

## INTERIM PROGRESS REPORT

### Greater Sage-Grouse Research in the Parachute-Piceance-Roan Region of Western Colorado Part I: Assessment of Greater Sage-grouse Response to Pinyon-Juniper Removal

AUTHORS: Dr. Brett L. Walker, Chris Binschus, Orrin Duvuvuei, Nathan Schmitz

PRINCIPAL INVESTIGATOR: Dr. Brett L. Walker

PLEASE DIRECT QUESTIONS TO: Dr. Brett Walker, Colorado Division of Wildlife, 711 Independent Ave., Grand Junction, CO 81505. Phone: 970-255-6125; E-mail: [brett.walker@state.co.us](mailto:brett.walker@state.co.us).

PERIOD COVERED: 1 September 2008 - 31 November 2009

PROJECT PERSONNEL: Brian Holmes, Wildlife Conservation Biologist (CDOW - Meeker); Heather Sauls, Wildlife Biologist (BLM - Meeker); Brad Petch, Senior Wildlife Conservation Biologist (CDOW - Grand Junction); Tom Knowles, DWM (CDOW - Meeker); Albert Romero, DWM (CDOW - DeBeque); J.T. Romatzke, AWM (CDOW - Grand Junction); Bill deVergie, AWM (CDOW - Meeker).

**\*\*Information in this report is preliminary and subject to further evaluation. Information herein may not be published or quoted without permission of the author. Manipulation of data beyond that contained in this report is discouraged.\*\***

*Abstract.* Large-scale changes to sagebrush habitats throughout western North America have led to growing concern for conservation of greater sage-grouse (*Centrocercus urophasianus*) and repeated petitions to list the species under the Endangered Species Act. Greater sage-grouse in the Parachute-Piceance-Roan (PPR) region of western Colorado face two major conservation issues: potential impacts from rapidly increasing energy development and a long-term decline in habitat suitability and range contraction associated with pinyon-juniper (PJ) encroachment. In 2006, the Colorado Division of Wildlife (CDOW) and industry partners initiated a 3-year study to obtain baseline data on seasonal habitat use, movements, vital rates, and genetics of greater sage-grouse in the PPR. CDOW has since expanded the original project to include generating high-resolution maps showing concentrated seasonal use areas and assessing the value of PJ removal to restore habitat as mitigation for energy development. Current and proposed energy development overlaps greater sage-grouse occupied range in the PPR. However, industry and agencies need higher-resolution maps showing where sage-grouse occur during each season to streamline development planning and mitigation and guide sage-grouse conservation efforts. We are currently conducting multi-scale habitat selection analyses for each season (breeding, summer-fall, winter) using ~2900 locations from 106 radio-marked greater sage-grouse collected from 2006-2009. This analysis is currently underway, and results and maps will be included in a subsequent progress report. We are also assessing the response of greater sage-grouse to experimental removal of encroaching PJ in otherwise sagebrush-dominated habitats using a before-after control-impact design. Pre-treatment surveys from winter 2008-2009 indicated that winter track occupancy, as expected, was higher on sagebrush control plots (0.012-0.069) than on plots with encroaching PJ (0.00). Data collection for winter 2009-2010 is still in progress. Summer pellet surveys indicated higher summer and winter use on sagebrush control plots than on plots with encroaching PJ, but detectability of pellets on test plots was low (mean = 0.118) and variable among observers (0.00-0.22), which may be problematic for interpretation of pellet survey data. Removal of encroaching PJ will continue in summer-fall 2010, and post-treatment monitoring will continue through 2012. Additional plots may be added in 2010 pending additional funding for removals and surveys.

Large-scale changes to sagebrush ecosystems and historical population declines (Schroeder et al. 2004) have raised concern about the status and conservation of greater sage-grouse (*Centrocercus urophasianus*) and repeated petitions for listing under the Endangered Species Act (DOI 2005). Greater sage-grouse in the Parachute-Piceance-Roan (PPR) region of western Colorado are of conservation concern due long-term declines in habitat suitability caused by pinyon-juniper (PJ) encroachment and potential impacts from rapidly increasing energy development. In 2006, the Colorado Division on Wildlife (CDOW) and industry and agency partners initiated a study to obtain baseline data on sage-grouse seasonal habitat use, movements, vital rates, and genetics for the PPR population. Location and movement data suggest that higher-resolution maps that show concentrated seasonal use areas would be valuable for improving sage-grouse conservation and development planning. PJ removal has been proposed as a way to restore sage-grouse habitat and offset or mitigate impacts of energy development in the PPR and elsewhere. However, we lack quantitative data on the magnitude and timing of such responses. The objectives of this study are: (1) to use locations of marked sage grouse to generate high-resolution habitat-use maps for each season covering the entire PPR population and, (2) to measure greater sage-grouse response to experimental removal of encroaching PJ using changes in winter track and pellet occupancy in a before-after control-treatment design.

This is the first of two consecutive progress reports. Here we summarize results of the research effort to date related to assessment of sage-grouse responses to PJ removal. A progress report on seasonal habitat use maps will follow.

#### SAGE-GROUSE RESPONSE TO PINYON-JUNIPER REMOVAL

Removal of pinyon and juniper trees from areas with an existing sagebrush understory may help restore sage-grouse habitat in the PPR. Pinyon-juniper encroachment into sagebrush has been identified as a threat to the species habitat in Colorado (CGSSC 2008; Chapter IV) and range-wide (CGSSC 2008). Encroachment in the PPR has occurred over the last 150 years and is thought to be caused by fire suppression, reduced fire frequency due to removal of residual grass via livestock grazing, and a window of climatic conditions suitable for PJ establishment during the late 1800s and early 1990s (Miller and Rose 1999).

The management goal of PJ removal in the PPR is to increase suitable habitat for sage-grouse as mitigation. This management technique has been widely implemented in Colorado and range-wide in the name of habitat improvement (CGSSC 2008). However, sage-grouse response to these management actions has been poorly studied. In fact, only one published study exists that addresses sage-grouse responses to PJ removal (Commons et al. 1999). Although we suspect that sage-grouse will eventually occupy areas where PJ removal has restored suitable local habitat conditions, three key questions remain unanswered. First, what level of PJ encroachment leads to avoidance of otherwise suitable sagebrush habitat? Second, how long does it take for sage-grouse to colonize an area following PJ removal? Third, how important are landscape-scale habitat features in determining sage-grouse response to PJ removal even if local habitat conditions are suitable?

## METHODS

#### STUDY AREA

The study area encompasses the majority of the current occupied range of the PPR sage-grouse population (Fig. 1). Within that area, we selected a subset of suitable ridges for the PJ removal study. We concentrated our efforts in the central portion of this region and did not work on Magnolia Ridge, Brush Mountain, Skinner Ridge, or Kimball Mountain. In this area, greater sage-grouse inhabit the tops of ridges and plateaus that are dissected by steep drainages. Vegetation is dominated by mountain big sagebrush (*Artemisia tridentata vaseyana*) and mountain shrubs (e.g., serviceberry, *Amelanchier* spp.; Gambel oak, *Quercus gambelii*, snowberry, *Symphoricarpos* spp.; wild rose, *Rosa* spp., etc.) interspersed with patches of aspen (*Populus tremuloides*) and Douglas-fir (*Pseudotsuga menziesii*). Sagebrush and mountain shrub habitats on ridges give way to pinyon pine (*Pinus monophylla*) and juniper (*Juniperus* spp.) forest at lower elevations that preclude use by sage-grouse. The southeast portion of the study area is experiencing intensive energy development, whereas only limited development is present in the western portion. Some parts of the study area were either temporarily or permanently inaccessible to field crews due to physical barriers (e.g. steep drainages, snow drifts), lack of roads, or lack of access to or across private land.

## FIELD METHODS

Data from newly-collared birds augmented an existing dataset from 85 radio-collared females and males monitored during 2006-2008 as part of the original project. Capturing females in the PPR population is difficult due to poor access during the lekking season when hens attend leks and because detectability is low in the tall, dense vegetation used by birds in spring, summer, and fall. Field crews captured or recaptured and radio-marked 12 females from 3 Oct - 8 Dec 2008, 13 females from 1 Apr - 28 Apr 2009, and 22 females from 31 Aug - 10 Nov 2009 within the study area using spotlights and hoop nets at night (Wakkinen et al. 1992), shoulder-mounted net-guns, and bumper-mounted net launchers (Fig. 2). All captured birds were sexed, aged, and fitted with aluminum, numbered leg bands and 17-g necklace-style radio collars (Advanced Telemetry Systems model A4060; Isanti, MN). Field crews collected exact GPS locations ( $\pm 10$ -15 m) on radio-collared birds approximately 1-2 times a week from September – November 2008, once approximately every 1-2 weeks from December 2008-March 2009, and approximately 1-2 times a week from April-November 2009. We regularly relocated missing birds on telemetry flights from fixed-wing aircraft as needed.

## ASSESSMENT OF PINYON-JUNIPER REMOVAL

This phase of research focuses on assessing short-term (2-5 years) responses of sage-grouse to PJ removal. We are using a before-after, control-treatment design to compare changes in sage-grouse winter track occupancy and summer pellet occupancy among control and treatment plots before and after encroaching PJ is removed. Caution must be exercised in interpreting results because estimates of occupancy only give an index of frequency of use, rather than of habitat quality or habitat selection.

We have three levels of treatment: (1) removal plots where encroaching PJ is removed, (2) control plots where encroaching PJ is present, but not removed, and (3) sagebrush control plots. Removal plots are used to document responses of sage-grouse to PJ removal. Surveying control plots where encroaching PJ remains untreated allows us to measure background changes in sage-grouse use of areas with encroaching PJ in the absence of treatment. Surveying sagebrush control plots without any PJ allows us to estimate background changes in sage-grouse use of nearby areas where sagebrush habitat is already suitable. All plots will be surveyed for 1-2 years prior to implementing removals and for 3-4 years following removal. We survey 3 plots per treatment. The number of plots per treatment is limited by the availability of suitable adjacent ridges with encroaching PJ. All plots selected for treatments had a sagebrush understory to ensure that habitat suitability for sage-grouse is maximized once PJ is removed.

*Plot selection.* – We used vegetation, topography, and marked bird locations in GIS to identify potential removal and control plots in 2008, then followed up with on-site visits in summer 2009 to select final site boundaries (Fig. 3). All removal plots have sparse PJ in the overstory, a sagebrush-dominated shrub layer, suitable topography, and are adjacent to where we already have radio-marked birds. Rapidly spreading energy development in the PPR may be a problem because it has the potential to confound response metrics, so we identified areas at which development is unlikely for several years. Although energy development may eventually negate the value of PJ removal, our findings can still be used to inform managers about the effectiveness of PJ removal as mitigation. Those findings can then be used to quantify the value of off-site mitigation in other areas with encroachment in northwestern Colorado.

*Winter track surveys.* We will estimate changes in frequency of use by sage-grouse using occupancy measured from ground-based track surveys (MacKenzie et al. 2006). We hypothesize that, after controlling for local- and landscape-scale habitat conditions, that winter use will increase following removal of encroaching PJ, but with a time lag due to fidelity to wintering areas. This estimator gives an estimate of the proportion of the plot that sage-grouse use during the 24-36 hr survey period following a winter storm. Winter track surveys have the following assumptions: (1) all animals move and leave tracks during the survey period (between when snowfall stops and when the survey is conducted); (2) all tracks deposited in sample units during the survey period can be seen and correctly identified; (3) surveys do not influence whether or not tracks are present in sampled units; (4) pre-storm tracks can be distinguished from post-storm tracks; and (5) all sample units within a plot are surveyed on the same day. Assumption 1 is likely to be met because wintering sage-grouse typically forage during the day. It is possible that sage-grouse may snow burrow for part or all of the survey period, but entrances to snow burrows are easily visible and can be counted as tracks. Tracks may also be buried if blowing

snow fills in fresh tracks. In western Colorado, winter storms are typically followed by 1-2 days of relatively calm, sunny, cold weather. To ensure that we meet Assumption 1, surveys will be aborted if windy conditions occur during the survey period. Assumption 2 is likely to be met because sage-grouse tracks can be distinguished from other birds with similar sized tracks by behavior, pellet smell, and pellet composition. Sage-grouse typically travel from one sagebrush to another, sometimes dropping leaves on the snow, as they forage, whereas dusky grouse (*Dendragapus obscurus*) typically forage on and travel between conifers and common ravens (*Corvus corax*) often double-hop on the ground rather than walking and do not eat sagebrush. Sage-grouse also leave distinctive sagebrush-filled pellets that smell strongly of sagebrush in winter. Assumption 3 may be violated if surveyors flush birds that then land within another sample unit later surveyed. Although this assumption cannot be tested or controlled for, we can record whether birds flushed from the sample unit, how many, and whether they flew toward or away from the unsurveyed portion of the plot. Birds thought to be part of a previously-detected flock can be noted as such and removed from analyses. Assumption 4 is met because surveys are conducted immediately following snowstorms. Snowfall during the storm buries old tracks, and fresh, post-storm tracks are easily distinguished from older, pre-storm tracks even when old tracks are still visible (often they are not). To meet assumption 5, we conduct surveys on one day across an equal number of plots in each treatment level following each storm. Different groups of plots may need to be sampled after different snowstorms depending on the manpower available. Vegetation data can be collected the day after if necessary, surveying to ensure that all selected sample units within plots are surveyed on the same day.

For surveys, we gridded each plot into 30 m x 30 m sample units and selected sample units to survey using a systematic-random sampling design. We selected a 30 x 30 m sample unit size so that sample units were large enough to contain sage-grouse tracks but small enough to ensure that all tracks within the sample unit were detected. Within each sample unit, we record presence or absence of sage-grouse tracks and estimate the number of individuals that left tracks. We also collect the following local habitat covariates likely to influence use at each sample unit surveyed: (1) pinyon-juniper height and density; (2) snow depth; (3) average exposed height for important dominant or co-dominant shrub species (e.g. sagebrush, mountain shrubs); (4) shrub cover of dominant or co-dominant species, and (5) approximate no. of hours since last snowfall. We will also measure important landscape-scale covariates identified as important predictors of use in winter habitat selection analyses on each sample unit in a GIS (e.g., terrain ruggedness, distance to nearest forested habitat, or amount of sagebrush habitat at specific scales) and include them as covariates in analyses to test for the influence of landscape-scale habitat variables on sage-grouse responses. Because it may take longer for sage-grouse to colonize areas farther away from currently used areas, regardless of habitat suitability following treatments, we will also include a covariate with approximate distance from nearest known-use area (estimated from habitat use by marked birds). To test for different possible patterns of the timing of colonization of treated areas by sage-grouse, we will incorporate a time-trend variable, with the prediction that use will increase either linearly or quadratically over time. We use a logit-link in the analysis to constrain occupancy estimates to a (0, 1) interval.

*Winter vegetation surveys.* – We measure snow depth at the sample unit center, average exposed shrub height of sagebrush and non-sagebrush shrubs, and no. of pinyon and juniper trees in three height categories (0-2 m, 2-4 m, > 4 m) within each sample unit on each visit (Connelly et al. 2003). The purpose of measuring vegetation cover is to determine whether local-scale habitat is already suitable for sage-grouse and to control for effects of among-sample unit and among-plot variation in sagebrush and non-sagebrush vegetation cover and height. We quantify sagebrush and non-sagebrush shrub cover using line-intercept methods (Canfield 1941) during the summer because using line-intercept technique is impractical in deep snow.

*Winter pellet collection for genetic analysis.* – No previous studies have estimated winter track occupancy for sage-grouse, and the relationship between track occupancy and the no. of individuals present remains unknown, so the method requires validation. We plan to test whether occupancy reflects true abundance by comparing occupancy estimates to abundance estimated from genetic mark-recapture results. We plan to use mark-recapture methods using non-invasive genetic samples based on winter pellet sampling to estimate the no. of individuals using each plot over the course of the winter. We collect  $\geq 1$  fecal pellet per individual track encountered during track occupancy surveys. Pellets deposited along tracks of foraging birds in winter are either fresh or recently frozen and thus highly suitable for DNA extraction. Oyler-McCance and St. John (2008) developed methods to identify individual sage-grouse from fecal pellets, and such methods appear to be reliable, with >10 polymorphic microsatellite loci available for analysis and relatively low rates of misclassification.

Statistical methods are also now available that allow estimation of genotyping error if sample sizes permit (Lukacs and Burnham 2005). Tracks typically have pellets on them every 10-20 ft. (B. Walker, pers. obs.), so it is likely that pellets can be obtained for most if not all birds whose tracks cross a surveyed sample unit. Because surveys of each plot are repeated, we can use pellets collected during the second and third survey periods to estimate detectability of individuals for mark-recapture analyses. Details of genetic methods are described in Oyler-McCance and St. John (2008). Genotypes encountered across survey periods allow us to generate an encounter history data for analysis in a mark-recapture framework and estimate the number of grouse using the survey plot, the probability of a grouse remaining in the survey plot among occasions, and detection probabilities.

*Summer pellet surveys.* We obtain an index of use during the summer-fall periods by estimating pellet occupancy in Jul-Oct (MacKenzie et al. 2006). Additionally, spring-fall (May-Oct) pellets can be distinguished by the presence of intact insect parts and flower heads in droppings, whereas winter (Dec-Feb) pellets consist entirely of digested sagebrush leaves (Wallestad et al. 1975). This allows us to generate separate estimates for spring-fall, winter, and year-round occupancy from pellet data. An occupancy estimator gives an estimate of the proportion of the plot on which sage-grouse have deposited pellets during the survey period. Because we cannot assume that all sage-grouse using a plot or sample unit deposit pellets (defecation rates for sage-grouse are unknown and sage-grouse may use a plot or sample unit without defecating), we cannot measure actual sage-grouse occupancy in any season, only pellet occupancy during the survey period (*contra* Dahlgren et al. 2006). Pellet surveys have the following assumptions: (1) all pellets can be correctly identified as adult or chick by size; (2) adult-sized pellets can be correctly identified as either sage-grouse or non-sage-grouse; and (3) surveys do not influence whether or not pellets are present in sampled units. Quantitative analyses only focus on adult-sized pellets because pellets from dusky grouse chicks and sage-grouse chicks probably cannot be differentiated, and both species occur in the study area. Adult pellets of the two species can probably be distinguished by smell. Adult-sized sage-grouse typically consume 13-39% sagebrush throughout the spring and summer (Wallestad et al. 1975, Schroeder et al. 1999) such that adult-sized pellets typically smell strongly of sagebrush, even in summer, whereas sagebrush has never been documented in the diet of dusky grouse in any season (Zwickel 1992). Dusky grouse pellets smell of plant material, but lack the pungent smell of sagebrush, a pattern that has been double-checked by smelling pellets deposited by sage-grouse and dusky grouse encountered in the field. We train all observers to identify sage-grouse pellets by appearance, composition, and smell prior to surveys. Assumption 3 may be violated if surveyors flush birds that then land within another sample unit later surveyed. However, violation of this assumption is unlikely to meaningfully influence analyses because the number of pellets deposited in an unsurveyed sample unit during the brief window before the unit is surveyed is small compared to the entire survey window (Aug-Sept).

We used a subset of the same systematic-random sample of 30 m x 30 m sample units selected for winter track surveys for conducting pellet surveys. This allows us to use vegetation sampling data for both analyses. Crews search for foraging pellets, roost piles (day or night), and cecal piles within each 30 x 30-m sample unit. Hereafter, we refer to single pellets, roost piles, and cecal droppings simply as “pellets”. Sample units are visited in July to document, count, and remove pellets, then surveyed again for newly deposited pellets in October. Pellets within 0.1 m of each other are recorded as one pellet cluster. Sample unit centers are marked using high-visibility flagging and numbered aluminum tags. Each observer carefully and thoroughly surveys the sample unit, counts the number of pellet clusters present, counts the number of pellets within each cluster, and removes all pellets encountered from the sample unit. Pellet detectability is typically low and may vary among observers (Dahlgren et al. 2006), so we estimate detectability of pellets and observer bias by having each observer survey eight sample units in which we place clusters of fresh pellets of various sizes (1, 4, 8, and 12 pellets) at random directions and distances up to 14 m from the sample unit center. Sample units used for testing detectability are exhaustively grid-searched prior to surveys to ensure that no fresh pellets are present before the test.

*Summer vegetation surveys.* – We will sample and compare vegetation at locations used by marked sage-grouse in winter and within each sample unit on treatment and control plots to determine whether local-scale habitat is already suitable for sage-grouse and to control for vegetation features known to influence breeding-season habitat selection (Hagen et al. 2007). We will establish two 30-m perpendicular intersecting transects running true N-S, E-W to measure local-scale vegetation features within sample units in Aug-Sep. Along each

transect, we will measure: (1) shrub canopy cover by species using the line-intercept method (Canfield et al. 1941); (2) height of the nearest shrub (excluding inflorescences) within 2.5 m; (3) height of nearest live grass (maximum droop height of leaves, excluding inflorescences); (4) height of residual dead grass (maximum droop height of leaves, excluding inflorescences); and (5) cover of “forage” forbs within Daubenmire quadrats at 5-m intervals along transect lines. Data collected at the sample unit center point only counts as one data point. We define “forage” forbs as those previously identified as major components of adult or juvenile spring and summer diets (Klebenow 1969, Drut et al. 1994, Barnett and Crawford 1994, Gregg et al. 2008).

*Pellet survey analysis.* – In the final analysis, we will consider the following local habitat covariates likely to influence grouse winter or spring-summer use at each sample unit surveyed: (1) pinyon-juniper density; (2) sagebrush and non-sagebrush canopy cover by species; (3) average sagebrush height; (4) average shrub height; (5) average live and residual grass height, and (6) “forage” forb cover. Important landscape-scale covariates identified as important predictors of use from summer habitat selection analyses will also be measured on each sample unit in GIS and included as covariates to test for the influence of landscape-scale habitat variables on sage-grouse responses. Because it takes longer for sage-grouse to colonize areas farther away, regardless of habitat suitability following treatments, we will also include a covariate with distance from nearest known active lek. To test for different possible patterns of the timing of colonization of treated areas by sage-grouse, we will incorporate a time-trend variable. Data from each survey of each sample unit will be maintained as a separate record in the analysis. We will use a logit-link to constrain occupancy estimates to a (0, 1) interval.

*Pinyon-juniper removal.* In areas with sparse PJ, we may use a chainsaw crew to minimize soil disturbance (\$100/acre) or a Bobcat with Fecon head (\$75/acre). In areas with denser PJ, we will use a Hydroaxe (\$175-\$300/acre, depending on PJ density). All areas selected for treatment were in the beginning stages of encroachment (i.e., numerous small trees) to ensure that PJ removal would produce the greatest suitable sagebrush habitat for the least amount of money.

## RESULTS

*Seasonal Locations.* Field crews and flights collected ~2900 locations from 106 marked birds (mostly females) from Apr 2006 - Aug 2009 (Fig. 4). These data are currently being used in multi-scale habitat selection models to create high-resolution maps of greater sage-grouse seasonal habitats throughout the PPR.

*Winter Track Surveys.* We conducted one complete set of winter track surveys on each of the 9 plots in Jan-Feb 2009. As expected, winter track occupancy was higher on sagebrush control plots than on plots with encroaching PJ (Table 1). Sagebrush control plots had winter track occupancy estimates of 0.012-0.069, whereas plots with encroaching PJ showed zero occupancy. We counted 17-45 individual tracks on control plots during the survey period, whereas we found zero tracks on plots with PJ (Table 1). Estimating the number of individuals using a sample unit based on tracks was difficult for large flock sizes greater than approximately 10, so counts of tracks must be considered an index of abundance rather than an exact count. Winter surveys from 2009-2010 are nearly complete, and those data will be analyzed in spring 2010.

*Genetics.* Although completing only one survey in winter 2008-2009 precluded genetic mark-recapture analyses, we collected 90 pellet samples from 10 sample units with tracks. Pellet collection is still underway this winter. These samples will provide a minimum estimate of the number of individuals using each plot from genetic markers. Contracting for the genetic analysis is underway and frozen pellet samples are in storage in Grand Junction.

*Summer Pellet Surveys.* We conducted one complete set of pellet surveys on each of the 9 plots in August 2009 to assess the feasibility of the survey methodology. Surveys took much longer than anticipated to complete, and we were unable to complete a follow-up survey in fall 2009. For that reason, occupancy estimates do not represent summer use of the plot in 2009, but rather accumulated use of the plot over a time period comparable with how long it takes pellets to deteriorate in the field (~2-3 years).

Pellet surveys indicated higher winter and summer occupancy rates on sagebrush control plots than on plots with encroaching PJ (Table 2). Fresh pellets (those from summer 2009) were found on 0.00-0.055 (mean = 0.018, n = 3) of control plots, whereas plots with encroaching PJ had none (mean 0.000, n = 6). Data from summer pellets of all ages indicated summer occupancy of 0.049-0.127 (mean = 0.098, n = 3) on control plots versus 0.000-0.061 (mean = 0.028, n = 6) on plots with encroaching PJ. Data from winter pellets of all ages

indicated higher winter occupancy (range 0.268-0.382, mean = 0.344, n = 3) on control plots than on plots with encroaching PJ (range 0.000-0.104, mean = 0.041, n = 6).

*Pellet detectability.* – Observers conducted pellet surveys on eight 30 x 30 m test plots. Each plot contained four piles of fresh sage-grouse pellets of different sizes (1, 4, 8, and 12 pellets). Detectability of fresh pellets was low overall (0.118) and variable among the four observers (0.00, 0.06, 0.13, and 0.22). Variable detectability may be an issue for interpretation of data from pellet surveys, particularly if effect sizes are small between treatment and control plots.

## DISCUSSION

Overall, occupancy data from winter track surveys and summer pellet surveys were largely as expected, with higher occupancy on sagebrush control plots than on plots with encroaching PJ. Genetic work to estimate the no. of individuals from pellet samples in spring 2010 will help resolve whether track counts within sample units are a reliable index of the number of birds using a sample unit and whether occupancy is a reliable index of the number individuals using a plot.

## RESEARCH TIMELINE

We are collecting data on locations of marked females in fall 2009 through spring 2010 as a validation dataset for seasonal habitat use maps generated from 2006-2009 data (Table 3). Three sets of winter track surveys will be conducted from December 2009 - February 2010. Two sets of summer pellet surveys will be conducted 2010, one in July and a follow-up in October.

## LITERATURE CITED

- Barnett, J. K., and J. A. Crawford. 1994. Pre-laying nutrition of Sage Grouse hens in Oregon. *Journal of Range Management* 47:114-118.
- Canfield, R. H. 1941. Application of the line interception method in sampling range vegetation. *Journal of Forestry* 39:388-394.
- Colorado Greater Sage-grouse Steering Committee (CGSSC). 2008. Colorado greater sage-grouse conservation plan. Colorado Division of Wildlife, Denver, CO, USA.
- Commons, M. L., R. K. Baydack, and C. E. Braun. 1999. Sage grouse response to pinyon-juniper management. Pages 238-239 in S. B. Monsen and R. Stevens, compilers. *Proceedings: ecology and management of pinyon-juniper communities*. RMRS-P-9. United States Department of Agriculture, Forest Service, Fort Collins, CO, USA.
- 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.
- Department of the Interior (DOI). 2005. 12-month finding for petitions to list the greater sage-grouse as threatened or endangered. *Federal Register* 70(8): 2244-2282.
- Drut, M. S., W. H. Pyle, and J. A. Crawford. 1994. Technical note: Diets and food selection of Sage Grouse chicks in Oregon. *Journal of Range Management* 47:90-93.
- Gregg, M. A., J. K. Barnett, J. A. Crawford. 2008. Temporal variation in diet and nutrition of preincubating greater sage-grouse. *Rangeland Ecology and Management* 61:535-542.
- Klebenow, D. A. 1969. Sage Grouse nesting and brood habitat in Idaho. *Journal of Wildlife Management* 33:649-662.
- Hagen, C. A., J. W. Connelly, and M. A. Schroeder. 2007. A meta-analysis of greater sage-grouse *Centrocercus urophasianus* nesting and brood-rearing habitats. *Wildlife Biology* 13:42-50.
- MacKenzie, D. I., J. D. Nichols, J. A. Royle, K. H. Pollock, L. L. Bailey, and J. E. Hines. 2006. *Occupancy estimation and modeling: inferring patterns and dynamics of species occurrence*. Elsevier Press.
- Miller, R.F. and J.A. Rose. 1999. Fire history and western juniper encroachment in sagebrush steppe. *Journal of Range Management* 52:550-559.

- Oyler-McCance, S. J. and J. St. John. 2008. Unpublished final report. Pilot study to assess the effectiveness of DNA extraction from Gunnison sage-grouse feces for use in population estimation studies. U. S. Geological Survey, Fort Collins, CO, 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, C. W. McCarthy. 2004. Distribution of Sage-grouse in North America. *Condor* 106:363-376.
- Schroeder, M. A., J. R. Young, and C. E. Braun. 1999. Sage-grouse (*Centrocercus urophasianus*). Account 425 in A. Poole and F. Gill, editors. *The birds of North America*. The Academy of Natural Sciences, Philadelphia, PA, USA.
- Wakkinen, W. L., K. P. Reese, J. W. Connelly, and R. A. Fischer. 1992. An improved spotlighting technique for capturing sage-grouse. *Wildlife Society Bulletin* 20:425-426.
- Wallestad, R., J. G. Peterson, and R. L. Eng. 1975. Foods of adult sage grouse in central Montana. *Journal of Wildlife Management* 39:628-630.
- Zwicker, F. C. 1992. Blue Grouse (*Dendragapus obscurus*). Account 15 in A. Poole, P. Stettenheim, and F. Gill, editors. *The birds of North America*. The Academy of Natural Sciences, Philadelphia, PA, USA.

#### ACKNOWLEDGEMENTS

We thank field crew leaders Brandon Miller, Evan Phillips, Kaylan Kemink, and Chris Binschus, as well as numerous field technicians and volunteers for collecting field data. We thank Brad Petch, Brian Holmes, Dan Neubaum, and Kellen Keisling for assistance with logistics and field work. Larry Gepfert piloted telemetry flights. Encana, Shell, Williams, Conoco-Phillips, and the Colorado Division of Wildlife provided funding and support for the project. We thank Encana, Exxon-Mobil, Williams, Conoco-Phillips, Chevron, and numerous private landowners and lessees for generously allowing access to private lands within the study area for research. We thank Heather Sauls, Ed Hollowed, and Kent Walters at the Bureau of Land Management White River Field Office for support of the project and for logistical assistance and funding for pinyon-juniper removal.

## TABLES

Table 1. Raw winter track occupancy estimates ( $\Psi$ )  $\pm$  SE, minimum total no. of tracks detected per plot (N), and no. sample units surveyed (n) for greater sage-grouse in January and February 2009 in the Parachute-Piceance-Roan region of western Colorado, USA.

	PJ – Pre-treatment			PJ – Control (No Treatment)			Sagebrush - Control		
	Upper Galloway	Black Sulphur	Ryan Gulch	Dry Ryan	Eureka	Stake Springs	Dry Gulch	Canyon Creek	Black Cabin
$\Psi$	$0.000 \pm 0.000$	$0.000 \pm 0.000$	$0.000 \pm 0.000$	$0.000 \pm 0.000$	$0.000 \pm 0.000$	$0.000 \pm 0.000$	$0.069 \pm 0.027$	$0.012 \pm 0.012$	$0.048 \pm 0.023$
N	0	0	0	0	0	0	45	17	18
n	(109)	(74)	(98)	(65)	(96)	(77)	(87)	(82)	(84)

Table 2. Raw occupancy estimates  $\pm$  SE for greater sage-grouse pellets surveyed in August 2009 in the Parachute-Piceance-Roan region of western Colorado, USA. n = no. sample units surveyed per plot.

PJ – Pre-treatment				PJ – Control (No Treatment)				Sagebrush - Control			
Upper Galloway n = 49	Black Sulphur n = 38	Ryan Gulch n = 48	Mean $\pm$ SE	Dry Ryan n = 55	Eureka n = 50	Stake Springs n = 38	Mean $\pm$ SE	Dry Gulch n = 55	Canyon n = 41	Black Cabin n = 42	Mean $\pm$ SE
2009 Summer Pellet Occupancy (fresh pellets)											
0.000 $\pm$ 0.000	0.000 $\pm$ 0.000	0.000 $\pm$ 0.000	0.000 $\pm$ 0.000	0.000 $\pm$ 0.000	0.000 $\pm$ 0.000	0.000 $\pm$ 0.000	0.000 $\pm$ 0.000	0.055 $\pm$ 0.031	0.000 $\pm$ 0.000	0.000 $\pm$ 0.000	0.018 $\pm$ 0.018
Summer Pellet Occupancy (all pellets)											
0.061 $\pm$ 0.034	0.000 $\pm$ 0.000	0.042 $\pm$ 0.029	0.034 $\pm$ 0.018	0.000 $\pm$ 0.000	0.040 $\pm$ 0.028	0.026 $\pm$ 0.026	0.022 $\pm$ 0.012	0.127 $\pm$ 0.045	0.049 $\pm$ 0.034	0.119 $\pm$ 0.050	0.098 $\pm$ 0.025
Winter Pellet Occupancy (all pellets)											
0.061 $\pm$ 0.034	0.000 $\pm$ 0.000	0.104 $\pm$ 0.044	0.055 $\pm$ 0.030	0.000 $\pm$ 0.000	0.000 $\pm$ 0.000	0.079 $\pm$ 0.044	0.026 $\pm$ 0.026	0.382 $\pm$ 0.066	0.268 $\pm$ 0.069	0.381 $\pm$ 0.075	0.344 $\pm$ 0.038
Year-round Pellet Occupancy (all pellets)											
0.082 $\pm$ 0.039	0.000 $\pm$ 0.000	0.146 $\pm$ 0.051	0.076 $\pm$ 0.042	0.000 $\pm$ 0.000	0.040 $\pm$ 0.028	0.105 $\pm$ 0.050	0.048 $\pm$ 0.031	0.436 $\pm$ 0.067	0.293 $\pm$ 0.071	0.452 $\pm$ 0.077	0.394 $\pm$ 0.051

TABLE 3. Revised timeline for greater sage-grouse research (seasonal habitat maps and assessment of pinyon-juniper removal) in the Parachute-Piceance-Roan population, western Colorado, 2006-2010.

Task	Initiation	Completion
<i>Seasonal habitat use maps</i>		
GIS analyses and seasonal model development	31 Aug 2009	IN PROGRESS
Collect validation location dataset	1 Sep 2009	30 June 2010
Complete final model assessment and GIS map processing.	1 Mar 2010	31 Mar 2010
Prepare final report on winter habitat-use maps	31 Mar 2010	30 April 2010
Prepare final report on breeding habitat-use maps	15 Jul 2010	15 Aug 2010
<i>Assessing response to PJ removal</i>		
Identification of plots for PJ removal	COMPLETE	COMPLETE
Winter track surveys, pellet collection (annually)	1 Jan	1 Mar
Remove encroaching PJ (2010)	1 Aug	15 Nov
Analysis of winter track data (annually)	1 Mar	1 Jun
Analysis of genetic samples (annually, depends on no. samples)	1 Apr	1 Jun
Analysis of genetic data (annually)	1 Jun	1 Aug
Prepare cumulative report (annually)	1 Aug	1 Oct
Prepare cumulative final report	1 Aug 2012	1 Oct 2012

FIGURES

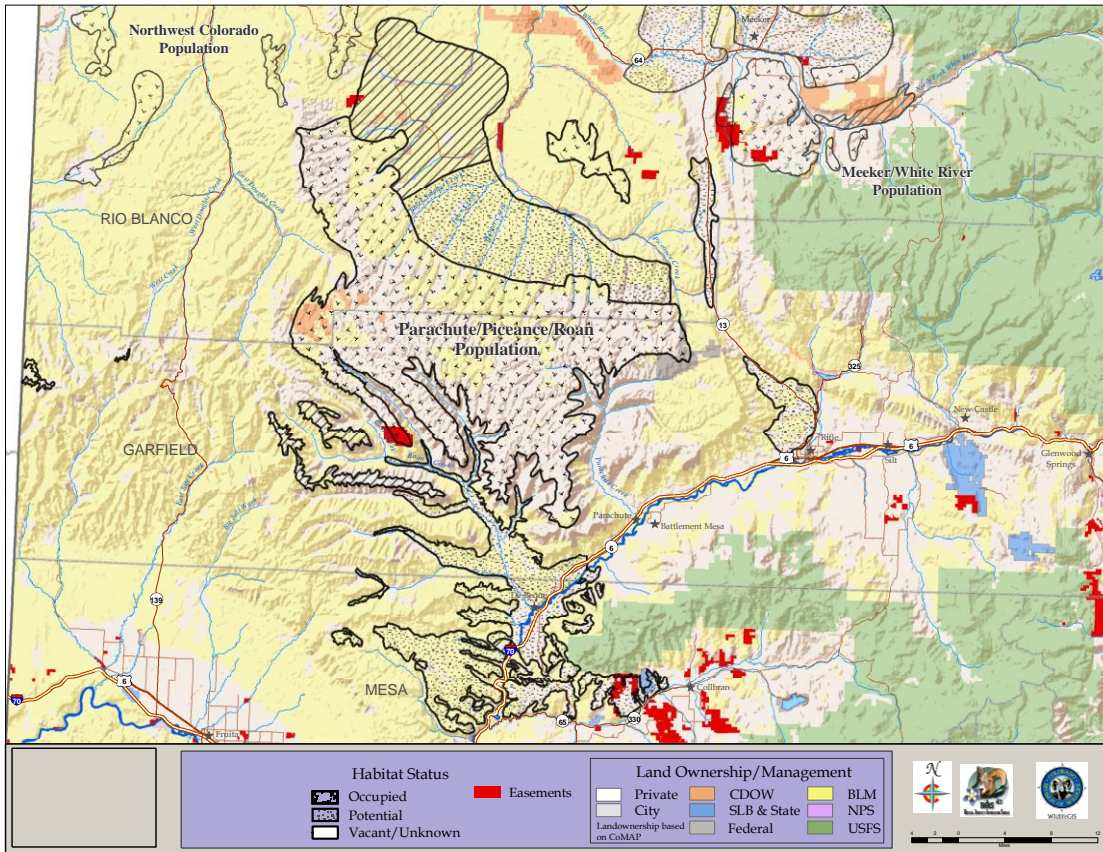


Figure 1. Distribution map of the Parachute-Piceance-Roan greater sage-grouse population showing occupied, potential, and vacant/unknown habitat (CGSSC 2008).



Figure 2. Bumper-mounted CODA net launcher used to capture greater sage-grouse.

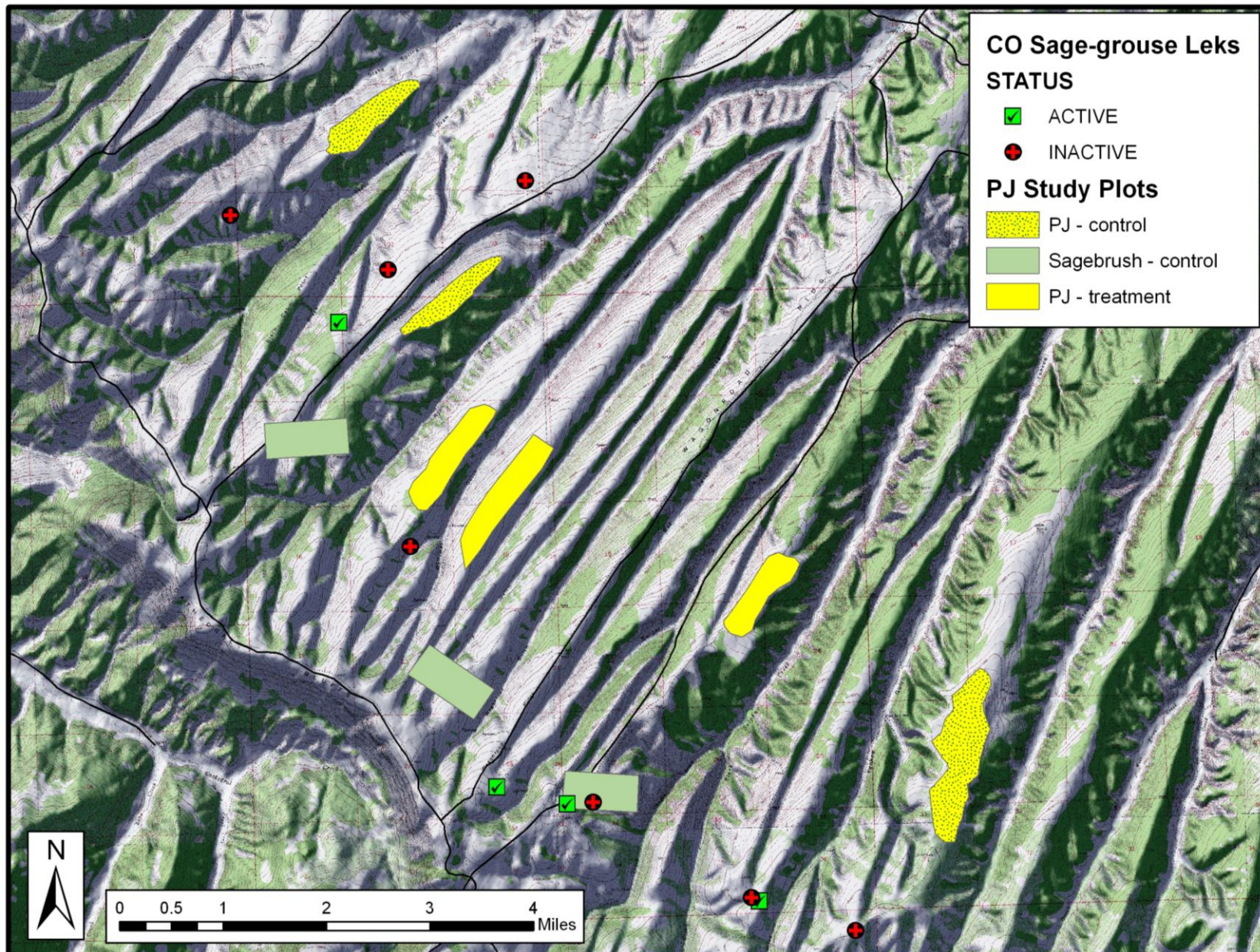


Figure 3. Study plots for the pinyon-juniper removal experiment on the west side of the PPR population.

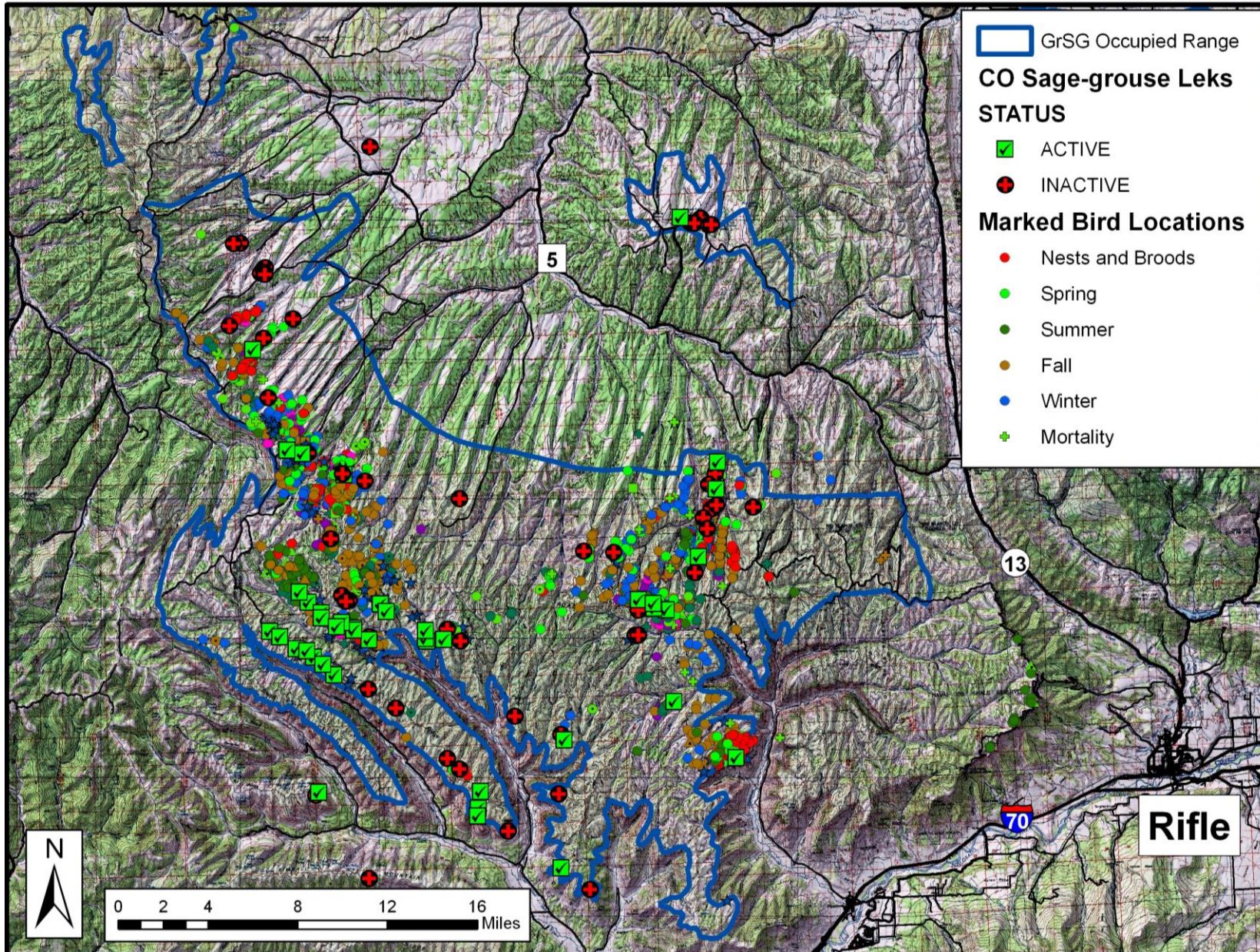


Figure 4. Occupied range, active and inactive leks, and seasonal locations of marked greater sage-grouse in the Parachute-Piceance-Roan population, northwestern Colorado, 2006-2009. Some flight locations were collected in areas inaccessible to field crews.