 Greater Sage-grouse Population Monitoring and Habitat Improvement
Permit Number: C/025/0005

Provide a detailed listing of all changes to the Mining and Reclamation Plan, which is required as a result of this proposed permit application. Individually list all maps and drawings that are added, replaced, or removed from the plan. Include changes to the table of contents, section of the plan, or other information as needed to specifically locate, identify and revise the existing Mining and Reclamation Plan. Include page, section and drawing number as part of the description.

			DESCRIPTION OF MAP, TEXT, OR MATERIAL TO BE CHANGED
☒ Add	☐ Replace	☐ Remove	MRP Vol. 2, Chapter 3, End of Appendix 3-6
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	
☐ Add	☐ Replace	☐ Remove	

Any other specific or special instruction required for insertion of this proposal into the Mining and Reclamation Plan.	Received by Oil, Gas & Mining
	RECEIVED FEB 02 2017 DIV. OF OIL, GAS & MINING

Greater Sage-grouse Population Monitoring and Habitat Improvement

Alton - Sink Valley, Utah

Progress Report

For

Alton Coal Development, LLC

December 26, 2016

INCORPORATED

FEB 03 2017

Div. of Oil, Gas & Mining

Prepared by
Steven L. Petersen, Ph.D.
Sage-grouse Population and Habitat Consultant

RECEIVED

FEB 02 2017

DIV. OF OIL, GAS & MINING

Greater Sage-grouse Population Monitoring and Habitat Improvement Alton – Sink Valley, Utah

Progress Report for Year 2015-2016

Steven L. Petersen, Ph.D., Consultant

Introduction and Background

The Alton/Sink Valley area, located in southcentral Utah, is home to the citizens of a thriving local community and is habitat to a diversity of plant and animal species. One species, the greater sage-grouse (*Centrocercus urophasianus*), has lived in this area for decades, sharing this landscape with ranchers, farmers, and recreationists. In 2010, Alton Coal Development (ACD) initiated mining operations in Sink Valley, extracting and exporting coal for energy production in Delta, Utah.

The conservation of greater sage-grouse in the Alton/Sink Valley area continues to be a high priority for ACD. The local sage-grouse population has remained stable throughout the life of the mine, and extensive work is done to ensure healthy sagebrush habitats. In comparison to challenges managers often face with declining sage-grouse populations speices-wide, the Sink Valley population is one of the few that have been able to demonstrate long-term population stability (Boyd et al. 2010, Petersen et al. 2016). Habitat management goals and improvements have included the reclamation of mine-related disturbances (including the historic lek), removing pinyon-juniper trees to extend sagebrush communities and increase habitat use potential (Baruch-Mordo et al. 2013, Braun et al. 1977, Doherty et al. 2008), and controlling sage-grouse predator species (i.e. ravens and coyotes).

A summary of the specific sage-grouse population monitoring and habitat conservation accomplishments for 2015-2016 include the following.

1. During non-breeding months, birds were consistently observed in the Sink Valley area, primarily in the sagebrush fields and bullhogged area southwest of the mine.
2. In October, 53 birds were observed in the mine area, the highest reported during any monthly survey in 2016.
3. ACD employees made 54 observations of birds within the immediate mining area, including inside mining pits and trenches.
4. DWR reported 15 strutting males in spring 2016. This is the highest reported lek count since 2001.
5. Reclaimed areas following the completion of mining activities in the south valley (historic lek area). Seeded plants included native and introduced grasses and forbs. Shrubs (i.e. big

and black sagebrush) are establishing within these reclaimed sites, resulting in early succession of potential sagebrush dominated communities.

6. Wildlife Services removed approximately 158 ravens and 3 coyotes.

Report Objectives

The purpose of this report is to present the accomplishments and sage-grouse conservation efforts that were completed during the 2015-2016 period (described above). This includes results of the sage-grouse monitoring program, data collection and assessment of reclamation efforts, additional habitat improvements, and predator control.

Table of Contents

Introduction and Background 2

Report Objectives 3

Table of Contents 3

1. Sage-grouse Population Monitoring 4

1.1 Employee Observations and Sage-grouse Population Monitoring 4

1.2 Sage-grouse Surveys 9

1.3 GPS Collaring and Monitoring 13

1.4 Historic and Current Lek use in Alton/Sink Valley 17

1.5 Manuscript production and publication 18

1.6 Noise Detection and Sound Assessment 18

2. Habitat Mitigation and Improvements 18

2.1 Reclamation Response 18

2.2 Juniper Mastication 22

3. Predator Control Activities 23

3.1 Raven Control 23

4. Participation and Involvement with Local Working Groups 26

References 26

Acknowledgements 26

INCORPORATED

FEB 03 2017

Div. of Oil, Gas & Mining

1. Sage-grouse Population Monitoring

1.1 Employee Observations and Sage-grouse Population Monitoring

During the year, ACD employees report any sightings of sage-grouse observed within the mining area. These observations are reported to Kirk Nicholes, ACD Environmental Manager, who keeps a log of all observations. Typical observations include sightings along roadsides, within mine sites and disturbed areas, and near ponds.

All ACD employee observations are casual (employees are not charged to survey for birds). While sighting locations may suggest spatio-temporal seasonal variability in sage-grouse occurrence within the mine footprint, variability in observations may be a result of heightened awareness by employees rather than an increase in bird use activity or density.

Of special note, employees frequently observed males strutting with females present within and surrounding the reclaimed historic Lek. The highest number of birds observed near the reclaimed historic lek was 12 males and 12 females.

ACD mine employee are trained in sage-grouse conservation strategies, and how to identify sage-grouse from other bird species. When reported, Kirk determines the exact location where birds were observed and identifies the coordinate location for that observation. The results of these sightings are used to assess population patterns and trends within the mining area (Table 1, Figure 1). This information is used to assess habitat use patterns.

INCORPORATED

FEB 03 2017

Div. of Oil, Gas & Mining

Table 1. Observations of sage-grouse reported by ACD employees between October 2015 and December 2016 within the Alton/Sink Valley region.

Obs ID	Date	Time of observation	Number of birds Observed	Location	State Plane Coordinates
1	Oct. 13, 2015	8:00 am	4	Observed east of the highwall trench backfilling operation (Scott C.)	351029 E 1768930 N
2	Oct. 14, 2015	11:00 am	7	Observed at base of subsoil stockpile from the excess spoils (Scott C.)	354724 E 1768190 N
3	Oct. 26, 2015	8:00 am	15	Crew observed 15 in field south of the excess spoils pile (Riley A.)	352591 E 1766302 N
4	Oct. 27, 2015	9:25 am	20	Observed in field south of the excess spoils pile (Scott C.)	352585 E 1766233 N
5	Oct. 28, 2015	7:35 am	17	Observed at northwest side of the new lek area (Cody M.)	351500 E 1765033 N
6	Nov. 3, 2015	7:30 am	4	Observed on haul road to spoils pile (Cody M.)	353674 E 1767438 N
7	Nov. 11, 2015	8:45 am	4	Observed north of topsoil stockpile #4 (Davey J.)	354630 E 1768868 N
8	Nov. 24, 2015	10:45 am	2	Observed at the wildlife exclosure fence. Birds flew to the west (Larry J.)	364563 E 1762222 N
9	Jan. 9, 2016	11:30 am	16	Observed between pit #10 and Robinson Creek (Riley A.)	353782 E 1768066 N
10	Jan 12, 2016	8:10 am	18	Observed between pit #10 and Robinson Creek (Riley A.)	353711 E 1768066 N
11	Jan. 13, 2016	7:43 am	25	Observed between pit #10 and Robinson Creek, down in snow (Scott C.)	353809 E 1767725 N
12	Jan. 18, 2016	8:00 am	16	Observed at CHM excess spoils pile (Riley A.)	357879 E 1766283 N
13	Jan. 19, 2016	9:00 am	20	Observed in the reclamation area below the haul road (Larry J.)	354473 E 1767888 N
14	Jan. 25, 2016	5:30 am	3	Observed at CHM excess spoils pile by a parked loader (Davey J.)	352919 E 1765910 N
15	Feb. 2, 2016	3:52 pm	25	Flying from subsoil stockpile #2 over the lower portion of Robinson Creek (Rod R.)	354652 E 1768231 N
16	Feb. 8, 2016	10:00 am	25	Observed flying over the excess spoils pile (ACD)	352975 E 1766077 N
17	Feb. 9, 2016	10:00 am	25	Observed flying over the excess spoils pile (ACD)	352905 E 1766101 N
18	Feb. 10, 2016	10:10 am	25	Observed flying over the excess spoils pile (ACD)	352975 E 1766111 N
19	Feb. 12, 2016	10:00 am	15	Observed south of pit #10 (Joe K.)	353397 E 1765774 N
20	Feb. 16, 2016	5:00 pm	20	Observed at Red Dog Hill (Jack K.)	353397 E 1765774 N
21	Feb. 17, 2016	7:46 am	4	Observed at the east entrance of pit #10 (Rod R.)	354176 E 1768415 N
22	Feb. 23, 2016	7:15 am	6	Observed at the southeast side of subsoil pile #2 (Davey J.)	354582 E 1768256 N

INCORPORATED
FEB 03 2017
Div. of Oil, Gas & Mining

Table 1 (*continued*).

Obs ID	Date	Time of observation	# of birds Observed	Location	UTM Coordinates
24	Feb. 29, 2016	6:40 am	8	Observed between Robinsons Creek and the county road (Riley A.)	354582 E 1767883 N
25	Mar. 7, 2016	6:40 am	8	Observed on the reclaimed area by ditch #4 (where the berm runs east-west) (Riley A.)	353903 E 1766698 N
26	Mar. 11, 2016	10:44 am	2	Observed between the southwest corner of NPL Area 1 (Drew C.)	362311 E 1762039 N
27	Mar. 16, 2016	6:25 am	6	Observed between the subsoil and topsoil stockpile (Riley A.)	355606 E 1760506 N
28	Mar. 17, 2016	8:30 am	20	Observed birds on both sides of Dames Road (Cody M.)	350135 E 1768675 N
29	Mar. 17, 2016	8:30 am	10	Observed where pipe comes from pit #10 (Cody M.).	353748 E 1768126 N
30	Mar. 18, 2016	8:40 am	24	12 male strutting, 12 females historic lek N. of Dame Road (Joe K.)	350388 E 1768447 N
31	Mar. 24, 2016	7:49 am	2	Males strutting at the reclamation site on pit #10 (Riley A.)	353672 E 1768119 N
32	Mar. 24, 2016	9:05 am	12	Flyover at UG laydown going east into juniper trees (Larry J.)	355676 E 1768767 N
33	Mar. 29, 2016	7:42 am	4	Males on west side of county road, west of pit #10 (Davey J.)	353643 E 1767868 N
34	April 1, 2016	1:00 pm	8	One hen and 7 chicks at the well site (Kirk N.)	353504 E 1770240 N
35	April 2, 2016	6:56 am	4	3 males and 1 hen observed south of HWT, north of Dame road. Noise from truck, dozer, and loader at HWT backfill (59-61 Htz). Males flush. (Kirk N.)	350388 E 1768447 N
36	April 2, 2016	7:13 am	2	Females, fly over HWT activity (Kirk N.)	350317 E 1768438 N
37	April 2, 2016	7:29 am	3	Hens flushed from reclaim site south of Dames road. Activity at HWT: truck and loader (60-61 Htz), wind 0-3 mph. (Kirk N.)	350317 E 1768438 N
38	April 27, 2016	7:45 am	2	Males at intersection of Dames road and the county road (Kirk N.)	349918 E 1768307 N
39	May 11, 2016	8:00 am	13	Observed on reclaim site and county road near pond #4 (Larry J.)	349057 E 1768500 N
40	May 13, 2016	8:07 am	3	Observed at the intersection of the haul road from the spoil and county road (Kirk N.)	353301 E 1767852 N
41	June 7, 2016	7:30 am	30	4-5 hens with 6-7 chicks each flew into conservation area (Cody M.)	353570 E 1770248 N
42	June 8, 2016	7:30 am	8	Observed at the well (Cody M.)	353505 E 1770347 N
43	June 24, 2016	9:04 am	7	7 chicks 50' north of the well, flushed to the east (Joe K.)	353586 E 1770196 N
44	June 24, 2016	9:04 am	5	Chicks walking on road toward the weather station (Joe K.)	353549 E 1770447 N

INCORPORATED
FEB 03 2017
Div. of Oil, Gas & Mining

45	June 24, 2016	11:20 am	5	Hens (1 collared) in the New Dame lease area (Steve Z. and Kirk N.)	352454 E 1770106 N
46	July 8, 2016	7:35 am	4	1 hen and 3 chicks at Dame north pond (Steve Z. and Kirk N.)	351093 E 1769949 N
47	July 8, 2016	8:06 am	5	Flushed in front of cows 300' west of well site (Steve Z. and Kirk N.)	353470 E 1769769 N
48	July 8, 2016	8:08 am	2	Flushed from below silver maples located near the orchard (Steve Z. and Kirk N.)	353290 E 1770465 N
49	July 9, 2016	11:00 am	4	1 hen and 3 chicks at Sorensen's place (Steve Z. and Kirk N.)	351361 E 1770348 N
50	July 28, 2016	9:00 am	4	County road bypass at north cattle guard (Kirk N.)	351594 E 1764940 N
51	Aug. 15, 2016	11:01 am	10-12	Flushed by the well (Riley A.)	353556 E 1770371 N
52	Aug. 19, 2016	11:36 am	8	Hens and chicks south of the well (Riley A.)	353242 E 1770194 N
53	Aug. 25, 2016	3:37 pm	8	Observed by the green gates on the reclaim site (Riley A.)	352286 E 1768034 N
54	Sept. 9, 2016	12:04 pm	4	Observed near the well (Riley A.)	353406 E 1770231 N

INCORPORATED

FEB 03 2017

Div. of Oil, Gas & Mining

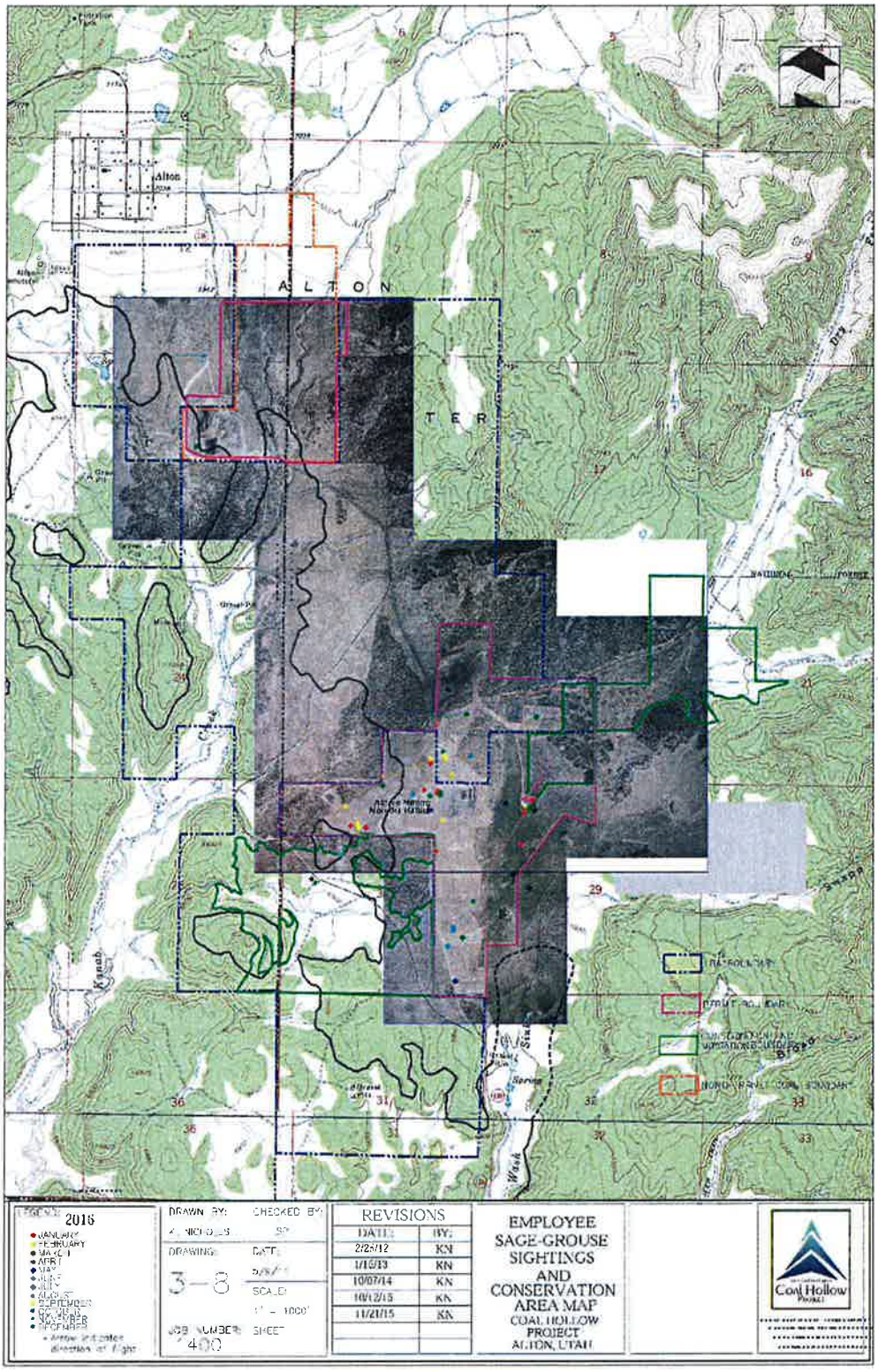


Figure 1. Location of sage-grouse observations made by ACD employees in 2016.

INCORPORATED

FEB 03 2017

Div. of Oil, Gas & Mining

1.2 Sage-grouse Surveys

Surveys were conducted by S. Petersen near the beginning of each month. The purpose of these surveys is to count the total number of sage-grouse observed within the Sink Valley and mining area. During breeding months, surveys are limited to non-nesting habitats and lek counts to prevent hens flushing from nests or disturbing hens with chicks during the early brood-rearing period. Habitats surveys are those dominated by sagebrush, primarily black and mountain big sagebrush.

Surveys are conducted by walking through each habitat along a pre-determined transects. Each time an individual bird or group of birds were observed, the coordinate position for that location was recorded (using GPS). The time of day and a decibel level (recorded during active mining periods) was also recorded.

During each survey, all areas where birds may be found were searched (Figure 2). These areas included 1) the sagebrush flat area 0.5 km south of the open coal pits (SF), 2) the new lekking area located at the top of the ridge at the south end of the sagebrush flat area, 3) the sagebrush patch located just south of the spoils pile (SMSP) and north of the spoils piles (NMSP), 4) the original lekking area (OL), 5) the wet meadow (WM) located in grass/rush/sedge community surrounding the well, 6) the sagebrush area immediately east of the open mine along the lower bench, 7) the conservation area east of the mine site along the upper bench (CA), 8) the bullhog area located south of the new lek, and 9) Ford's Pasture located 10 miles south of Sink Valley.

No dogs were used to assist in locating birds during survey. Over time as the bullhog effort continues, dogs may be beneficial with surveys due to the higher total acreage that should be surveyed.

INCORPORATED

FEB 03 2017

Div. of Oil, Gas & Mining

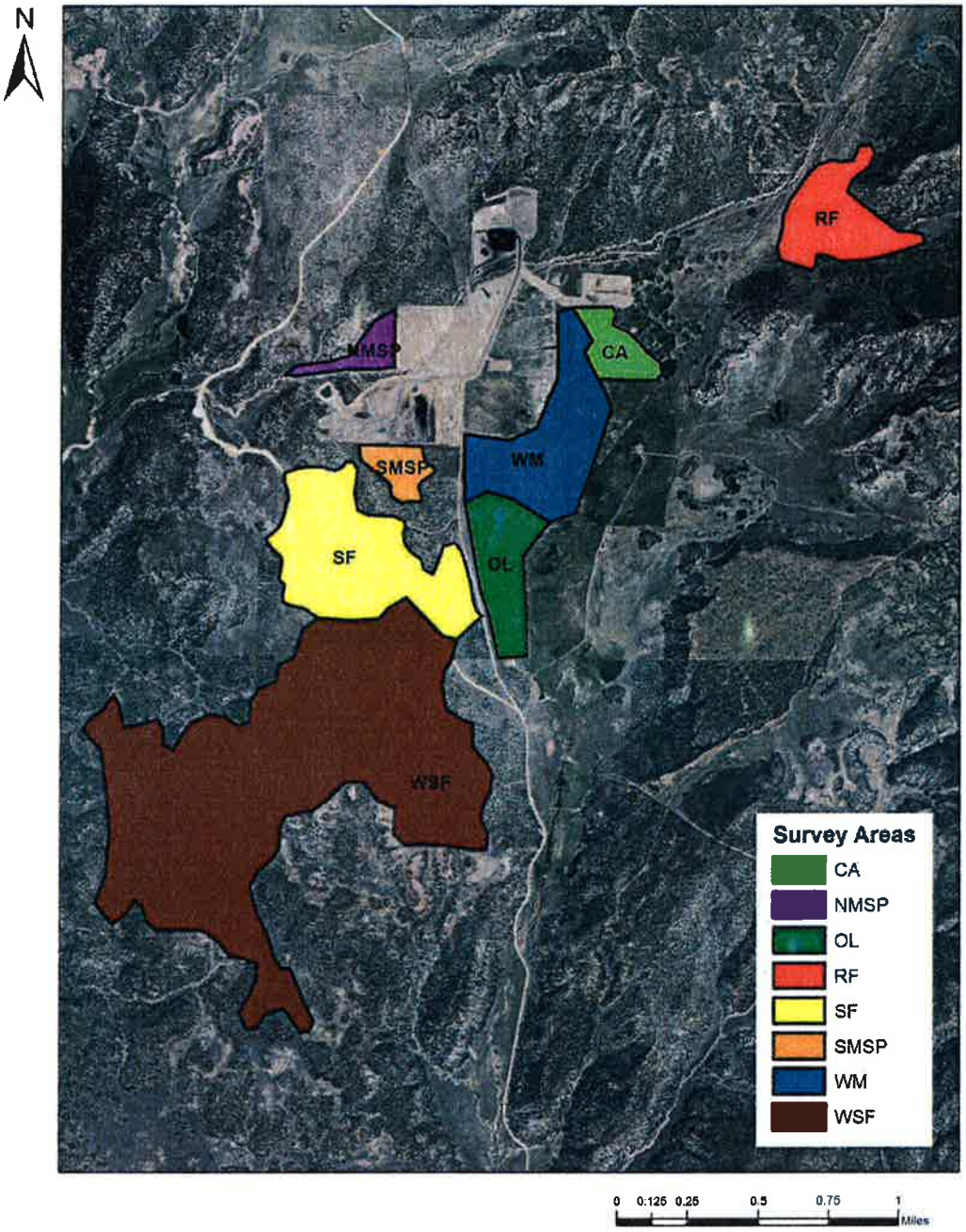


Figure 2. Location of survey areas for greater sage-grouse during the 2012-2016 monitoring seasons. CA = Conservation area, NMSP = North mine sagebrush patch, OL = Original lek, Rabbitbrush field, Sagebrush flat, SMSP = South mine sagebrush patch, WM = Wet meadow, and WSF = West sagebrush fields. Additional sites not shown above include the corridor (C) and the alfalfa fields (AF) south of Alton.

INCORPORATED

FEB 03 2017

Div. of Oil, Gas & Mining

A summary of the results recorded for each monthly sage-grouse survey is provided in table 2. Of all sites observed during surveys, birds were most consistently found in the sagebrush flat area south of the mine, within the new lek area, in the bullhogged area south of the new lek, and in the region surrounding the conservation area (Figure 2).

Habitats where birds were most frequently observed are dominated by black sagebrush (*Artemisia nova* A. Nelson) and mountain big sagebrush (*Artemisia tridentata* Nutt. ssp. *vaseyana* (Rydb.) Beetle). Within these habitats, other species are common including a diversity of perennial grasses and forbs. Chicks and young juveniles were consistently observed using habitat near the well on the east side of the mine (near the conservation area and in the lower sagebrush patch immediately adjacent to the active mining area east of the haul road).

INCORPORATED

FEB 03 2017

Div. of Oil, Gas & Mining

Table 2. Observations from monthly surveys conducted by S.L. Petersen.

Date	Time of observation	Number of birds	Location
Jan 1, 2016	8am-12pm	40	Flushed 14 birds at FP (10-11:15pm) while spotlighting. Flushed 26 birds from the spoils pile. No birds flushed in SF or surrounding area. No mining activity.
Feb 6, 2016	7am–12pm	26	23 birds observed at the SF/NL, 12 males were at the lek (3 displaying). Observed 3 birds at FP, 2 hens and 1 male. Many roost piles and tracks (from 10-20 birds but not observed)
March 5, 2016	6:30-11am	21-27	No birds at FP. 12 males lekking on southeast end of NL and into the new SB. 6-7 hens observed near the lek. 2 males strutting on the west end of the NL. 3 birds at the scraped area (2 males, 1 hen).
April 2, 2016	6:30-11am	18	8 males strutting at NL and in the middle of SB. 10 birds observed at reclaimed HL. Last week all 12 were observed lekking at that site. Survey limited to prevent flushing hens from nests.
May 2, 2016	6:30–10am	21	18 birds flushed from the new lek site. 4 flushed on the lek road and east end of NL. Survey limited to prevent flushing hens from nests. Mining activity was high.
June 3, 2016	7–11am	16	1 hen with 5 chicks in sagebrush flat. 10 birds observed in SB.
July 9, 2016	7–11am	4	1 hen with 3 chicks from the west CA.
Aug 6, 2016	6:45am–11pm	23-31	All birds in SF and SB. Spotlighted FP.
Sept 3, 2016	7-11am	45	42 birds in SF and SB. 2 in HL and 1 in upper CA. Spotlighted FP.
Oct 6, 2016	7:30-11am	50-53	11 in SF, 11 at NL, 31 in SB. Spotlighted FP.
Nov 4, 2016	8-12am	41	1 at FP (spotlighting). 23 in SF, 13 in SB, and flushed 4 out of CA (first time ever seeing birds in the mechanically treated sagebrush area).
Dec 3, 2016	7:30-11am	10	4 in SF and 9 in SB. It was a windy and bitter cold. Birds were hesitant to flush. When they did, they didn't fly far.

Birds were surveyed along transects within each of the following area. SF = sagebrush field located along the bypass haul road south of the mine, **MSP** = mine sagebrush patch located adjacent to (south) of the reclaimed area of pit #1, **HL** = historic lek located in Sink Valley, **FP** = Fords pasture located 10 miles south of the mine site, **SP** = Spoils Pile, **AF** = Alfalfa field, located immediately south of the town of Alton, **WSF** = West sagebrush fields located .5 to 1 mile west of SF, **WM** = wet meadow area located in close proximity to the well (pump) southwest of the conservation area, **CA** = conservation area, **NMSP** = North Mine Sagebrush Patch, **NL** = New lek located south of SF, **SB** = South Bullhog.

INCORPORATED

FEB 03 2017

Div. of Oil, Gas & Mining

1.3 GPS Collaring and Monitoring

On November 2 and November 3, 2016, K. Nicholes assisted Dr. Nicki Frey and her crew trap birds in the Sink Valley area. On November 2, two hens were collared and 1 young male was caught and released without being collared because he had lost too many feathers during the trapping and collaring process. On November 3, 1 young female was trapped and collared. Of the two birds (one male, one female) that were trapped last year, the hen is still transmitting currently. However, the male is no longer transmitting a signal. Dr. Frey believes that the bird is still alive but that the backpack has malfunctioned.

Dr. Frey is currently monitoring all 4 birds. These data are used to assess habitat use and movement patterns (Figure 3, 4 and 5). All 3 collars were purchased by ACD for use in monitoring the Sink Valley population. Collars provide 4 point locations per day resulting in approximately 112 points per month per bird. ACD (Petersen) also assisted Dr. Frey and the BLM with trapping and collaring birds at the Dog Valley lek, north of Panguitch.

INCORPORATED

FEB 03 2017

Div. of Oil, Gas & Mining

Greater Sage-grouse, Alton-Sink Valley Vicinity, Oct 2104 - Dec 2016

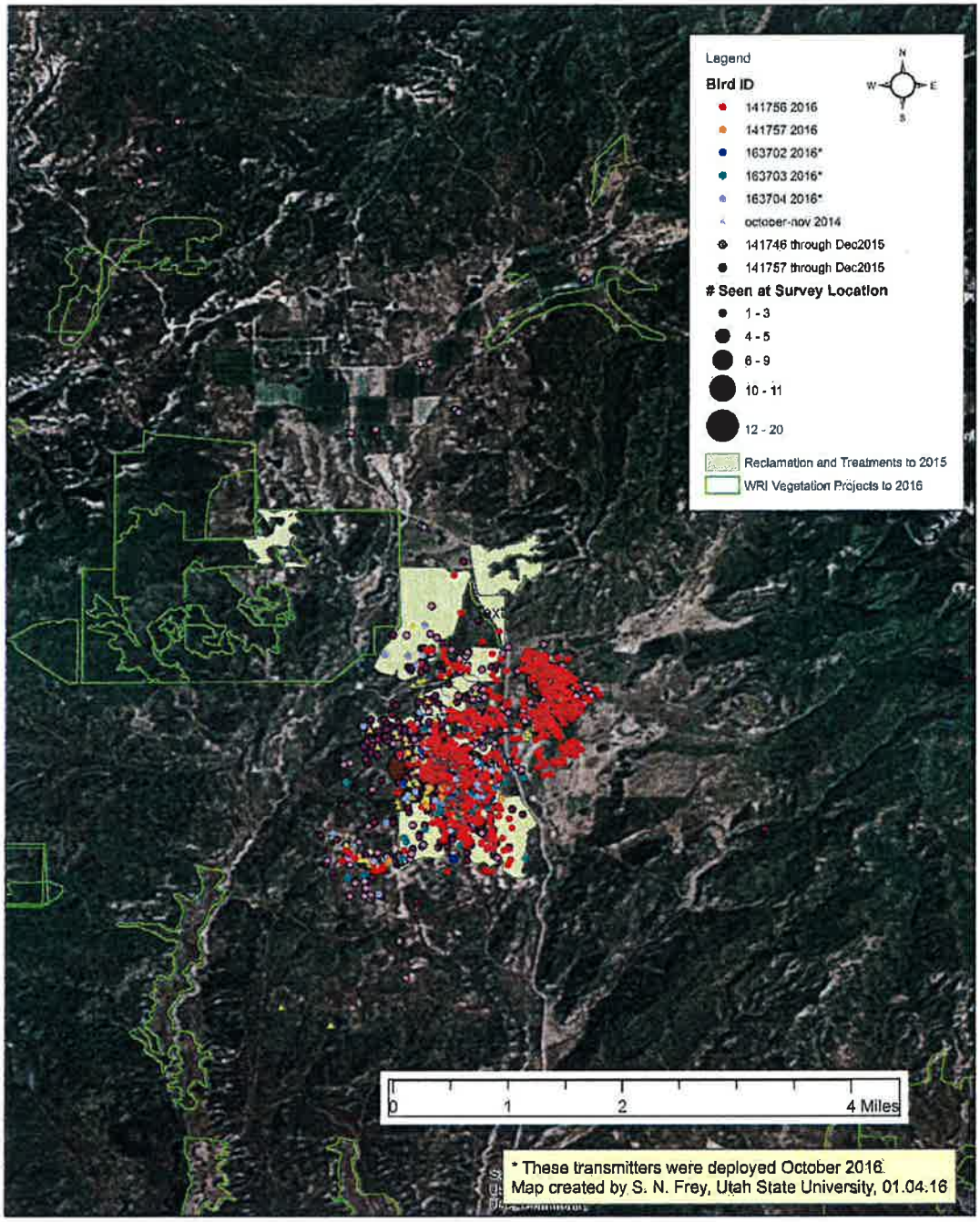


Figure 3. Location of collared sage-grouse in the Sink Valley area. Data were collected during fall and winter 2016. Sage-grouse were collared and monitored by Dr. Nicki Frey.

INCORPORATED
FEB 03 2017
Div. of Oil, Gas & Mining

Greater Sage-grouse, Alton Mine Vicinity, Oct 2104 - Dec 2016

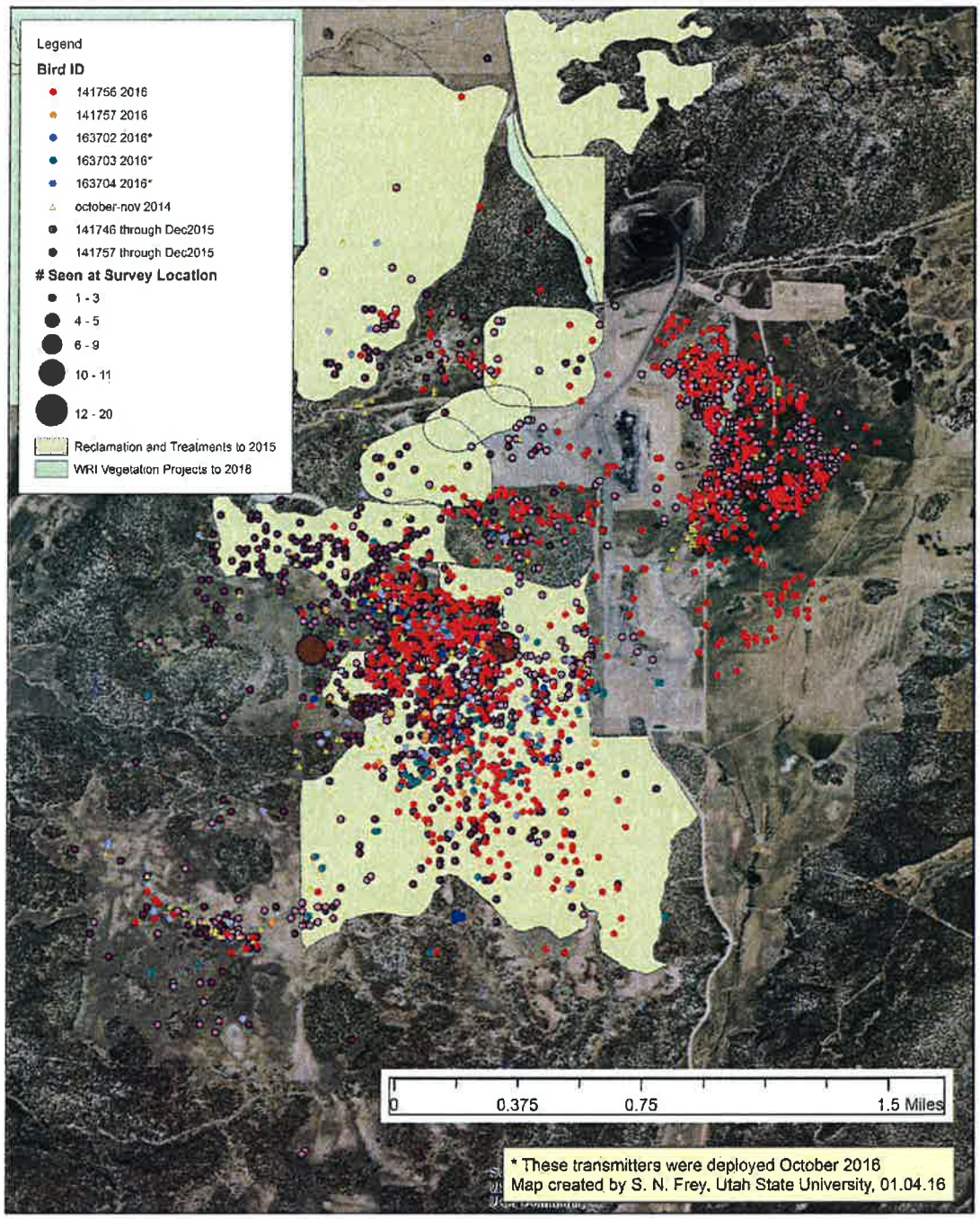


Figure 4. Close-up view of the area where the highest concentration of sage-grouse coordinate locations were collected. Data were collected during fall and winter 2016. Sage-grouse were collared and monitored by Dr. Nicki Frey.

INCORPORATED

FEB 03 2017

Div. of Oil, Gas & Mining

Distribution of tracked Greater Sage-grouse Oct 2104 - Dec 2016

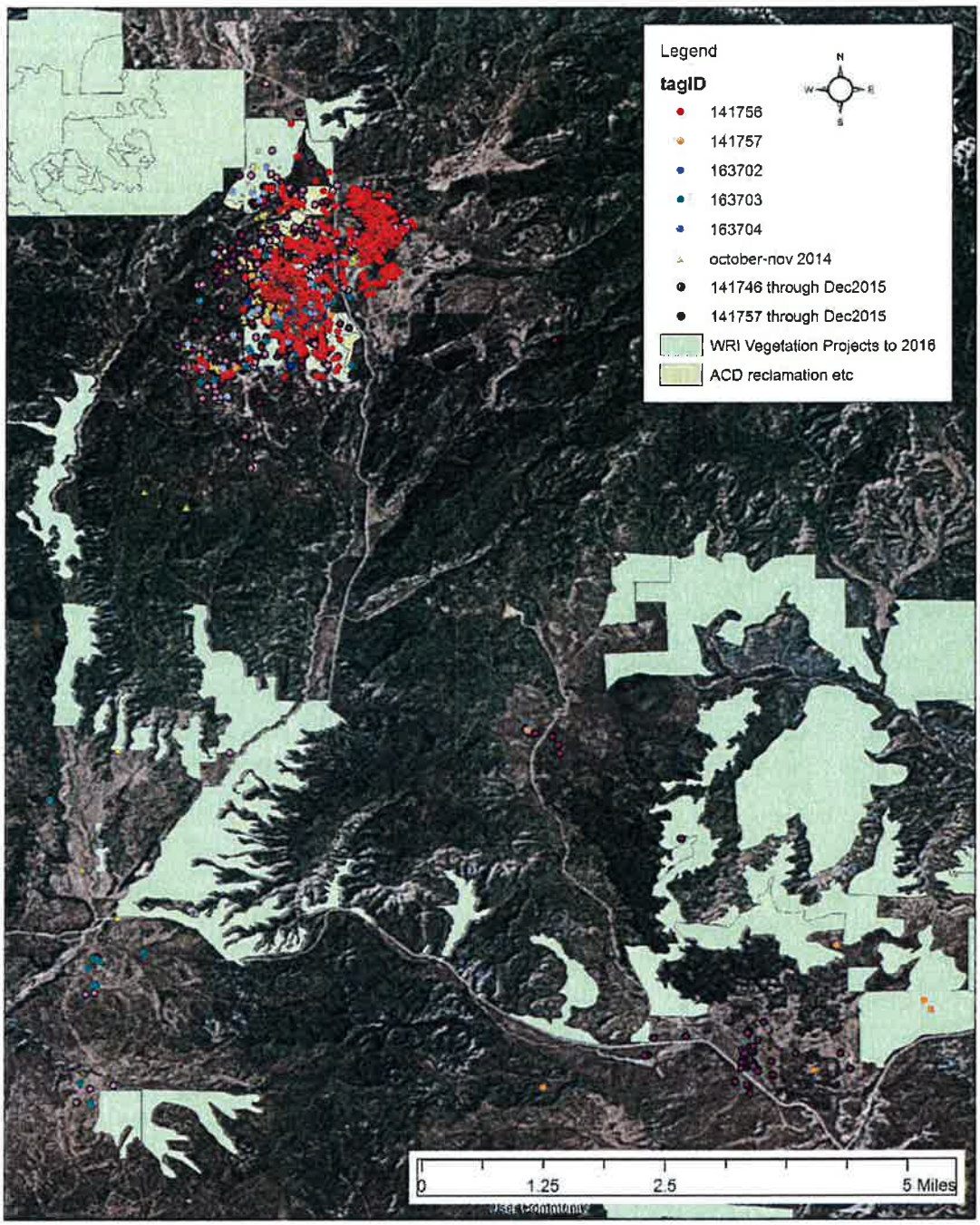


Figure 5. Coordinate locations of sage-grouse located within the southern extent of the species. Birds are observed in Sink Valley, Fords Pasture, and sagebrush habitats in-between both locations. Data were collected during fall and winter 2016. Sage-grouse were collared and monitored by Dr. Nicki Frey.

INCORPORATED
FEB 03 2017
Div. of Oil, Gas & Mining

1.4 Historic and Current Lek use in Alton/Sink Valley

Greater sage-grouse have been observed using the Sink Valley and Alton areas of Kane County, Utah for many generation, including breeding activity (at the Sink Valley lek), nesting and brood rearing, and winter habitat use primarily in Sink Valley and the Alton area (personal communication with Kevin Heaton). The density of birds reported using the Sink Valley area has fluctuated widely during the time they have been observed (Figure 6). The most accurate estimates of bird densities in this region are provided by lek counts conducted annually by wildlife biologists with the Utah Division of Wildlife Resources (UDWR).

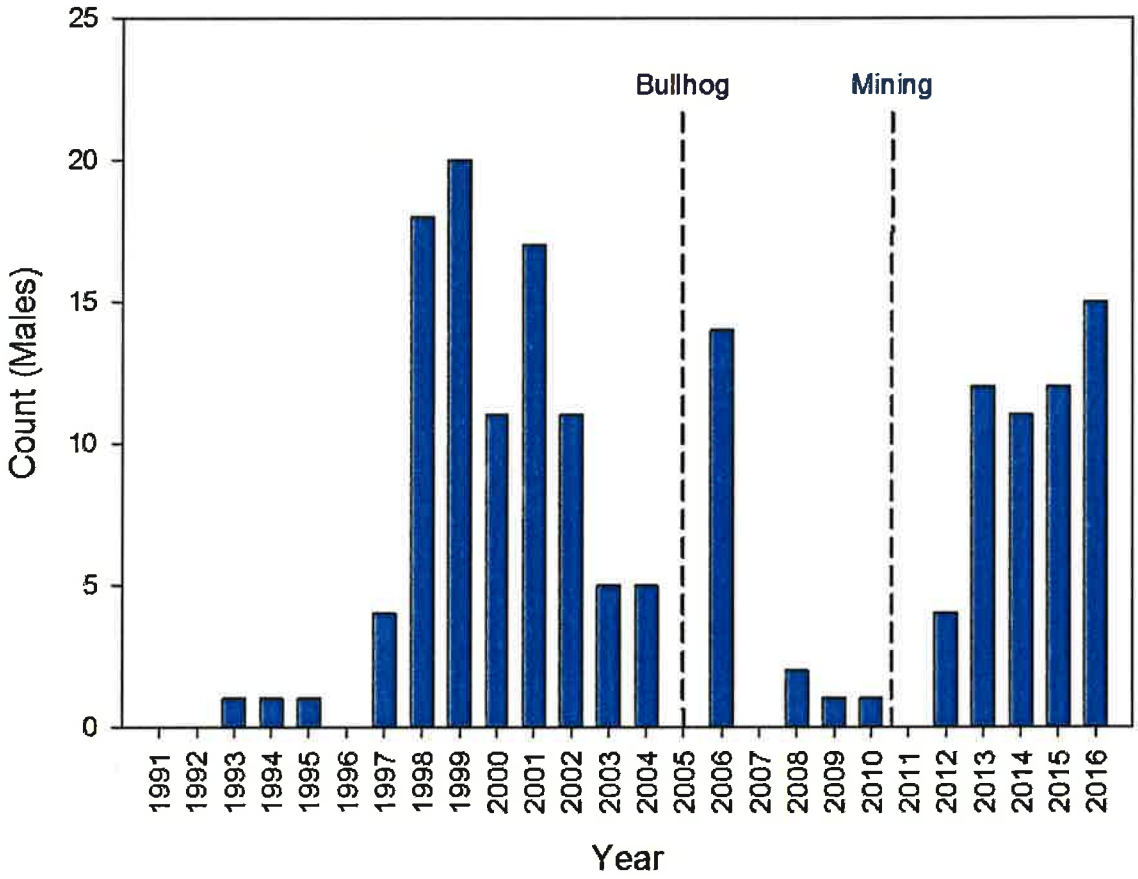


Figure 6. Male bird attendance at the Sink Valley lek, located south of Alton, Utah. Observations were made by Utah DWR employees observing during the spring breeding months (February – April). Both 2005 and 2007 data reported no males at the lek. In 2011, no males were counted, but it was assumed that the bird were displaying at the new lek and went unobserved until the following year. Birds recorded from 2012-16 were located on the new lek. Previous observations were observed at the historic lek.

INCORPORATED

FEB 03 2017

Div. of Oil, Gas & Mining

1.5. Manuscript production and publication

A manuscript of the Sink Valley sage-grouse population was produced using data from the past 10 years. This included an analysis of the Sink Valley lek count data and distribution of sage-grouse surrounding the mine site over time (Petersen et al. 2016). The article was published in the Journal of Human-Wildlife Interactions (Appendix A).

1.6 Noise Detection and Sound Assessment

The influence of sound (noise pollution) on sage-grouse continues to be measured at each observation location when mining activity is active and wind levels are low enough to provide reliable data. Decibels have been recorded using an Extech 407735 Sound Level Meter.

2. Habitat Mitigation and Improvements

Land improvements in relation to coal mining are a primary goal for ACD. Most improvements are designed to improve habitat conditions for sage-grouse. To date, a total of 2,296 acres have been treated by ACD (Figure 7).

2.1 Reclamation Response

Post-mining reclamation is critical for stabilizing soils, restoring plant community composition, returning ecological structure and function, and improving habitat for grassland and shrubland species (i.e. sage-grouse, sage sparrows). Dahlgren et al. (2006) found that habitat treatments can improve habitat conditions required by sage-grouse such as forage, shelter and reproduction.

Following mining operations, the landscape has been recontoured to resemble pre-mining landform conditions. Topsoil was then replaced and reseeded using a mix of native and introduced shrub and herbaceous species. Seed was distributed using a seed drill pulled behind a John Deer tractor. To date, a total of 178 acres of land has been reclaimed (Figure 8). Most reclamation has been completed within the Sink Valley area, however, 11 acres have been reclaimed to date in the North Lease area, located 2 miles northwest of the mine crushing facility and headquarters (Figure 9).

Germination and establishment response has been comparable to data collected from the spoils pile in 2015. Reclamation success for much of the reclaimed area has been high, based on species diversity, high plant canopy cover, and relatively low bare ground cover. Quantitative data of plant community response and surface characteristics will be sampled in summer 2017 and included in the 2017 annual report. Photos of bird use within the reclaimed area are provided in Figure 10.

INCORPORATED
FEB 03 2017
Div. of Oil, Gas & Mining

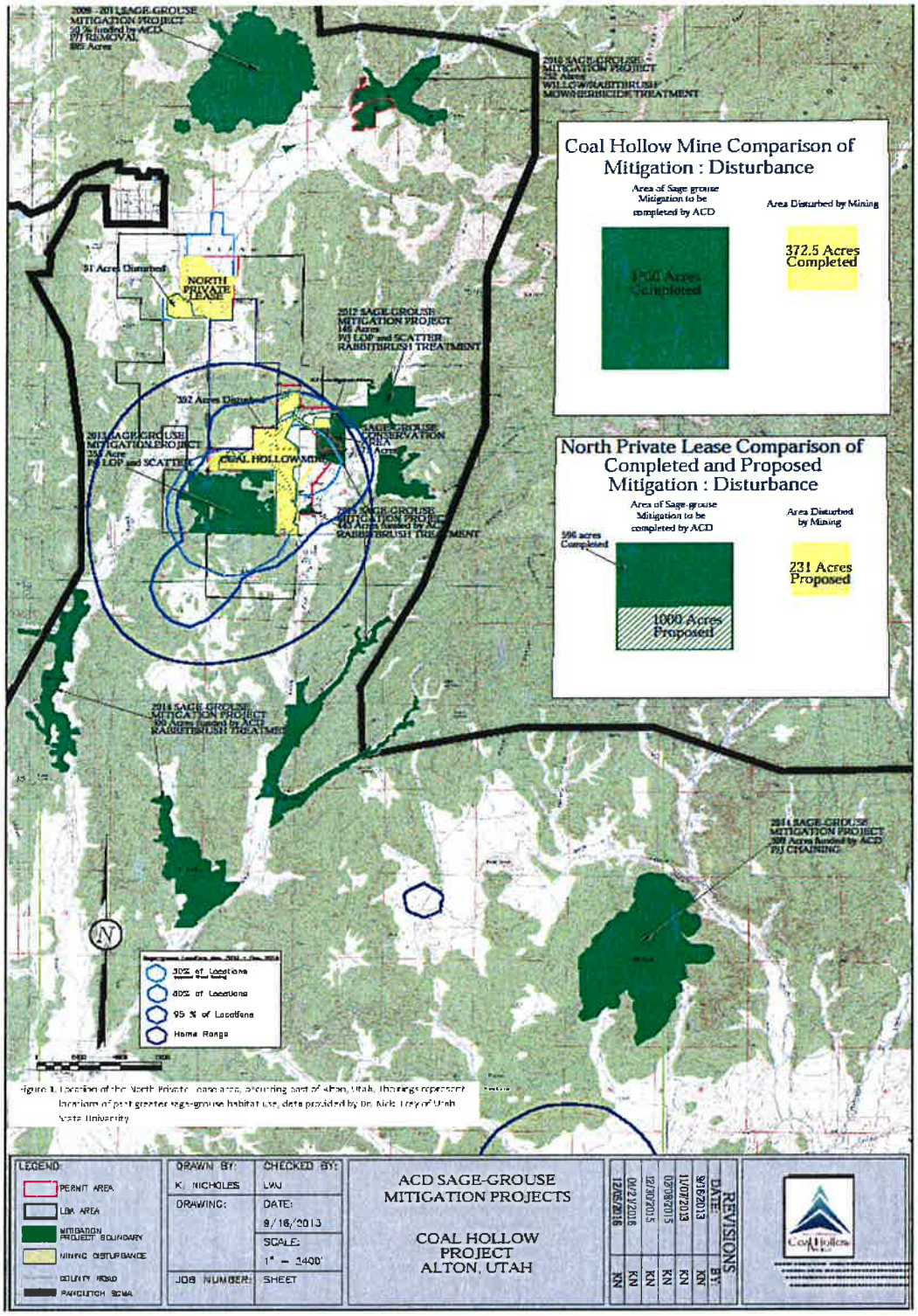


Figure 7. Total mitigation completed for the mine to date.

INCORPORATED
FEB 03 2017
Div. of Oil, Gas & Mining

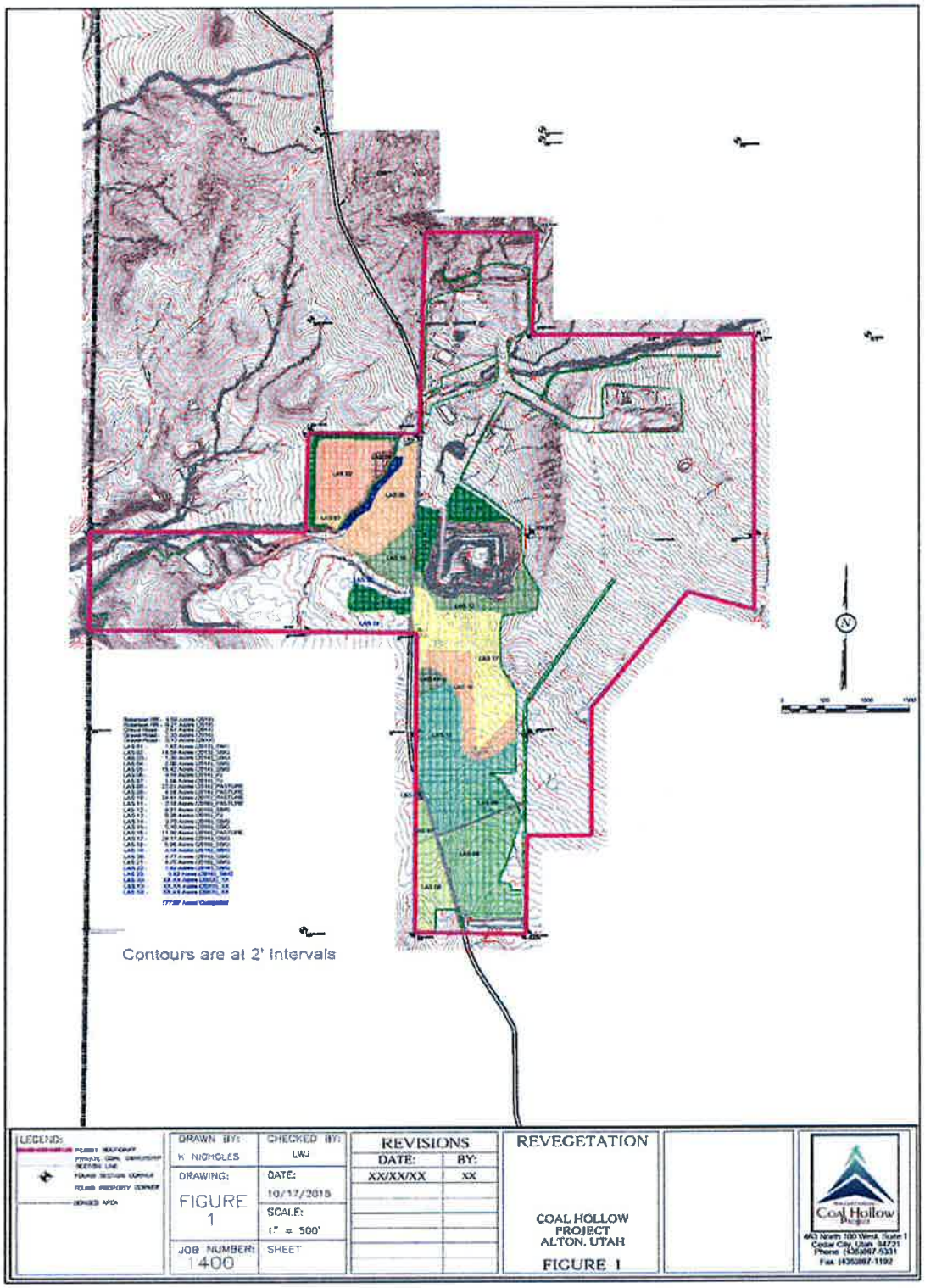


Figure 8. Post-mining reclamation completed to date (Dec. 2016). These areas have been seeded with a mix of native and introduced grass, forb and shrub species. Total area reclaimed is 178 acres.

INCORPORATED
FEB 03 2017
Div. of Oil, Gas & Mining

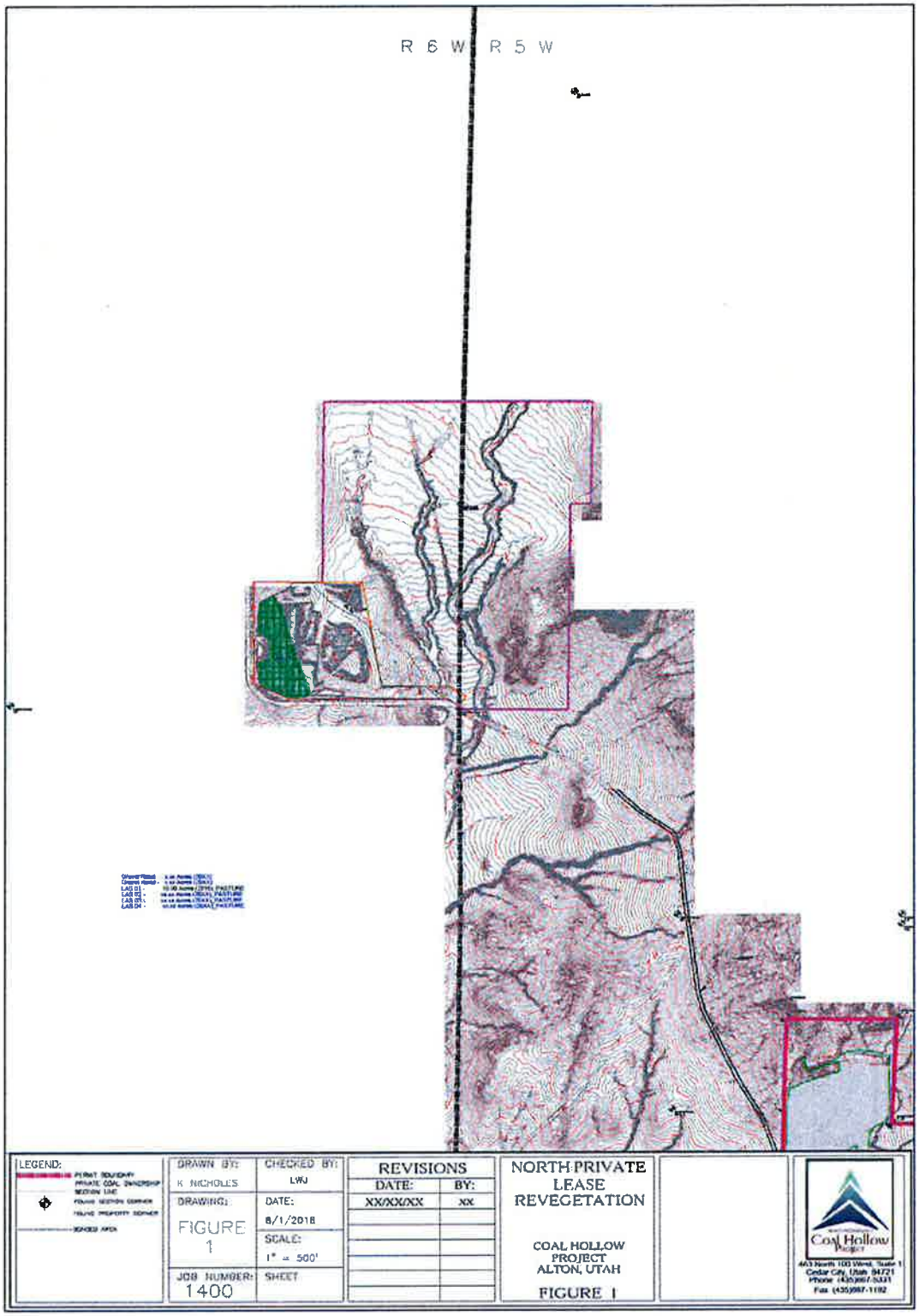


Figure 9. Reclamation within the North Lease area for a total of 11 acres.

INCORPORATED

FEB 03 2017

Div. of Oil, Gas & Mining

Figure 10. Sage-grouse use in the post-mining reclamation area. All photos are taken of birds located within the Sink Valley reclamation site, located in close proximity to the historic lek.

2.2 Juniper Mastication

Pinyon-juniper mastication being conducted by the BLM (Kanab field office) has resulted in a total of 1,362 acres of woodland removal and habitat improvement by reseeding (Figure 11). Mastication contractors report observing sage-grouse near the treatment areas while operations are underway. According to biologists from the Salt Lake BLM office, this may be due to the high availability of insects that are accessible to birds during the mastication process (personal communication Dec 2016).

Pinyon-juniper woodland mastication continues to serve a primary role in habitat improvement for sage-grouse throughout the mining area. According to Frey et al. (2013), sage-grouse utilize mastication treatment sites throughout much of the year.

INCORPORATED

FEB 03 2017

Div. of Oil, Gas & Mining

3. Predator Control Activities

During 2016, sage-grouse predators were removed to increase potential nesting and brood rearing success. The types of predators that were removed included common ravens (*Corvus corax*), American crows (*Corvus brachyrhynchos*), coyotes (*Canis latrans*), and red fox (*Vulpes vulpes*). All predator control activities were conducted by USDA Wildlife Services. Locations where eggs were distributed and coyotes trapped are displayed in Figure 12.

3.1 Raven Control

Teresa Wright, a raven control specialist with USDA wildlife services, has been funded by ACD to control ravens within the Alton/Sink Valley area. Raven control occurred from December 1, 2015 through November 2016. A total of 950 poisoned eggs were distributed within target areas shown in Figure 8. Eggs are hard boiled and then injected with DRC1338, a toxin that targets corvids specifically. According to Teresa, one raven is taken for every 6 eggs applied. Therefore, it is presumed that approximately 158 ravens were killed throughout the year (Personal Communication November 2016). The numbers of eggs distributed was lower than 2015 (1500 eggs) because the toxin DRC1339 was not manufactured this past year. There was also a delay in distributing eggs for several weeks due to a problem related to product labeling.

INCORPORATED

FEB 03 2017

Div. of Oil, Gas & Mining

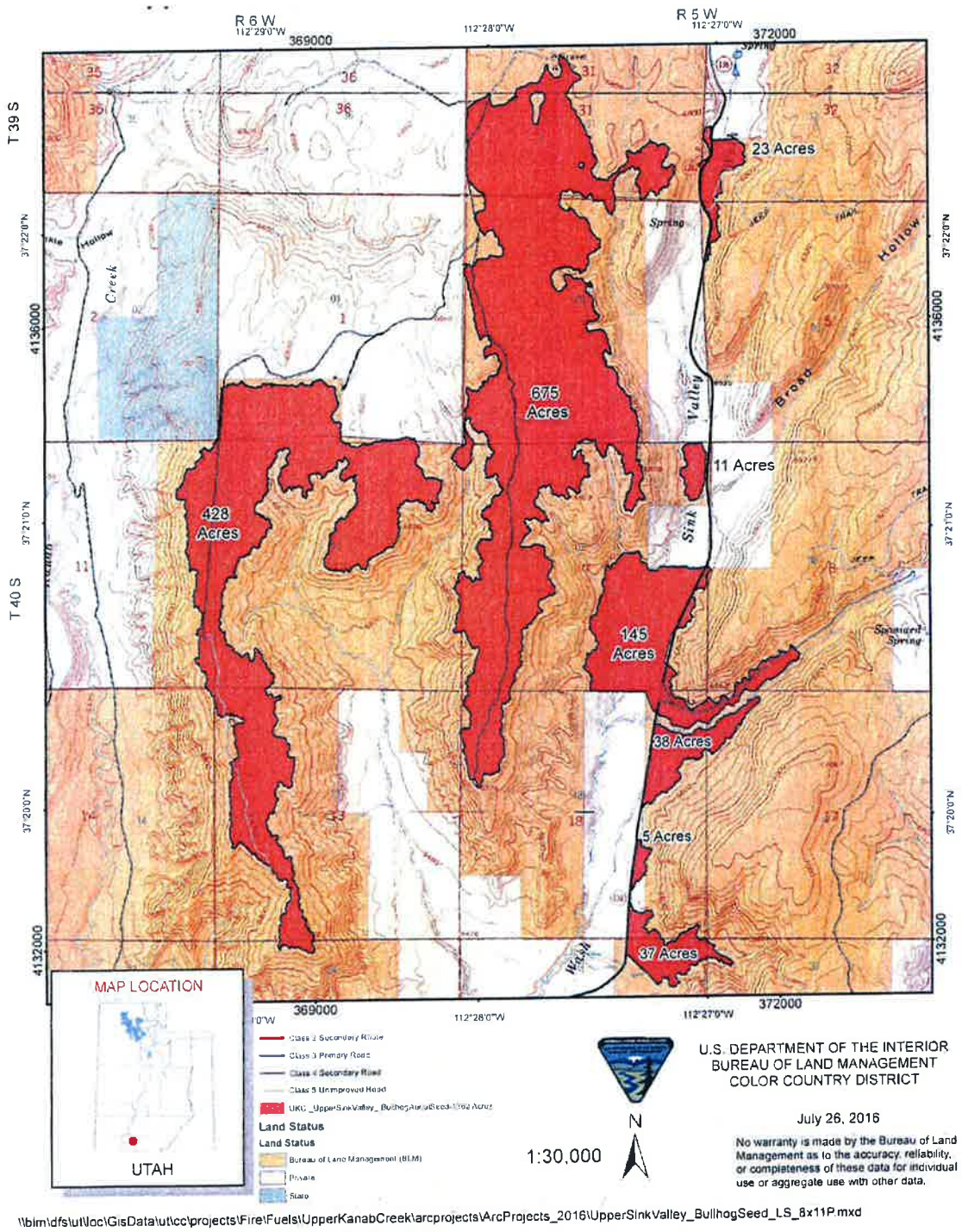


Figure 11. Upper Sink Valley mastication project with aerial seeding. 1362 total acres were treated.

INCORPORATED

FEB 03 2017

Div. of Oil, Gas & Mining

Figure 12. Blue polygons indicate areas where poison eggs were distributed by USDA Wildlife Services for raven control. This includes roadsides near critical habitat and the stock yard near Alton where birds congregate. The yellow polygon represents the location where coyote snares are set and trapped.

3.2 Mesopredator Control

Roger Nauer, USDA Wildlife Services trapper and mesopredator control specialist, harvested 3 coyotes within the mining area. Coyote control occurred from January 1, 2016 through November 1, 2016. Coyotes were killed using foot snares, traps, and fixed-wing aircraft.

INCORPORATED

FEB 03 2017

Div. of Oil, Gas & Mining

4. Participation and Involvement with Local Working Groups

ACD participates in the Color Country Adaptive Resource Management (CCARM) bi-monthly meetings. CCARM provides valuable input and support in relation to sage-grouse population and habitat conservation planning (for the Alton/Sink Valley area). Feedback is considered in all aspects of project planning and implementation. Maintaining this cooperation with CCARM has been instrumental in the success of this project.

References

Boyd, C. et al. 2011. Looking toward a brighter future for lekking grouse. Rangelands 33:2-11.

Braun, C.E., T. Britt, and R.O. Wallestad. 1977. Guidelines for maintenance of sage grouse habitats. Wildlife Society Bulletin 5:99-106.

Baruch-Mordo, S., J.E. Evans, J.P. Severson, D.E. Naugle, J.D. Maestas, J.M. Kiesecker, M.J. Falkowski, C.A. Hagen, and K.P. Reese. 2013. Saving sage-grouse from the trees: a proactive solution to reducing a key threat to a candidate species. Biological Conservation 167:233-241.

Dahlgren, D.K., R. Chi, and T.A.. Messmer. 2006. Greater sage-grouse response to sagebrush management in Utah. Wildlife Society Bulletin 34:975-985.

Doherty, K.E., D.E. Naugle, B.L. Walker, and J.M. Graham. 2008. Greater sage-grouse winter habitat selection and energy development. Journal of Wildlife Management 72:187-195.

Frey, S.N., R. Curtis, and K. Heaton. 2013. Response of a small population of greater sage-grouse to tree removal: implications of limiting factors. Human-Wildlife Interactions 7:260-272.

Petersen, S.L., B.K. Nicholes, S.N. Frey, K.M Heaton, and D.L. Eggett. 2016. Response of greater sage-grouse to surface coal mining and habitat conservation in association with the mine. Journal of Human-Wildlife Interactions 10:205-216.

Acknowledgements

Many thanks to all of those who were involved in planning, implementation of projects, and monitoring of the Sink Valley sage-grouse population and associated habitat. In particular we express our appreciation to Kirk Nicholes (ACD Environmental Scientists), Larry Johnson (ACD Project Manager), Kevin Heaton (USU Extension, habitat reclamation), biologists from UDOGM, Nicki Frey (SUU/USU Extension, sage-grouse collaring and monitoring), Rhett Boswell (UDWR, project planning and assessment), Teresa Wright (USDA WS, raven control), Roger Nauer (USDA WS, coyote control), the Color-Country Adaptive Resource Management group (project feedback and input). The work of this team has continued to result in maintaining a stable sage-grouse population in the Alton/Sink Valley area.

INCORPORATED

FEB 03 2017

Div. of Oil, Gas & Mining

APPENDIX A

Petersen, S.L., B.K. Nicholes, S.N. Frey, K.M. Heaton, and D.L. Eggett. 2016. Response of greater sage-grouse to surface coal mining and habitat conservation in association with the mine. Journal of Human-Wildlife Interactions 10(2):205-216.

INCORPORATED

FEB 03 2017

Div. of Oil, Gas & Mining

Human–Wildlife Interactions 10(2): 205–216, Fall 2016

Response of greater sage-grouse to surface coal mining and habitat conservation in association with the mine

Steven L. Petersen, Department of Plant and Wildlife Sciences, Brigham Young University, 5027 LSB, Provo, UT, 84604 USA *Steven_Petersen@byu.edu*

B. Kirk Nicholes, Alton Coal Development, 463 N. 100 W, Cedar City, UT 84721, USA

S. Nicole Frey, Department of Wildland Resources, Utah State University, 5230 Old Main Hill, Logan, UT 84322, USA

Kevin M. Heaton, Utah State University Cooperative Extension, Garfield County Courthouse, 55 South Main, P.O. Box 77, Panguitch, UT 84759, USA

Dennis L. Eggett, Department of Statistics, Brigham Young University, 223 TMCB, Provo, UT 84602, USA

Abstract: Greater sage-grouse (*Centrocercus urophasianus*; sage-grouse) is a sagebrush-obligate species that has experienced species-wide declines in population density and distribution. Sage-grouse habitats support human-related needs including domestic livestock grazing, urban development, and energy extraction. The U.S. Fish and Wildlife Service identified energy extraction as a range-wide sage-grouse conservation threat. Mining has been of specific concern because of observed sage-grouse population declines and impaired habitat within close proximity to the activity. Mining may be particularly problematic for small, isolated sage-grouse populations. In southwestern Utah, proactive habitat improvements and predator management have been implemented to mitigate the potential effects of surface mining on the southernmost population of sage-grouse in the United States. We evaluated sage-grouse lek attendance trends before (1991–2010) and during (2011–2016) mining on a lek located near the mine (Sink Valley lek) to assess population responses to coal mining and related mitigation activities. Changes in lek trends have been demonstrated as a valid metric to assess the effects of conservation actions on sage-grouse populations. We used a paired *t*-test to compare differences in male lek attendance before and during mining and analysis of variance to determine if sage-grouse densities and distance to mining changed during the mining period. We recorded bird coordinate location and the number of birds observed at each sighting location along 10 transects within the study site area. Differences in location from mining was tested using Analysis of Variance with $\alpha < 0.5$. There was no difference in the number of males attending the Sink Valley lek before and during mining. Population cycles were consistent over the time period sampled. With the exception of 2013, which had an unusually high number of sage-grouse found within the Sink Valley area, there were no differences in the number of birds observed at each sighting location in relation to the mine center ($P = 0.37$), the coal crushing facility ($P = 0.34$), and the mine boundary ($P = 0.24$). Coupled with ongoing mitigation activities including habitat restoration, pinyon-juniper (*Pinus edulis, Juniperus osteosperma*) removal, aggressive predator control, pre-mining acclimation to human influences, and removal of pinyon-juniper woodlands, surface coal mining had no negative effect on population cycles in the Alton/Sink Valley area.

Key words: *Centrocercus urophasianus*, coal mining, greater sage-grouse, habitat restoration, lek, population cycles, reclamation

Greater sage-grouse (*Centrocercus urophasianus*; sage-grouse) have experienced population declines range-wide, due primarily to environmental factors that affect reproduction and survival (Connelly and Braun 1997, Dahlgren et al. 2016*b*). Because sage-grouse rely on sagebrush habitats for year-round habitat needs, anthropogenic developments and large-scale transformations have been reported to decrease suitable sagebrush habitats, alter ecosystem processes, decrease biodiversity, and fragment historic wildlife habitats (Knick et al. 2003, Schroeder et al. 2005, Davies et al. 2011, Miller et al. 2011, Chambers et al. 2014).

Energy demands across western North America (renewable and nonrenewable) have resulted in the extraction of natural resources and exploration of new energy sources within sagebrush ecosystems. The U.S. Fish and Wildlife Service (USFWS) has identified energy development as a range-wide species conservation threat (USFWS 2015). Mining

INCORPORATED
FEB 03 2017
Div. of Oil, Gas & Mining

Figure 1. Three male sage-grouse strutting on a lek located approximately 2.2 km from a coal crushing facility (shown in background) and 0.5 km from the nearest mining activity. Birds are lekking on a juniper removal treatment site.

and oil and gas extraction modify sage-grouse behavior and fragment sagebrush habitats to the detriment of sagebrush-obligate and facultative plant and animal species (Connelly et al. 2000, Lyon and Anderson 2003, Holloran et al. 2005, Naugle et al. 2011). While energy extraction practices vary, sage-grouse response to disturbance was related to the intensity of the energy extraction activity, rather than the specific activity type; responses included changes in lekking behavior and lek attendance (Holloran 2005). Similarly, Braun et al. (2002) found that leks located within 200 m of oil and coal mining activities (roads, well sites) in southeastern Alberta resulted in lower lek attendance.

One of the major concerns for sage-grouse above mining impacts is surface disturbance, habitat loss, and noise pollution (Dahlgren et al. 2016*b*). The most effective way to mitigate these impacts is through habitat management and improvement. Dahlgren et al. (2016*a*) found that Utah sage-grouse populations are primarily limited by space. The removal of pinyon-juniper (*Pinus edulis* Engelm.; *Juniperus osteosperma* [Torr.] Little) woodlands (PJ) has been found to significantly increase sagebrush habitat availability. Utah's Greater Sage-grouse Conservation Strategy recognized the potential for mining to impact local sage-grouse populations (UDWR 2013). The plan recommended the implementation of mitigation activities to include creating habitat and predation management to abate these potential impacts. Dahlgren et al. (2016*b*,*c*) recommended habitat restoration projects with the removal of conifers that have encroached into historical sage-grouse habitat as an effective strategy with the potential for immediate populations benefits. Frey et al. (2013) reported immediate sage-grouse use of areas where conifers have been removed.

Increased predation by corvids, particularly common ravens (*Corvus corax*) and mesopredators, have impacted sage-grouse populations throughout some of Utah's sage-grouse management area (UDWR 2013, Baxter et al. 2013), especially in areas associated with human activities (Coates and Delehanty 2004, Bui et al. 2010). Anthropogenic activities, such as resource extraction, transmission lines, and urban development increase food and perching substrates for ravens, resulting in increased raven populations around these areas (Kristan et al. 2004, Messmer et al. 2013). Furthermore, loss of habitat can increase predation on sage-grouse nests by increasing the ability of predators to detect nests and observe hen activity (Coates and Delehanty 2010, Baxter et al. 2013).

Habitat management and predator control can result in stable or even improving sage-grouse populations (Boyd et al. 2011, Baxter et

INCORPORATED
FEB 03 2017
Div. of Oil, Gas & Mining

Table 1. Total land disturbed during coal mining at the Coal Hollow Mine in southwestern Utah.

Year	Hectares disturbed	Hectares reclaimed
2010	70.8	0.0
2011	8.5	0.0
2012	9.7	0.0
2013	21.9	5.5
2014	23.5	24.3
2015	4.0	11.8
Total	138.4	41.6

al. 2013, Dahlgren et al. 2015, Dahlgren et al. 2016*b*). Research in southern Utah determined that sagebrush treatments (mechanical and chemical) created habitat that increased sage-grouse use both within and adjacent to treated areas (Dahlgren et al. 2006, Frey et al. 2013). Baxter et al. (2013) found that enhancing habitat and controlling predators improved sage-grouse survival in Strawberry Valley, Utah. Frey et al. (2013) reported that pinyon-juniper mastication increased sage-grouse habitat and expanded sage-grouse distribution where treatments occurred. One source of possible restoration effort may be in off-site mitigation or habitat restoration within mined landscapes. In areas where the increase in tree density has fragmented or decreased habitat availability, mitigation practices may be used to restore these areas. In areas where sage-grouse habitat has been highly fragmented or deteriorated, it is possible that the benefits of mitigating mining activities may offset the negative impacts to this resource use (UDWR 2013, Dahlgren et al. 2016*c*). The purpose of this study was to determine how mining activities in concert with habitat management and mitigation strategies affect sage-grouse population cycles.

Study area

The sage-grouse population in the Alton/Sink Valley is the southernmost extent of the species (Dahlgren et al. 2016*a*), adjacent to and south of the town of Alton, Utah (37°26′20″ N 112°20′ W). Average annual precipitation is approximately 43.2 cm, delivered generally in 2 annual wet periods. During winter, cyclic storms bring precipitation as snowfall, and in summertime, storms originating from convection air masses from the Gulf of Mexico or the Pacific Ocean provide rainfall to the region. Of the 2 annual wet cycles, summer rainfall is most reliable and consistent. Monthly average minimum temperatures range from a low of -9.4°C during January to a high of 28.1°C in July. The study area covers approximately 1,575 ha, comprised of both private and public land ownership. The vegetation is dominated by black sagebrush (*A. nova* A. Nelson) that supports a diversity of plant communities including sagebrush grasslands, Gambel oak (*Quercus gambelii* Nutt.) woodlands, seep and spring fed wet meadows, pastures used for livestock grazing, and alfalfa fields. Much of this area has been heavily encroached by pinyon pine (*Pinus edulis* Engelm.) and Utah juniper (*Juniperus osteosperma* [Torr.] Little) woodlands, reducing and fragmenting available and suitable sagebrush habitats (Frey et al. 2013, Dahlgren et al. 2016*b*, Dahlgren et al. 2016*c*).

The habitat occupied by the Sink Valley sage-grouse population has been influenced by human-related impacts and ecological succession pathways (Frey et al. 2013). In addition to providing year-round sage-grouse habitat, this region also supports human development and activity including alfalfa farming, pasture for livestock grazing, residential homes and seasonal cabins, and a network of maintained gravel county roads and unimproved dirt roads that transects the habitat use area (UDWR 2013). Pinyon-juniper (PJ) has expanded into much of the landscape, including tree encroachment into extensive regions that would have once been sagebrush grasslands (Frey et al. 2013). Additionally, PJ woodlands have experienced infill where they have outcompeted sagebrush and other shrub and herbaceous species. This PJ invasion has constricted suitable sage-grouse nesting, brood-rearing, and winter habitat throughout the Alton and Sink Valley (UDWR 2013).

Prior to mining, a relatively small population of sage-grouse have occupied the region that surrounds the Sink Valley lek (UDWR 2013). The study area is part of the Pangutich Sage-grouse Management Area (SGMA), which consists of 245,729 ha. The Panguitch SGMA is one of 11 SGMAs that occur within the state of Utah, serving as high priority habitat for

INCORPORATED
FEB 03 2017
Division of Oil, Gas & Mining

sage-grouse management and conservation. The occurrence of a coal mine within an SGMA has been of significant importance regarding the relationship between surface coal mining and sage-grouse conservation in the state. It has provided the state of Utah a unique opportunity to assess sage-grouse population patterns in association with disturbance related to surface mining activities (UDWR 2013). The Utah Division of Wildlife Resources (UDWR) conducts annual lek counts of the Sink Valley sage-grouse population. UDWR biologists monitor each lek in the region multiple times per year, recording the total number of strutting males observed at dawn. Lek count data used in this study were provided by the UDWR Cedar City office.

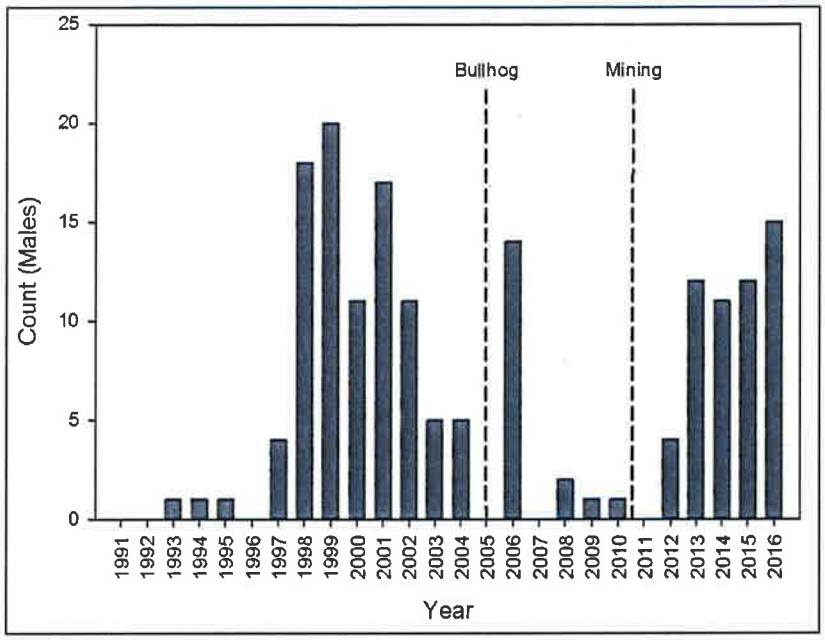


Figure 2. Male lek attendance between 1991 and 2016 at the Sink Valley lek located in southwestern Utah. In 2006, a bullhog mastication project was completed to remove encroached pinyon-juniper woodlands and enhance sage-grouse habitat within the region. Coal mining began in fall 2010.

During the breeding season, an average of 6.0 ± 1.6 male birds attended the lek prior to mining activity (1991–2009; UDWR unpublished data; Figure 1). This ranged from no birds in 5 non-consecutive years to a maximum of 20 birds in 1999. Between 1998 and 2006, male lek attendance was highest with 11.2 ± 2.3 males attending the lek annually (based on highest count on a single day). During a period of low lek attendance (2007–2011), an average 3.4 ± 1.9 males were observed. In 2012, a new lek was identified approximately 0.8 km southwest of the historic lek. Lek count data, however, cycle on a period of 9–12 years (UDWR unpublished data), which is a similar pattern observed in the Sink Valley lek data.

The original lek was located along a fenced wet meadow pasture within the valley bottom of the study area (Sink Valley). This site was dominated primarily by pasture grasses (*Poa pratensis, Phleum pratense, Dactylis glomerata*). Prior to mining, male counts at the original lek dropped to low numbers, including no birds observed. Between 2013–2014, the original lek was mined for coal and then reseeded in 2015 using a mix of native and introduced grasses and forbs. In 2012, males were observed strutting on the new lek area, located 0.8 km southwest of the original lek. This lek was positioned on the top of a ridgeline adjacent to and overlooking the sagebrush field where the highest bird counts and number of observation had occurred. The new lek occurred within a previously bull-hogged area, consisting of scattered shrubs (*Artemisia nova*), perennial grasses (i.e., *Elymus trachycaulus, Poa pratensis, Elymus elymoides*), and forbs (i.e., *Melilotus officinalis*). Reclamation of the original lek was assessed with mean values and the coefficient of determination.

Surface coal mining operations

Land ownership within the mining area is approximately 65% federal (Bureau of Land Management) and 35% private ownership. Private lands are used primarily for livestock production (pasture) and 2 ranch homes and stock yards. Mining operations began in 2010 with coal extracted from shallow coal beds. Since then, 138.4 ha have been mined (Table 1). Initially, topsoil and subsoil were stockpiled or live-hauled for later use in habitat reclamation. Mining operations employed standard, open-pit methods using truck/loader type equipment

INCORPORATED
FEB 03 2017
Div. of Oil, Gas & Mining

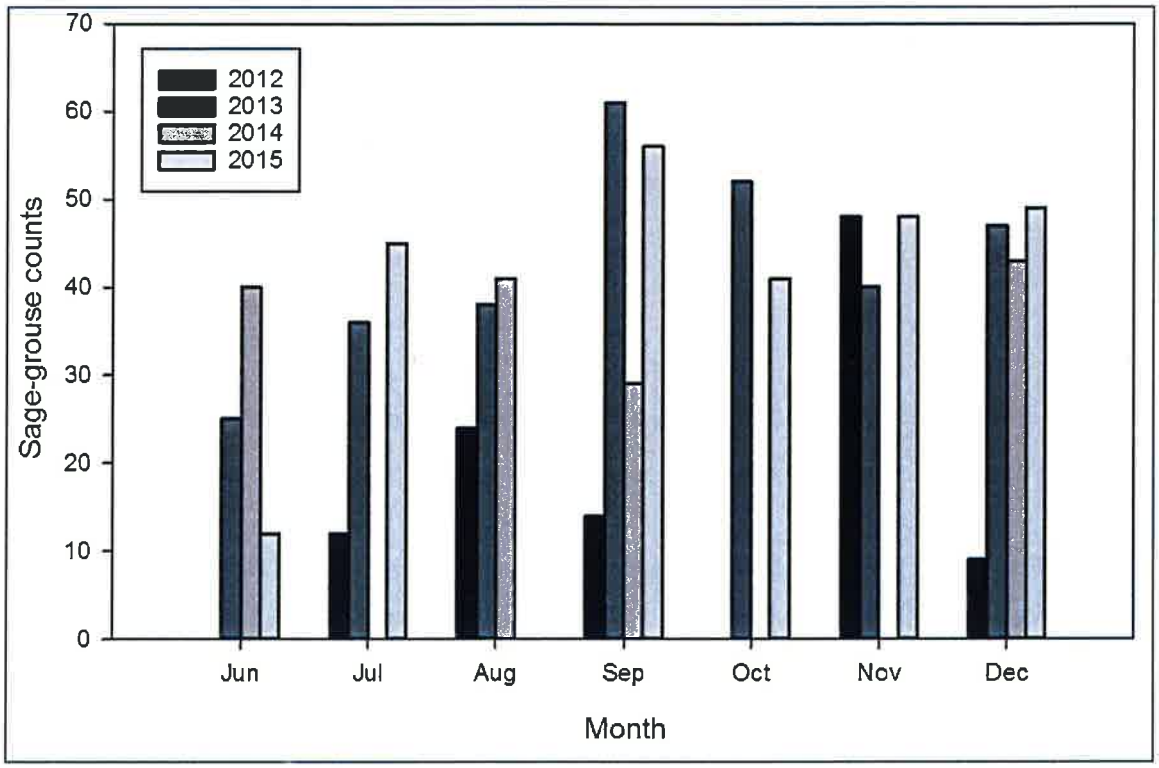


Figure 3. Sage-grouse counts during late brood-rearing and winter months within the mining region. All observations occurred <2 km from the center of the mine. No data were due to periods that did not have a survey conducted.

to remove overburden and recover the coal. Mining advanced across the property in successive cuts approximately 76.2 m in width and 243.8–396.2 m in length, with the previous pit being filled to approximate original contour from the current excavation. Extracted coal is transported from open pits to a coal crushing facility where trucks are filled and the coal is hauled from the mine site at a rate of up to 6 trucks per hour. Daily mining activity levels have been variable (4–6 days per week, 10–24 hours per day). Prior to mining, sagebrush habitats located east and south of the mine were excluded from the mining permit because these were identified as critical sage-grouse nesting and brood-rearing habitats. Throughout the mining period, sage-grouse have continued to lek at a new site located 2.2 km south of the coal crushing facility, 0.8 km from the historic lek, and ranging 0.25–0.5 km from the nearest edge of the mine footprint.

Habitat reclamation, vegetation improvements, and predator control

As part of their mitigation, the mining company reduced all tree canopy cover within the primary habitat areas to increase available sagebrush habitat both inside the mining footprint and throughout mapped sage-grouse habitat in Sink Valley and Alton. Pinyon-juniper woodlands were reduced both before and during mining by both tree cutting and mastication with a bullhog shredder. This was conducted to expand sagebrush grassland habitat that could eventually provide the structure required by sage-grouse for breeding, brood-rearing, and winter use. In 2006, PJ woodlands were thinned by mastication with the intent to increase suitable sagebrush habitat. In 2015, the same areas were treated by clearing trees not removed in 2006, providing more suitable habitat conditions for nesting and brood-rearing. In addition to reducing tree canopy cover, the mining company conducted shrubland habitat treatments to improve existing sagebrush-steppe habitats. Habitat improvements included the reduction of rubber rabbitbrush (*Ericameria nauseosa*) by treating shrubs with the herbicide Tordon 22k® and an increase in sagebrush density, cover, and vigor.

To reduce the impact of common ravens on nest and chick predation, USDA Wildlife

INCORPORATED
FEB 03 2017
Div. of Oil, Gas & Mining

Services (USDA-WS) distributed hard-boiled eggs treated with DRC 1339, an avicide used to control corvid species (Spencer 2002). Eggs were placed along roadsides near the mine, within sage-grouse habitat areas, and at the feedlot located at the north end of town that provides a consistent food source and generates high raven concentrations. Each year (2012–2015) an average of 1,344 (SD = 144) eggs were distributed throughout the area, resulting in an estimated removal of 122–672 ravens from the area (Coates et al. 2007). Wildlife Services removed coyotes (*Canis latrans*) using bait traps placed along fencelines and near dens as well as ground and aerial shooting. From 2012 to 2015, an average of 17.8 (SD = 1.3) animals were removed annually. Both raven and coyote removals were aimed at lessening the degree of predation on chicks, young of the year, and adult sage-grouse.

Methods

Sage-grouse response to mining activity and restoration

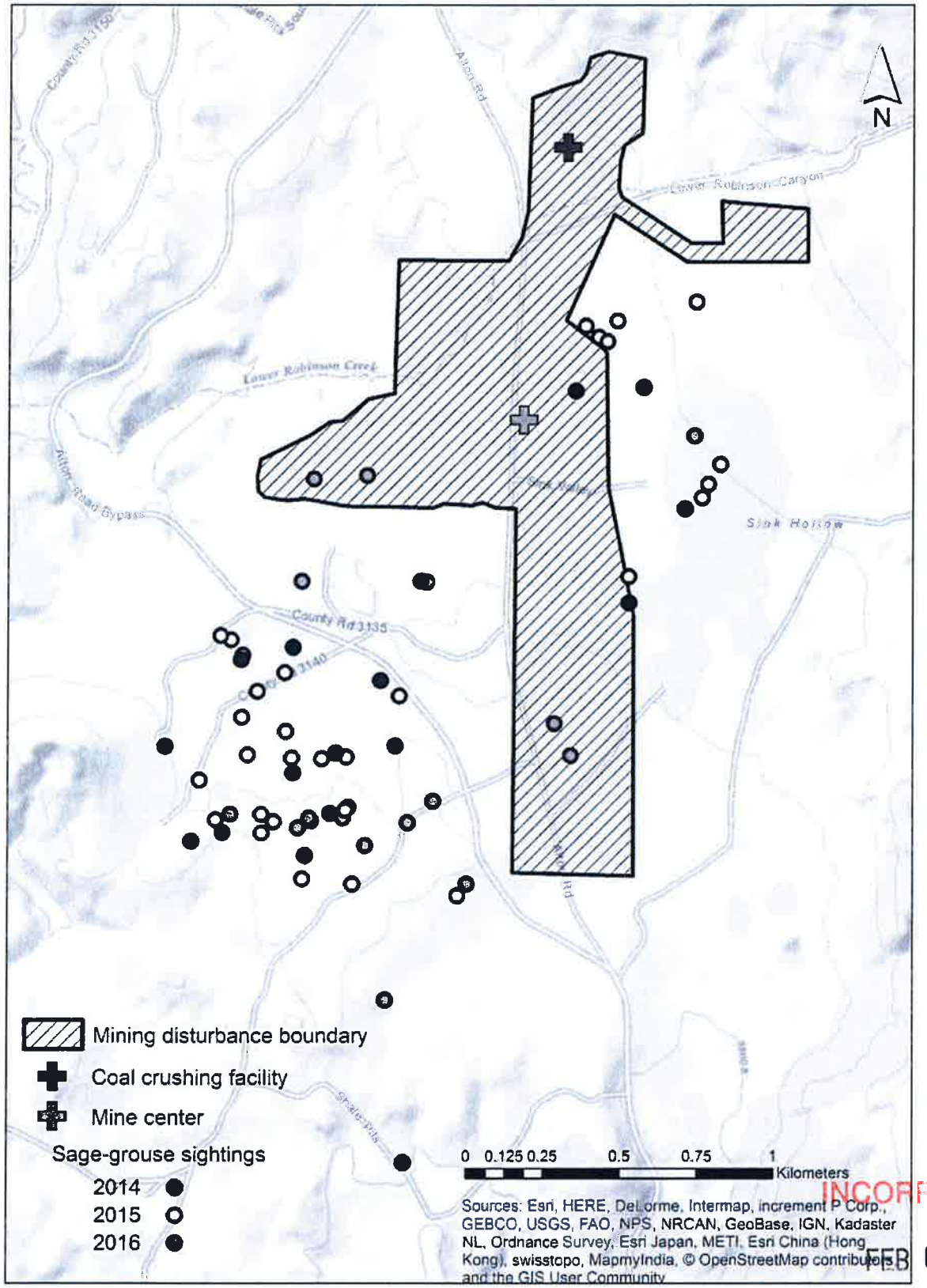
To determine how sage-grouse responded to mining activities and the reclamation and restoration activities, we analyzed annual lek count data, relative to both pre- and post-mining activity (Dahlgren et al. 2016*b*, Dahlgren et al. 2016*c*). Dahlgren et al. (2016*b*) found that male-based lek counts of sage-grouse are an effective index to overall population change. These data provide insight into population dynamics at sites where the annual lifecycle is undetermined and to be used to examine population dynamics at greater spatio-temporal scales. Furthermore, perturbation analyses such as this long-term demographic analysis is needed to enhance scientific rigor for prioritization of the most cost-effective species conservation and management actions (Akçakaya and Raphael 1998, Cooch et al. 2001, Baxter et al. 2008).

Within the study area, which extends 1.7 km to the south of the mine footprint, 0.7 km to the west, 0.6 km to the north, and 1.1 km to the east, there is 1 lek (Sink Valley Lek). We used the lek count data provided by the UDWR (unpublished data), determined from the highest count recorded following multiple lek visits during the breeding season. For this study, lek counts recorded before and during mining were compared using a 2-way Kruskal-Wallace non-parametric test of variances with $\alpha < 0.5$. Because lek counts were highly variable during pre-mining years, potentially due to typical population cycles (Dahlgren et al. 2016*b*), data were analyzed across all years and for years with >1 bird per lek count in the case that birds were present but not detected.

We recorded the coordinate location of all sage-grouse observed within the mine area between June and January during 2012 to 2016 to detect sage-grouse habitat use and to determine shifting patterns in the distance birds were observed from mining activities. Observations were not conducted during the nesting and early brood-rearing periods (February through May) to prevent any disruption to breeding hens or young chicks. Observations were conducted during morning hours at the beginning of each month. We searched for birds along 10 established transect lines within sagebrush and meadow habitats surrounding the mine/lek area each month. Transect lines ranged between 0.3 and 0.75 km in length and were located in habitat patches that we determined from past studies and observations were the most likely to provide habitat for sage-grouse. The same survey lines were followed each year. The coordinate locations for each sage-grouse observation were recorded using Global Positioning System (GPS) or aerial photographs. The researcher also recorded the time of day, weather conditions, habitat type, number of birds observed, and age/sex when discernable. To avoid repeat counts of the same birds along the transect line. We also took note of the direction flushed birds moved.

To determine the correlation of sage-grouse sightings to mining activity, we used ArcGIS (ESRI 2011) to analyze the locations with spatial information. We calculated the minimum Euclidian distance from each bird/flock sighting and measured the 1) center of the mine, 2) center of the coal crushing facility, and 3) closest area within the mine footprint (boundary). We divided bird sightings into 3 categories (near, mid, far) to compare differences in bird use patterns across years. Bird observations near the center of the mine (0–800 m) were in close proximity to roads, high traffic, and long-term mining activity compared to mid (800–1,500 m) and far (>1,500 m), which included birds with low to no visual or auditory mine-related

INCORPORATED
FEB 03 2017
Div. of Oil, Gas & Mining



INCORPORATED
FEB 03 2017
Oil, Gas & Mining

Figure 4. Location of sage-grouse habitat use (sightings) 4–6 years since the start of coal mining (Fall 2010). Bird sightings were recorded during ground surveys conducted monthly. The coal crushing facility represents stationary mining while the center of the mine site has high traffic patterns and transitional mining activity.

influences. The coal crushing facility was located at the north end of the mine footprint, adjacent to a PJ woodland and more distant from suitable sage-grouse habitat. Birds located near the coal crushing facility (0–1,500 m) had long-term mining activity, high traffic, with higher occurrence of people outside of vehicles compared to mid (1,500–2,300 m) and far (>2,300 m) distances. The mine footprint is located substantially closer to most of the intact sagebrush habitats, with closer proximity to bird observations compared to the mine center and coal crushing facility. Sage-grouse sighted near the footprint (0–400 m) included short- and long-term mining activity with less consistent traffic and human activity compared to mid (400–850 m) and far (>850 m) distances. We used Analysis of Variance (SAS® 2013) with $\alpha < 0.5$ to detect significant differences among distances and years, including an assessment of interactions between distances and years.

Results

Sage-grouse response to mining activity and restoration

When considering all lek count years, there was no difference in male lek attendance before and during mining ($T = 1.10$, df = 24, $P = 0.28$) with 5.6 ± 1.5 and 9.0 ± 2.7 birds observed, respectively (Figure 2). There was similarly no difference in lek counts before and during mining when >1 male was observed ($T = 1.31$, df = 14, $P = 0.98$) with 10.8 ± 2.6 and 10.7 ± 1.7 males observed, respectively. Bird sightings were recorded on average 1.2 ± 0.1 km from the center of the mine, 2.0 ± 0.1 km from the coal crushing facility, and 0.5 ± 0.03 km from the mine footprint. A total of 68.8% of all bird observations were located in the sagebrush-steppe habitat southwest of the mine footprint. Sage-grouse occurrence in this region was year-round. Sage-grouse were observed 9.8% of the time in the wet meadow area east of the mine. Observations occurred primarily from early to late brood-rearing periods. Considering all years combined, there was no intersection between year and location ($F = 1.15$, df = 61, $P = 0.34$) for sage-grouse counts. When testing for main effects, there were differences in bird numbers averaged across all locations among years ($F = 7.53$, $P < 0.001$). This was due to an unusually high number of birds in 2013 (31.3 ± 3.8) compared to 2012, 2014, and 2015 with 10.7 ± 3.4, 9.7 ± 3.2, and 10.2 ± 2.3 birds, respectively (Figure 3). When 2013 was removed from the analysis, there were no differences in the number of birds counted by year ($F = 0.03$, $P = 0.97$).

We detected no significant interactions between year and distance the mine center ($F = 1.09$, $P = 0.37$), the crushing facility ($F = 1.15$, $P = 0.34$), and the boundary ($F = 1.36$, $P = 0.25$). Considering main effects, the distance of birds from mining activity was different across years, with more birds in the mid-range in 2013 compared to the same year in both near and far ($P < 0.001$ for all distances). Similar to count data, an unusually high number of sage-grouse were observed in the region during 2013. With 2013 excluded from the analysis, there were no differences in bird sightings by year for the mine center ($F = 0.53$, $P = 0.66$), the coal crushing facility ($F = 0.60$, $P = 0.62$), and the mine boundary ($F = 0.62$, $P = 0.61$; Figure 4). During our flush surveys, an average of 6.6 ± 3.8 ($\bar{x}$ ± SD) chicks were observed with a hen during both early and late brood rearing periods across all survey years. Hens with chicks were observed during early brood-rearing periods in sagebrush habitats and during late brood-rearing periods in wet meadow habitats approximately 0.59 km and 0.36 km from the active mine site, respectively. Between 2013–2015, an average of 4.8 chicks were observed adjacent to the mine site, primiarly within the wet meadow area east of the mining activity. Chicks were observed 0.08 km from the mine footprint. Since completing reclamation on the historic lek, 12 males have been observed displaying in this location following 5 years of no activity. This area is located 1.9 km from the coal crushing facility and 0.7 km from active mining activity (Figure 5).

Discussion

Sage-grouse occupied the same general habitat area during breeding and non-breeding periods for the duration of the study. While others have found that sage-grouse are less likely to use habitat within 4 km of energy extraction activity (oil, gas) compared to undisturbed areas (Lyon and Anderson 2003, Doherty et al. 2006, Naugle et al. 2006), the birds occupying our study site were observed within 2 km of the center of the mine throughout the duration of the study period. Before mining, this sage-grouse population was in close

INCORPORATED
FEB 03 2017
Div. of Oil, Gas & Mining

Figure 5. Sage-grouse at the reclaimed historic lek following 5 years with no sightings and 2 years with 1 male attending only.

proximity to human-related activities including frequent vehicle traffic, farming and ranching operations, and urban development. Mining equipment and facilities may have provided a similar set of conditions to pre-mining that would create a similar behavioral response. In contrast to this study, Naugle et al. (2006) characterize declining trends in sage-grouse lek attendance relative to natural gas mining activities (permanent wells, power lines, and roads). They observed 516 leks from 1990–2005 and found that overall populations declined with extensive natural gas development (>40% within 3.2 km). They also attribute avoidance behavior to agricultural practices.

It is possible that site and habitat fidelity have played a large role in the location of the grouse in proximity to the mine. There are large patches of suitable habitat >1 km from the mine that are not frequently used by sage-grouse, which suggests that sage-grouse are not so limited in habitat that they are required to use sub-optimal habitat rather than leave the area entirely. We acknowledge that using an area near mining activity does not necessarily indicate that sage-grouse are thriving alongside such activity. However, we suggest that the restoration and habitat mitigation efforts that were initiated during the onset of mining activity, coupled with the reclamation of habitat as mining activity moved across the landscape, worked to maintain the existing sage-grouse population.

Lek counts did not decline as a result of the mining activity; the lek moved (resulting in low lek attendance counts until the UDWR found the new location) but remained stable. According to Dahlgren et al. (2016*c*), population cycles are typical for sage-grouse lek attendance, a pattern detectable at the Sink Valley Lek. Subsequently, attendance by male sage-grouse may not signify successful recruitment. Although this study did assess movement data, there was no data indicating recruitment success in Alton/Sink Valley prior to mining; therefore, we did not attempt to make the comparison of recruitment before and during mining. However, during our monthly observation surveys, we consistently observed hens and chicks, which may indicate that recruitment was occurring within the study area. Additionally, a recent

INCORPORATE
FEB 03 2017
Div. of Oil, Gas & Mi

study designed to monitor hens with GPS radio-telemetry repeatedly identified young hens within the study area, supporting the hypothesis that sage-grouse are successfully rearing brood in the area during the mining activity. Sage-grouse recruitment within 2 km of the mine is potentially increased with a combination of consistent and aggressive predator control, which was conducted as mitigation and increased habitat availability (i.e., PJ mastication, sagebrush treatments).

Management implications

Effective sage-grouse conservation practices are needed that reduce impacts while sustaining energy development demands. Increasing habitat suitability and availability while reducing threats from predators may contribute to sustainable and stable sage-grouse populations. The impacts of energy development on sage-grouse populations and sagebrush habitats has been a concern for land managers. Applying practices that minimize these impacts are needed. Because we did not evaluate the direct influence of predator control on sage-grouse survival, this aspect of management was not included in this study. However, extensive raven and coyote control was implemented to reduce predator threats to eggs, chicks, and adult sage-grouse. This effort may be an important factor in sustaining sage-grouse populations.

Acknowledgments

We appreciate B. Nead and Alton Coal Development for funding this research and to the Utah Division of Oil, Gas, and Mining for their project oversight and guidance. We appreciate the Utah Division of Wildlife Resources (R. Boswell, J. Polluck, and D. Schaible) for assisting with bird monitoring and for providing habitat improvement recommendations. We thank the members of the Color Country Adaptive Resource Management (CCARM) counsel for providing helpful feedback and suggestions for improving sage-grouse conservation and habitat improvement efforts. We thank T. Wright and R. Nowers from USDA Wildlife Services for their services in controlling impacts from predators. We appreciate the reviewers of this journal for their helpful recommendations that improved the quality of this article.

Literature cited

Akçakaya, H. R., and M. G. Raphael. 1998. Assessing human impact despite uncertainty: viability of the northern spotted owl metapopulation in the northwestern USA. Biodiversity and Conservation 7:875–894.

Baxter, R. J., J. T. Flinders, and D. L. Mitchell. 2008. Survival, movements, and reproduction of translocated greater sage-grouse in Strawberry Valley, Utah. Journal of Wildlife Management 72:179–186.

Baxter, R. J., R. T. Larsen, and J. T. Flinders. 2013. Survival of resident and translocated greater sage-grouse in Strawberry Valley, Utah: A 13-year study. Journal of Wildlife Management 77:802–811.

Boyd, C., S. L. Petersen, W. Gilgert, R. Rodgers, S. Fuhlendorf, R. Larsen, D. Wolfe, K. C. Jensen, P. Gonzles, M. Nenneman, R. Danvir, D. Dahlgren, and T. Messmer. 2011. Looking toward a brighter future for lekking grouse. Rangelands 33:2–11.

Braun, C. E., O. O. Oedekoven, and C. L. Aldridge. 2002. Oil and gas development in western North America: effects on sagebrush steppe avifauna with particular emphasis on sage grouse. Transactions of the North American Wildlife and Natural Resources Conference. 67:337–349.

Bui, T. D., J. M. Marzluff, and B. Bedrosian. 2010. Common raven activity in relation to land use in western Wyoming: implications for greater sage-grouse reproductive success. Condor 112:65–78.

Chambers, J. C., R. F. Miller, D. I. Board, D. A. Pyke, B. A. Roundy, J. B. Grace, E. W. Schupp, and R. J. Tausch. 2014. Resilience and resistance of sagebrush ecosystems: implications for state and transition models and management treatments. Rangeland Ecology and Management 67:440–454.

Coates, P. S., and D. J. Delehanty. 2004. The effects of raven removal on sage-grouse nest success. Proceedings of the Vertebrate Pest Conference 21:17–20.

Coates, P. S., and D. J. Delehanty. 2010. Nest predation of greater sage-grouse in relation to microhabitat factors and predators. Journal of Wildlife Management 74:240–248.

Coates, P. S., J. O. Spencer, Jr., and D. J. Delehanty. 2007. Efficacy of CPTH-treated egg baits for removing ravens. Human–Wildlife

INCORPORATED
FEB 03 2017
Oil, Gas & Mining

Conflicts 1:224–234.

Connelly, J. W., and C. E. Braun. 1997. Long-term changes in sage grouse *Centrocercus urophasianus* populations in western North America. Wildlife Biology 3:229–234.

Connelly, J. W., M. A. Schroeder, A. R. Sands, and C. E. Braun. 2000. Guidelines to manage sage-grouse populations and their habitat. Wildlife Society Bulletin 28:967–985.

Cooch, E., R. F. Rockwell, and S. Brault. 2001. Retrospective analysis of demographic responses to environmental change: a lesser snow goose example. Ecological Monographs 3:377–400.

Dahlgren, D. K., R. Chi, and T. A. Messmer. 2006. Greater sage-grouse response to sagebrush management in Utah. Wildlife Society Bulletin 34:975–985.

Dahlgren, D. K., M. R. Guttery, T. A. Messmer, D. Caudill, R. D. Elmore, R. Chi, and D. N. Koons. 2016*b*. Evaluating vital rate contributions to greater sage-grouse population dynamics to inform conservation. Ecosphere 7:1–15.

Dahlgren, D. K., R. T. Larsen, R. Danvir, G. Wilson, E. T. Thacker, T. A. Black, D. E. Naugle, J. W. Connelly, and T. A. Messmer. 2015. Greater sage-grouse and range management: insights from a 25-year case study in Utah and Wyoming. Rangeland Ecology and Management 68:375–382.

Dahlgren, D. K., R. T. Larsen, R. Danvir, G. Wilson, E. T. Thacker, T. A. Black, D. E. Naugle, J. W. Connelly, and T. A. Messmer. 2016*a*. Corrigendum to "greater sage-grouse and range management: insights from a 25-year case study in Utah and Wyoming." Rangeland Ecology and Management 69:235–235.

Dahlgren, D. K., T. A. Messmer, B. A. Crabb, R. T. Larsen, T. A. Black, S. N. Frey, E. T. Thacker, R. J. Baxter, and J. D. Robinson. 2016*c*. Seasonal movements of greater sage-grouse populations in Utah: implications for species conservation. Wildlife Society Bulletin 40:288–299.

Davies, K. W., C. S. Boyd, J. L. Beck, J. D. Bates, T. J. Svejcar, and M. A. Gregg. 2011. Saving the sagebrush sea: an ecosystem conservation plan for big sagebrush plant communities. Biological Conservation 144:2573–2584.

Doherty, K. E., D. E. Naugle, B. L. Walker, and J. M. Graham. 2006. Greater sage-grouse winter habitat selection and energy development. Journal of Wildlife Management 72:187–195.

ESRI. 2011. ArcGIS Desktop: Release 10.3.1. Environmental Systems Research Institute, Redlands, California, USA.

Frey, S. N., R. Curtis, and K. Heaton. 2013. Response of a small population of greater sage-grouse to tree removal: implications of limiting factors. Human–Wildlife Interactions 7:260–272.

Holloran, M. J. 2005. Greater sage-grouse (*Centrocercus urophasianus*) population response to natural gas field development in western Wyoming. Dissertation, University of Wyoming, Cheyenne, Wyoming, USA.

Holloran, M. J., and S. H. Anderson. 2005. Spatial distribution of greater sage-grouse nests in relatively contiguous sagebrush habitats. Condor 107:742–752.

Holloran, M. J., B. J. Heath, A. G. Lyon, S. J. Slayter, J. L. Kuipers, and S. H. Anderson. 2005. Greater sage-grouse nesting habitat selection and success in Wyoming. Journal of Wildlife Management 69:638–649.

Knick, S. T., D. S. Dobkin, J. T. Rotenberry, M. A. Schroeder, W. M. Vander Haegen, and C. V. Riper. 2003. Teetering on the edge or too late? Conservation and research issues for avifauna of sagebrush habitats. Condor 105:611–634

Kristan, W. B., W. I. Boarman, and J. J. Crayon. 2004. Diet composition of common ravens across the urban-wildland interface of the West Mojave Desert. Wildlife Society Bulletin 32:244-253.

Lyon, A. G., and S. H. Anderson. 2003. Potential gas development impacts on sage-grouse nest initiation and movement. Wildlife Society Bulletin 31:486–491.

Messmer, T. A., R. Hasenyager, J. Burruss, and S. Ligouri. 2013. Stakeholder contemporary knowledge needs regarding the potential effects of tall structures on sage-grouse. Human–Wildlife Interactions 7:273–298.

Miller, R. F., S. T. Knick, D. A. Pyke, C. W. Meinke, S. E. Hanser, M. J. Wisdom, and A. L. Hild. 2011. Characteristics of sagebrush habitats and limitations to long-term conservation. Pages 145–184 in S. T. Knick and J. W. Connelly, editors. Greater sage-grouse: ecology and conservation of a landscape species and its habitats. Studies in Avian Biology. Volume 38. University of Berkeley Press, Berkeley, California, USA.

Naugle, D. E., K. E. Doherty, B. L. Walker, M. J.

INCORPORATED
FEB 03 2017
Div. of Oil, Gas & Mining

Holloran, and H. E. Copeland. 2011. Energy development and greater sage-grouse Studies in Avian Biology 38:489–503.

Naugle, D. E., B. L. Walker, and K. E. Doherty. 2006. Sage-grouse population response to coal-bed natural gas development in the Powder River Basin: interim progress report on region-wide lek-count analyses. Unpublished Report, University of Montana, Missoula, Montana, USA.

SAS. 2013. SAS Institute Inc., Cary, North Carolina, USA.

Schroeder, M. A., C. L. Aldridge, A. D. Apa, J. R. Bohne, C. E. Braun, S. D. Bunnell, J. W. Connelly, P. A. Deibert, S. C. Gardner, M. A. Hilliard, G. D. Kobriger, S. M. McAdam, C. W. McCarthy, J. J. McCarthy, D. L. Mitchell, E. V. Rickerson, and S. J. Stiver. 2005. Distribution of sage-grouse in North America. Condor 106:363–376.

Spencer, J. O., Jr. 2002. DRC-1339 use and control of common ravens. Proceedings of the Vertebrate Pest Conference 20:110–113.

U.S. Fish and Wildlife Service. 2015. Historic conservation campaign protects greater sage-grouse. U. S. Fish and Wildlife Service, <https://www.doi.gov/pressreleases/historic-conservation-campaign-protects-greater-sage-grouse>. Accessed October 28, 2016.

Utah Division of Wildlife Resources. 2013. Conservation plan for greater sage-grouse in Utah. Utah Division of Wildlife Resources, Salt Lake City, Utah, USA, <https://wildlife.utah.gov/uplandgame/sage-grouse/pdf/greater_sage_grouse_plan.pdf>. Accessed September 24, 2014.

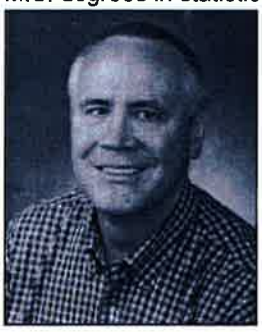
Steven L. Petersen received his Ph.D. degree in rangeland resources from Oregon State University (OSU) in 2004. He was an assistant professor at OSU in the Department of Rangeland Ecology and Management through 2007. He is currently an associate professor of wildlife and wildlands conservation in the Department of Plant and Wildlife Sciences at Brigham Young University (BYU) in Provo, Utah. He resides in Elk Ridge, Utah. His research focuses on assessing and characterizing the impacts of natural and human-related disturbance on range, forest, and wildlife habitat using geospatial technology (GIS, Remote Sensing).

B. Kirk Nicholes is the environmental specialist for Alton Coal Development, LLC. He has a degree in biology with an agricultural emphasis from Southern Utah State College. He has worked in the mining industry for 28 years, actively working with sage-grouse monitoring and mitigation for the last 6 years.

S. Nicole Frey received her Ph.D. degree in wildlife biology from Utah State University (USU) in 2004. She has worked for USU Cooperative Extension since 2004, addressing issues in wildlife conservation, human–wildlife interactions, and youth education in southern Utah. Her interest in wildlife management focuses on increasing the positive interactions between human activity (towns, agriculture, recreation) and wildlife. She currently is an extension wildlife assistant professor for Utah State University and resides in Cedar City, Utah.

Kevin M. Heaton received his B.S. degree in agribusiness in 1995 and M.S. degree in nutrition and food science in 1998, both from Utah State University. Since 1999, he has worked for Utah State University Extension as the Kane and Garfield Agriculture/Natural Resource/4-H Extension faculty. His current focus is to provide ecological and economic sustainability to the agriculture and livestock industries in southern Utah. Currently, he is an extension full professor and the county extension director in both Kane and Garfield counties in Utah.

Dennis L. Eggett received his B.S. and M.S. degrees in statistics from Brigham Young University (BYU) and his Ph.D. degree in applied statistics from North Carolina State University. He worked for 10 years at Pacific Northwest National Laboratory. Since 1997, he has been the director of the Center for Statistical Consultation and Collaborative Research at BYU.



INCORPORATED
FEB 03 2017
of Oil, Gas & Mining