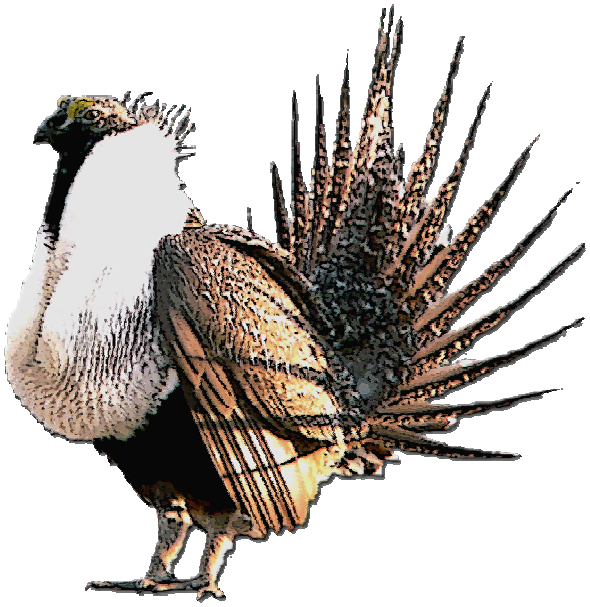
GREATER SAGE-GROUSE (*Centrocercus urophasianus*) ECOLOGY IN WESTERN BOX ELDER COUNTY, UTAH
2006 Annual Report

submitted to



Box Elder County Adaptive Management Local Working Group

Utah Division of Wildlife Resources

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Introduction

Historically, greater sage-grouse (*Centrocercus urophasianus*) were believed to be one of the most abundant and widely distributed indigenous upland game birds in the western United States (Dalke et al. 1963). Sage-grouse were once found in portions of at least 12 states and 3 Canadian provinces (Connelly et al. 2004, Schroeder et al. 2004). In Utah, sage-grouse once occupied all 29 counties. The species is currently found in 26 counties and inhabits 50% of their historical distribution (UDWR 2002, Beck et al. 2003). Western Box Elder County supports one of the largest greater sage-grouse populations in the state (UDWR 2002, Beck et al. 2003).

Due to continued downward population trends, several organizations have petitioned the U.S. Fish and Wildlife Service to list greater sage-grouse for protection under the Endangered Species Act of 1973 (Connelly et al. 2004). In 1996, the Western Association of Fish and Wildlife Agencies (WAFWA) recommended the formation of local working groups in each state that the birds occupy (Connelly et al. 2004). One of the main goals of these working groups is to research and address local area conservation issues regarding sage-grouse and their required habitat. By 2004, a total of 44 groups had been formed (Connelly et al. 2004). Sage-grouse are not currently listed for protection in the United States.

Box Elder County Adaptive Resource Management (BARM)

The Box Elder County Adaptive Resource Management Coalition (BARM) is a public and private partnership that was organized in 2002 to address stakeholder concerns about declining sage-grouse populations. The partnership employs an adaptive management approach designed to address local stakeholder concerns while working toward achieving the goal of providing multiple resource benefits (Bergerud 1988). These benefits include conservation of greater sage-grouse populations and local community economic sustainability.

The partnership is chaired by local landowners and administered by Utah State University Extension's Community-Based Conservation Program (CBCP). The working group proposes to implement a 10-year adaptive resource management plan that blends greater sage-grouse conservation and regional socio-economic sustainability with restoration of sagebrush communities. The group believes that baseline information on sage-grouse ecology in Box Elder County is needed to prioritize conservation actions and measure impacts.

Research conducted by Utah State University in south-central Utah suggests that chemical and mechanical manipulations in degraded sage-grouse brood-rearing habitat can successfully restore sagebrush steppe environmental functions, resulting in increased forage production, plant diversity, and grouse use (Dahlgren et al. 2006). The research demonstrated that plant diversity and production in sagebrush habitat types can be increased if sagebrush canopy cover is reduced to 19-20% (Braun et al.1977, Connelly and Braun 1997, Connelly et al. 2000). This work was conducted at elevations above

2600 meters in brood-rearing areas. The size of the treatments were limited to 40.5 ha plots that exhibited 30-70% sagebrush (*Artemisia* spp.) canopy cover.

The results of preliminary research conducted by BARM in cooperation with Utah State University suggests that brood-rearing habitat may also be limiting sage-grouse populations in western Box Elder County. To address this, BARM has implemented similar sagebrush treatments on larger plots (120 ha) of private lands on the Grouse Creek Mountain range in western Box Elder County. The project area is < 2000 meters in elevation (Figure 1).

The need for conducting these types of management experiments at different elevations and scales has been highlighted in both the Utah and the Western Association of Fish and Wildlife Agencies (WAFWA) sage-grouse management guidelines. The results of this research will be used to guide the management activities of the local working group. In addition, this information will be important in assisting the U.S. Fish and Wildlife Service in making decisions regarding the impacts of conservation efforts when reviewing petitions to list sensitive species.

Purpose

The purpose of this project is to describe the ecology of the greater sage-grouse population in western Box Elder County and evaluate the effect of site-specific sagebrush management treatments conducted on private land to enhance livestock production and sage-grouse habitat. Completion of this project will result in the identification of conservation technologies and strategies that can assist Natural Resources Conservation Service (NRCS) field staff in the planning and implementation of habitat projects and practices on private lands. These projects also will contribute to range-wide sage-grouse conversation efforts.

This research will document the effect of larger scale chemical and mechanical treatments on rangeland forage production and greater sage-grouse habitat and habitat-use.

Study Objectives

The objectives of this study are:

1) To collect baseline data on greater sage-grouse ecology in western Box Elder County, including information on general habitat-use, nesting and brood-rearing habitat, nesting initiation and success, survival, and seasonal movement patterns.

2) To document interlek movements or nomadic breeding of male sage-grouse in the study area.

3) To delineate winter habitat for the sage-grouse in the Grouse Creek Valley and to evaluate the ecological stability of the wintering habitat.

4) To evaluate the effects of the 2 sagebrush treatments [spike (herbicide), and Lawson aerator (mechanical)] on pre-laying sage-grouse hens and brooding sage-grouse within treated areas as it compares to the control treatments.

Study Area

The study area is located in the Grouse Creek Mountain range in western Box Elder County, Utah (Figure 1). This area is a sub-management unit of the Box Elder County Adaptive Resource Management area. The area is bounded by the Idaho border on the north, Nevada border on the west, Grouse Creek Mountains on the east, and Route 30 on the south. There are 37 active leks within the study area, ranging from 1500-2100 m in elevation. Sage-grouse leks have been counted in this area since 1959 (Figure 2.) The area encompasses approximately 1572 km^2 of public and private lands. Grazing by domestic livestock is the primary use of these lands.

The vegetation in the study area consists mainly of shrub-steppe intermixed with grassy meadows, and woodlands. Common shrubs and trees include big sagebrush (*Artemisia tridentata*), black sagebrush (*A. nova*), rabbitbrush (*Chrysothamnus* spp.), serviceberry (*Amelanchier utahensis*), snowberry (*Symphoricarpos albus*), bitterbrush (*Purshia tridentata*), juniper (*Juniperus osteosperma*), quaking aspen (*Populus tremuloides*), and chokecherry (*Prunus virginiana*). Common grasses include wheatgrasses (*Agropyron* spp., *Elymus* spp.), Kentucky bluegrass (*Poa pratensis*), cheatgrass (*Bromus tectorum*), and great basin wildrye (*Elymus cinereus*). Common forbs include phlox (*Phlox* spp.), astragalus (*Astragalus* spp.), arrowleaf balsamroot (*Balsamorhiza sagittata*), lupine (*Lupinus caudatus*), western yarrow (*Achillea millefolium*), prickly pear (*Opuntia humifusa*), and wild onion (*Allium acuminatum*).

Methods

Sage-grouse Ecology

Lek surveys

The methods used to obtain the sage-grouse population data follow UDWR standard protocols and those of Connelly et al. (2003). The completed counts from each lek are estimated to represent 75% of the total male attendance. Using a 2:1 female to male ratio, population estimates are calculated. The population estimates are useful in comparing relative changes from year to year (Beck and Braun 1980).

Lek sites within the study area were counted once a week from the last week in March to the end of April 2006. The lek counts were conducted using a combination of the techniques described by Patterson (1952) and Beck and Braun (1980). Lek counts were conducted one half hour before sunrise in reasonably good weather, light or no wind and partly cloudy to clear skies (Emmons and Braun 1984). A location was selected near the lek that allowed for good visibility of the lek but did not disturb the birds. The time that

the lek count began was recorded, and the number of males on the lek was counted from right to left. The observer waited 5 to 10 minutes and counted the males from left to right; waited 5 to 10 minutes, and counted a third time from right to left. The highest number of males observed in one of the three counts was recorded. This was repeated for two or three more lek sites. A maximum of four lek sites was observed per morning.

Captures and radio-telemetry

To collect baseline habitat use and ecology data on greater sage-grouse, we proposed to capture up to 30 birds (at least 75% females) annually and fit them with radio-transmitters. The birds were captured March - May 2006 on or near leks. Sage-grouse were located by spotlighting from the back of a truck or ATV and captured with a long-handled net (Giesen et al. 1982). Age (adult or juvenile) was assigned based on primary feather characteristics (Dalke et al. 1963). The birds were then fitted with an ATS (19 hours on, 5 hours off) or Holohil (24 hours on) radio-collar. A GPS location was also recorded within 5 m accuracy for each capture site.

Radio-tracking enabled the evaluation of movement, number of nests initiated, brood survival, adult mortalities, and habitat use of greater sage-grouse in the study area. Radio-collared birds were located using Communications Specialists receivers and Telonics 3-element hand-held Yagi antennae, and omni antennae.

Nests were identified and marked at a distance of 50-100 m for future reference. Nests were checked approximately every 3 days from the time they were located until they were predated, abandoned, or successfully hatched. Predated nests were evaluated for potential identification of nest predators from any eggshells, scat, tracks, or hairs. Visual locations were obtained on females with broods approximately 3 times a week between May and September of 2006. Females with broods were not flushed until chicks were at least 3 weeks old to avoid chick abandonment. Visual locations on females without broods and males were obtained at least once a week. Birds were located at least once from fixed-wing aircraft from September to April. Adult mortalities were examined to determine depredating species (Zablan et al. 2003).

Habitat monitoring

There are four general reasons for assessing habitats: 1) to document current conditions and trends of habitat; 2) to evaluate impacts of a land treatment; 3) to assess the success of a habitat restoration program; and 4) to evaluate the ability of habitat to support a reintroduction population (Connelly et al. 2003). We hope to determine the baseline information that will aid management in the future to decide which options will best meet the desired goals and objectives.

At each nest site, GPS location (within 5 m), slope, aspect, and clutch size were recorded, along with predation information if necessary. Vegetation measurements were taken in four directions (every 90° starting with a randomly chosen direction). The visual obstruction of the vegetation to and from the nest was measured using a Robel pole

(Robel et al. 1970). The Robel pole is a widespread method of measuring visual obstruction and is applicable for numerous species and habitats, and is generally recommended for assessing sage-grouse habitat (Connelly et al. 2003). We sampled shrub canopy coverage using a modified line intercept method (Canfield 1941), and the percentage of ground vegetation was measured using 20x50 cm Daubenmire frames (Daubenmire 1959). Percent cover of shrubs was measured with a 15-meter tape. The amount of live shrub canopy intersecting an imaginary vertical plane on the tape was measured. Gaps in the foliage smaller than 5 cm were counted as continuous, gaps 5 cm and larger were not counted. The amount of total shrub intersecting the line was summed and then divided by the length of the line to determine total shrub canopy coverage (Connelly et al. 2003). Use of the line intercept method will allow us direct comparison with data from many other studies because this is a very common method of measuring sagebrush canopy cover (Lyon 2000, Connelly et al. 2003). The Daubenmire frame is one of the most common methods of estimating herbaceous cover in sagebrush habitats (Connelly et al. 2003). Daubenmire frames were placed every 3 m along the 15 m tape to estimate percentages of grasses, forbs, litter, rock, and bare ground (Daubenmire 1959).

At locations of collared hens with broods, a measurement of slope, aspect, and number of visible chicks was recorded, as well as a GPS location (within 5 m). Within 24 hours, the vegetation at each brood location was also measured using the Robel pole and line-intercept method, but with a 10-meter tape. A 20x50 cm Daubenmire frame (Daubenmire 1959) was placed every 2.5 meters along the tape. These measurements were only made if the hen had or was suspected to still have a brood. In addition, locations of females without broods and males were randomly chosen for vegetation sampling.

For each nest, brood, and random bird vegetation measurement site, a random site was also selected by moving 80 m in a randomly chosen direction. Vegetation measurements were taken at each random site using identical techniques. Measuring the vegetation at random sites will allow us to compare use sites to other random sites within the same habitat.

Arthropod sampling

Arthropods, particularly insects, are an essential element of early brood-rearing habitat (Patterson 1952). Sage-grouse chicks require insects in their diet for survival and normal growth, especially in the first 3 weeks after hatching (Johnson and Boyce 1990). In order to assess insect abundance in brood foraging habitat, we used pitfall traps (Morrill 1975, Connelly et al. 2003).

Hens with broods were located 3 times each week for 7 weeks after hatching, unless it was determined that chicks were no longer present. Each week one location from each hen with a brood was randomly selected to test insect abundance and diversity. After vegetation measurements were taken, a total of 8 pitfall traps were placed flush with the ground along each of the 4 transects used in the line intercept method (see above). Pitfall

traps were placed at 5 and 10 m from the hen location along each transect. Insects were also sampled at the random site chosen for vegetation measurements.

Pitfall traps were filled with a 50/50 solution of water and antifreeze. All traps were opened for 48 hours, at which time all insects were collected. Insects from all traps in a single site were consolidated and refrigerated for preservation. All insects from each location will be separated by class, and each class will then be counted for individuals and measured for volume (E. Evans, Utah State University, personal communication).

Sage-grouse Habitat Treatments

Experimental Design

In 2005, we identified twenty four 120 ha plots on the Grouse Grazing Association land holdings that exhibited dense sagebrush canopy. Of these, we randomly selected 18 plots to conduct the experiment. There were 6 replications for each of the three treatments. The three treatments are a control (no treatment), Lawson aerator (mechanical treatment) and tebuthiron herbicide (chemical treatment). The plots were within 3 km of active leks and within summer brood-rearing habitat. Baseline data for herbaceous cover, plant species composition, shrub canopy cover, shrub densities and forb densities were collected in 2006. The treatment plots will be seeded with a mixture provided by the UDWR. Grazing will be deferred for 2 growing seasons following the completion of all treatments. Four permanent 10 m transects were established in each treatment replication. Transects were placed in representative areas within each treatment, the direction of the transect was randomly chosen by spinning a logging pin. The herbaceous cover was collected using the line intercept method. Shrub densities were taken along the same transect by laying a 10 m x 1m belt transect over the top and counting the number of shrubs present within the belt transect. The shrubs were also categorized by age class. Forb density was estimated by counting the number of forbs within the belt transect. Each treatment and control will have two paired sets of exclosures; one that eliminates small mammal use and one that allows small mammal use, but restricts use by large ungulates.

Sage-grouse use data were also collected to document grouse use in the treatments prior to treatment. Sage grouse pellet counts and bird dog flushes were used. Both measures will be taken pre and post treatment so that grouse use can be compared for each treatment as well as the relative differences in grouse use between treatments. The pellet counts were conducted along four 100 m transects. We placed $2m^2$ hoops on the line at 0, 15, 25, 50 and 100 meters. All of the pellets and cecal droppings were counted and removed from within the hoop. The bird dog flushes were conducted by allowing 1 of 3 bird dogs to cover an entire plot and the numbers of sage-grouse flushed by age class were recorded. Sage-grouse use measures will be repeated following the treatments in 2007 and 2008.

To complete the treatments, we worked with the Grouse Creek Grazing Association to prepare and submit an EQIP/WHIP proposal to NRCS. The proposal was funded and the treatments were initiated in the fall of 2005.

Monitoring

Greater sage-grouse habitat use patterns in 2006 were monitored on the treatment and control sites and will be monitored for the duration of the study. In addition, we will monitor vegetation changes and determine the effect of sagebrush treatments on sagebrush-steppe systems.

In 2005, we measured the baseline shrub canopy cover and composition of the understory in each plot. We used a variation of the line intercept method (Canfield 1941) and sampled the big sagebrush areas within each plot. We mapped the big sagebrush and randomly chose five points from which to start a 100 m sampling transect. We recorded a GPS location for each starting point. Then, a 100-meter tape was stretched in a randomly chosen direction. The amount of live shrub canopy intersecting an imaginary vertical plane on the tape was measured. Gaps in the foliage smaller than 5 cm were counted as continuous, gaps 5 cm and larger were not counted. The amount of total shrub intersecting the line was summed and then divided by the length of the line to determine total shrub canopy coverage (Connelly et al. 2003). Shrub height was measured at all locations where line intercepts were taken; the tallest live part of the shrub recorded. The highest point excluded the seed head and was reported as the highest live leaves or branch. In addition, percent cover of forbs, grasses, litter, and bare ground were measured using a 20x50 cm Daubenmire frame. The frame was placed every 10 m along the 100 m transect to estimate percent understory coverage. We believe that by increasing vegetation diversity, chick survivorship will increase as the condition of nesting and brood-rearing habitats improve.

Data Analysis

To describe pre- and post-treatment spring and summer greater sage-grouse habitat use patterns, logistic regression will be used to compare vegetation parameters of use to non-use areas ($P<0.05$). Logistic regression will be used to evaluate selection of nest sites for vegetation composition and to compare with random sites ($P<0.05$). Descriptive statistics will be used to describe sage-grouse nesting success, mortality, and survival of broods.

Anticipated Benefits

Completion of this project will provide BARM and NRCS with information on the role of existing conservation practices and technologies relative to conserving sage-grouse and other sagebrush obligate species.

Results

Sage-grouse Ecology

Lek surveys

There are 37 active leks within the study area. In the spring of 2006, 30 of these leks were surveyed (Table 1). We counted 361 strutting males attending these leks. The spring population of sage-grouse in the study area was estimated to be 1400 - 1500 birds. This count is higher than most historical counts (Figure 2).

Captures and radio-telemetry

Twenty-six Greater Sage-grouse (8 female and 18 male) were captured and fitted with radio-collars between 23 March and 10 May 2006. Of the females, 6 were juveniles and 2 were adults, weighing 1200 - 1720 g. Of the males, 3 were juveniles and 15 were adults, weighing 2200 - 2900 g. In addition to the birds captured in 2006, 11 collared birds (8 female and 3 male) remained from the 2005 season. Five females were also captured and marked in August 2006.

Sage-grouse were captured between the hours of 2300 - 0530 on or in the areas surrounding leks. The captures took place surrounding Badger Flat, Ray Kimber Ranch, Dry Canyon Mountain, Meadow Creek, Twin Meadows, and Kimbell Creek leks.

Nesting

Of the 16 collared females in spring 2006, 2 could not be located to determine nesting status. Ten females (71%) initiated nests that were located between 5 and 24 May. Nesting locations were 230 m to 17.6 km from original trapping locations. Nests were initiated under big sagebrush, juniper, wildrye, rabbitbrush, and hopsage (*Grayia spinosa*). Nest shrub heights were 56 to 400 cm (mean = 140 cm). Mean shrub canopy cover at nest sites was 20.5%. Forb and grass cover at nest sites were 15.8% and 27.9%, respectively. Arthropod data collected at nest sites are still in the process of being analyzed.

Three nests were predated. Likely nest predators included both avian and mammalian species. In most cases, we could not be certain of the specific predator. Predated nests were located under big sagebrush, rabbitbrush, and wildrye. Seven nests successfully hatched between 25 May and 14 June. The number of days between the location of the nest and hatching was 15 - 26 days. The average clutch size was 6.

Brood survival and habitat use

Two females with broods (29%) were successful in raising juveniles past 50 days. Both successful brooding hens were observed with 3 juveniles. Kimbell Creek, Twin Meadows, Simplot property, and the Cotton Thomas basin were identified as key brood-

rearing areas. Mean shrub canopy cover at brood sites was 21.3%. Forb and grass cover at these sites were 16.2% and 14.8%, respectively. Insects, especially ants, beetles, and Mormon crickets, were abundant in brood-rearing areas. Arthropod data collected in these areas are still in the process of being analyzed.

Movements and habitat use

Between the hatching date and 10 August, females with broods traveled 640 m to 9.8 km from their nesting locations. Females without broods traveled up to 26 km (mean = 6.5 km) from their initial trapping location (Figure 3). Mean shrub canopy cover at single female locations was 29.4%. Forb and grass cover at these sites were 18.4% and 20.8%, respectively. Males traveled up to 25 km (mean = 18.5 km). Mean shrub canopy cover at male locations was 29.6%. Forb and grass cover at these sites were 4.9% and 11.9%, respectively.

Common shrubs in bird locations included big sagebrush, rabbitbrush, bitterbrush, snowberry, and Utah serviceberry. Common forbs included phlox, astragalus, arrowleaf balsamroot, lupine, and wild onion. Common grasses included wheatgrasses, Kentucky bluegrass, cheatgrass, and great basin wildrye.

Bird use of the proposed treatment area

Eight birds (7 female and 1 male) that were tracked in 2006 were initially trapped and collared in the proposed treatment study area. One female successfully nested in this area, but died before her brood had aged to 50 days. One unsuccessful nest was also located within the treatment area. By 16 August, only 2 females remained. The birds that left the area either moved east to Kimbell Creek, or north into the Cotton Thomas basin. Numerous uncollared hens with broods were observed in this area in June and July.

Mortality

Four female and 2 male birds (35%) died in winter 2005-2006. Between 14 May and 15 December, 6 female and 5 male birds (31%) died. Direct causes of mortality were unknown in most cases, but several collars appeared to have been chewed, indicating mammalian predation. 2 females were found fully intact. These birds were swabbed and tested for West Nile virus, but the results were negative. One female was harvested by a hunter in fall 2006.

Interstate Sage-grouse Movements

In March 2006, 18 males (3 juvenile and 15 adult) were captured and radio-collared on Badger Flat, the southernmost lek in the Grouse Creek valley, to evaluate interlek movements and nomadic breeding. These birds were tracked until 19 May, when males were no longer observed strutting on the lek. Collars fell off of 2 males during this time due to loose crimps. One adult male spent approximately one week on a lek 7.7 km from

Badger Flat, then returned until the end of the season (Figure 4). One adult male moved into Idaho in mid-April, and was located with another collared adult male that had been trapped on a different lek. These birds traveled 50 and 75 km from their original trapping locations. 12 males (86%) did not leave the Badger Flat vicinity.

Two females and 1 male that were trapped on Twin Meadows, Kimbell Creek, and Dry Canyon Mountain leks in 2005 were located on the Dry Basin lek, east of the Grouse Creek Mountain range, in March 2006 (Figure 5). Dry Basin is outside of the study area of this project, but is the largest lek in western Box Elder County. Over 300 males were counted strutting on this lek in spring 2006. Dry Basin is assumed to be a vital wintering area for the sage-grouse population in western Box Elder County. All 3 collared birds that were located here in March returned to their original trapping locations in April, traveling 20 to 25 km.

2007 Plan of Work

All of the current research will be continued in 2007. There will be the addition of a few addition projects.

Sage-grouse Winter Habitat Use

This study will assist in the management of sage-grouse by identifying important factors influencing the stability of winter habitats. If cheatgrass is shown to be destabilizing these sagebrush ecosystems it could prove to be the limiting factor on the growth and/or stability of the Grouse Creek Valley sage-grouse population.

Study Objectives:

1. Delineate winter habitat for the sage-grouse in Grouse Creek Valley.

2. Evaluate the ecological stability of the wintering habitat.

Methods

The study will be conducted using about 30 Radio collared sage-grouse (cocks and hens) to identify the habitat inhabited by wintering sage-grouse. To do this the collared birds will be located throughout the winter (approximately 2 times a month) using fixed-wing air craft. A GPS point will be taken for each bird. Those GPS locations will then be used for subsequent measurements and analysis.

Habitat delineation (winter measures) will include; 1) shrub cover (line Intercept) above the snow , 2) snow depth, 3) slope and aspect, 4) elevation, and 5) vegetation community preferences (Wyoming vs. black sage). During the spring, we will assess site ecological conditions by measuring the following parameters; 1) vegetation cover (shrub, grass, and forbs), 2) cheatgrass occupancy, 3) plant diversity, 4) habitat stability, 5) potential

habitats, 6) use of potential habitats, 7) stability of winter habitats, and 8) comparing existing habitat conditions to published guidelines.

Sage-grouse Daily Habitat Use

This study will identify if sage-grouse broods use different habitat types throughout the course of an entire day. If sage-grouse do select different habitat types throughout the day, it could result in the need to ensure a heterogeneity of habitats available on the landscape for brooding sage-grouse.

Objective

Delineate the different habitat types used by greater sage-grouse throughout the brooding season.

Methods

The radio-collared hens with broods will be monitored every third day as described in the methods above. However, the time of the day when the hen is located will be altered so that the hen will be located during roosting (midnight), during feeding (sunrise), and while loafing (afternoon). The same vegetation measures will be taken as they have been in the past.

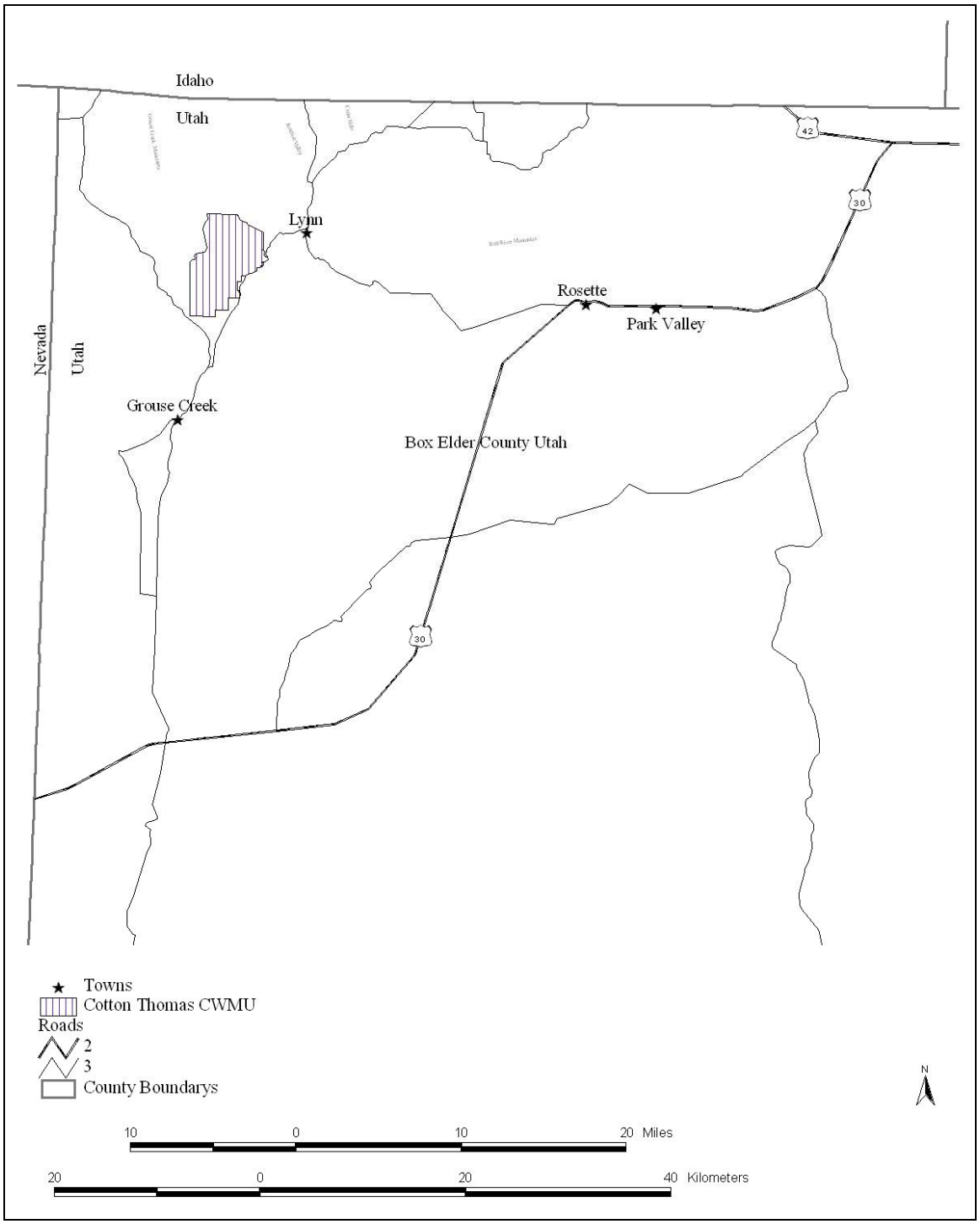

Figure 1. The Box Elder County Study Area

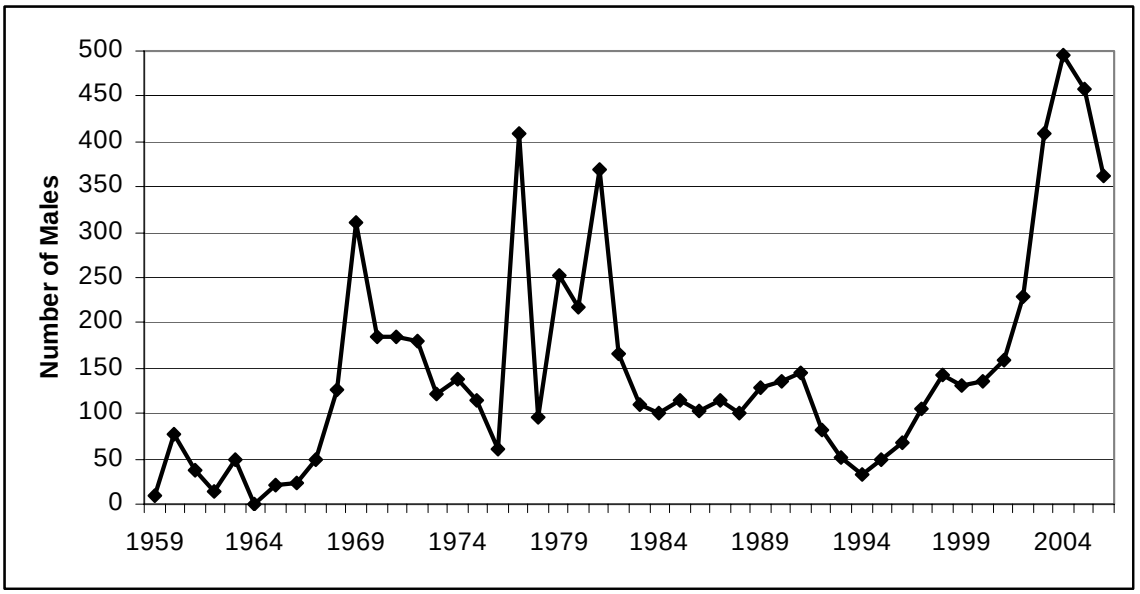

Figure 2. Historical lek count data in the study area.

Table 1. Lek count results in the study area in spring 2006. Numbers in parentheses indicate the number of individual leks in a group.

LEK	NUMBER OF MALES
Grouse Creek Complex	
Badger Flat	35
Dairy Valley Wash	16
Dake's Pass	8
Kimber Ranch Spring	28
Ray Kimber Ranch	24
Tom's Cabin Creek	13
Meadow Creek Complex	
Devil's Gate	3
Dry Canyon Mountain Group (2)	28
Hardister Creek	49
Meadow Creek Pass	16
Meadow Creek North Butte	0
Goose Creek Complex	
Goose Creek Road Group (2)	2
Goose Creek Nevada Line	0
Cotton Thomas Basin Complex	
Cotton Thomas Group (3)	0
Kimbell Creek Group (5)	34
Kimbell Creek Turnoff	11
Quaking Aspen	52
Red Bank Springs Group (5)	42

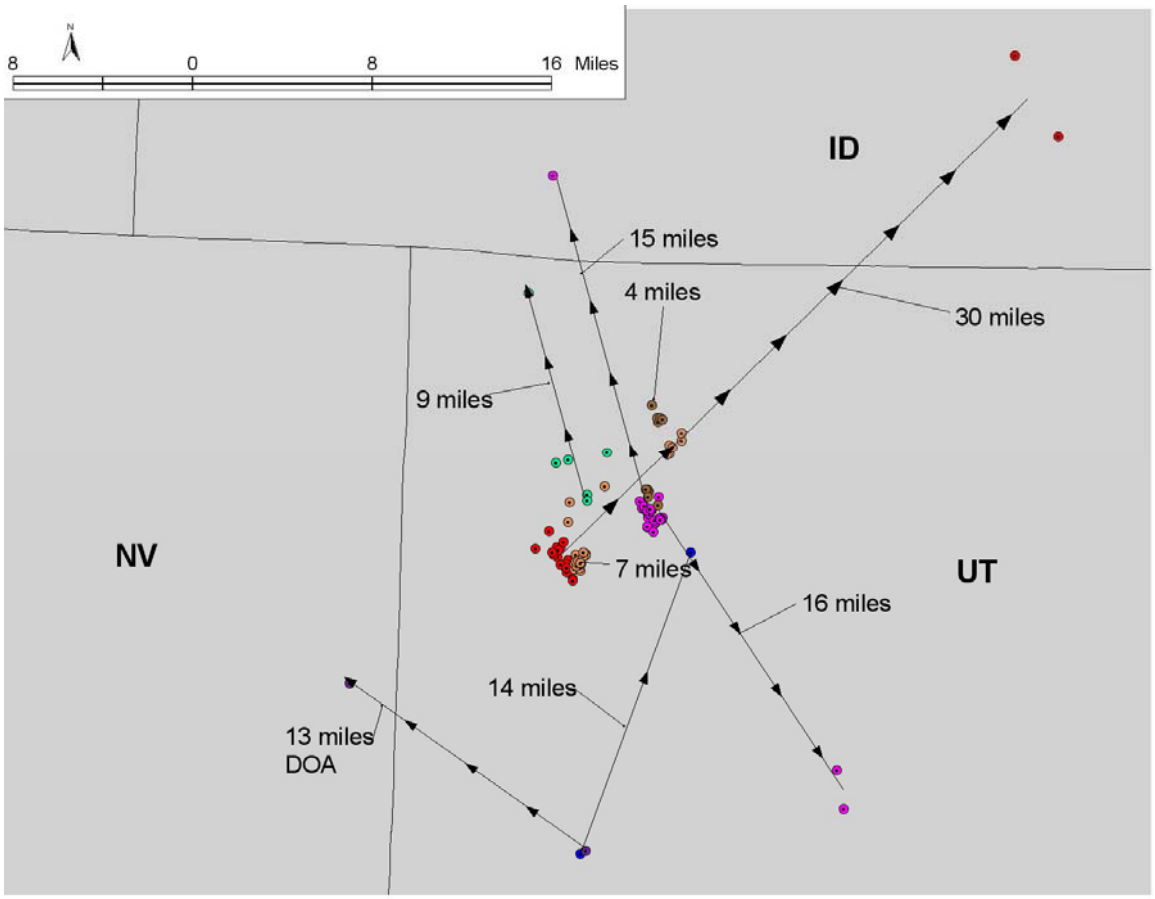

Figure 3. Greater sage-grouse long distance movements in 2005 and 2006.

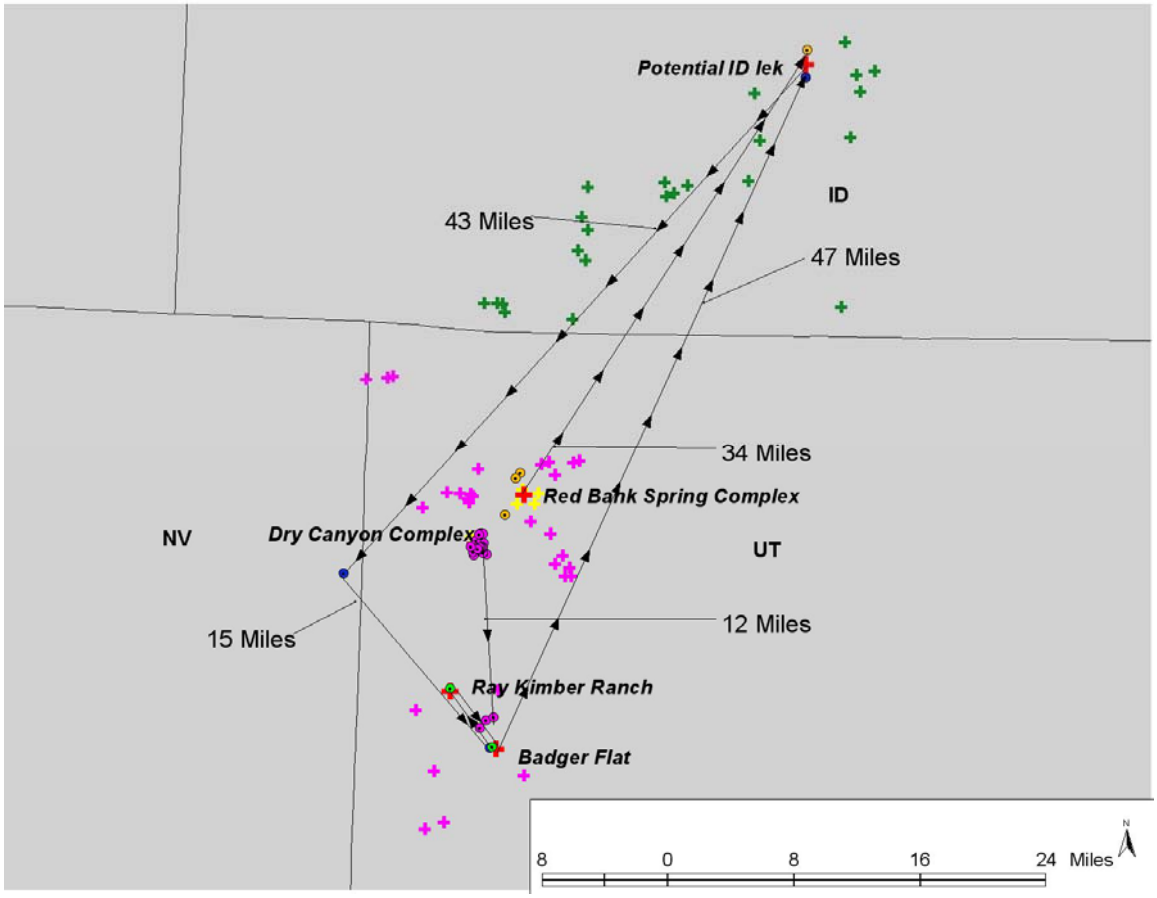

Figure 4. Greater sage-grouse long distance movements in spring 2006. Crosses indicate locations of known leks.

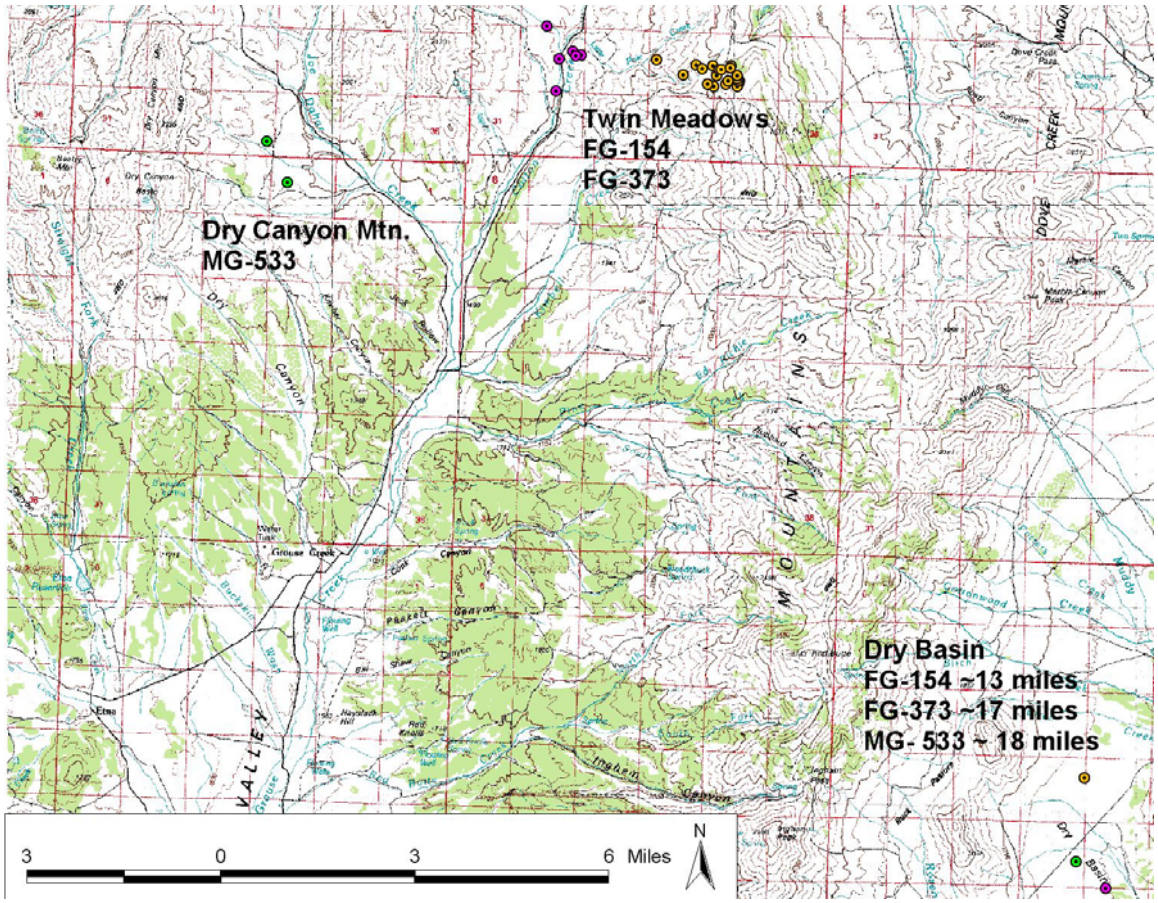

Figure 5. Greater sage-grouse long movements in winter 2005/2006.

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