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Ecology and Seasonal Habitat Use Patterns of Columbian Sharp-Tailed Grouse in Northern Utah

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ECOLOGY AND SEASONAL HABITAT USE PATTERNS OF
COLUMBIAN SHARP-TAILED GROUSE IN
NORTHERN UTAH

by

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ABSTRACT

Ecology and Seasonal Habitat Use Patterns of Columbian Sharp-tailed Grouse in Northern Utah

by

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Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*: hereafter sharp-tailed grouse) populations have been declining. These declines have been attributed to a number of factors, including habitat loss due to agriculture, habitat fragmentation, overgrazing by livestock, and the loss to fire.

To gather information about their status in northern Utah, I radio-marked sharp-tailed grouse in 2003 (n=15) and 2004 (n=20) in two research areas. The study areas were located on the south end of Cache County and in eastern Box Elder County. In the Cache study area, I monitored 7 males and 1 female in 2003, and 6 males and 3 females in 2004. In the Box Elder study area, I monitored 6 males in 2003 and 6 males and 5 females in 2004. I then located the radio-marked sharp-tailed grouse using telemetry and collected Visual Obstruction Readings (VOR) and vegetation data on each flush site and on a randomly selected paired point. I completed an unsupervised classification of the two study areas to determine if habitats were used more than would be expected based on availability. I then used a paired point linear regression to determine if vegetation parameters were correlated with sharp-tailed grouse on the landscape.

Sagebrush in the Box Elder County study area and forbs in the Cache County study area were significantly correlated with habitat use by sharp-tailed grouse. The VOR readings were higher at the flush sites than at the paired points. The unsupervised classification showed that in Box Elder County, sagebrush was used in greater proportion than is available, while in the Cache County study area there were no habitat types that were used in greater proportion than was available on the landscape.

I collected information on nest sites, nest success, broods, and mortality of these 2 populations. Nest success was 75% combined over the 2-year study, and mortality was 72% for both populations over the 2 years. Seasonal habitat use and distance travelled were determined using Global Positioning System points collected at every flush point. The distance traveled ranged from 0.9 km to 14.7 km, with the longest distance being travelled in the winter.

(75 pages)

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I am grateful to my family, especially my children for their understanding of my being away for long hours and many weekends. It was fun to have you join me on my excursions when we trapped and followed the sharpies around.

Ron D. Greer

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CHAPTER 1

INTRODUCTION

DESCRIPTION

Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*; hereafter sharp-tailed grouse) are the smallest, palest, and grayest of the six sub-species of sharp-tailed grouse found in North America (Hart et al. 1950, Johnsgard 1983). Weights for males range from 660-760 grams while females are 595-705 grams (Oedekoven 1985, Marks and Marks 1987, Giesen 1992). Males and females are similar in plumage and thus difficult to distinguish unless closely examined (Johnsgard 1983). Both sexes have cryptic gray-brown coloring, with defining markings on the crest and tail feathers that can be used to differentiate between the genders. Males have a solid crest marking and longitudinal white markings on the tail feathers, while the crest of a female is more barred and the tail feathers have horizontal white markings, with less white present than on males. Both sexes have yellow eye combs that are usually not visible, except during the mating display when the male eye comb is highly visible while dancing (Hart et al. 1950).

GENERAL HABITAT REQUIREMENTS

Sharp-tailed grouse utilize the sagebrush-steppe (*Artemesia* spp.) desert regions of the Great Basin and grassland regions of the West (Johnsgard 1983). The dominant vegetation of these communities is generally perennial bunchgrasses such as western wheatgrass (*Pascopyrum smithii*), bluebunch wheatgrass (*Pseudoroegneria spicata*), *Stipa* spp. and some introduced species such as crested wheatgrass (*Agropyron cristatum*) and intermediate wheatgrass (*Thinopyrum intermedium*), along with sagebrush species, and mountain shrubs (Hart et al. 1950, Johnsgard 1983, Oedekoven 1985, Marks and Marks 1988, Meints 1991, Ulliman 1995).

Winter habitat.—Sharp-tailed grouse heavily depend on riparian and upland deciduous plant species, and may move longer distances to reach these areas for the winter (Marks and Marks 1988, Giesen and Connelly 1993). The areas contain serviceberry (*Amelanchier* spp.), chokecherry (*Prunus virginiana*), hawthorn (*Crataegus* spp.), Antelope bitterbrush (*Purshia tridentata*), birch (*Betula* spp.) and other deciduous trees and shrubs (Hart et al. 1950, Marks and Marks 1988, Giesen and Connelly 1993, Ulliman 1995). Waste grains from harvested grain fields are also used if snow depth allows (Hart et al. 1950, Giesen and Connelly 1993). Sharp-tailed grouse will also burrow into the snow and roost if snow conditions will permit (Giesen and Connelly 1993).

Lekking habitat— In the spring males congregate on a lek and display for mating purposes. Females attend the leks in search of a mate (Ulliman 1995). Leks are conspicuously located on knolls benches, or ridge tops that are higher in elevation than the surrounding area (Ulliman 1995). Visibility on a lek is higher than at random sites (Klott and Lindzey 1989, 1990), but leks with lower visibility have not been shown to decrease reproductive success (Parker 1970, Johnsgard 1983).

Nesting habitat— Habitats used for nesting are a consequence of land use. Hart et al. (1950) observed that the majority of nests on their Utah study area were located in wheat stubble and alfalfa (*Medicaga sativa*) due to conversion of rangeland habitat to cropland. However, when native rangeland was used for nesting, most females selected a nest site under or within close proximity of a shrub (Hart et al. 1950, Evans 1968, Parker

1970, Giesen 1987, Marks and Marks 1987, Meints 1991). Shrubs species most commonly used for nesting are sagebrush species, Antelope bitterbrush, serviceberry, snowberry (*Symphoricarpos* spp.) and other mountain shrubs (Parker 1970, Giesen 1987, Meints 1991). Meints et al. (1992) determined that a minimum cover height of 25 cm was required for nesting.

Brood-rearing habitat.— Columbian sharp-tailed grouse generally utilize shrub-steppe vegetation that contains a high diversity of forbs and bunchgrasses (Hart et al. 1950, Klott and Lindzey 1989, Meints 1991). Serviceberry or Gambel oak dominated habitats in mountain shrub communities are also used (Giesen 1987). An important component of brood-rearing habitat is edge. Marks and Marks (1987) reported that 40% of brood-rearing habitat used by sharp-tailed grouse in Idaho was within 20 m from habitat edges.

The vegetation composition of brood-rearing cover varied by region. Brood-rearing habitat in Colorado contained more than 70% shrub cover (Giesen 1987) while in eastern Idaho broods selected Conservation Reserve Program (CRP) fields over native rangeland and agricultural fields (Sirotnak et al. 1991). Vegetation cover height at brood rearing sites was greater than random or independent sites both in Colorado and eastern Idaho (Giesen 1987, Meints 1991). A high diversity of forbs characterized brood use in Wyoming and western Idaho (Marks and Marks 1987, Klott and Lindzey 1989, 1990).

FACTORS IMPACTING COLUMBIAN SHARP-TAILED GROUSE POPULATIONS

Conservation Reserve Program — The advent of CRP has been cited as one of the major factors contributing to a range wide increase in sharp-tailed grouse populations. In Idaho, population numbers have increased 2 to 3 times in agricultural areas dominated by

CRP because these lands provide important habitats for the sharp-tailed grouse (Idaho Department of Fish and Game 1995). In Utah, some local populations also increased by as much as 400% when CRP connected isolated habitats and increased available habitat (Utah Division of Wildlife Resources 2002). The loss of these CRP lands would most likely have a detrimental effect on the overall population of the sharp-tailed grouse in Idaho and Utah.

Grazing— Grazing by domestic livestock is the dominant land use of native rangelands inhabited by sharp-tailed grouse. Overgrazing of native rangelands by domestic livestock can lead to loss of nesting and brood rearing habitat (Hart et al. 1950, Yocom 1952, Parker 1970, McArdle 1977). Additionally, the loss of deciduous trees and shrubs in riparian areas as a result of trampling and rubbing can be severe in areas that attract livestock with water and shade (Hart et al. 1950, Parker 1970, Kessler and Bosch 1982). While numerous studies have documented that heavy grazing pressure can be detrimental to sharp-tailed grouse habitat, no studies have documented that light or medium pressure grazing has a negative effect on habitat, or that a no-grazing regime has a positive effect on habitat (Kessler and Bosch 1982).

Chemical Treatments— Because of the detrimental impact of herbicide application to sagebrush and other deciduous shrubs such as snowberry, serviceberry, chokecherry, and hawthorn, sharp-tailed grouse populations are believed to be negatively impacted by chemical treatments (McArdle 1977, Oedekoven 1985). The recovery of the habitat and plants impacted can be affected by the intensity of the livestock grazing after application (Giesen and Connelly 1993).

Insecticides and herbicides can have direct and indirect negative impacts on chicks by eliminating a crucial component of their diet. Sharp-tailed grouse chicks are highly dependent on insects for the first 2 – 3 weeks of life (Bergerud and Gratson1988). Increased insect abundance is correlated with greater forb diversity. Herbicide applications can reduce forb diversity thus affecting insect abundance. Insecticide applications can reduce populations of insects which are important food resources for chicks.

In some instances, chicks have been found dead from pesticide exposure (Ritcey 1995). Adult sharp-tailed grouse were tested in Montana and found to be susceptible to doses of Malathion and Dieldrin. Of those treated, death occurred within 72 hours. Sub-lethal doses increased vulnerability to predation and decreased breeding (McEwen and Brown 1966).

Conversion of habitat to agricultural uses— Loss of habitat to clean farming practices and conversion to agriculture is the foremost reason for the population decline that the species is experiencing (Giesen and Connelly 1993, Idaho Department of Fish and Game 1995). Tirhi (1995) found that agricultural conversions caused a decline in riparian shrubs and plants necessary for winter habitat.

In the Okanogan Valley of British Columbia, sharp-tailed grouse habitat has been converted to agriculture and the population is probably lost except in small intensively managed pockets (Ritcey 1995). In eastern Washington, where 80% of all land was under cultivation by 1920 (Buss and Dziedzic 1955, Ulliman 1995) the amount of potential habitat has decreased by 76% from historic levels (McDonald and Reese 1998). Although the species has adapted somewhat, agricultural practices such as burning of fields can destroy nests and cover (Yocom 1943). Agricultural fields are used sparingly by sharp-tailed grouse for cover or food (Meints 1991, Sirotnak et al. 1991, Ulliman 1995).

Fire— Fire has been reported to improve and to damage sharp-tailed grouse habitat. Some vegetation components of the habitat such as snowberry, quaking aspen, and chokecherry, can recover quickly when burned, while sagebrush takes much longer to recover (Ulliman, 1995). In small burn areas, sharp-tailed grouse will use these cleared areas if surrounded by dense brush (Rogers 1969), while McArdle (1977) found less use in burned areas by sharp-tailed grouse. Sharp-tailed grouse may benefit from using burned areas that were previously thick stands of sagebrush (Hart et al. 1950, Oedekoven 1985). If stubble fields are used for nesting, fire can destroy nests when burned (Yocom 1952). The use of fire can have mixed results on lek sites. Hart et al. (1950) observed the abandonment of a lek, while Sexton and Gillespie (1979) reported the use of a previously abandoned lek after a fire.

Habitat fragmentation and genetically isolated populations— While no research has identified the impacts of habitat fragmentation, it is a concern to wildlife managers in states where sharp-tailed grouse are present (Ulliman 1995). Sharp-tailed grouse movements are generally ≤ 20 km (Meints 1991). Therefore, those populations that are separated by a distance greater than 20 km are at risk of becoming genetically isolated. In Washington, the viability of small isolated populations is questioned (Schroeder et al. 2000). Genetic variation has not been firmly established in sharp-tailed grouse. This is due to the rapid decline of populations and the lack of long-term data to support the supposition that genetic drift and loss of alleles will occur in an isolated population

(Schroeder 2007, WDGF, personal communication). In greater prairie chickens *(Tympanuchus cupido)*, loss of alleles has been documented from historical samples compared to present day samples (Bouzat et al. 1998, Bellinger et al. 2003), suggesting that in the long term the same is possible with sharp-tailed grouse. In the Mono Basin of California, the greater sage grouse *(Centrocercus urophasianus)* has been isolated and is genetically different enough to warrant protection as a separate unit (Oyler-McCance et al. 2005).

Predation— Predation likely does not influence sharp-tailed grouse numbers in most populations with adequate escape cover (Bendell 1972). Adult sharp-tailed grouse are preyed upon primarily by avian predators such as hawks, owls, eagles and falcons. Mammalian predators such as coyotes (*Canis latrans),* red fox (*Vulpes vulpes)*, and striped skunks (*Mephitis mephitis*) are common nest predators, with some corvids (*Corvus* spp.) readily taking nests and young (Ulliman 1995).

Hunting— Hunting with unrestricted seasons can have a detrimental effect on sharp-tailed grouse populations, although researchers cannot agree whether it is additive mortality or compensatory to annual mortality (Ulliman 1995). Because males congregate on leks not only in the spring but also in the fall during hunting seasons, it is believed that sharp-tailed grouse are more vulnerable to over harvest and recommend closing hunting where there are small isolated populations (Marks and Marks 1987). In Utah, populations were declining even though there was not an open hunting season (Hart et al. 1950). According to Braun (1975), 70-80% of sharp-tailed grouse die each year even if they are not being hunted, and that up to a 25% harvest have not affected spring populations. In Michigan and North Dakota, hunted populations showed negative effects of hunting those populations. Age and sex class of sharp-tailed grouse was younger (Kobriger 1993) and spring populations increased after closed seasons (Ammann 1963).

Weather— While adult sharp-tailed grouse are not greatly affected by severe weather, chick mortality can be increased by severe weather in the first 3 weeks of life due to the inability to thermoregulate properly (Bergerud and Gratson1988). Also, hen productivity can be decreased by cold, wet spring weather (Bendell 1972). Drought or prolonged dry weather can impact vegetation, leading to a decrease in cover and nesting habitat. This in turn can affect predation and nesting productivity. Because of its importance, soil moisture was correlated with sharp-tailed grouse production by Bergerud and Gratson (1988) in North and South Dakota.

STUDY PURPOSE

The Utah Division of Wildlife Resources (UDWR) is the responsible agency managing sharp-tailed grouse in the state. To ensure management decisions made by UDWR benefit sharp-tailed grouse populations in northern Utah, better information regarding the species ecology is needed. The purpose of this research was to: 1) identify the breeding and seasonal ecology of 2 distinct populations of sharp-tailed grouse occupying Cache Valley and eastern Box Elder county and, 2) describe seasonal habitat use patterns and the vegetation structure associated with use and cover preferences. This information will provide managers with a better understanding of the habitat use, vegetation requirements, and seasonal movements of sharp-tailed grouse to aid in management. This thesis is written using the style guidelines accepted and recognized by the *Journal of Wildlife Management.*

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CHAPTER 2

VEGETATION CHARACTERISTICS OF HABITATS USED BY COLUMBIAN SHARP-TAILED GROUSE IN NORTHERN UTAH

ABSTRACT: Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*; hereafter sharp-tailed grouse) were historically found in shrub-steppe (*Artemesia* spp.) communities throughout northern Utah. The range of the sharp-tailed grouse has declined to approximately 10% of their historic range in Utah. The destruction and degradation of grasslands, riparian corridors and shrub-steppe habitat from overgrazing and conversion to agricultural uses are thought to be the primary causes for the decline of the species. While general habitat requirements are known, little is known about the vegetation characteristics of habitats used by sharp-tailed grouse in northern Utah for application to management. The purpose of this study was to collect information about the vegetation characteristics of the habitats used by two sharp-tailed grouse populations occurring in Box Elder and Cache Counties of northern Utah. I monitored 15 and 20 radio-collared sharp-tailed grouse in 2003 and 2004, respectively, to determine the vegetation characteristics of the habitats used by the species. In the Cache County study area, I monitored 7 males and 1 female in 2003, and 6 males and 3 females in 2004. In the Box Elder County study area, I monitored 6 males in 2003 and 6 males and 5 females in 2004. Sharp-tailed grouse in the Cache County study area selected for habitat that as forb cover decreased and diversity increased, the likelihood of finding a sharp-tailed grouse increased, while in the Box Elder County study area they selected for areas that exhibited greater shrub cover. Sharp-tailed grouse habitat use sites exhibited greater visual obstruction readings than randomly paired points in both study areas. Forb density

was higher in the flush point transects than in the paired point transects. Managers should seek to protect habitats inhabited by sharp-tailed grouse in northern Utah that exhibit increased vegetation cover generally and more shrub and forb cover specifically. In areas lacking this cover, management actions should be implemented to increase the availability of desirable habitat types.

INTRODUCTION

The range of Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) has decreased over the last 100 years as native habitats were lost or fragmented because of home development, agricultural encroachment and habitat type change (Yocom 1943, Parker 1970, Braun 1991, Giesen and Connelly 1993, Ritcey 1995). Range wide, the sharp-tailed grouse population has declined, being extirpated from California, Nevada, and Oregon. They inhabit historic range in small percentages (1-20%) in Washington, Idaho, Wyoming, Montana, Colorado, while in British Columbia they remain in 60-80% of the historic range (Ulliman 1995).

Sharp-tailed grouse utilize the sagebrush-steppe (*Artemesia* spp.), desert regions of the Great Basin and grassland regions of the West. Vegetation composition of these communities is generally perennial bunchgrasses such as western wheatgrass (*Pasopyrum smithii*), bluebunch wheatgrass (*Pseudoroegneria spicata*), *Stipa* spp. and some introduced species such as crested wheatgrass (*Agropyron cristatum*) and intermediate wheatgrass (*Thinopyrum intermedium*), along with various species of sagebrush and mountain shrubs (Hart et al. 1950, Johnsgard 1983, Oedekoven 1985, Marks and Marks 1988, Meints 1991, Ulliman 1995).

Sharp-tailed grouse heavily depend on riparian and upland deciduous plant species, and will move longer distances to reach these areas for the winter (Marks and Marks 1988, Giesen and Connelly 1993). The areas contained serviceberry (*Amelanchier* spp.), chokecherry (*Prunus virginiana*), hawthorn (*Crataegus* spp.), antelope bitterbrush (*Purshia tridentata*), birch (*Betula* spp.) and other deciduous trees and shrubs (Hart et al. 1950, Marks and Marks 1988, Giesen and Connelly 1993, Ulliman 1995). Waste grains from harvested grain fields were also utilized if snow depth allowed (Hart et al. 1950, Giesen and Connelly 1993). Sharp-tailed grouse will also burrow into the snow and roost if snow conditions permit (Giesen and Connelly 1993).

In the spring, males congregate on a lek and display for mating purposes while females will attend the leks in search of a mate (Ulliman 1995). Leks are conspicuously located on knolls benches, or ridge tops that are higher in elevation than the surrounding area (Ulliman 1995). Visibility on a lek is higher than at random sites (Klott and Lindzey 1989, 1990), but leks with lower visibility have not been shown to decrease reproductive success (Parker 1970, Johnsgard 1983).

Habitats that are used for nesting are related to land use. Hart et al. (1950) observed that the majority of nests were located in wheat stubble and alfalfa (*Medicaga sativa*) due to conversion of rangeland habitat to cropland. However, when native rangeland was used for nesting, most females selected a nest site under or within close proximity of a shrub (Hart et al. 1950, Evans 1968, Parker 1970, Giesen 1987, Marks and Marks 1987, Meints 1991). Shrub species most commonly used for nesting are sagebrush species, antelope bitterbrush, serviceberry, snowberry (*Symphoricarpos* spp) and other mountain shrubs (Parker 1970, Giesen 1987, Meints 1991). Meints et al. (1992) determined that a minimum cover height of 25 cm was required for nesting.

Columbian sharp-tailed grouse generally utilize shrub-steppe vegetation that contains a high diversity of forbs and bunchgrasses (Hart et al. 1950, Klott 1989, Meints 1991). Serviceberry or Gambel oak (*Quercus gambelii*) dominated habitats in mountain shrub communities are also used (Giesen 1987). An important component of brood-rearing habitat is edge, with 40% of available habitat used by sharp-tailed grouse being within 20 m of the edge of habitat (Marks and Marks 1987). Vegetation use was varied depending on region. Brood use in Colorado was in habitat that contained more than 70% shrub cover (Giesen 1987). Cover in brood use sites is higher than in random or independent sites both in Colorado and eastern Idaho (Giesen 1987, Meints 1991). A high diversity of forbs characterized brood use in Wyoming and western Idaho (Marks and Marks 1987, Klott and Lindzey 1990).

In 1986, the Conservation Reserve Program (CRP) was implemented to take marginally productive agricultural lands out of production and seed to various types of permanent vegetation cover. Sirotnak et al (1991) reported that sharp-tailed grouse broods in eastern Idaho selected CRP fields over native rangeland and agricultural fields. This program is also believed to have positively impacted sharp-tailed grouse numbers in Utah.

SHARP-TAILED GROUSE IN UTAH

Seasonal habitat use for the Utah population is not well known and such information is required to implement management actions to conserve the species. The Utah estimated population in 1935 was approximately 1500 birds. In the fall of 1999, survey data was used to estimate the population at approximately 11,000 birds (UDWR 2002). As part of the management of this species, a local working group consisting of UDWR biologists, Utah State University Extension (USUEXT), landowners, conservation groups and concerned citizens are being established to assist in developing a management plan and to provide input on habitat restoration projects focusing on sharp-tailed grouse habitat.

STUDY AREA

This research was conducted within the current range of the Columbian sharp-tailed grouse in northern Utah (UDWR 2002). I studied habitat use preferences of two meta-populations; West Hills/Whites Valley and Long Valley/4 Mile Complex. The West Hills meta-population is located in eastern Box Elder County, specifically the West Hills and the Whites Valley lek complexes. This area encompasses approximately 14,400 ha (Fig. 2-1). In the southern part of Cache Valley, the populations consisted of the 4 Mile lek complex located on private land in South Canyon owned by the Selman family and the leks on the property of John and Grant White. This research area is comprised of approximately 3,400 ha (Fig. 2-2). These leks, not previously in the UDWR database of known dancing grounds, were named Long Valley #1 and Long Valley #2.

The research area consisted largely of private land with the exception of 2.6 km^2 owned by of Utah State Institutional Trust Lands Administration located in eastern Box Elder and 1.9 km^2 managed by the U.S. Forest Service within the Selman Ranch boundaries. The habitat in these areas includes agricultural fields, land enrolled in CRP and native rangeland.

The primary use in Long Valley lek complexes is grazing by domestic livestock. The 4 Mile Ranch is primarily used for grazing sheep, with a small herd of cattle and horses using the range. In eastern Box Elder County, cattle primarily use the range, with a small amount of sheep grazing. In addition to sharp-tailed grouse, the area is inhabited by greater sage grouse (*Centrocercus urophasianus*) and mule deer (*Odocoileus hemionus)*. Rocky Mountain elk (*Cervus elaphus*) and moose (*Alces alces*) occur on the 4 Mile Ranch.

Precipitation in the east Box Elder County study areas ranged from 25.4-38.1 cm, while in the Cache County study area it was 50.8-63.5 cm, with variations in precipitation amounts dependent upon elevation, with higher elevations benefiting from higher precipitation. Precipitation occurs mostly in the winter and spring. Elevations range from 1500-2200 m in Cache Valley to 1300-2050 m in eastern Box Elder County.

Land enrolled in CRP constitutes a major habitat type in the study area of Whites Valley in Box Elder County and Long Valley in Cache County. Dominate CRP vegetation include crested wheatgrass, intermediate wheatgrass, Wyoming (*A. tridentata wyomingensis*) and basin big sagebrush (*A. t tridentata*), onion (*Allium* spp.), showy milkweed (*Asclepias speciosa*), scarlet globemallow (*Sphaeralcea coccinea*), alfalfa, yellow salsify (*Tragopogon dubius*), yarrow (*Achillea millefolium*), prickly lettuce (*Lactuca serriola*) and numerous other broadleaf forbs, along with invasive noxious plants such as cheatgrass and weeds such as thistle (*Cirsium* spp.) and curlycup gumweed (*Grindelia squarrosa*).

Another habitat type is native range that includes the same sagebrush species as in the CRP, but also includes black sage (*A. nova*), low sage (*A. t. arbuscula*) and mountain big sage (*A. t. vaseyana*), antelope bitterbrush, snowberry (*Symphoricarpos alba*), serviceberry, rabbitbrush (*Chrysothamnus* spp.), chokecherry, lupine (*Lupinus* spp.), bluebunch wheatgrass, basin wildrye (*Leymus cinereus*) and bluegrasses (*Poa* spp.), with a number of different broadleaf forbs and deciduous trees.

METHODS

To conduct the research I trapped sharp-tailed grouse on leks during the spring breeding season. Males and females were trapped using walk-in traps connected by chicken wire runners that would funnel the birds into the traps (Schroeder and Braun 1991). The trapped birds were then radio marked using a 21 gram necklace style radio collar (Advanced Telemetry Systems, 470 First Avenue N, Isanti MN., 55040), leg banded and released on site. I then attempted to locate all radio-collared birds weekly using radio telemetry. In the Cache County study area, I monitored 7 males and 1 female in 2003, and 6 males and 3 females in 2004. In the Box Elder County study area, I monitored 6 males in 2003 and 6 males and 5 females in 2004. When located, the birds were flushed and vegetation characteristics measured and recorded at each flush point. This method was used at all times of the day. In addition a Global Positioning System (GPS) reading was recorded for each site and entered onto the data sheet. The datum used was NAD 27 CONUS.

Vegetation data collected included visual obstruction readings (VOR) in each of the cardinal directions (Robel et al. 1970). To estimate percent vegetation presence by vegetation type I used a Daubenmire frame (Daubenmire 1959). Percent vegetation cover broken down into species was estimated at the flush point, then at 1 m intervals for 9 m along a transect in a randomly chosen direction. I divided the compass points into 5 degree increments, then randomized the points and printed out the results. A compass was used to approximate the random direction to begin the transect.

To compare the information collected on the flush point and subsequent transect, I then would continue on in the same direction as the randomly chosen transect line for another 20 m after the 10 points were read. I would then collect the same information on this paired point using the Robel pole and Daubenmire frame. I would record VOR measurements, followed by 10 Daubenmire readings in a randomly selected compass direction in a line. This information was entered on a data sheet along with the bird identification, date and general weather conditions.

HABITAT CLASSIFICATION

I completed an unsupervised Geographical Information System (GIS) classification of habitat types to determine if any of the habitats were used by radio-collared birds more than would be expected based on availability in study area. Each of the two areas was treated as a separate experimental unit to conduct this analysis. Area 1 encompassed the Box Elder County study area to include Whites Valley and Johnson Canyon extending into the Bear River bottoms northwest of Tremonton, Utah (Fig. 2-1). Area 2 encompassed the Cache County study area to include the 4 Mile area and the White Ranch south of Avon, Utah and west of Paradise, Utah, respectively (Fig. 2-2).

The classification was done using ERDAS Imagine® software version 9.3 (ERDAS 2007, Atlanta, GA) and using LandSat TM year 2003 data. The Polygon Attribute Table was 38 and the row was 31. All other information was collected from LandSat. I used imagery from 2000 and 2006 to conduct the classification. These were the only 2 years for which images were available for the study areas. Both years were run using a 20 cluster and a 40 cluster, running 6 iterations. A cluster is the assignment of a set of observations into subsets so that observations in the same cluster are similar in characteristics. The scaling was automatic on the primary axis (T. Black, Utah State University, personal communication).

The 2000 images and the 20 cluster runs were used for analysis. I used 2000 images because they better represented the areas based on my knowledge of the areas and follow up ground truthing. Using these images, I developed 5 habitat type clusters. These clusters were: 1) riparian-maple draws (hereafter riparian), 2) sagebrush draws and heavy sagebrush patches, 3) CRP and native rangeland, 4) shrub-juniper-maple mix, and 5) agricultural fields. The clusters are representative of the primary vegetation or habitat types used by radio-collared birds.

DATA ANALYSIS

Prior to analysis, data were manipulated as follows to produce a single value of each variable for each flush or random point. Daubenmire (Daubenmire 1959) classes were scored at the midpoint of each interval and the scores were summed over all species within each vegetation component. The mean of the total score was computed over the 10 quadrats at each point, to obtain an estimate of percent cover for each vegetation component. The mean VOR was computed over the 4 cardinal direction measurements.

Matched pair multiple logistic regression (Hosmer and Lemeshow 1989) was used to test whether points from which birds flushed differed from paired random points with respect to vegetation components and VOR. To assure that the assumption of linearity in the logit was adequately met, I determined an appropriate scale for continuous covariates following procedures recommended by Hosmer and Lemeshow (1989). While 6 general vegetation components (i.e., annual grass, perennial grass, shrubs, forbs, weeds and trees) were measured, only 4 were analyzed. Weeds and trees were rarely encountered, and so data on these components were insufficient for statistical analysis. Data from 2003 and 2004 were pooled. Separate analyses were conducted for the Cache and Box Elder County study areas and for each vegetation component and VOR individually.

For spring, summer, and fall data and for data combined across seasons in each area, I used a chi-square test of goodness-of-fit to compare the observed distribution of sharp-tailed grouse locations across the 5 habitat types to their proportional availability. For each area, I used a chi-square test of homogeneity of proportions to assess whether the distribution of sharp-tailed grouse locations across the 5 habitats was the same in all 3 seasons. Due to the generally small sample size, exact P-values were obtained. Data analyses were generated using the FREQ procedure in SAS/STAT software, Version 9.1.3 of the SAS System for Windows (SAS Institute Inc. 2002, Cary, NC, USA).

RESULTS

Cache County

The mean VOR reading for flush points ($n = 45$) was 8.28 dm ($SE = 0.55$). The mean for paired points ($n = 44$) was 4.26 dm ($SE = 0.56$) (comparison of flush point to paired point, $p < 0.001$). Of the 4 vegetation components, flush and random points differed by forb cover (slope estimate = -0.17, $p = 0.04$, $n = 45$, Fig. 2-3). Annual grass cover (slope estimate = -0.04 $p = 0.34$, $n = 45$), perennial grass cover (slope estimate = -0.02, $p = 0.70$, $n = 45$) and shrub cover (slope estimate = 0.01, $p = 0.78$, $n = 45$) were not found to be distinguishing characteristics (Table 2-1).

Box Elder County

The mean for flush points for VOR readings ($n = 78$) was 7.13 dm (SE =0.29). The mean for the paired point ($n = 77$) was 3.68 dm (SE = 0.29) (comparison of flush point to paired point, $p < 0.001$). Of the 4 types of vegetation classes analyzed comparing the flush point against the paired point, only shrubs differed (slope estimate = 0.15, $p < 0.01$, n=76, Fig. 4). Forbs (slope estimate = 0.07, p=0.18), perennial grasses (slope estimate = -0.04, $p = 0.38$), and annual grasses did not differ at flush locations (slope estimate = -0.05, $p = 0.27$), (Table 2-2). In the Box Elder County research area, more sharp-tailed grouse were flushed from shrub cover than from any other cover type (Fig. 2-4).

Habitat Type Classifications

In the Box Elder County study area, sagebrush draws-heavy sagebrush and CRP-native rangeland were used by radio-collared sharp-tailed grouse in greater proportion to their availability ($p < 0.01$, Table 3). The test percent which is the percentage expected under the null hypothesis for sagebrush draws-heavy sagebrush was 32.8%, while actual use of that habitat type was 45.9%, ($n = 45$). The expected percent use for CRP-native rangelands was 28.2% and the observed percentage was 35.7%, ($n = 32$). Riparian-maple, shrub-juniper-maple and agricultural fields expected percentages were 11.7, 12.9, and 14.3%, respectively. The actual percent of observations recorded in these habitat types was1.3, 8.2, and 9.2% respectively, with $n = 1$ for riparian-maple, $n = 8$ for shrub-juniper-maple and $n = 9$ for agricultural fields.

Combined habitat use for radio-collared birds by type in the Cache County study area did not differ ($p > 0.46$, Table 2-4). Sagebrush habitat was 9.7 % observed versus

15.3% test with n = 6, type 2 was 20.9% versus 22.6% with n = 13, type 3 was 33.9% versus 27.3% with n = 21, type 4 was 24.2% versus 19.6% with n = 15 and type 5 was 11.3% versus 15.1% with n = 7.

DISCUSSION

Visual Obstruction Readings

For both research sites, the VORs at sharp-tailed grouse flush points were higher than for paired points. Most radio-collared birds were flushed from under a shrub or dense grass cover. Although the bird might have moved to these locations when approached by a human, the flushed sharp-tailed grouse when first located were in or near dense vegetation (i.e., sagebrush, bitterbrush, snowberry, serviceberry or tall grass) which would afford them escape and foraging cover. McArdle (1977), Marks and Marks (1987), Meints (1991) and Giesen and Connelly (1993) also reported sharp-tailed grouse preferred habitat edges and dense vegetation as escape and foraging cover. Giesen and Connelly (1993) suggested in their guidelines for sharp-tailed grouse habitat management that shrub vegetation manipulation should not be enacted during nesting season and that a mean of 2.5 dm VOR of residual grasses be maintained.

Vegetation Cover Preferences

The vegetation composition of the cover at sharp-tailed grouse flush points differed by study area and was closely related to available habitat types. In the Cache County population sharp-tailed grouse preferred areas with a lower density of forbs and a greater density of perennial grasses and shrubs. With decreasing forb cover the likelihood that a sharp-tailed grouse would be found increased. Because data were collected at points where birds flushed, higher percent perennial grass and shrub cover at these points will affect the amount of forbs present. As density of the forb component increases, the likelihood of a radio-marked bird being flushed from that point decreases. Some of the forbs found were alfalfa, salsify (*Tragopogon* spp.), common dandelion, (*Taraxacum officinale*), arrowleaf balsamroot (*Balsamorhiza sagittata*), and wild onion (*Allium* spp.). Forbs generally grow in areas between grass and shrubs species, utilizing those sites where there is generally less competition for resources. Giesen and Connelly (1993) reported that a high diversity of grasses and forbs were utilized by sharp-tailed grouse, and that these sites had a greater number of forb and grass species than random sites. The sites that were at late seral stages, such as those that grow arrowleaf balsamroot, show that sharp-tailed grouse prefer those undisturbed sites (Marks and Marks 1987).

This could also suggest that sharp-tailed grouse selected for areas with higher cover potential, using available cover such as shrubs which may offer better protection from predation (Ziegler 1979, Moyles 1981). Marks and Marks (1987) found that flush sites had denser cover than random sites, and that canopy cover of shrubs was higher at flush points than at random sites.

In the Box Elder County study area, shrubs constituted an important habitat component utilized by sharp-tailed grouse. As shrub density increased, the likelihood of flushing a grouse increased (i.e., as the slope of the line in Fig. 2-4 increases). This is consistent with the recommendations of Giesen and Connelly (1993) to maintain adequate shrub, deciduous tree and grass densities in sharp-tailed grouse habitat, especially in riparian areas. Shrubs are a highly utilized component of sharp-tailed grouse habitat in the range of the sharp-tailed grouse. Moyles (1981) found that sharp-tailed grouse would move into shrubs for relief from heat, and also for protection from avian predators. McArdle (1977) found that 77% of located sharp-tailed grouse used shrub densities in the 20-40% cover. McArdle (1977) also found that >70% of birds located in more open areas were within 30 m of edge cover of shrubs, again indicating the high importance of shrubs. While sagebrush is the dominate shrub, other shrub species are used for cover and nesting, such as snowberry, Antelope bitterbrush, serviceberry, as well as other mountain shrub species (Parker 1970, Giesen 1987, Meints 1991).

Habitat Classifications

In the Box Elder County study area sharp-tailed grouse used sagebrush draws-heavy sagebrush and CRP-native rangeland type habitats proportionately more than other habitat types. Sharp-tailed grouse selected for these types of habitats using heavier sagebrush sites and the shrub-steppe type habitats that are available in this research area. This was also found by Marks and Marks (1987) as well as Klott and Lindzey (1990). Shrub cover use was a good predictor of habitat use, thereby reinforcing the need for good shrub component in the shrub-steppe habitat as critical for the success of sharp-tailed grouse. Giesen and Connelly (1993) stressed the importance of maintaining adequate shrub densities for the necessary canopy cover.

In the Cache County study area, habitat use for the radio-collared birds monitored did not differ based on habitat availability. The habitat in this study area was more diverse and offered greater habitat availability. Giesen and Connelly (1993), and Marks and Marks (1987) also found that habitats with greater diversity than random sites were used by sharp-tailed grouse.

MANAGEMENT IMPLICATIONS

Radio-marked birds in the Cache County and Box Elder County study areas selected habitats with higher vegetation visual obstruction readings than random sites. Habitat edges consisting of greater shrub cover likely provided increased availability to foraging plants while offering escape opportunities. Larger areas with sagebrush plots and shrub-steppe habitats exhibiting shrub cover were a very important habitat component of the sharp-tailed grouse species studied.

Private landowners and government agencies have been reducing sagebrush densities as a program to increase livestock numbers, which could negatively impact the sharp-tailed grouse by removing an important and vital element of their escape and cover habitat. State management agencies should work with landowners and other agencies to limit the removal of the shrub component of habitats in the sharp-tailed grouse range. Grazing practices should leave enough grass height and density to provide the necessary cover for sharp-tailed grouse during the summer and fall seasons.

The continuation of the CRP program and maintenance of existing CRP in its current acreage is valuable to the habitat needs of the sharp-tailed grouse. In Cache and Box Elder Counties, the CRP enrollment is in danger of being reduced by at least 50% in 2010 and 2011 (K. Fullen, NRCS, personal communication). This could negatively impact habitat availability for sharp-tailed grouse.

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Table 2-1. Analysis of Maximum Likelihood Estimates for Cache County Study Area, 2003-2005. (Note: The likelihood of a Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) utilizing the habitat increased as forb density decreased.)

Analysis of Maximum Likelihood Estimates					
Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Pgrass	1	-0.0166	0.0427	0.1508	0.6978
Agrass	1	-0.0405	0.0429	0.8933	0.3446
Shrubs	1	-0.00795	0.0279	0.0810	0.7759
Forbs	1	-0.01654	0.0787	4.4175	0.0356

Table 2-2. Analysis of Maximum Likelihood Estimates for Box Elder County Study Area, 2003-2005. (Note: the likelihood of Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) utilization of habitat increased as shrub density increases).

Analysis of Maximum Likelihood Estimates					
Parameter	DF	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Pgrass	1	-0.0368	0.0423	0.7568	0.3843
Agrass	1	-0.0501	0.0455	1.2113	0.2711
Shrubs	1	0.1479	0.0484	9.3212	0.0023
Forbs	1	0.0717	0.0540	1.7637	0.1842

Table 2-3 Frequency of occurrence for observed versus expected use for Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) by major habitat types, Cache County Study Area 2003-2005.

Habitat type	Frequency	% observed	Test %	Cumulative Freq.	Cumulative %
Riparian-Maple draws	6	9.68	15.33	6	9.68
Sage draws/ Heavy sage	13	20.97	22.58	19	30.65
CRP/native Rangeland	21	33.87	27.36	40	64.52
Shrub-juniper Maple mix	15	24.19	19.63	55	88.71
Agricultural fields	7	11.29	15.10	62	100.00

Table 2-4. Frequency of occurrence for observed versus expected use for Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) by major habitat types, Box Elder County Study Area 2003-2005.

Habitat type	Frequency	% observed	Test %	Cumulative Freq.	Cumulative %
Riparian-Maple draws	1	1.02	11.73	1	1.02
Sage draws/ Heavy sage	45	45.92	32.78	46	46.94
CRP/native Rangeland	35	35.71	28.24	81	82.65
Shrub-juniper Maple mix	8	8.16	12.91	89	90.82
Agricultural fields	9	9.18	14.34	98	100.00

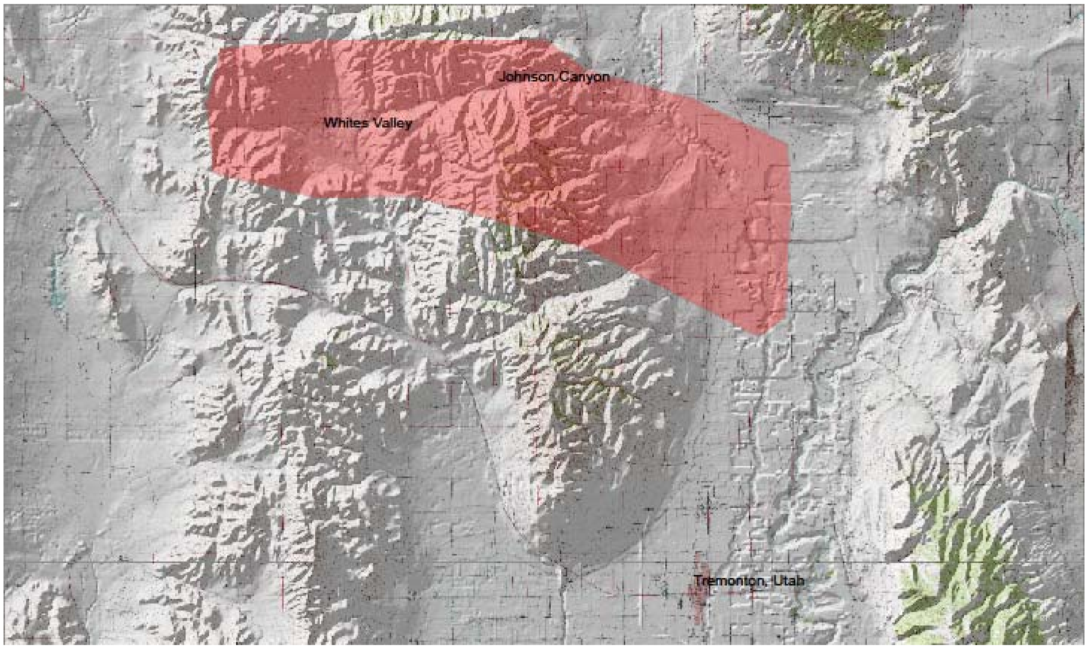

Fig. 2-1. The Box Elder County Study Area consisted of 14,400 ha located in eastern Box Elder County, 2003-2005.

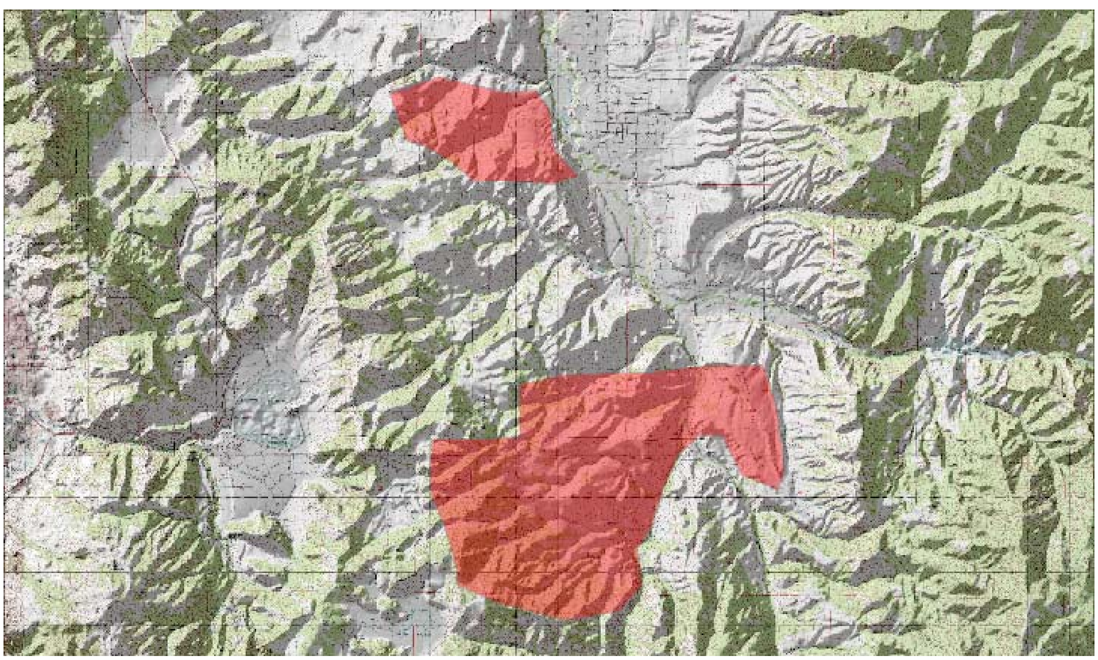

Fig. 2-2. The Cache County Study Area consisted of 3400 ha located in the southern end of Cache Valley, 2003-2005.

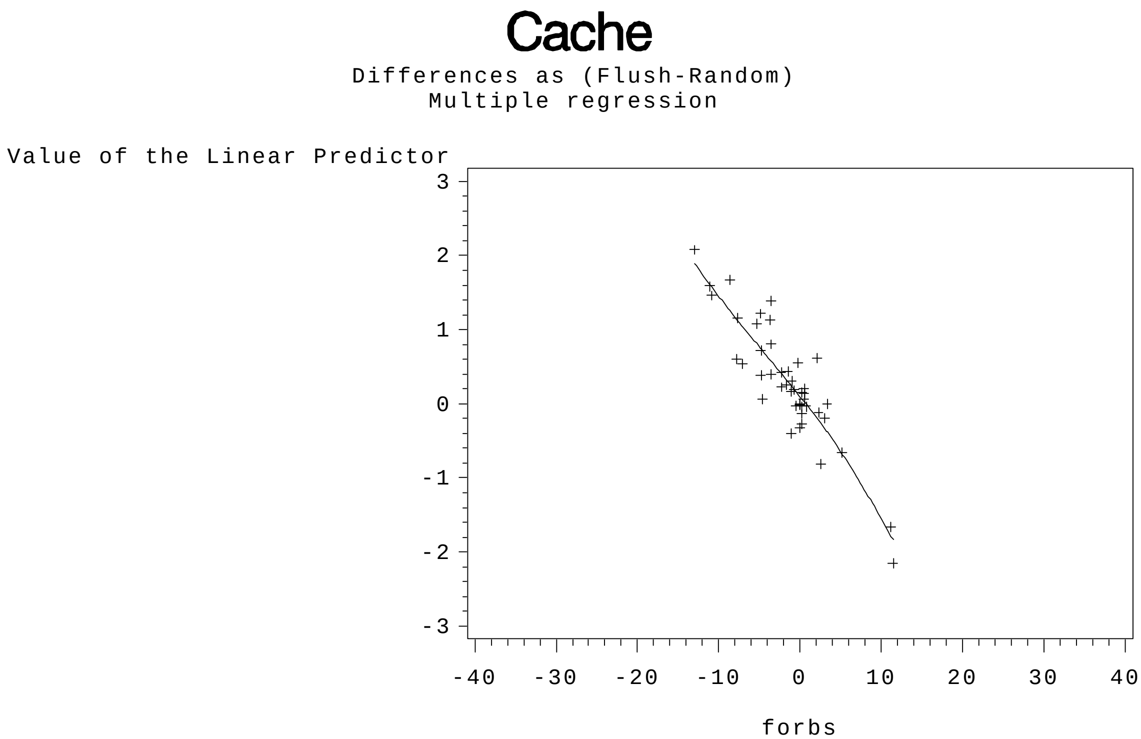

Fig. 2-3. The negative slope of the paired point multiple logistic regression showing the relationship of forbs to other vegetation types at Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) flush sites, Cache County Study Area 2003-2005. The likelihood that a radio-collared sharp-tailed grouse would be flushed increased as forb cover decreased.

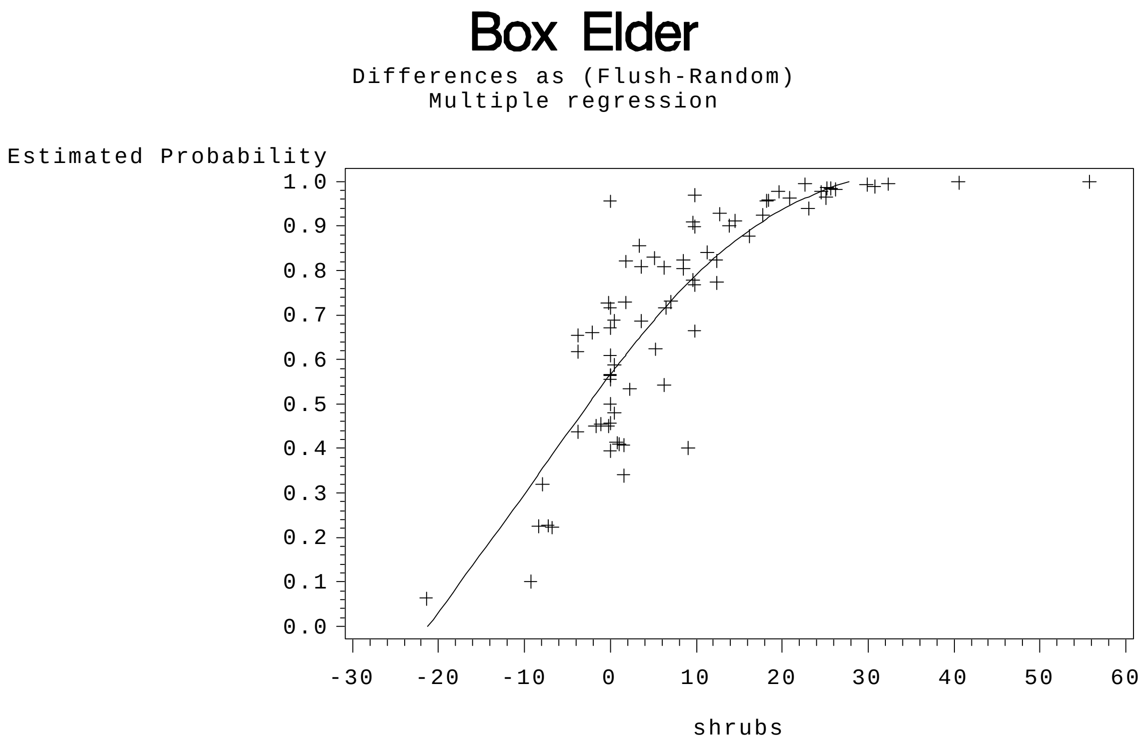

Fig. 2-4. The positive slope of the paired point multiple logistic regression showing the relationship of shrubs to other vegetation types at Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) flush sites, Box Elder County Study Area 2003-2005. As the density of shrubs increased, the likelihood that a sharp-tailed grouse would utilize the habitat type also increased.

CHAPTER 3

NESTING ECOLOGY, SEASONAL MOVEMENT, AND MORTALITY OF COLUMBIAN SHARP-TAILED GROUSE IN NORTHERN UTAH.

ABSTRACT: The range of the Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*; hereafter sharp-tailed grouse) has declined to approximately 10% of their historic range in Utah. Because of the decline in population and range, and loss of habitat, the sharp-tailed grouse is considered a state sensitive species in Utah, and is listed in the 1989 Federal Registry by the U. S. Fish and Wildlife Service as a Category 2 Candidate Species for listing under the Endangered Species Act. Little is known about the reproductive ecology and factors affecting population dynamics of this species in northern Utah. This information is needed to plan management actions to conserve the species. The purpose of this research was to describe the breeding and seasonal ecology of 2 distinct populations of sharp-tailed grouse occupying Cache and eastern Box Elder Counties in northern Utah. This information is needed to plan management actions to conserve the species. I monitored 15 and 20 radio-collared sharp-tailed grouse in 2003 and 2004, respectively, to describe the breeding ecology and population dynamics of the species. In the Cache County study area, I monitored 7 males and 1 female in 2003, and 6 males and 3 females in 2004. In the Box Elder County study area, I monitored 6 males in 2003 and 6 males and 5 females in 2004. During my study 4 of the hens monitored initiated nests and 3 of these were successful. The successful nests were located under sagebrush. Predation on radio marked birds was 72%. Identifiable mortality factors were predation.

Seasonal movements were calculated by study area and season, with sharp-tailed grouse travelling distances from 0.9 to 14.7 km, with winter the season that the greatest distance was travelled. I measured the distance travelled to nesting sites from leks of capture, with the mean distance travelled correlating with other studies that have been done.

INTRODUCTION

The range of Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*: hereafter sharp-tailed grouse) has decreased over the last 100 years as native habitats were lost or fragment because of residential development, agricultural encroachment and conversion, and habitat type change (Yocom 1943, Parker 1970, Braun 1991, Giesen and Connelly 1993, Ritcey 1995). Range wide, sharp-tailed grouse populations have declined, being extirpated from California, Nevada, and Oregon. They now inhabit historic range in small percentages (1-20%) in Washington, Idaho, Wyoming, Montana, Colorado, while in British Columbia they remain in 60-80% of the historic range (Ulliman, 1995).

Breeding Ecology

In the spring, males congregate on a lek and display for mating purposes, and females attend leks in search of a mate (Ulliman 1995). Migration from wintering areas to spring lek sites usually occurs after the first snowmelt and warming of spring (Giesen 1987). Sharp-tailed grouse usually select lek sites on bench tops, ridges, knolls, or other areas that afford high visibility and sound transmission (Evans 1968, Parker 1970). These areas are typically more open vegetation structure such as grasslands and sparse sage patches. Ward (1984) and Klott and Lindzey (1989, 1990) found that sharp-tailed grouse selected for sites with higher visibility than at random sites.

After copulating on a dancing ground, a female will go to a nest site and begin laying eggs. She will lay one egg a day, usually between 10-14 eggs per clutch, with 12 being the mean. The hen will then incubate the eggs for 21-24 days. All young hatch on the same day. If the first nest is depredated the hen will commonly renest, but the hen will only raise one brood per year (Evans 1968, Johnsgard 1983).

Bergerud and Gratson (1988) summarized information from 16 sharp-tailed grouse studies conducted between the years of 1930 and 1976. Successful nests occurred 54 % ± 4.4 % of the time. Depredation occurred in 36 % ± 4.2% of the nests. In North Dakota and Minnesota, nest success was higher in the second attempt than in the first, and sometimes third and fourth nesting attempts occurred (Bergerud and Gratson 1988).

Vegetation cover at nest sites typically approximates habitat availability. Hen have nested in cultivated fields, grasslands, and native and introduced grass rangelands, (Hart et al. 1950, Yocom 1952, Parker 1970, Oedekoven 1985, Meints 1991). Evans (1968) found that shrubs are the preferred habitat for nesting, with nests being directly under or within a few feet of shrubs. Hart et al. (1950) found that the most common nesting sites in Utah were in alfalfa (*Medicaga sativa*) or wheat stubble. Nest success of these sites was 47% for alfalfa and 18% for wheat stubble, while in rangeland habitats, nest success was much higher at 70%. Reports of nesting success in Conservation Reserve Program (CRP) habitats have been mixed. Schroeder (1994) found that only 20% of nests located were in CRP with no successful nests, while Meints (1991) found that success in CRP and alfalfa was 86%, while native ranges were at 53%.

Meints et al. (1992) suggests that sharp-tailed grouse need a minimum Visual Obstruction Reading of 2.5 dm (using a method defined by Robel et al. 1970) for nesting habitat. Shrub densities play an important role in nest selection. Meints (1991) found that shrub densities at nest sites in eastern Idaho had a mean of 11,000 shrubs per ha and 5,000 shrubs per ha at independent sites. Giesen (1987) found that sharp-tailed grouse nests were located in dense shrub cover with 32,500 shrubs per ha, with snowberry (*Symphoricarpos albus*) and sagebrush (*Artemesia tridentata* spp.) being the dominant shrubs. Bredehoft (1981) reported a density of 17,800 shrubs per ha, and that snowberry, serviceberry (*Amelanchier alnifolia*) and sagebrush were the dominant species.

Seasonal Movements

Oedekoven (1985) and Giesen and Connelly (1993) found that most hens selected sites less than 1 km from the lek. Meints (1991) reported 1.2 km ± 0.9 km distance traveled from the lek to initiate nests. Gratson (1988) and Meints (1991) surmised that the distance traveled likely was impacted by available habitat and predator abundance.

Movement from leks and nesting sites to summer habitats is typically less than 1.6 km for females and 0.6 km for males, with an average home range of 1.03 km^2 (Giesen 1987). Marks and Marks (1987) found that most remained within 1 km of the lek for brood rearing, with an average home range of 1.87 km^2.

Travel to winter habitat can vary from 1.7 km (Marks and Marks 1987) to 20.0 km (Meints 1991). Females travelled farther to find high quality winter forage, while males would remain closer to the lek, surviving on lower quality food in the winter (Giesen 1987, Marks and Marks 1987). It is believed that males will remain closer to the lek to maintain position of dominance on the lek for the dominant males, and for the new and subordinate males to be able to secure a position on the lek for spring mating.

Mortality Factors

Predation likely doesn't influence sharp-tailed grouse numbers in most populations with adequate escape cover (Bendell 1972), but it does account for 85% of mortality (Bergerud and Gratson 1988). Adult sharp-tailed grouse are preyed upon primarily by avian predators such as hawks, owls, eagles and falcons. Mammalian predators such as coyotes (*Canis latrans)*, red fox (*Vulpes vulpes)*, and striped skunks (*Mephitis mephitis*) are common nest predators, with some corvids (*Corvus* spp.) readily taking eggs and young (Ulliman 1995). While adult sharp-tailed grouse are not greatly affected by severe weather, chick mortality can be increased by severe weather in the first 3 weeks of life due to the inability to thermoregulate properly (Bergerud and Gratson 1988). Also, hen productivity can be decreased by cold, wet spring weather (Bendell 1972). Drought or prolonged dry weather can negatively impact production of vegetation, leading to a decrease in cover and nesting habitat. This in turn can affect predation and nesting productivity.

STUDY AREA

This research was conducted within the current sharp-tailed grouse range in northern Utah (UDWR 2002). I studied habitat use preferences of two meta-populations; West Hill/White Valley and Long Valley/4 Mile Complex. The West Hills meta-population is located in eastern Box Elder County, specifically the West Hills and the Whites Valley lek complexes. This area encompasses approximately 14,400 ha (Fig. 3-1). In the southern part of Cache County, the populations consisted of the 4 Mile lek complex located on private land in South Canyon owned by the Selman family and the leks on the property of John and Grant White. This research area is comprised of approximately 3,400 ha (Fig. 3-2). These leks were named Long Valley #1 and Long Valley #2. These leks were not previously in the UDWR database of known dancing grounds.

The research area consisted largely of private land with the exception of 2.6 km^2 owned by of Utah State Institutional Trust Lands Administration located in eastern Box Elder County and 1.9 km^2 managed by the U.S. Forest Service within the Selman Ranch boundaries. The habitat in these areas includes agricultural fields, land enrolled in CRP and native rangeland.

The primary use in Long Valley lek complexes is grazing by domestic livestock. The 4 Mile Ranch is primarily used for grazing sheep, along with a small herd of cattle and horses. In eastern Box Elder County, cattle primarily use the range, with a small amount of sheep grazing. In addition to sharp-tailed grouse, the area is inhabited by greater sage grouse (*Centrocercus urophasianus*) and mule deer (*Odocoileus hemionus)*. Rocky Mountain elk (*Cervus elaphus*) and moose (*Alces alces*) occur on the 4 Mile Ranch.

The predator community in the study areas include coyote (*Canus latrans*), fox (*Vulpes vulpes)*, striped skunks (*Mephitis mephitis*), bobcat (*Lynx rufus*), mountain lion (*Felis concolor*), golden eagles (*Aquila chrysaetos*), red tailed hawk (*Buteo jamaicensis*), Swainsons hawk (*Buteo swainsoni*), and northern harriers (*Circus cyaneus*). There are also great horned owls (*Bubo virginianus*), and short-eared owls (*Asio flammeus*). The Wellsville Mountain Range, which is a migration route for raptor species (Smith and

Neal 2009), is located between the 2 research areas and in the spring and fall will have large numbers of raptors pass through.

Precipitation in the eastern Box Elder County study areas ranges is 25.4 to 38.1 cm, while in the Cache County study area it is 50.8 to 63.5 cm, with variations in precipitation amounts dependent upon elevation, with higher elevations benefiting from higher precipitation. Precipitation occurs mostly in the winter and spring. Elevations range from 1500-2200 m in Cache Valley to 1300-2050 m in eastern Box Elder County.

Land enrolled in CRP constitutes a major habitat type in the study area of Whites Valley in Box Elder County and Long Valley in Cache County. Dominate CRP vegetation included crested wheatgrass (*Agropyron cristatum*), intermediate wheatgrass *(A. intermedium*), Wyoming big sagebrush (*Artemesia tridentata wyomingensis*) and basin big sagebrush (*Artemesia tridentata tridentata*), onion (*Allium* spp.), showy milkweed (*Asclepias speciosa*), scarlet globemallow (*Sphaeralcea coccinea*), alfalfa, yellow salsify (*Tragopogon dubius*), yarrow (*Achillea millefolium*), prickly lettuce (*Lactuca serriola*) and other broadleaf forbs, along with invasive noxious plants such as cheatgrass (*Bromus tectorum*), and weeds such as thistle (*Cirsium* spp.) and curlycup gumweed (*Grindelia squarrosa*).

Another habitat type is native range that includes the same sagebrush species as in the CRP, but also includes black sage (*A. tridentata nova*), low sage (*A. tridentata arbuscula*) and Mountain big sage (*Artemesia tridentata vaseyana*), Antelope bitterbrush (*Purshia tridentata*), snowberry, serviceberry, rabbitbrush (*Chrysothamnus* spp.), chokecherry (*Prunus virginiana*), lupine (*Lupinus* spp.), bluebunch wheatgrass

(*Pseudoroegneria spicatum*), basin wildrye (Leymus *cinereus*) and bluegrasses (*Poa* spp.), with a number of different broadleaf forbs and deciduous trees.

METHODS

I trapped sharp-tailed grouse on leks in eastern Box Elder County and the south end of Cache County. In the Cache County study area, I monitored 7 males and 1 female in 2003, and 6 males and 3 females in 2004. In the Box Elder County study area, I monitored 6 males in 2003 and 6 males and 5 females in 2004. Males and females were trapped using walk-in traps connected by chicken wire runners that would funnel the birds into the traps (Schroeder and Braun 1991). The trapped birds were then radio marked using a 21 gram necklace style radio collar (Advanced Telemetry Systems, 470 First Avenue N, Isanti MN, 55040), banded, and released on site. I then attempted to locate all radio-collared sharp-tailed grouse weekly using radio telemetry. When located, the birds were flushed and vegetation characteristics measured and recorded at each flush point. In addition a Global Positioning System (GPS) reading was recorded for each site and entered onto the data sheet. The datum used was NAD 27 CONUS.

Nests were located by following radio marked hens and finding them on the nest. These hens were then monitored to determine when broods were hatched or if the nest was successful. Nest success was defined as hatching at least 1 chick from the nest (Bergerud and Gratson 1988). A nest was determined successful if at least 1 live chick was seen with the radio-marked female. Brood success was determined to be successful if a chick survived $\geq$ 50 days.

Using data collected from flush points and identifying those birds that had data points in all seasons, I calculated the farthest distance travelled by each bird. Distance was determined by taking the farthest GPS location from the lek of capture. This was done using the mapping program ARCGIS. Twelve birds met this criterion. Using the farthest distance that each bird travelled, I then calculated the mean distance travelled for each sub-population, with the standard deviation, maximum and minimum distances. I then calculated the mean distance travelled during each of the seasons, along with the standard deviation, maximum and minimum.

The locations for each bird were plotted, and then the farthest point from the lek of capture was calculated. This was calculated for 12 birds, with some points spanning both study years. I then took the different birds from each sub-population and calculated the mean and standard deviation for the distance travelled for each sub-population to determine which population travelled most. Finally, I calculated which season that these birds travelled farthest in.

Mortality was determined by carcass evaluation. If the carcass was intact with evidence of avian mortality (i.e., feathers removed and breast meat consumed), then avian predation was determined to be the cause. If the carcass was consumed and feathers were all that was left, the cause was deemed undeterminable. This determination was made because of the possibility of avian predation and mammalian scavenge. I was unable to determine mammalian predation.

RESULTS

Nesting Ecology

In 2003, 1 hen was captured at the Long Valley 1 lek on the White property. This hen initiated a nest and was successful. In 2004, 8 hens were trapped and radio-marked. Of the 8 females, 3 initiated nests with 2 being successful. In the Cache County study area, 4 hens were radio-marked in 2003 and 2004. Of these four, 2 initiated nests and both were successful. All successful nest sites were located under sagebrush in sagebrush stands.

In the Box Elder County study area, 5 hens were radio-marked in 2004. Of these 5 marked hens, 2 initiated nests, with 1 being successful. The unsuccessful nest was depredated, with no attempt at renesting. Of the 4 nests initiated in this study, 3 were under sagebrush and 1 was in alfalfa cover. The 3 successful nests were located under sagebrush. The unsuccessful nest was located in a CRP field under an alfalfa plant. Collectively, the nesting success for all nests in both counties was 75%. Although the sample size is small, the success rate is on the upper end of what is reported in the literature (Table 3-1).

Of the 3 successful nests, 1 hen in the Cache County study area and 1 hen in the Box Elder County study area raised chicks to greater than 50 days. The unsuccessful brood in Cache County was due to hen predation a week after hatching. The chicks were never found, but I assume they did not survive.

Seasonal Movements

The mean distance of initiated nests from the dancing grounds where the hens were trapped is 1.5 km with a SD of 1.2 km (n = 4). Available nesting habitat varied depending on the study area. The hen identified as Long Valley 1-1 traveled to the closest available sagebrush stand (0.97 km to nest), while Whites Valley #7 bypassed a large stands of sagebrush to nest under an alfalfa plant (1.2 km to nest).

To determine if the populations travelled distances greater than previously reported, I calculated seasonal movement distances for each bird. Travel distances ranged from 0.9 to 14.7 km (Table 3-3). The sub-population of Whites Valley travelled 4.8 km as a mean, with a maximum of 14.7 km and a minimum of 1.2 km. The SD was 6.6. The sub-population of Long Valley had a mean of 4.1 km, with a maximum of 5.7 km and a minimum of 0.9 km. The SD was 2.7. The sub-population of Selmans had a mean of 3.3 km, with a maximum of 4.0 km and a minimum of 2.4 km. The SD was 0.8. For the West Hills, the mean was 2.7 km, with a maximum of 3.1 km and a minimum of 2.2 km. The SD was 0.6. The distance travelled in the different seasons were 4.5 km mean distance for winter, with a maximum of 14.7 km and a minimum of 0.9 km (Table 5). The SD was 4, with n = 9. For fall, the mean was 1.3 km, with a maximum of 3.1 km and a minimum of 1.2 km. The SD was 1.3 and n= 2. During summer, there was 1 point of 2.2 km.

Mortalities

In Cache County, 17 birds were radio marked over the course of 2 years. Of the radio marked birds 13, were mortalities. The mortalities that were determinable as to a cause were determined to be avian predation. This is a mortality rate of 76%.

In Box Elder County, 18 birds were radio marked in the two years of trapping. There were 12 mortalities sustained in the two sub-populations. This is a mortality rate of 67%. This is a combined mortality rate of 72%, which is consistent with literature measuring mortality rates of sharp-tailed grouse (Table 3-2).

DISCUSSION

Nesting Ecology

Of the four nests initiated by sharp-tailed grouse hens in this study, 3 were under sagebrush and 1 under alfalfa. Of the 3 under the sagebrush, all were successful, while the nest under the alfalfa plant was predated before hatching and unsuccessful. Hart et al. (1950) found that most nests at the time of his study were under alfalfa, with a success rate of 47% under alfalfa, while 70% in rangeland. Marks and Marks (1987) and Meints (1991) found that nest success was 56% and 72% in western and eastern Idaho, respectively. Giesen (1987) reported 61% nest success. Most were found in shrub habitat. All nests were found in cover > 25 cm, which is what was recommended by Meints (1991). The 75% nest success I observed is slightly higher than the ranges reported in other studies.

Seasonal Movements

The mean distance from the lek of capture to nesting site of the 4 nests that were initiated was 1.54 km. The farthest distance travelled by a female sharp-tailed grouse was in the Cache County study area at 3.32 km, and the shortest was in the Box Elder County study area at 0.71 km. Meints (1991) found that 1.2 km for initial attempts were average, while Giesen (1987) found that he had nests out to 2 km. The 3.32 km distance travelled by 1 nesting hen is on the upper end of what was found in the literature, while the other 3 nesting hens were closer to the 1.2 km found by Meints (1991), with all 3 being less. Giesen and Connelly (1993) reported that most of the hens they studied moved < 1.0 km. Other than the long distance moved by 1 hen, distance travelled to initial nesting sites is within the reported range from other studies, with the mean of 1.54 km of all birds being within the 2 km range reported by Giesen (1987). This hen might have visited other leks in addition to the dancing ground where she was captured. Her nest site was closer to a dancing ground to the north. She was predated shortly after hatching and no further data were available.

I used data from GPS points for 12 birds to measure the maximum distance moved, the minimum, the mean winter, fall and summer movements and mean movements by sub-population. The sub-populations with the highest means of distance travelled were the Whites Valley at 4.8 km and Long Valley at 4.1 km. These 2 populations reside in CRP/agricultural type habitat, with some agricultural disturbance either currently or historically. The 2 remaining sub-populations, Selmans with a mean of 3.3 km and West Hills with a mean of 2.7 km, are both native range habitats. These findings thus suggest birds that reside in native ranges tend to travel less distance than those in CRP/agricultural areas. Brood rearing and summer-fall habitats are in close proximity and meet the needs of the sharp-tailed grouse more readily than those habitats that are fragmented and used for agriculture.

Marks and Marks (1987) reported mean distances of 1.7 km distance travelled to winter habitat. Giesen (1983) found that birds traveled up to 4.5 km. Meints (1991) found some large pre- and post-winter movements of up to 25 km, but that most sharp-tailed grouse stayed closer to the leks, travelling only about 1.7 km. The birds I monitored in Utah had a mean travel distance of 4.5 km, with one hen travelling 14.7 km. Most winter travel of birds in Utah was within the range of studies in other states. The hen that travelled 14.7 km would move from riparian area in the lower elevations to the mountain tops trying to get back to the lek area. These winter movements appeared to be dependant on snow depth and severity of weather. She moved from the river bottoms of the Bear River to the ridge tops of the West Hills west of the river as the snow melted and the depth decreased. When it snowed again, she moved back to the river bottoms where good winter habitat was available. As snow melt proceeded and spring approached, she moved into the Whites Valley area.

Mortality Factors

The main cause of predation I was able to positively confirm in my study was avian. Bergerud and Gratson (1988) found that the major cause of predation of both adult and juvenile sharp-tailed grouse was avian predation. Other mortality causes are vehicle collisions, fences, power lines and agricultural equipment, excluding hunting and research activities (Aldous 1943, Hart et al. 1950). Annual mortality rates of 70% and 72% were reported for 2 separate populations in North Dakota (Robel et al. 1972), while Ulliman (1995) reported an annual mortality rate of 65% in Montana. Braun (1975) reported a 76% mortality rate on sharp-tailed grouse in Minnesota.

The Cache County birds studied experienced a 2 year combined mortality rate of 76%, while the Box Elder County study area birds had a 67% mortality rate over the 2 years (Table 3-2). The mortality rate of both study areas combined over the 2 years was 72%. Mortality rates in other studies range from 76% in Minnesota to 65% in Montana (Ulliman 1995). Mortality in Utah is within the ranges found in other research areas.

Raptor predation was the only identifiable cause of mortality, which occurred in all seasons of the year. The spring of 2004 was drier than average and vegetation production was sparser than in wetter years. The lack of vegetation cover for escape and hiding likely contributed to mortality. While mortality was recorded throughout the year, I believe better habitat and cover would reduce mortality. Some mortality occurred in open grain fields while birds were eating waste grain. If more desirable habitat was available, the use of these high risk areas might not occur.

The research areas in Cache County are in a raptor migration corridor (Smith and Neal 2009). As such, raptor densities increase during the spring and fall migrations. In the Whites Valley area, I recorded numerous northern harriers (*Circus cyaneus*) and observed several attempts of the harriers to prey on sharp-tailed grouse feeding on waste grain in harvested fields. These attempts were actual strikes or attempted strikes that were near misses. Some attempts lasted 20-30 minutes, with multiple raptors trying to attack the same group of sharp-tailed grouse. During 1 observation, there were a group of harriers circling 2 sharp-tailed grouse feeding in a cut alfalfa field. On 4 or 5 occasions 1 harrier would break from the group and attempt to strike a sharp-tailed grouse. At least 35 harriers were counted roosting in 1 field in January 2004 in Whites Valley. I observed a female northern harrier take a healthy adult male from the Whites Valley lek in April 2003, and also witnessed numerous predation attempts by harriers and other raptors on the leks monitored. Harriers were the raptor most observed in attempting to forage on sharp-tailed grouse. Other raptors observed attempting to forage were golden eagles, red-tailed and Swainson's hawks.

MANAGEMENT IMPLICATIONS

Habitat degradation and loss are thought to be one of the main factors contributing to the historic decline of sharp-tailed grouse. As wildlife managers, habitat needs to be a major concern for the restoration of the species. The conservation and restoration of nesting habitat in close proximity of leks is an important function of successful nest success. Land managers and managing agencies need to work in conjunction with private landowners in conserving and improving necessary habitat types for nesting, and also for escape and hiding. With suitable escape and hiding habitat, mortality can remain in an acceptable range. Habitat conservation of wintering areas within distance limits established by research would help in reducing winter mortality and travel.

In Cache County, development and fragmentation of native ranges is a concern. As the Cache County area grows, housing developments are moving south towards the study areas. This development is removing habitat and leks. There are also the small subdivisions that are sprouting up away from developed areas and fragmenting habitat. Conservation of these critical habitats should be an important concern within this County. Conservation easements could help reduce the loss of the habitats necessary for continued survival of the species in Cache County.

In Box Elder County, habitat restoration should be used to augment and improve habitat to offset the loss to wildfire, agricultural conversion and development. I have initiated some habitat restoration projects specifically targeting sharp-tailed grouse habitat needs, and more are needed.

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Table 3-1. Nesting information for Cache and Box Elder County study areas for Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*), 2003-2004.

Nest Data	Cache County				Box Elder			
	2003		2004		2003		2004	
	#	%	#	%	#	%	#	%
Total hens	1		3		0		5	
Nests initiated	1		1		0		2	
Successful nests	1		1		0		1	
Nests Predated	0		0		0		1	
radio-collared								
Females initiating nests		100		33		0		40
Successful		100		100		0		50

Table 3-2. Radio collared Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*), information by study area and year. Number of mortalities and percentages of mortalities for 2003 through spring of 2005.

Information	Cache County		Box Elder	
	2003	2004	2003	2004
Males radio marked	7	6	7	6
Females radio marked	1	3	0	5
Mortalities	6	7	4	8
% mortality	75	78	57	73

Table 3-3. Greatest seasonal distance travelled by radio-collared Columbian Sharp-tailed grouse (*Tympanuchus phasianellus columbianus*), from lek site trapped and study area, 2003-2004.

Bird ID.	Study area	Maximum Distance (km)	Season
Whites Valley 7	Box Elder Co.	14.7	Winter
Whites Valley 4	Box Elder Co.	2.2	Winter
Whites Valley 3	Box Elder Co.	1.2	Winter
Whites Valley 1	Box Elder Co.	1.2	Fall
Johnson Canyon 1	Box Elder Co.	3.1	Fall
Johnson Canyon 4	Box Elder Co.	2.2	Summer
Long Valley 2-1	Cache County	5.7	Winter
Long Valley 2	Cache County	5.6	Winter
Long Valley 1	Cache County	0.9	Winter
4 Mile 3	Cache County	4.0	Winter
4 Mile 2-1	Cache County	2.4	Winter
4 Mile 1-1	Cache County	3.5	Winter

Table 3-4. Mean distance travelled by radio-marked Columbian Sharp-tailed grouse (*Tympanuchus phasianellus columbianus*) in Cache and Box Elder Counties in 2003-2005.

	Whites Valley	Johnson Canyon	Long Valley	4 Mile
Mean Distance (km)	4.8	2.7	4.1	3.3
Standard Deviation	6.6	0.6	2.7	0.8
Maximum Distance (km)	14.7	3.1	5.7	4.0
Minimum Distance (km	1.2	2.2	0.9	2.4
Number of points	4	2	3	3

Table 3-5. Mean distance travelled by Columbian Sharp-tailed grouse (*Tympanuchus phasianellus columbianus*), from both study areas by season in 2003-2005.

	Winter	Fall	Summer
Mean distance (km)	4.5	2.2	2.2
Standard Deviation	4.2	1.3	
Maximum distance (km)	14.7	3.1	2.2
Minimum Distance	0.9	1.2	2.2
Number of points	9	2	1

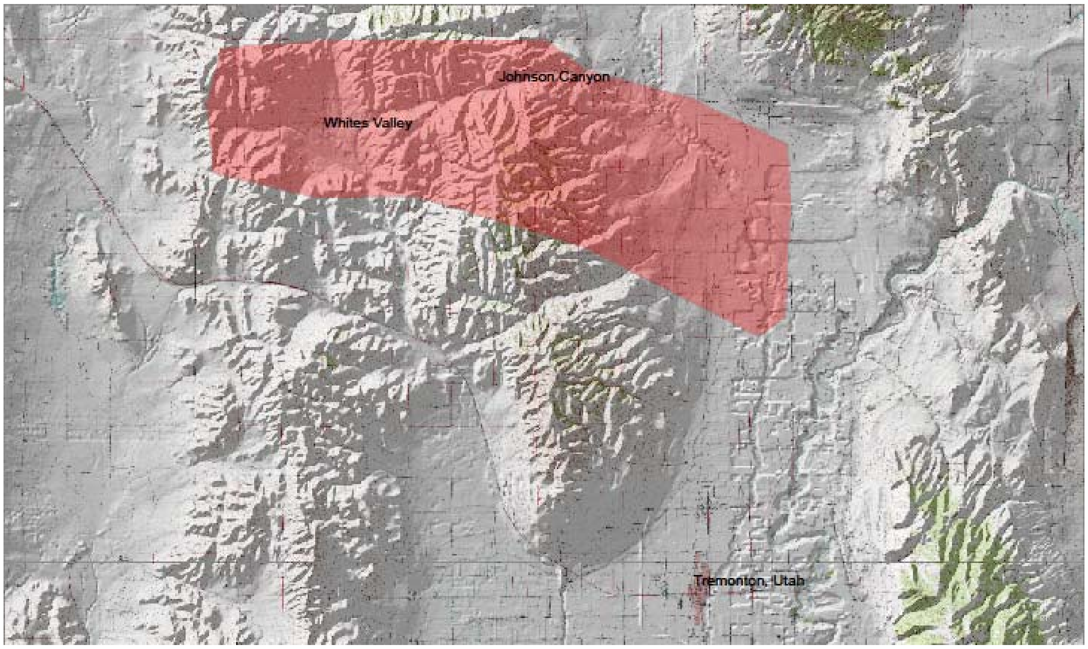

Fig. 3-1. The Box Elder County Study Area consisted of 14,400 ha located in eastern Box Elder County, 2003-2005.

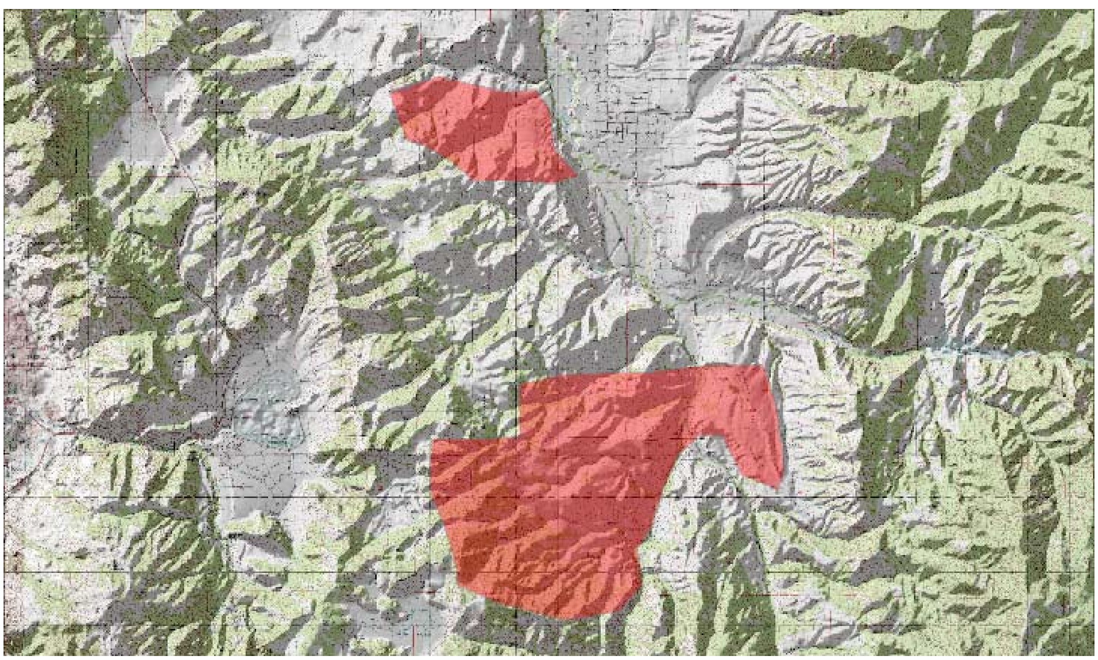

Fig. 3-2. The Cache County Study Area consisted of 3400 ha and is located in the southern end of Cache Valley, 2003-2005.

CHAPTER 4

CONCLUSIONS

Columbian sharp-tailed grouse (*Tympanuchus phasianellus columbianus*; hereafter sharp-tailed grouse) have declined from historic numbers, occupying about 10% of their historic range (Ulliman 1995). The destruction and degradation of grasslands, riparian corridors and shrub-steppe habitat from overgrazing and conversion to agricultural uses are thought to be the primary causes of the decline of the species (Hart et al. 1950, Rogers 1969, Parker 1970, Marks and Marks 1987). The State of Utah estimated the population in 1935 at approximately 1500 birds. In the fall of 1999, survey data was used to estimate the population at approximately 11,000 birds (UDWR 2002). While this loss of habitat has led to a decline of the species population range wide, the trend is now upward.

The advent of the Conservation Reserve Program (CRP) has been cited as one of the major factors leading to a range wide increase in sharp-tailed grouse populations. In Utah, some local populations also increased by as much as 400% when CRP connected isolated habitats and increased available habitat (UDWR 2002). The loss of these CRP lands would most likely have a detrimental effect on the overall population of the sharp-tailed grouse in Idaho and Utah.

The purpose of this research was to describe the nesting ecology, habitat use patterns relative to available vegetation, and seasonal movements of 2 distinct populations of sharp-tailed grouse occupying Cache and eastern Box Elder Counties. Seasonal habitat use for the Utah population is not well known and such information is required to implement management actions to conserve the species. I studied 2 meta-populations; West Hill/White Valley and Long Valley/4 Mile Complex. The West Hills meta-population is located in eastern Box Elder County, specifically the West Hills and the Whites Valley lek complexes.

For both research sites, the VOR for flush points were higher than for random paired points. The majority of flush sites were from under a shrub or from dense grass cover. McArdle (1977), Marks and Marks (1987), Meints (1991) and Giesen and Connelly (1993) all reported the importance of habitat edge and cover, and the proximity of sharp-tailed grouse to edge habitat and escape cover.

Sharp-tailed grouse in the Cache County study area selected habitat that contained forbs within a certain range of density. This range was not able to be numerically defined, but suggested that sharp-tailed grouse used habitat closely associated with the density of the forb component. As forb density decreases, the diversity of the habitat increases and the likelihood of being used by sharp-tailed grouse would increase. Box Elder County study area birds selected for sites that had higher shrub availability. Shrubs are a highly utilized component of sharp-tailed grouse habitat in the range of the sharp-tailed grouse. Meints (1991) found that 74% of nests were located in shrub habitat, while Marks and Marks (1987) found that 78% of nests were found in this type of habitat. Moyles (1981) found that sharp-tailed grouse would move into shrubs for relief from heat, and also for protection from avian predators.

In the Box Elder County study area, sharp-tailed grouse used sagebrush draws-heavy sagebrush and CRP-native range type habitats proportionately more than other habitat types, while in the Cache County study area no habitat type was used in a higher proportion than was available in the habitat. Conservation of sage steppe habitat and shrub component, along with CRP is a vital component of the conservation of the sharp-tailed grouse in Utah. With the possibility of the loss of up to 50% of CRP within the study areas in the next 2 years, the importance of this habitat is being addressed at the highest levels in state management. Working with the Natural Resource Conservation Service, the possibility of losing large amounts of CRP has been avoided. The state managing agency realizes the importance of this habitat type to sharp-tailed grouse as well as other wildlife species.

Nesting initiation and success in the study areas in Utah is within the ranges reported in other studies. The mean distance travelled to nest sites at 1.5 km is under the 2 km found in other studies (Giesen 1987), and the nesting cover greater than 25 cm is within the guidelines suggested by Meints (1991).

Marks and Marks (1987) had a mean distance of 1.7 km distance travelled to winter habitat. Giesen (1983) found that birds were travelling up to 4.5 km. Meints (1991) found some large pre and post winter movements of up to 25 km, but that most sharp-tailed grouse stayed closer to the leks, travelling only about 1.7 km. I found that the birds I studied in Utah had a mean travel distance of 4.5 km, with 1 hen travelling 14.7 km. Most winter travel of birds in Utah was within the range of other studies in other states. Other movement data suggested that birds that utilize CRP/agricultural type habitats would move farther than those inhabiting native rangelands.

The sharp-tailed grouse experienced a 2 year combined mortality rate of 76% in the Cache County study area, while the mortality rate for sharp-tailed grouse in the Box Elder County study area was 67%. The mortality rate of both study areas combined over the 2 years was 72%, which is within the ranges found in studies in Minnesota (76%) and Montana (65%) (Ulliman 1995).

As wildlife managers, habitat needs to be a major concern for the restoration of the species. The conservation and restoration of nesting habitat in close proximity of leks is an important function of successful nest success (Meints 1991, Giesen 1987). Land managers and managing agencies need to work in conjunction with private landowners in conserving and improving necessary habitat types for nesting, and also for escape and hiding. With suitable escape and hiding habitat, mortality can remain in within a range that has been established in other studies, thereby maintaining an increasing population. Habitat conservation of wintering areas within distance limits established by research would help in reducing winter mortality and travel. From the results of this study and from observations made, habitat conservation and enhancement is crucial to the survival, growth and expansion of this species.

As a habitat biologist working within these critical areas, I have the opportunity to help manage for the type of habitats that would benefit the sharp-tailed grouse in northern Utah. The importance of maintaining the areas that are in CRP as well as the other habitat types that are necessary for the continued upward trend is critical. The information of what habitat types the sharp-tailed grouse in the Cache and Box Elder study areas are selecting for is information that can be used to benefit this species as habitat improvement projects are undertaken.

To improve upon my research, I suggest collecting canopy cover data using a line transect method to more readily compare and contrast with other studies. I would have liked to have had more hens collared to improve the nesting and brood rearing data.

Capturing hens is a very difficult undertaking, and the first year and part of the second year were spent learning this technique.

Additional research could be done to better understand nesting and brood rearing information in the Utah range, as well as nest fidelity. More information needs to be obtained on how hens attend leks and their behavior on leks. There is much information yet to be gathered about the sharp-tailed grouse in northern Utah.

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