

ABSTRACT

GUNNISON SAGE-GROUSE WINTER AND SUMMER
ECOLOGY IN SAN JUAN COUNTY, UTAH

by

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An isolated, remnant population of Gunnison sage-grouse (*Centrocercus minimus*) exists in southeastern Utah. Interest in sage-grouse ecology has increased because of the observed population declines throughout the western United States. Because much more is known about greater sage-grouse (*C. urophasianus*) and their ecology, biologists have relied on information relating to their life history and habitat use patterns to make management inferences for the Gunnison sage-grouse. Little information is available on Gunnison sage-grouse winter and summer ecology in Utah for application in management. More information is needed regarding summer use of Conservation Reserve Program (CRP) lands and how arthropod abundance and diversity may influence habitat use. This research was conducted to fill these information gaps. I monitored movements and habitat use of 29 radio-collared birds during 2 winters in 2002-2003 and 2003-2004. During both winters, sage-grouse preferred to roost in black sagebrush even when snow depths were greater in 2003-2004 compared to 2002-2003.

The black sagebrush cover type constituted only 7% of the study area. Average distance traveled for adult males and females from summer to winter range during 2002-2003 was 4.6 km (range 3.5-5.6 km), and 4.4 km (range 2.5-7.2 km), respectively. The average distance traveled from summer to winter range during winter 2003-2004 for adult males and females was 2.9 km (range 0.3-3.5 km), and 5.9 km (range 3.4-8.2 km), respectively. Approximately 150 km² of additional land was enrolled in the CRP as a conservation initiative for Gunnison sage-grouse and planted with a wildlife seed mix. No information is available regarding use of CRP lands and other habitat types by Gunnison sage-grouse relative to arthropod abundance and diversity. Approximately 60% of the total number of arthropods collected was obtained from the CRP/grassland cover types. CRP lands exhibited a greater abundance of arthropods; in addition, more insect families were identified in CRP fields. My results suggest that greater forb cover increased arthropod abundance and diversity. This combination was readily apparent in CRP fields and appears to have influenced Gunnison sage-grouse habitat use patterns during springs and summers of 2003 and 2004.

(85 pages)

DEDICATION

This thesis is dedicated to my parents; my father, Delbert B. Ward who passed away November 2003 after a brief, but courageous struggle with ALS (Lou Gehrig's), and to my mother Nadine Ward who lovingly cared for him.

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CONTENTS

	Page
ABSTRACT	ii
DEDICATION	iv
ACKNOWLEDGEMENTS	ii
LIST OF TABLES	vi
LIST OF FIGURES	viii
CHAPTER	1
1. INTRODUCTION	
Description	
Sage-grouse distribution.....	2
Gunnison sage-grouse population status.....	3
Conservation efforts	
Sage-grouse life history	4
Reproduction.....	5
Nesting Habitat	5
Brood-rearing and Foraging.....	6
Winter Ecology	7
Land Use - Conservation Reserve Program.....	8
.....	9
WINTER ECOLOGY OF GUNNISON SAGE-GROUSE	15
IN SAN JUAN COUNTY, UTAH	15
Introduction.....	16
Study Area	18
Methods.....	20
Results.....	22
Bird Status.....	22
Habitat Preference.....	23
Winter Movements and Behavior	24
Discussion	25
Winter Habitat Preferences	26
Management Implications.....	29
Literature Cited	29
.....	
GUNNISON SAGE-GROUSE HABITAT USE DURING THE BREEDING	42
AND BROOD-REARING PERIODS RELATIVE TO ARTHROPOD.....	42
ABUNDANCE AND DIVERSITY IN	42

SAN JUAN COUNTY, UTAH.....	42
Introduction.....	43
Methods.....	47
Results.....	51
Bird Status.....	51
Nesting	51
Habitat and Vegetation Preferences.....	53
Arthropod Abundance and Diversity	54
Discussion.....	55
Management Implications.....	57
Literature Cited.....	59
CONCLUSIONS.....	72
Literature Cited.....	77
APPENDICES	79

LIST OF TABLES

Table	Page
2.1 Mean monthly temperature, precipitation and annual precipitation, San Juan County, Utah, 2002-2004.....	36
2.2 Mean winter wind speeds, San Juan County, Utah, 2002-2004.	36
2.3 Dominant vegetation cover types and percent available in the study area, San Juan County, Utah, 2004.....	37
2.4 Gunnison sage-grouse habitat use by cover type and proportion available for winters 2002-2003 and 2003-2004 using Goodman's 90% confidence intervals, San Juan County, Utah.....	38
2.5 Mean percent canopy cover for shrubs, bare ground, snow and litter for winters 2002-2004.....	39
2.6 Gunnison sage-grouse movements from summer to winter range 2002-2004, San Juan County, Utah.	39
2.7 Gunnison sage-grouse mean home range sizes November through February, San Juan County, Utah, 2002-2004.	40
3.1 Dominant vegetation cover types and percent available in the Conservation Study Area, San Juan County, Utah, 2004	
3.2 Gunnison sage-grouse use by cover type and proportion available for summers 2003-2004 using Goodman's 90% confidence intervals, San Juan County, Utah.....	62
3.3 Nesting data for Gunnison sage-grouse hens and vegetation cover types, San Juan County, Utah, 2003-2004.....	63
3.4 Mean percent vegetation cover (SD) at sagebrush (nest) and CRP sites, San Juan County, Utah, 2003-2004.	63
3.5 Mean percent vegetation cover (SD) at sagebrush (nest) and CRP sites, San Juan County, Utah, 2003-2004.....	63
3.6 Total number of arthropods collected from a D-vac and pitfall traps at nest and CRP sites in 2003 and 2004, San Juan County, Utah	64

3.7	Abundance of arthropods from non-insect orders collected from sagebrush and CRP lands with pitfall traps and a D-vac, San Juan County, Utah, 2003-2004.....	67
3.8	Abundance of insects from taxa collected from sagebrush and CRP lands with pitfall traps and a D-vac (number of families identified within the specific taxa), San Juan County, Utah, 2003-2004.....	65
3.9	Most abundant insect and non-insect taxa from sagebrush and CRP lands using negative binomial regression model, 2003-2004	66

LIST OF FIGURES

Figure	Page
1.1 Historic and current distribution of Gunnison sage-grouse in Colorado and Utah (Young et al. 2000).....	14
2.1 Gunnison sage-grouse Conservation Area, San Juan County, Utah, 2002-2004.....	33
2.2. Dominant vegetation cover types in the Conservation Study Area, San County, Utah (Lupis 2005).....	34
2.3 Gunnison sage-grouse winter use sites, San Juan County, Utah, 2002-2003...34	34
2.4 Gunnison sage-grouse winter use sites, San Juan County, Utah, 2003-2004...35	35
3.1 Gunnison sage-grouse Conservation Area, San Juan County, Utah, 2002-2004.....	63
3.2 Dominant vegetation cover types in the Conservation Study Area, San County, Utah Lupis 2005).....	64

CHAPTER 1

INTRODUCTION

Description

Sage-grouse (*Centrocercus spp.*) have long captivated the interest of wildlife biologists, managers and sportsmen (Patterson 1952, Connelly et al. 2000). This interest is well documented by the extensive body of literature published about this species. Recent interest has increased because of the observed population declines throughout the western United States. The decreases have continued in spite of management efforts to reduce the loss of sagebrush (*Artemisia spp.*) (Connelly et al. 2000). Sagebrush losses have been attributed to the alteration and elimination of sagebrush-steppe habitat for agricultural purposes, housing and road developments, conversion to grasslands, chemical and mechanical treatments to increase the forage base for livestock and the installation of power lines (Schneegas 1967, Braun et al. 1977, Connelly and Braun 1997, Oyler-McCance 1999). In addition to the direct habitat loss, each of the above factors contributes to increased habitat fragmentation and degradation.

Utah is home to two species of sage-grouse (*Centrocercus spp.*), the Greater sage-grouse (*C. urophasianus*) and the Gunnison sage-grouse (*C. minimus*). The Gunnison sage-grouse was described as a separate species in 2000 and exhibits genetic, behavioral and phenotypic differences when compared to Greater sage-grouse (Young et al. 2000).

Gunnison sage-grouse population declines have been linked primarily to fragmentation of sagebrush communities in southwestern Colorado (Commons 1997, Oyler-McCance 1999). Sagebrush habitat fragmentation has occurred in Utah leaving a

remnant, isolated population of Gunnison sage-grouse in the extreme southeastern portion of the state (Connelly and Braun 1997, Oyler-McCance 1999).

Sage-grouse Distribution

Sage-grouse were once abundant throughout western North America. They were distributed in 16 states and 3 Canadian provinces in areas that contained suitable sagebrush habitat (Braun 1998, Young et al. 2000). Sage-grouse are believed to have been extirpated from five states (Arizona, Kansas, Nebraska, New Mexico, and Oklahoma) and one Canadian province (British Columbia) (Braun 1998). Greater sage-grouse populations have declined to 56% of their presettlement distribution (Schroeder et al. 2004). Historically, Gunnison sage-grouse are believed to have been distributed in shrub-steppe habitat south of the Colorado River and Eagle River in Colorado, to the New Mexico boundary, and west into San Juan and Grand counties in southeastern Utah (Young et al. 2000). Little is known about historic population levels (Young et al. 2000).

Schroeder et al. (2004) reported the current distribution for Gunnison sage-grouse at approximately 4790 km², or 10% of the potential habitat prior to European settlement. The habitats they now occupy are not contiguous, creating isolated and fragmented populations (Hupp and Braun 1991).

Gunnison sage-grouse were believed to have occurred in 17 southwestern counties in Colorado and two southeastern counties in Utah. They currently exist in five counties in Colorado and only one county in Utah (Oyler-McCance 1999). In Utah, the only known populations are found in the extreme southeastern portion of the state, in San Juan County (Young et al. 2000). Few studies have been conducted on Utah's population

of Gunnison sage-grouse. Research on the ecology, food availability, reproductive biology and habitat requirements for Utah's population as compared to populations in Colorado is greatly needed.

Gunnison sage-grouse Population Status

The estimated population for Gunnison sage-grouse in southwestern Colorado and southeastern Utah is 3,500-4,000 breeding birds (Apa 2003). Utah supports approximately 3% of this population, or 120-150 birds based on lek count data (Beck et al. 2003). The Utah Division of Wildlife Resources (UDWR) has counted strutting males on seven different leks in San Juan County since 1970 (UDWR 2000). The highest count was 129 males in 1972. The population has declined to 31 males in 2004 on three leks and one satellite lek (G. Wallace, UDWR, personal communication).

Conservation Efforts

In response to concern over the decline of the Gunnison sage-grouse population, the San Juan County Gunnison sage-grouse Working Group (SWOG) was organized in 1996. The purpose of the group was to obtain habitat use information about Gunnison sage-grouse in Utah and develop a conservation plan which would benefit the species in the county. SWOG consists of state and government representatives, local landowners, Utah State University Extension and private conservation groups (SWOG 2000). SWOG recognizes the importance of collaborating with the local community to conserve and enhance the local Gunnison sage-grouse population, which depends heavily on private

lands for habitat use while concurrently preserving the community's economic viability (SWOG 2000).

Because of SWOG's efforts, Gunnison sage-grouse conservation strategies have increased dramatically in the county. SWOG negotiated with two private landowners to purchase conservation easements protecting the remaining two most active leks. This cooperative effort was funded through UDWR, The Department of Natural Resources, Endangered Species Mitigation Fund, The Nature Conservancy, U. S. Fish and Wildlife Services (USFWS) and an anonymous natural gas pipeline company (SWOG 2002).

Another major conservation effort included the re-enrollment of private lands in the Conservation Reserve Program (CRP). This occurred because SWOG collaborated with the Natural Resource Conservation Service (NRCS) to have San Juan County designated as a CRP priority conservation area. Thus, in 1997 150 km² were enrolled in this program. These areas were seeded with a vegetation mixture designed to benefit local wildlife and sage-grouse (SWOG 2000).

Critical to the conservation effort is guidance of local conservation efforts. SWOG has implemented a research program to learn more about Gunnison sage-grouse ecology in the area. This information will help to guide future conservation efforts.

Sage-grouse Life History

Because much more is known about the greater sage-grouse and their ecology, biologists have relied on information relating to the life history and habitat use patterns to make inferences for the Gunnison sage-grouse. However, with the recent designation of Gunnison sage-grouse as a separate species and their status as a candidate species under

the Endangered Species Act, wildlife managers have increased their efforts to learn more about the species.

Reproduction

Greater sage-grouse hens typically lay 6-9 eggs at a rate of 1.3 eggs/day and incubate the clutch for 25-27 days (Patterson 1952). Young (1994) reported average clutch size was 6.8 eggs for Gunnison sage-grouse hens monitored in southwestern Colorado. This is similar to other reported sage-grouse studies (Sveum et al. 1998). Young (1994) reported eight of 28 (29%) Gunnison sage-grouse hens nested as yearlings during her 3-year study. Lupis (2005) reported average clutch size for three Gunnison sage-grouse hens in Utah was 8.3 eggs. These clutch sizes were larger than those reported by Young (1994). Males are not involved in brood-rearing, while hens generally leave the breeding area immediately after mating to begin nesting (Patterson 1952).

Nesting Habitat

Sagebrush plays an important role during nesting for greater sage-grouse (Patterson 1952, Wallestad and Pyrah 1974, Gregg et al. 1994). In addition, tall grass with shrub cover may reduce predation (DeLong et al. 1995) aiding in nest success (Wakkinen 1990, Gregg et al. 1994, Sveum et al. 1998). DeLong et al. (1995) concluded that medium height sagebrush and tall grass at nest sites lowered the risk of predation for artificial sage-grouse nests. Medium height shrub cover selected by nesting hens was 40-80 cm in height (Gregg et al. 1994). Wakkinen (1990) reported similar findings in his study; the average height of shrubs selected for nesting sites was 70.2 cm. Wallestad and Pyrah (1974) reported that on their Montana study site greater sage-grouse nests occurred

in sagebrush stands with an average height of 40.4 cm and a canopy cover greater than 15%.

One study in Utah explored nesting habitat use and nesting requirements for Gunnison sage-grouse. In this 2001-2002 study, average height of vegetation in nesting areas was 21.5 cm and all nests were located under sagebrush plants (Lupis 2005). Sagebrush plants selected by Gunnison sage-grouse for nest sites were much shorter than those reported by Young (1994) in Colorado. Although sample size was small, nest sites had greater shrub cover than comparative sites selected randomly (Lupis 2005).

Brood-rearing and Foraging

Forbs and insects are required for successful brood-rearing for greater sage-grouse (Drut et al. 1994). Consequently, wet meadows constitute important habitat for broods during late summer (Klebenow 1969). Arthropods are an essential part of greater sage-grouse chick's diet for the first three weeks of life (Johnson and Boyce 1990). Although chicks greater than three weeks old survived without arthropod diets, their growth rate was decreased. These observations suggest that arthropods are an important nutritional component even after 3 weeks of age (Johnson and Boyce 1990).

Drut et al. (1994) looked at diets and food selection by sage-grouse chicks in two areas that had very different productivity. In the area with high sage-grouse productivity, forbs and invertebrates composed 80% of dietary mass, whereas in the less productive area, chicks consumed primarily sagebrush (65%). Peterson (1970) reported similar findings suggesting animal matter was the most important component for the first week of life in sage-grouse chicks, although sample size was small. Grasshoppers

(*Orthoptera*), ants (*Hymenoptera*), and beetles (*Coleoptera*) are the primary taxa of insects in greater sage-grouse chick diets (Patterson 1952, Peterson 1970).

No specific studies in San Juan County, Utah have been conducted on the dietary behavior of Gunnison sage-grouse chicks. However, since their life history requirements are so similar to Greater sage-grouse, most biologists believe dietary needs are comparable.

Winter Ecology

During winter, greater sage-grouse depend on sagebrush (*Artemisia spp.*) for food and cover (Eng and Schladweiler 1972, Beck 1975, Remington and Braun 1985, Robertson 1991). Connelly et al. (1988) reported migration to wintering areas beginning in late August and continuing into December for Greater sage-grouse in southeastern Idaho. Similar findings were reported for Greater sage-grouse in central Montana (Eng and Schladweiler 1972). Connelly et al. (2000) reported non-migratory sage-grouse using contiguous sagebrush areas for winter and breeding habitat. In contrast, migratory sage-grouse may use separate habitats and travel long distances (>75 km) each season (Connelly et al. 2000). Sage-grouse tend to group together forming flocks during wintertime and prefer southern to western facing aspects (Beck 1977) with vegetation providing greater than 20% canopy cover (Eng and Schladweiler 1972). Beck (1977) reported that areas used by sage-grouse appeared to be determined by snow accumulations rather than preference for a particular site.

Although much of the published literature on sage-grouse habitat use refers to Greater sage-grouse, biologists believe that Gunnison sage-grouse exhibit similar winter habitat use patterns. Commons (1997) reported Gunnison sage-grouse in Colorado used

sagebrush almost exclusively during winter. No information exists regarding Gunnison sage-grouse winter habitat use in San Juan County, Utah.

Land Use - Conservation Reserve Program

The area inhabited by Gunnison sage-grouse in Utah experiences periodic droughts, which may negatively affect populations through decreased forb, grass and insect production (SWOG 2000). During the 1980's, many landowner's in the area enrolled their land in the Conservation Reserve Program (CRP). CRP is a government program for landowners who voluntarily agree to convert agricultural land to permanent vegetation cover in exchange for annual lease payments from the government (Lupis 2005). In 1997, approximately 150 km² of private land was enrolled in CRP and was then seeded with a vegetation mixture designed to benefit Gunnison sage-grouse and other wildlife (SWOG 2000).

Apa (2003) suggested that cropland and CRP land in the Dove Creek area of Colorado may play an important role in brood-rearing, however, this has not been well-documented. In 2002, a severe drought impacted the forage base in San Juan County, Utah. To mitigate the economic impact of the drought on private landowners, NRCS allowed emergency livestock grazing on CRP land during the summer and fall. Lupis (2005) reported extensive use of CRP lands for nesting and brood-rearing for Gunnison sage-grouse in San Juan County, Utah. During summers 2001 and 2002, sage-grouse also used CRP lands more than expected based on the percentage that was available.

Beck and Mitchell (2000) reported that indirect effects of grazing appear to adversely impact sage-grouse habitat more than direct impacts. They suggested livestock grazing in the spring most likely affects nest success and productivity by decreasing

herbaceous cover. Braun (1987) concluded that indirect evidence suggests grazing by cattle decreases available herbaceous cover and understory and may have negative impacts on sage-grouse.

Study Objectives

Little information is available on Gunnison sage-grouse winter ecology, nesting success and the role of arthropods on habitat use. This research was conducted to fill these information gaps. Initial research in Utah focused on summer ecology, nesting and brood rearing success, and habitat use patterns in a changing landscape (Lupis 2005). However, additional information is needed on winter ecology and habitat use, use of CRP lands by sage-grouse and how this use may be related to arthropod abundance in sagebrush habitats (nesting sites) and potential brood rearing habitat (CRP lands). The specific objectives of this research were to:

1. Identify and evaluate winter habitat use of Gunnison sage-grouse in San Juan Juan County, Utah.
2. Evaluate reproductive success, survival and mortality of Gunnison sage-grouse in San Juan County, Utah.
3. Assess nesting and brood-rearing success for Gunnison sage-grouse hens.
4. Evaluate arthropod abundance and diversity related to vegetation composition at nest (sagebrush) and potential brood-rearing sites (CRP lands) for Gunnison sage-grouse hens.

Style

This thesis is written in a multi-chapter style. Chapters 2 and 3 are written using the editorial guidelines of the Wildlife Society Bulletin.

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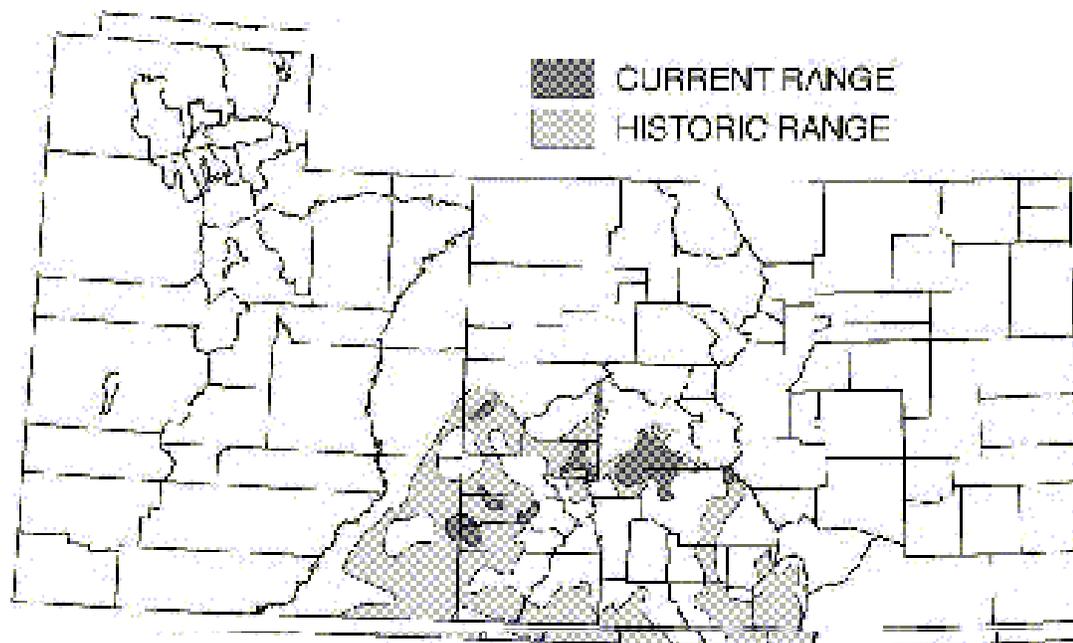


Figure 1.1. Historic and current distribution of Gunnison sage-grouse in Colorado and Utah (Young et al. 2000).

CHAPTER 2
WINTER ECOLOGY OF GUNNISON SAGE-GROUSE
IN SAN JUAN COUNTY, UTAH

Abstract Gunnison sage-grouse (*Centrocercus minimus*) populations have declined throughout their historic range. A small, isolated population of Gunnison sage-grouse exists in San Juan County, Utah. Little information exists about their habitat use patterns, specifically, their winter range. Movements and habitat use of 29 radio-collared birds were monitored during 2 winters in 2002-2003 and 2003-2004. During both winters, grouse preferred to roost in black sagebrush (*Artemisia nova*) even though snow depths were greater in 2003-2004. The black sagebrush cover type constituted only 7% of the study area. Other preferred cover types included big sagebrush with 15-25% canopy cover and big sagebrush mixed with CRP land. Average distance traveled for adult males and females from summer to winter range during 2002-2003 was 4.6 km (range 3.5-5.6 km), and 4.4 km (range 2.5-7.2 km), respectively. The average distance traveled from summer to winter range during winter 2003-2004 for adult males and females was 2.9 km (range 0.3-3.5 km), and 5.9 km (range 3.4-8.2 km), respectively. Average home range for adult males and females for both winters was 2.5 km² and 3.0 km², respectively. No radio-collared birds moved out of the Utah site despite the nearest population occurring approximately 20 miles to the east in Dove Creek, Colorado. This population is considered non-migratory because of their limited seasonal movements.

Introduction

Sage-grouse require relatively large expanses of sagebrush-steppe habitat to accomplish their life cycle. This may be particularly important in areas where deep snow covers seasonal ranges (Dalke et al. 1963). Greater sage-grouse (*Centrocercus urophasianus*) depend on sagebrush (*Artemisia spp.*) during winter for food and cover (Patterson 1952, Eng and Schladweiler 1972, Beck 1977, Remington and Braun 1985). Many of the sagebrush-steppe communities that sage-grouse depend on have been lost and fragmented from conversion to other land uses or have undergone habitat degradation (Oyler-McCance 1999).

Connelly et al. (1988) reported that Greater sage-grouse move to wintering areas beginning in late August and into December in southeastern Idaho. Similar findings were reported for Greater sage-grouse in central Montana (Eng and Schladweiler 1972). Dunn and Braun (1986) reported juvenile sage-grouse movements during late November were related to available sagebrush and when snowfall depths reached 20-50 cm in northwestern Colorado.

Migratory sage-grouse may use separate seasonal habitats and thus travel long distances during migration (Connelly et al. 2000). Berry and Eng (1985) reported a radio-collared hen traveling 114 km from fall through spring, moving from winter range to summer range and back to winter range in southwestern Wyoming; they attributed this extensive movement to an unusually moderate winter. Connelly et al. (2000) reported non-migratory sage-grouse using contiguous sagebrush areas for winter and breeding habitat. Dalke et al. (1963) reported that the size of Greater sage-grouse winter range in southern Idaho fluctuated from year to year and appeared related to varying snow depths;

black sagebrush (*A. nova*) was preferred by sage-grouse. However, when snow depths were > 25 cm, this habitat was unavailable and sage-grouse selected other habitat types.

Greater sage-grouse winter movements may vary with geographic topography, vegetation and snow depth (Beck 1975). Similar results have been reported for Gunnison sage-grouse. Commons (1997) reported that male Gunnison sage-grouse monitored in one southwestern Colorado study area moved from agricultural lands and wintered in areas containing sagebrush and Gambel oak (*Quercus spp.*). This movement was attributed to the fact that most of this available habitat was used for agricultural production and during winter was unavailable due to snow cover. In Commons' other study areas, she reported little difference in use of other habitat types. Schoenberg (1982) reported sage-grouse in Colorado moved to areas with ridges, drainages and benches after winter storms left deep snow that covered most of the open, flat areas.

Hupp and Braun (1989) reported in the Gunnison Basin of Colorado, Greater sage-grouse foraged in areas where sagebrush height above snow was maximized. Sage-grouse utilized drainages and southwest slopes when snow depth exceeded 30 cm because snow was less deep in comparison to other habitat types. Beck (1977) reported similar findings in North Park, Colorado for Greater sage-grouse; radio-marked birds formed flocks during winter and preferred southern to western facing aspects.

Homer et al. (1993) reported Greater sage-grouse in north central Utah preferred shrub classes with canopy cover between 20-30% and an average sagebrush height of 40-56 cm for winter habitat use. Eng and Schladweiler (1972) reported similar behavior in Montana for Greater sage-grouse; they preferred vegetation which provided > 20% canopy cover during winter. In contrast, Robertson (1991) reported migratory Greater

sage-grouse in southeastern Idaho preferred Wyoming big sagebrush (*A. tridentata wyomingensis*) and selected areas with canopy cover between 8-12%. Commons (1997) reported Gunnison sage-grouse in Colorado used sagebrush almost exclusively during winter.

Connelly et al. (2000) recommended that sage-grouse winter range have shrub canopy cover of 10-30% and heights approximately 25-35 cm regardless of snow cover. Based on this information, the San Juan County Gunnison Sage-Grouse Working Group (SWOG) adopted guidelines for winter habitat which include a canopy cover of 15% big sagebrush with an average height of 30 cm for south and west-facing slopes (SWOG 2000).

Although much of the published literature on sage-grouse habitat use refers to Greater sage-grouse, biologists believe that Gunnison sage-grouse may exhibit similar habitat use patterns. No information currently exists regarding Gunnison sage-grouse winter habitat use in San Juan County, Utah. This study was conducted to determine Gunnison sage-grouse winter habitat preferences. The information will be used to refine SWOG's winter habitat recommendations and guide future conservation efforts.

Study Area

The study area is located in San Juan County, Utah, approximately 20 km northeast of Monticello, Utah (Figure 2.1). San Juan County consists of 20,256 km², over 90% is federally owned (SWOG 2000). The study area is bordered by U.S. Highway 491 to the south and U.S. Highway 191 to the west. A total of 208 farms exist

in San Juan County and agricultural croplands make up roughly 6% of the land area or 1,314 km².

The study area is located within the conservation area (CA) and consists of approximately 39,200 km² (SWOG 2000). The CA is comprised of agricultural fields, rural residences and rangelands. The CA was identified by delineating historic and current leks sites, an assessment of potentially suitable sage-grouse habitat and sage-grouse observations (SWOG 2000). Within the CA, a Conservation Study Area (CSA) was delineated based on previous research and consists of approximately 2417 km² (Lupis 2005). The CSA consists of multiple habitat types including rangelands, sagebrush, CRP fields and agricultural lands and greater than 93% is privately owned (SWOG 2000). Elevations within the CSA range from 2040 - 2150 m with mostly level terrain and some gentle rolling topography. Multiple county dirt roads divide the CSA. Two ravines running north and south dissect part of the CSA.

The average annual precipitation for Monticello, Utah is 38 cm with an annual total snowfall of approximately 150 cm (Lupis 2005). January is typically the coldest month of the year. The majority of precipitation falls as rain during the monsoon period from July through September. The majority of precipitation as snow falls during December through February. During this study, January and February 2004 were colder than the 30 year average. In contrast, January 2003 was above the 30 year average. Precipitation for 2002-2004 study periods was below the 30-year average (Table 2.1.). Average winter wind speed for November through February 2002-2003 was 9.3 km/hr and 10.6 km/hr for November through February 2003-2004 (Table 2.2).

Methods

Gunnison sage-grouse were captured at night during fall and spring 2003 and 2004 on or adjacent to lek sites and in CRP/grass fields with long-hand-held nets or net guns using spotlighting techniques (Giesen et al. 1982, Wakkinen 1990, Wakkinen et al. 1992). Captured birds were fitted with an ATS necklace radio transmitter (ATS Incorporated, Isanti, MN) with a programmed mortality signal if movement stops; the signal is on for 19 hours and off for 5 hours. The age of birds (juvenile or adult) was determined using primary feather patterns (Beck 1975). Bird capture locations, in Universal Transverse Mercator (UTM's), were recorded with a handheld Global Positioning System (GPS) unit. Captured birds were released at their capture site after information and samples were obtained.

To determine winter habitat use radio-collared sage-grouse were monitored and locations were obtained weekly from November through February 2002-2004. Radio-collared birds were located using receivers (Communications Specialists Inc., Orange, CA), Omni antennae and a 3-element hand-held Yagi antenna (Telonics Inc., Mesa, AZ). Sage-grouse locations were recorded with a GPS unit in UTM's. The observations recorded included date, time, bird number, sex, number of birds (collared/uncollared), habitat description and location.

The cover type characteristics for winter habitat were determined by measuring vegetation from a subsample of radio-collared sage-grouse locations from November through February 2002-2004. At each bird location, temperature ($^{\circ}\text{C}$) and wind speed (km/hr) were compared with random locations (Schoenberg 1982, Robertson 1991). Snow depth and percent canopy cover were recorded at bird and random sites.

Two 20-m transects oriented along east-west and north-south coordinates beginning at the center of the bird location were used to measure vegetation site characteristics. Random sites were located at least 30 m from the initial site. The direction from the initial site was randomly selected for each site. Percent cover was measured using a Daubenmire frame every 5 m along the 20-m transects (Daubenmire 1959). A visual estimate of percent canopy cover for the categories of grasses, forbs, shrubs, bare ground, rocks, snow, litter and other were classified into percentages: 0-5%, 5-25%, 25-50%, 50-75%, 75-95%, 95-100% (Daubenmire 1959). A Robel pole was used to estimate vertical visual obstruction (VOR) in each north-south, and east-west direction (Robel et al. 1970). The readings were averaged to give a VOR measurement at bird locations and random sites.

Dominant vegetation types in the study area were classified and mapped in 1998 using GIS technology (Table 2.3). Vegetation cover types for the CSA were determined using Landsat 30m resolution imagery. These data were ground-truthed using 50 randomly selected training sites. Eighteen vegetation and landscape cover classes were identified. The dominant vegetation types identified included agricultural lands, sagebrush, CRP/grasslands and rangelands (Figure 2.2) (Lupis 2005).

Because of the sparseness of data, an exact chi-square goodness-of-fit and Goodman's simultaneous confidence intervals were constructed at 90% to determine if there were any preferences of radio-collared birds for habitat cover types (Neu et al. 1974, May and Johnson 1997). Winter habitat preference/avoidance was assessed by computing number of bird locations in a specific cover type compared to the percent cover type available (May and Johnson 1997) (Table 2.4). I chose 90% confidence

intervals as a compromise in balancing Type I and Type II errors. Results were interpreted in the following manner: when the percent available cover type was below the 90% interval, the cover type was preferred. Conversely, the cover type was avoided if the percent available cover type was above the 90% interval. I tested for differences in cover type use of radio-collared sage-grouse for each winter separately.

Because of small sample sizes and number of observations, the data did not fit any specific type of statistical analysis. The approach of Neu et al. (1974) was used to describe and compare habitat use and availability. Several assumptions were made, including animals have access to all cover types and radio-tracked animals are independent (Alldredge and Ratti 1986, Aebischer et al. 1993).

Due to small sample sizes, a Multi-response Randomized Block Procedure (MRBP) with Blossom statistical program (USGS 2001) was used to determine if differences existed between bird locations and random sites as characterized by percent shrub, snow, bare ground and litter. The MRBP was used for the categories of shrub, snow, bare ground and litter in combination and separately. Winter home range for birds was determined using GIS (ArcView GIS3.2) with a minimum convex polygon (MCP). A *t*-test was used to test for differences in wind speed, temperature and VOR's at bird use and random sites. Results were considered significant at $P < 0.05$.

Results

Bird Status

During this study, 29 Gunnison sage-grouse were monitored during winters 2002-2004. Twelve (6 adult males, 6 adult females), and 17 (7 adult males, 3 juvenile males and 7 adult females) sage-grouse were monitored during 2002-2003 and 2003-2004

winters, respectively. From November through the beginning of March, 91 and 145 bird locations were obtained, respectively. Several radio-collared birds were monitored for both winters, while others were monitored for only 1 season. Even though different birds were monitored, habitat use was similar for both winters (Figure 2.3 and 2.4). One adult male that was not monitored in 2002-2003, but was monitored in 2003-2004, exhibited different habitat use patterns compared to other birds (Figure 2.4).

Habitat Preference

Snow cover during winter (November through February) 2002-2003 was almost nonexistent in the CSA. In comparison, winter 2003-2004 snow depth averaged 7.8 cm for bird-use areas (range 0-30 cm), and average snow depth was 8.0 cm at randomly selected sites (range 0-28 cm). In 2003-2004, snow remained on the ground for approximately 2-3 months from December 2003 through February 2004 as compared to the previous winter where snow cover persisted for only 1-2 weeks.

During winter 2002-2003, wind speed differed at bird locations compared to random locations ($P=0.05$) (Table 2.2). There was no difference in ambient temperatures for bird-use sites when compared to random locations ($P=0.79$) (Table 2.1). VOR measurements at bird-use sites did not differ compared to random sites ($P=0.12$). For winter 2003-2004, there was no difference in wind speed at bird-use sites compared to random sites ($P=0.71$). The ambient temperature at bird-use sites did not differ compared to random locations ($P=0.09$). VOR's at bird-use sites differed from random sites ($P=0.04$).

During both winters, radio-collared birds preferred specific habitat cover types ($P<0.001$) (Table 2.4). In 2002-2003, black sagebrush and big sagebrush with 15-25%

canopy cover were used more than expected based on availability. Non-irrigated agricultural land was avoided.

In 2003-2004, black sagebrush and big sagebrush mixed with CRP cover types were selected in greater proportion based on availability. Wet meadow, agricultural lands, CRP with >70% canopy, CRP with 41-70% canopy and rangelands were used less than expected in proportion to availability (Table 2.4).

In 2002-2003, percent shrub canopy cover was greater at bird-use locations compared with random sites ($P=0.02$) (Table 2.5). There were no differences in percent cover for snow, bare ground or litter separately. The average sagebrush height for bird-use locations was 49.4 cm (range 17.8-91.4 cm) compared to 47.0 cm (range 7.6-88.4 cm) for random sites.

During winter 2003-2004, percent shrub, snow, bare ground and litter was similar at bird-use locations compared to random sites (Table 2.5). Sagebrush height for bird-use sites was 56.0 cm (range 22.9-78.7 cm) compared to 30.3 cm (range 0-58.4 cm) for random sagebrush height. Sagebrush height above snow at bird-use sites averaged 51.6 cm (range 14.9-73.7 cm) compared to 49.4 cm (range 17.8-91.4 cm) for bird-use sites in 2003-2004.

Winter Movements and Behavior

During winter 2002-2003, the average distance traveled for adult males and females from summer to winter range was 4.6 km (range 3.5-5.6 km), and 4.4 km (range 2.5-7.2 km), respectively (Table 2.6). The average distance traveled from summer to winter range during winter 2003-2004 for adult males was 2.9 km (range 0.3-3.5 km), and for adult females the average distance was 5.9 km (range 3.4-8.2m). Based on the

movement data from radio-collared birds, this population would be considered non-migratory because of the minimal distance moved to seasonal ranges.

Home range sizes varied for adult males and females during winter 2002-2003 (Table 2.7). Mean home range size for adult males and females was 2.3 km² and 3.5 km², respectively. During winter 2003-2004 home range sizes varied between adult males and females and juvenile males. Mean home range size for adult males and females was 2.8 km² and 2.5 km², respectively. Mean home range size for 2 juvenile males was 1.2 km².

Gunnison sage-grouse flock sizes consisted of 2-30+ birds during the wintertime. During winter 2002-2003, 1 adult male was observed alone 4 times, while 2 other males were observed alone once on separate occasions. There were 13 observations of only 2 birds together and 3 observations of 20+ birds together. These large flocks of birds were observed in black sagebrush cover type mixed with Wyoming sage brush patches in close proximity.

In contrast, during winter 2003-2004, there were 3 separate observations of 1 female and 2 males alone and 6 observations of only 2 birds together. However, there were 11 observations of 20+ birds located together. These large mixed flocks were observed in approximately the same locations throughout most of the winter in black sagebrush cover type mixed with Wyoming sagebrush patches.

Discussion

Little information exists regarding this remnant population of Gunnison sage-grouse in San Juan County, Utah. Their remaining habitat consists of a fragmented, mixture of different land types. This population is isolated from other Gunnison sage-

grouse populations with the nearest population in Dove Creek, Colorado, almost 20 miles to the east. During the past 4 years, no radio-collared birds have been observed moving into Colorado.

Although the sample size that I observed was small, I believe the sample of radio-collared birds is representative of the population. Based on lek count data from 2004, the population is believed to be between 120-175 birds (SWOG 2004). My sample size of 12 and 17 birds for winters 2002-2003 and 2003-2004, respectively, represents approximately 10% of this population.

Winter Habitat Preferences

Selection of vegetation by sage-grouse appears to be related to availability of cover during winter time. Robertson (1991) reported Wyoming sagebrush was the most important factor in habitat suitability in southeast Idaho; Greater sage-grouse selected areas dominated by Wyoming sagebrush with greater canopy cover and taller shrubs compared to randomly selected sites. Schoenberg (1982) also reported sage-grouse in North Park, Colorado preferred sagebrush >50 cm in height and >60 % canopy cover during winter. Robertson (1991) reported Greater sage-grouse in southeast Idaho used sagebrush, which was above snow, with an average height of 46 cm. Commons (1997) reported Gunnison sage-grouse in Colorado preferred sagebrush cover types during winter at her 3 study sites. Mean sagebrush height was 40 and 56 cm for bird-use sites in Dove Creek, Colorado. Many of her random sites were used, suggesting suitable habitat is used throughout the year (Commons 1997).

The sage-grouse population I studied exhibited winter habitat use behaviors similar to those reported in other sage-grouse studies. While black sagebrush was the

dominate vegetation, other shrubs were present, including big sagebrush (*A. tridentata*), rabbitbrush (*Chrysothamnus spp.*) and saltbush (*Atriplex canescens*). It is not clear if sage-grouse preferred the black sagebrush cover type for food or cover or both. Big sagebrush is a highly digestible browse during winter for mule deer (Welch and Pederson 1981) and is preferred over black sagebrush during winter by mule deer near Gardiner, Montana (Personius et al. 1987). It is not known which species of sagebrush are preferred by sage-grouse.

Winter Movements

Movements for this population of Gunnison sage-grouse are similar to the movements reported for male and female Greater sage-grouse in North Park, Colorado (Beck 1975). Commons (1997) reported minimal movements year-round for Gunnison sage-grouse in southwest Colorado. Most of her collared Gunnison sage-grouse remained within 5 km of leks; the furthest distance traveled by sage-grouse was 14 km. In contrast, Connelly et al. (1988) reported Greater sage-grouse movements of > 60 km from summer to winter range in southeast Idaho. Dalke et al. (1963) reported Greater sage-grouse in southeastern Idaho migrated up to 100 km for suitable winter range relating to winter conditions.

I observed several different movement patterns. One juvenile male captured near the lek in the western part of the CSA during spring 2003 remained with other birds in this area until winter 2003-2004. He then moved approximately 12 km to the eastern portion of the study area. He remained with birds associated with this area of the CSA. In May 2004, this male then returned to the western part of the CSA to the lek where he was captured and remained there during the breeding season. The furthest distance

moved during this 2-month period was approximately 0.5 km. The male then returned to the eastern part of the CSA where he remained throughout June-August 2004 and was observed associating with other males from this area.

Two adult females also exhibited unique movement patterns during winter. They traveled from the western part of the CSA to the eastern part of the area to winter in Wyoming sagebrush patches. They remained in the eastern portion of the CSA during both winters in association with other radio-collared birds from this area.

During winter 2003-2004, only 1 radio-collared female remained in the western part of the CSA. She, however, moved further north, perhaps in search of available suitable habitat and remained in the area for the winter. Three adult females, 1 the same from the previous winter, moved to the eastern part of the CSA where they remained for the winter in various sagebrush cover types.

In years of deep snow cover, vegetation canopy cover is reduced. Snow cover also may limit what habitat cover types are available. Consequently, larger flocks of birds may congregate and use communal roost sites.

Many of the habitats I sampled exhibited no vegetation above the snow during winter 2003-2004. This was apparent from the VOR's obtained at bird use sites and random sites. Mean sagebrush height at bird use areas ($\bar{x}=56.0$ cm) differed from random sites ($\bar{x}=30.0$ cm). Sage-grouse selected taller sagebrush patches when compared with random sites. During this year, I recorded more communal bird use sites when compared with the winter of 2002-2003.

Management Implications

Available suitable winter habitat appears to be limited in the CSA. Most of the black sagebrush cover type that birds used during both winters are located in the eastern portion of the CSA. Conservation efforts should be directed at preserving and enhancing the remaining sagebrush patches, with attention directed at establishing additional areas of Wyoming and black sagebrush in CRP fields throughout the western and eastern parts of the study area.

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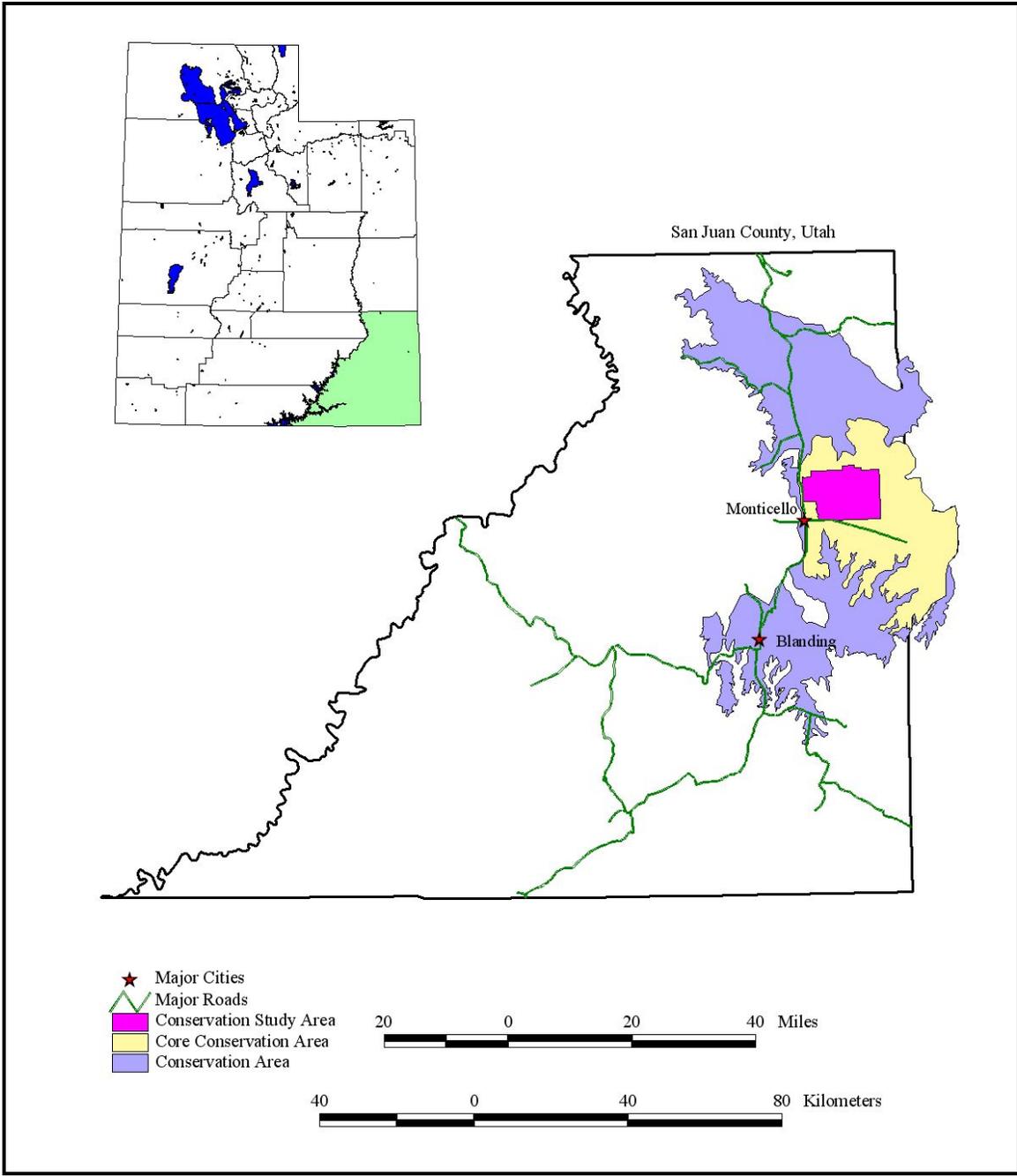


Figure 2.1. Gunnison sage-grouse Conservation Area, San Juan County, Utah, 2002-2004.

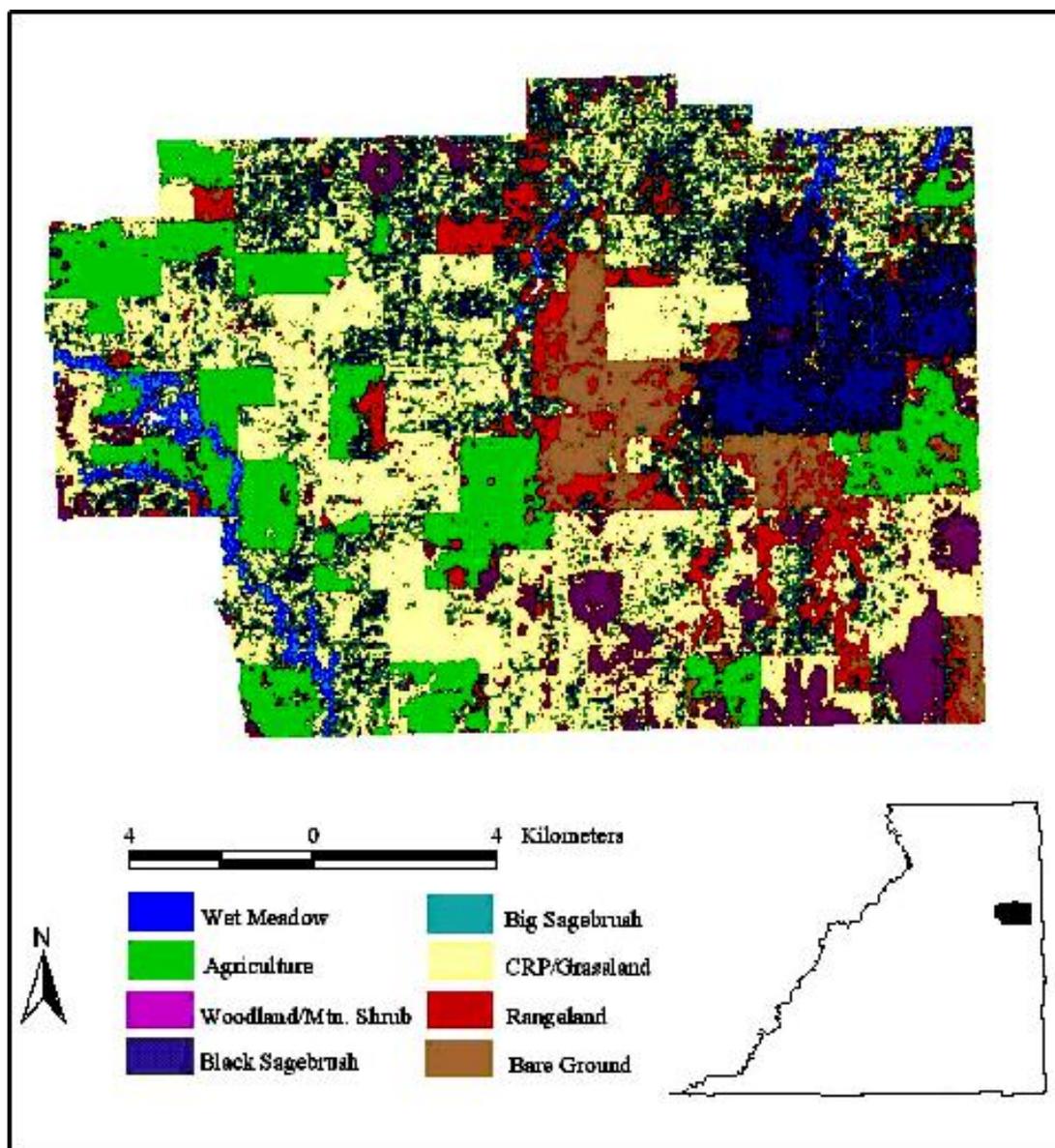


Fig. 2.2. Dominant vegetation cover types in the Conservation Study Area, San Juan County, Utah, (Lupis 2005).

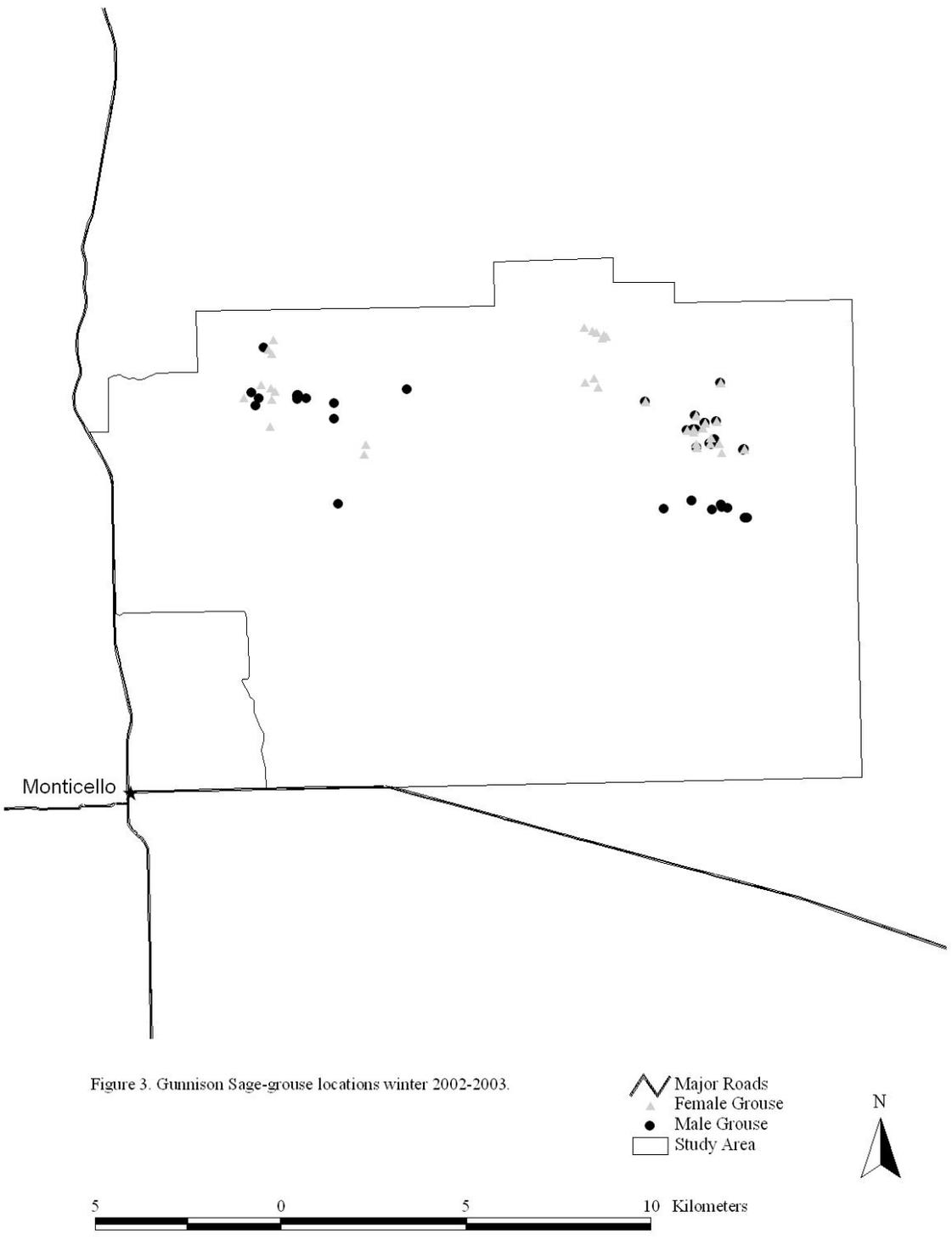


Figure 3. Gunnison Sage-grouse locations winter 2002-2003.

Figure 2.3. Gunnison sage-grouse winter use sites, San Juan County, Utah 2002-2003.

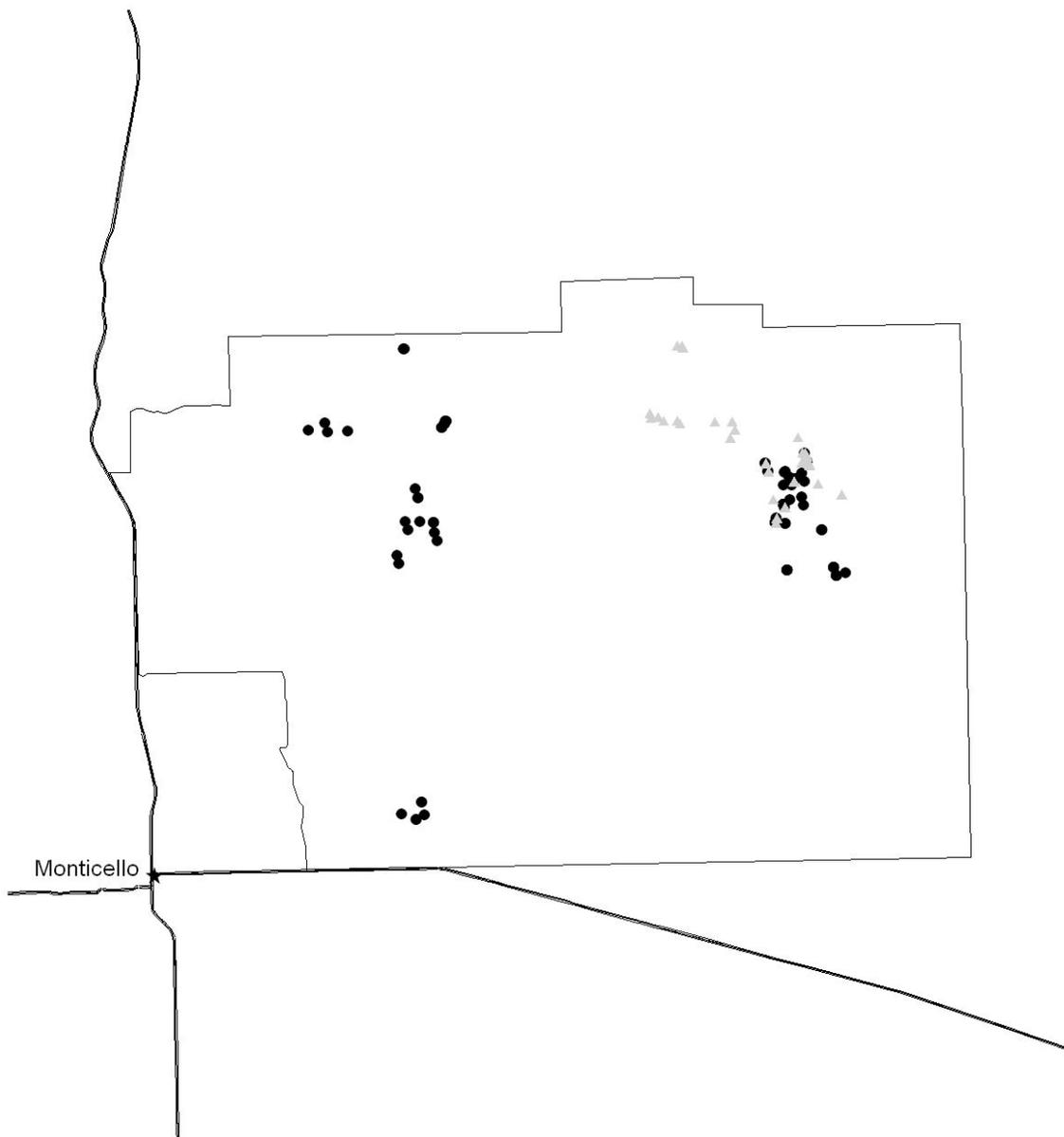


Figure 4. Gunnison Sage-grouse locations winter 2003-2004.

- Major Roads
- Female Grouse
- Male Grouse
- Study Area



Figure 2.4. Gunnison Sage-grouse winter use sites, San Juan County, Utah, 2003-2004.

Table 2.1. Mean monthly winter temperature, precipitation and annual precipitation, San Juan County, Utah, 2002-2004.

	Temperature (°C)				Precipitation (cm)				Annual precip.
	Nov.	Dec.	Jan.	Feb.	Nov.	Dec.	Jan.	Feb.	
2002-03	1.6	-3.2	0.7	-1.3	3.4	1.0	0.4	8.2	31.5
2003-04	1.2	-2.1	-6.1	-4.3	5.0	3.9	1.6	4.3	39.8
Avg ¹	2.0	-3.0	-4.0	-1.0	4.2	2.9	4.6	3.8	41.9

¹ Thirty-year average, 1974-2004

Table 2.2. Mean winter wind speeds, San Juan County, Utah, 2002-2004.

	Mean monthly wind speeds (km/hour)				Mean
	Nov	Dec	Jan	Feb	
2002-03	10.1	8.9	7.7	10.3	9.3
2003-04	11.1	11.1	8.7	11.4	10.6

Table 2.3. Dominant vegetation cover types and percent available in the study area, San Juan County, Utah, 1998.

Vegetation cover types	Hectares	% total available
Agriculture	3115	12.9
Black sagebrush	1734	7.2
Big sagebrush >25% canopy	1739	7.2
Big sagebrush 15-25% canopy	998	4.1
Big sagebrush <15% canopy	1460	6.0
CRP > 70% canopy	3150	13.0
CRP 41-70% canopy	3444	14.3
CRP 15-40% canopy	1855	7.7
Rangelands	1936	8.0

Table 2.4. Gunnison sage-grouse habitat use by cover type and proportion available for winters 2002-2003 and 2003-2004 using Goodman's 90% confidence intervals, San Juan County, Utah.

Cover type	Proportion						
	available	2002-2003				2003-2004	
		Observations	Lower	Upper	Lower	Upper	Observations
Wet meadow	.020	0	0.000	0.076	0	0.000	0.049
Irrigated agriculture	.002	0	0.000	0.076	0	0.000	0.049
Non-irrigated agriculture	.127	2 ^o	0.004	0.113	0 ^o	0.000	0.049
Pinyon/Juniper	.038	0	0.000	0.076	0	0.000	0.049
Black sagebrush	.072	47*	0.378	0.653	76*	0.412	0.634
Pinyon/Juniper/Mountain shrub	.024	0	0.000	0.076	0	0.000	0.049
Big Sagebrush >25% canopy	.072	4	0.012	0.145	6	0.014	0.113
Big sagebrush 15-25% canopy	.041	9*	0.042	0.217	8	0.022	0.132
Big sagebrush <15% canopy	.061	5	0.017	0.160	11	0.034	0.159
Mountain shrub	.003	0	0.000	0.076	0	0.000	0.049
Big sagebrush/CRP	.047	5	0.017	0.160	19*	0.072	0.226
CRP >70% canopy	.131	5	0.017	0.160	4 ^o	0.008	0.094
CRP 41-70% canopy	.143	5	0.017	0.160	1 ^o	0.000	0.061
CRP 15-40% canopy	.077	5	0.017	0.160	16	0.057	0.201
Rangelands	.080	4	0.012	0.145	2 ^o	0.002	0.073
Bare ground	.062	0	0.000	0.076	2	0.002	0.073

*preferred
^oavoided

Table 2.5. Mean percent canopy cover of shrubs, bare ground, snow and litter for winters 2002-2004, San Juan County, Utah.

Mean percent canopy cover				
Cover type	2002-2003		2003-2004	
	Bird-use sites	Random sites	Bird-use sites	Random sites
Shrubs	27.1*	20.6*	19.2	18.8
Bare ground	42.7	41.8	17.4	16.8
Snow	0.1	0.3	56.7	55.4
Litter	4.5	4.6	2.9	1.4

* Shrub canopy cover differed ($P < 0.05$) by multi-response blocked permutation process (MRBP).

Table 2.6. Gunnison sage-grouse mean movements from summer to winter range 2002-2004, San Juan County, Utah.

Year	Adult (km)		Juvenile (km)	
	Male	Female	Male	Female
2002-2003	4.6	4.4	-*	-*
2003-2004	2.9	5.9	0.3	-*

*no data

Table 2.7. Gunnison sage-grouse mean home range sizes November through February
San Juan County, Utah 2002-2004

Year	Adult (km ²)		Juvenile (km ²)	
	Males	Females	Males	Females
2002-2003	2.3	3.5	*	*
2003-2004	2.8	2.5	1.2	*

*no data

CHAPTER 3
GUNNISON SAGE-GROUSE HABITAT USE DURING THE BREEDING
AND BROOD-REARING PERIODS RELATIVE TO ARTHROPOD
ABUNDANCE AND DIVERSITY IN
SAN JUAN COUNTY, UTAH

Abstract Gunnison sage-grouse (*Centrocercus minimus*) in southeastern Utah occur almost exclusively on private lands. Most of this land is presently used for agricultural production. Prior to the 1970's, the predominate agricultural products grown included winter wheat, dry land alfalfa, irrigated pastures and beans. Sage-grouse populations during this period were the highest on record. Currently, the population is at historic lows. Ironically, these lows have coincided with the advent of the Conservation Reserve Program (CRP). However, most of the land enrolled in CRP in the county at this time was located outside the area occupied by Gunnison sage-grouse. Little information currently exists regarding factors affecting Gunnison sage-grouse habitat use patterns during the breeding and brood-rearing period, specifically their use of CRP lands. This information will be important in developing guidelines for future management of CRP lands and conservation of this species. Twenty-nine Gunnison sage-grouse (11 females and 18 males) were monitored in 2003 and 2004 to determine habitat use patterns. Gunnison sage-grouse hens were monitored to determine nest site selection and nest success. Arthropods are an important food source for chicks during the first several months of life. Therefore, vegetation characteristics and arthropod abundance and diversity were collected in sagebrush cover types and compared with randomly selected CRP sites that may serve as critical brood-rearing habitat. From May through August in

2003 and 2004, 135 and 92 bird locations were obtained, respectively. For both years, 75% of bird habitat use locations were in CRP cover types. The CRP cover type exhibited greater forb and grass cover than other habitat types. Sixty percent of the total number of arthropods collected were obtained from CRP fields. In addition, more arthropod families were identified from CRP fields. In San Juan County, Utah, CRP fields appear to serve as substitute habitat for arthropod populations in lieu of irrigated pastures, wheat and bean fields. Continued enrollment and management of the current CRP lands as well as new enrollment into the federal program should be a priority for land managers and private landowners as this habitat now appears to provide critical seasonal use for sage-grouse except during winter.

Introduction

The Gunnison sage-grouse population in southeastern Utah occurs primarily on private lands. Most of this privately-owned land is presently in agricultural production. The major agriculture products produced in the area includes winter wheat, dry land alfalfa and beans. Gunnison sage-grouse population levels during the 1970's were at historic highs which coincided with peak agricultural production (SWOG 2000). In 1972, the highest number on record was 175 males counted on 6 leks with an estimated population between 583-1050 birds (SWOG 2002)

Land-use changes have occurred in the county over the last 10-15 years. The major changes include declines in non-irrigated lands, black sagebrush (*Artemisia nova*) and sagebrush habitat with 15% canopy cover (SWOG 2000). Declines in the population of Gunnison sage-grouse also coincided with these land-use changes. The population is

currently at historic lows. Ironically, these lows coincided with the advent of the federal Conservation Reserve Program (CRP). The CRP program allows landowners to enroll their land in a set-aside program in exchange for annual payments. If landowners agree to implement this voluntary program, they must establish permanent cover and maintain this cover for the life of the contract (Lupis 2005). Most of the land enrolled in the CRP program, however, occurred outside of the area occupied by Gunnison sage-grouse (SWOG 2000).

In 1997, the Gunnison sage-grouse range in San Juan County, Utah was designated a priority conservation area for the species (SWOG 2000). This designation increased the amount of land that could qualify for enrollment in CRP. Approximately 150 km² of additional land was enrolled in the CRP as a conservation initiative for Gunnison sage-grouse and planted with a wildlife seed mix. The Utah Division of Wildlife Resources (UDWR) provided the seed mixture as part of the CRP cost-share requirement (SWOG 2002) (Appendix A).

Two previous studies have been conducted on Gunnison sage-grouse in Utah. The first was Barber (1991) who evaluated male reproductive behavior and the most recent study which monitored summer habitat use was conducted during 2001 and 2002 (Lupis 2005). Lupis (2005) reported that the CRP/ grassland cover type was preferred by radio-collared birds for brood-rearing and summer habitat use. The CRP fields exhibited greater percent grass and forb cover than other cover types. One of the reasons suggested for high brood use of CRP lands was increased availability of arthropods that may serve as an important food source for sage-grouse (Lupis 2005).

Drut et al. (1994) and Johnson and Boyce (1990) reported that forbs and insects are required for successful brood-rearing for Greater sage-grouse. Wet meadows constitute important habitat for broods (Klebenow 1969). Drut et al. (1994) looked at diets and food selection by Greater sage-grouse chicks in 2 areas in southeastern Oregon that had very different productivity. Sage-grouse at Hart Mountain in Lake County, Oregon exhibited higher productivity and were more abundant than sage-grouse at Jackass Creek in Harney County. They found chicks from both of these areas selected similar foods, however, relative dry mass of the food sources differed and was directly related to availability. In the area with high sage-grouse productivity (Hart Mountain), forbs and invertebrates composed 80% of dietary mass and were more abundant, whereas, in the lower productive area (Jackass Creek), chicks consumed primarily sagebrush (65%).

Peterson (1970) reported similar findings, suggesting animal matter was the most important component during the first several weeks of life in sage-grouse chicks, although sample size was small. Grasshoppers (*Orthoptera*), ants (*Hymenoptera*), and beetles (*Coleoptera*) are the primary sources of insects for Greater sage-grouse chick diets (Patterson 1952, Peterson 1970).

In 2002, San Juan County experienced a severe drought. In response to the drought, most of the CRP lands in San Juan County, including the area occupied by Gunnison sage-grouse, were opened for grazing by livestock (Lupis 2005). Drought conditions are believed to impact sage-grouse populations through increased nest predation and early brood mortality caused by decreased herbaceous cover and forb

availability. Decreased forb and herbaceous cover can also affect insect populations (Braun 1998).

My study compared arthropod abundance and diversity between CRP and sagebrush (nesting) cover types. No information is currently available regarding use of CRP lands and other habitat types by Gunnison sage-grouse relative to arthropod abundance.

Study Area

The study area is located in extreme southeastern Utah in San Juan County, approximately 20 km northeast of Monticello, Utah. San Juan County consists of 20,256 km² of land (SWOG 2000). The study area is bordered by U.S. Highway 491 to the south and U.S. Highway 191 to the west (Figure 3.1). A total of 208 farms exist in San Juan County and agricultural croplands make up roughly 6% of the land area or 1,314 km² generating approximately 10% of personal income (SWOG 2000).

The study area is located within the conservation area (CA) and consists of approximately 39,000 km² (SWOG 2000). The CA is comprised of agricultural fields, rural residences and rangelands. The CA was identified by encompassing historic and current leks sites, assessment of potentially suitable sage-grouse habitat and sage-grouse observations (SWOG 2000). Within the CA, a Conservation Study Area (CSA) was identified based on previous research and consists of approximately 2417 km² (Lupis 2005). The CSA consists of fragmented, multiple habitat cover types and includes rangelands, sagebrush, CRP and agricultural lands of which over 93% is privately owned (SWOG 2000). Habitat in the western portion is dissimilar to the eastern portion of the

CSA. The western portion contains less black sagebrush cover type (Figure 3.2).

Elevations within the CSA range from 2040 meters to 2150 meters. The CSA is mostly flat terrain with some gentle rolling topography. Multiple county dirt roads traverse the

CSA. Two ravines running north and south dissect part of the CSA.

The average annual precipitation for Monticello, Utah is 38 cm with an annual total snowfall of approximately 150 cm (Lupis 2005). The average annual temperature is 15 °C (Utah Climate Center 2004). In 2003 and 2004, from April through August, the average monthly temperature was 16.2 °C and 15.1 °C, respectively. This compares to the 56-year average temperature of 14.9 °C for this same period of time. In 2003 and 2004, from April through August, the average monthly precipitation was 2.2 and 1.7 cm, respectively, as compared to the 56-year average of 3.0 cm.

Methods

Gunnison sage-grouse were captured at night during fall and spring 2003 and 2004 on or adjacent to lek sites and in CRP/grass fields with long-handled-nets or net guns using spotlighting techniques (Giesen et al. 1982, Wakkinen 1990, Wakkinen et al. 1992). Captured birds were fitted with an ATS necklace radio transmitter (ATS Incorporated, Isanti, MN) with a programmed mortality signal, 19 hours on and 5 hours off (Lupis 2005). The age of birds (juvenile or adult) was determined using primary feather patterns (Beck 1975). Bird capture locations were recorded with a handheld Global Positioning System (GPS) unit. Captured birds were released at their capture site after information and samples were obtained.

Radio-collared birds were monitored from April through August of 2003 and 2004. Some birds were only monitored for one season. Even though different birds were monitored, they used similar habitat. Radio-collared birds were located using receivers (Communications Specialists Inc., Orange, CA), Omni antennae and a 3-element hand-held Yagi antenna (Telonics Inc., Mesa, AZ) (Lupis 2005). Sage-grouse locations were recorded with a GPS unit in Universal Transverse Mercator (UTM) coordinates. The observations recorded included date, time, bird number, sex, number of birds (collared/uncollared), and habitat description.

Radio-collared hens were located every 2-5 days to determine nesting success and habitat use. During both spring and summer periods, male and female birds were monitored 2 times weekly to determine habitat use. Vegetation characteristics were measured at nest and randomly selected sites. Vegetation measurements were obtained using a perpendicular 10-m transect oriented along north-south and east-west coordinates. Percent cover of grasses, forbs, shrubs, bare ground, rocks and litter were measured every 2 m and classified into percentages: 0-5%, 5-25%, 25-50%, 50-75%, 75-95%, 95-100% (Daubenmire 1959, Bureau of Land Management 1996). An estimated visual obstruction (VOR) measurement was recorded at bird locations and random sites (Robel et al. 1970).

Dominant vegetation types in the study area were classified and mapped in 1998 using GIS technology (Table 3.1). Vegetation cover types for the CSA were determined using Landsat 30m resolution imagery. These data were ground-truthed using 50 randomly selected training sites. Eighteen vegetation and landscape cover classes were identified. The dominant vegetation cover types identified included, agricultural lands, sagebrush, CRP/grasslands and rangelands (Lupis 2005) (Figure 3.2).

Because of the sparseness of data, an exact chi-square goodness-of-fit and Goodman's simultaneous confidence intervals were constructed at 90% to determine if there were any preferences of habitat cover types for radio-collared birds (Neu et al. 1974, May and Johnson 1997). Summer habitat preference/avoidance was assessed by computing number of bird locations in a specific cover type compared to the percent cover type that was available (May and Johnson 1997) (Table 3.2). I chose 90% confidence intervals as a compromise in balancing Type I and Type II errors. Results were interpreted in the following manner, when the percent available cover type was below the 90% interval, the cover type was preferred. Conversely, the cover type was avoided if the percent available cover type was above the 90% interval. Because of small sample sizes and numbers of observations, the data did not fit any specific statistical analysis. Therefore, several assumptions were made, including animals had access to all cover types and radio-tracked animals were independent of each other (Alldredge and Ratti 1986, Aebischer et al. 1993). A *t*-test was used to determine if there were differences in mean sagebrush height at nest, bird location and random sites.

In addition, during springs 2003 and 2004, arthropods were collected at a total of 6 nest sites (3 each year) and in 6 nearby CRP/grassland cover types (3 each year), believed to be potential brood-rearing areas to determine if relative abundance and diversity differed by cover types. Arthropods were collected with pitfall traps and a motorized vacuum sampler (D-vac, E. J. Dietrick, Ventura, CA) (Pedigo and Buntin 1993). Two perpendicular 10-m transects oriented along north-south and east-west coordinates were established at each nest site once hens had completed nesting and at CRP/grassland locations. Arthropods were collected beginning on 28 May 2003 and 26

May 2004. Seven pitfall traps were buried at ground level in a random fashion throughout transects with at least one trap in each 90° quadrant (Morrill 1975). Pitfall traps were covered with plastic plates with a clearance of approximately 8 cm and were left in place for 6 days. After 6 days, the contents of the traps were emptied into separate plastic bags with a 70% isopropyl alcohol solution for identification at a later date.

In addition, sagebrush and grasses intersecting each 10-m transect were vacuumed with the D-vac on two different days in the mornings (0800-1200) and evenings (1500-1900) beginning on 28 May in 2003 and 26 May in 2004 to collect shrub-dwelling insects. The D-vac bag was then emptied into separate containers with a 70% isopropyl alcohol solution after each site was vacuumed for future quantification and identification (Pedigo and Buntin 1993). Later, insects were sorted into taxa and quantified to determine the relative abundance for each. Pitfall traps and the D-vac sampling process were repeated 1-2 weeks later at the same sites.

A negative binomial regression model (Proc GENMOD, SAS Institute) (Agresti 2002) was used to test for differences in relative abundance of arthropods between 2 habitat cover types including sagebrush (nest) and CRP/grassland (random). Statistical analysis was performed on the most abundant insect and non-insect orders. Results were pooled for individual birds at sagebrush (nest) and CRP/grassland (random) samples and expressed as the total for each insect and non-insect order. Results were considered significant at $P < 0.05$.

Results

Bird Status

During this study, 29 Gunnison sage-grouse were monitored. Twelve (6 adult males, 6 adult females), and 17 (7 adult males, 3 juvenile males, and 7 adult females) sage-grouse were monitored during spring and summer 2003 and 2004, respectively. From April through August 2003 and 2004, 135 and 92 bird locations were obtained, respectively. Several adult radio-collared birds were monitored for both summers; most birds were monitored for 1 season. Even though some different birds were monitored, habitat use was similar. Two females that were monitored for both seasons used similar habitat and exhibited nest fidelity.

Nesting

A total of 11 radio-collared hens were monitored during both nesting seasons in 2003 and 2004 (Table 3.3). Five hens initiated nesting in spring 2003 and 6 hens initiated nesting in spring 2004. In 2003, nest initiation began in mid-April. I was unable to locate nest sites for 2 hens; however, I suspect these hens abandoned their nests early May. They were located together towards the end of May and remained together through the first part of July.

Of the remaining 3 nests, 2 were depredated close to their hatch dates. Each nest contained fragments of approximately 6 eggs. The remaining nest hatched on 23 May and contained 6 eggs. The nest was located under a black sagebrush plant in black sagebrush cover type. The hen was located 25 May in a CRP field adjacent to her nest site. No chicks were observed with her at that time. One hen was believed to not have initiated nesting; she re-located to a CRP/grassland cover type during May and June

2003. No broods were observed throughout the summer of 2003 with radio-collared hens or non-radio-collared hens.

In summary, in 2003, 2 of 3 hens nested under Wyoming sagebrush (*A. wyomingensis*) plants in black sagebrush cover type and 1 hen nested under a black sagebrush bush in CRP with 15-40% canopy cover. Sagebrush height of nest sites ranged from 48.3-76.2 cm in 2003 (n=3) with a mean height of 61 cm. Nest site sagebrush height differed from random sagebrush height ($x=31.3$ cm) ($P=0.006$).

In 2004, nest initiation began early April. One female was accidentally flushed off her nest 14 April. Her nest contained 10 eggs. The hen returned to her nest site the next day, however, several days later her signal could not be picked up. Her nest was presumed abandoned; she did not return and was not located again. One hen captured in March did not nest. One hen died at the beginning of nesting season. Two hen's nests were depredated, one the first part of May and the other mid-May. Each of these nests contained approximately 6 eggs. Neither of these hens renested. One of these hens was subsequently located as a mortality 1 June.

Another hen's nest was never located, although she was suspected of nesting. She was observed mid-May after moving from her suspected nesting site, no chicks were observed. One hen hatched a successful nest the beginning of June 2004. Six eggs were discovered in her nest. Due to her radio failure several weeks after she left her nest site, I was not able to determine if she had a brood that survived. Only 1 non-radio-collared hen was observed with 1 chick in mid-July 2004 in a CRP field.

In summary, for 2004, 1 hen nested in black sagebrush cover type, 2 hens nested in CRP with 15-40% canopy cover, 1 hen nested in CRP with >70% canopy cover and

the remaining hen nested in big sagebrush with 15-25% canopy cover. One nest was located under a black sagebrush bush and one nest was located under rabbit brush; the remaining nests were located under Wyoming sagebrush. In 2004, sagebrush height of nest sites ranged from 43.2-63.5 cm (n=4) with a mean height of 54.6 cm. Height of sagebrush at nest sites did not differ from randomly selected locations (\bar{x} =43.2 cm) ($P=0.44$).

Because of small sample sizes for nest and random sites, results were pooled to determine any differences in percent canopy cover. Percent canopy cover for forbs and shrubs at nest sites did not differ when compared to random sites. However, percent canopy cover for grasses at nest sites was greater when compared with random sites ($P=0.04$) (Table 3.4).

Habitat and Vegetation Preferences

During both summers, all the radio-collared birds monitored preferred specific habitat cover types ($P<0.001$) (Table 3.2). In 2003, big sagebrush/CRP lands, CRP > 70% canopy cover and CRP 41-70% canopy cover were used in greater proportion than expected based on what was available. In 2003, percent cover of forbs was greater in CRP fields compared to other habitat types ($P=0.05$). There was no difference in grasses, shrubs or litter in CRP fields or other habitat types measured (Table 3.5).

In 2004, birds selected CRP 41-70% canopy cover greater than expected based on what was available (Table 3.2). In 2004, percent canopy cover for grasses in CRP fields was greater compared to other habitat types ($P=0.04$). Percent canopy cover for shrubs was greater in sagebrush cover types when compared to CRP ($P=0.002$). There was no difference for forbs or litter at bird use sites in CRP fields compared to other habitat

cover types (Table 3.5). There was no difference in height of vegetation in CRP fields and for other cover types for 2003 ($P=0.79$) or 2004 ($P=0.20$).

Arthropod Abundance and Diversity

In 2003 and 2004, a total of 9 insect and 5 non-insect orders were identified from D-vac and pitfall trap samples. In addition, a total of 75 families of insects were identified from the 9 insect orders from 2003 and 2004. More arthropods from insect and non-insect orders were collected in 2004 when compared with 2003 (Table 3.6 and Table 3.7). Approximately 60% of the total numbers of arthropods collected in each year were obtained from the CRP/grassland cover types as compared to sagebrush sites. CRP lands exhibited a greater abundance of arthropods (Table 3.6). Additionally, more insect orders and families were identified in CRP than sagebrush sites, suggesting more diversity. In 2003 and 2004, 52 and 54 families were identified from the CRP cover types from 9 insect orders, respectively. In contrast, 46 and 45 families were identified from sagebrush sites in 2003 and 2004, respectively (Table 3.8).

Numbers of insects from the order Coleoptera (beetles) did not differ between habitat types but did differ between years; they were more abundant in 2003 ($P=0.04$) (Table 3.9). Numbers of insect in the order Diptera (flies) were more abundant in CRP fields compared to sagebrush cover types ($P=0.0001$) and were more abundant in 2003 than 2004 ($P=0.0003$). Insect abundance in the order Heteroptera (true bugs) differed between habitat types; they were more abundant in CRP fields ($P=0.0002$). Numbers of insects from order Lepidoptera (butterflies and moths) differed between years ($P=0.01$); they were more abundant in 2003. Orthoptera (grasshoppers and crickets) abundance did not differ between habitat types but were more abundant in 2004 ($P=0.007$). Numbers of

insects from order Thysanoptera (thrips) differed between habitat types and years; they were more abundant in CRP ($P=0.000$) and in 2004 ($P=0.000$). Comparisons of some non-insect orders revealed differences: Araneida (spiders) and Sulpugida (sun scorpions) were more abundant in CRP ($P=0.0001$) and ($P=0.004$), respectively. Sulpugida were also more abundant in 2004 ($P=0.017$) (Table 3.9).

Discussion

Although the Gunnison sage-grouse sample size used to conduct this study was small, I believe the sample of radio-collared birds is representative of the population. Based on lek count data from 2004, the population is believed to be between 120-175 birds (SWOG 2004). My sample size of 12 and 17 birds for summers 2003 and 2004, respectively, represents approximately 10% of this population.

Two hens monitored in 2003 and 2004 exhibited nest fidelity (Berry and Eng 1985). In 2004, they nested in close proximity to their old nest sites from 2003. In 2004, 1 hen's nest site was located < 30 m from her nest site in 2003. She was the only hen who had a successful nest for both years. In 2004, another hen's nest site was located < 600 m from her nest site in 2003. In both years, her nests were depredated; both were located in black sagebrush cover type under Wyoming sagebrush but had little herbaceous cover. Nest fidelity has also been reported for Gunnison sage-grouse hens in the Gunnison Basin in Colorado (Young 1994).

The average height of nest bushes selected by Gunnison sage-grouse hens in this study were similar to the height of nest bushes reported by Young (1994) for hens in

Colorado. In contrast, Lupis (2005) reported an average nest bush height of only 21.5 cm for successful Gunnison sage-grouse hens in 2001 and 2002 in San Juan County.

Seventy-five percent of radio-collared bird locations during summers 2003 and 2004 were located in CRP/grassland cover type. These results are similar to those reported by Lupis (2005); CRP cover types were preferred by Gunnison sage-grouse males, brood and non-brood hens during summers 2001 and 2002. Hays et al. (1998) suggested because CRP lands provide permanent cover the nesting habitat is better quality for Greater sage-grouse in eastern Washington. Commons (1997) reported male Gunnison sage-grouse in Dove Creek, Colorado used agricultural fields, including alfalfa, wheat and beans during summers. Young (1994) reported Gunnison sage-grouse broods in Colorado used habitats consisting of hay meadows and wet meadows interspersed with sagebrush.

More arthropods were collected in 2004 compared with 2003. This may be related to greater precipitation during April through August 2004 (11.0 cm) when compared to 2003 (8.4 cm), contributing to more vegetation growth. CRP lands exhibited a greater abundance and diversity of arthropods which may be related to a more diverse vegetational structure, including more grasses and forbs compared to sagebrush or other cover types. Braun (1998) suggested that drought can indirectly impact insect populations through decreased forb and herbaceous cover. In 2003, 1 year post-grazing, the percent cover of forbs was higher in CRP fields compared to other cover types, although insect abundance was much lower when compared to 2004. In 2004, 2 years post-grazing, there was no difference in percent cover for forbs, however, grass cover was greater in CRP fields compared to sagebrush cover types. This may explain the

greater abundance of arthropods collected during this period. Insect orders Orthoptera (grasshoppers), Hymenoptera (ants) and Coleoptera beetles are the primary sources of insects for Greater sage-grouse chick diets (Peterson 1970); they contributed 67% to the total number of insects collected in 2003 and only 28% in 2004 in CRP. While in 2004, insect order Heteroptera (true bugs) contributed 65% of the total insects collected from CRP land (Table 3.8).

Blenden et al. (1986) reported in central Missouri arthropod abundance was related to herbaceous biomass. Additionally, Dennis et al. (1998) reported in Scotland, greater arthropod diversity was found in habitats that were structurally more complex. My results suggest that greater grass cover also increased arthropod abundance and diversity. Greater grass and forb cover in CRP fields appears to have influenced Gunnison sage-grouse habitat use patterns during the springs and summers of 2003 and 2004.

Management Implications

Given the preference of CRP lands for radio-collared Gunnison sage-grouse in San Juan County from this study and a previous study (Lupis 2005), CRP appears to provide critical seasonal habitat use throughout most of the year except during winter. Most of the CRP fields that were studied were originally agricultural landscapes consisting of winter wheat, alfalfa and beans (SWOG 2000).

In the 1970's and early 1980's when sage-grouse populations were at record highs, it is quite possible that the wheat, dry land alfalfa and bean fields provided critical brood-rearing areas for Gunnison sage-grouse. Although Gunnison sage-grouse hens

nest in and under sagebrush habitats, once their eggs hatch they would most likely move their broods to the wheat, dry land alfalfa, bean fields and irrigated pastures which would provide abundant forbs and insects critical for chick survival. Irrigated pastures would create wet meadows which would provide excellent brood-rearing habitat. However, once irrigated pastures and fields were replaced with CRP fields, this may have impacted the arthropods available to Gunnison sage-grouse chicks during the initial establishment period. This could also have contributed to the dramatic populations declines that were observed.

In northern Switzerland, Di Giulio et al. (2001) reported for agricultural lands that were cut less frequently and not fertilized, the diversity of arthropods was greater compared to lands that were more intensively managed. Blenden et al. (1986) reported in central Missouri that arthropod abundance was related to herbaceous biomass. In Colorado, Huwer (2004) reported an increased growth rate for human-imprinted Greater sage-grouse chicks when forb abundance increased. Hence, in San Juan County, CRP fields appear to serve as substitute habitats for arthropod populations in lieu of irrigated pastures, wheat and bean fields.

Continued enrollment and management of the current CRP lands as well as new enrollment into the federal program should be a priority for land managers and private landowners as this habitat now appears to provide most year-round use for sage-grouse. In addition, emphasis should also be directed at planting Wyoming sagebrush seedlings in CRP cover types to provide additional seasonal use as well as providing larger, contiguous areas.

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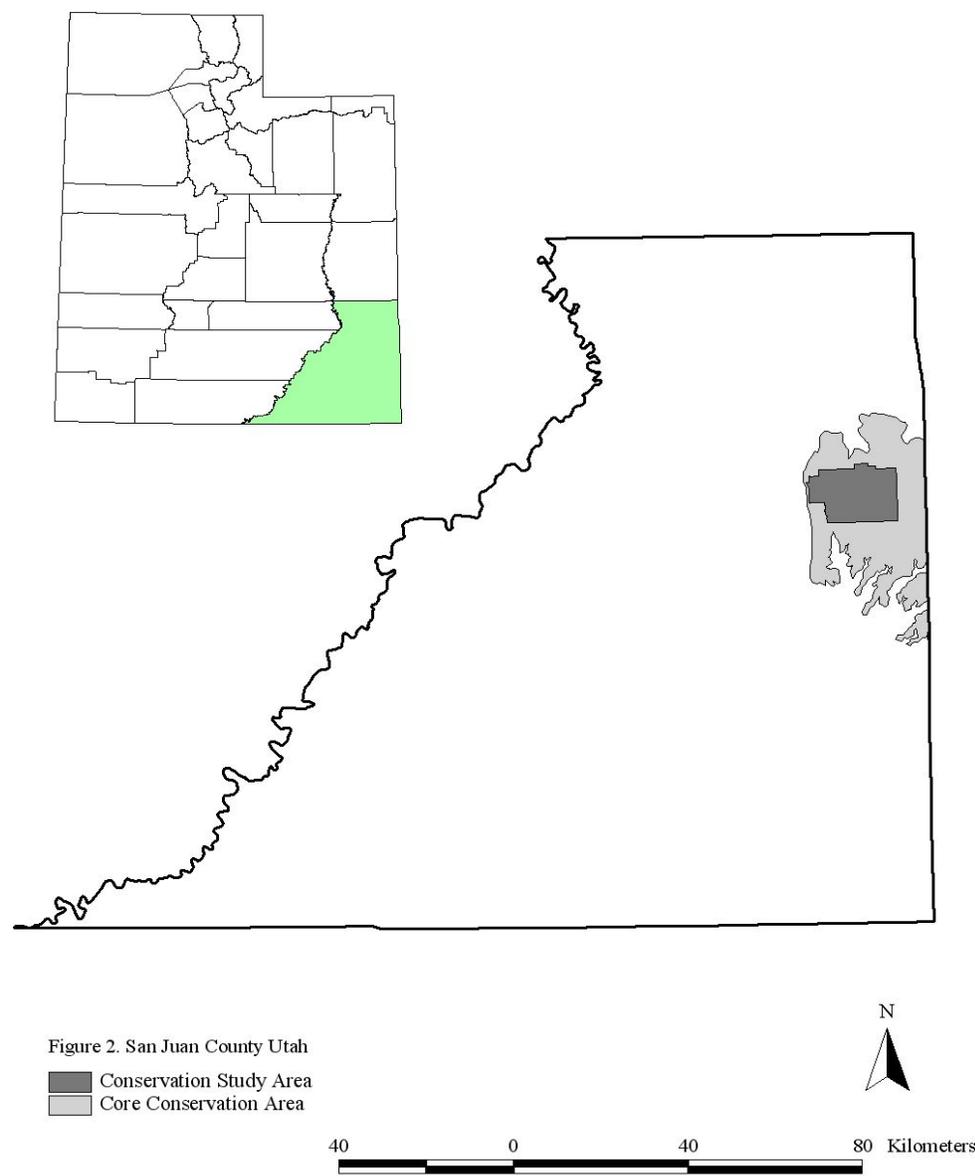


Figure 3.1 Gunnison sage-grouse Conservation Area, San Juan County, Utah, 2004.

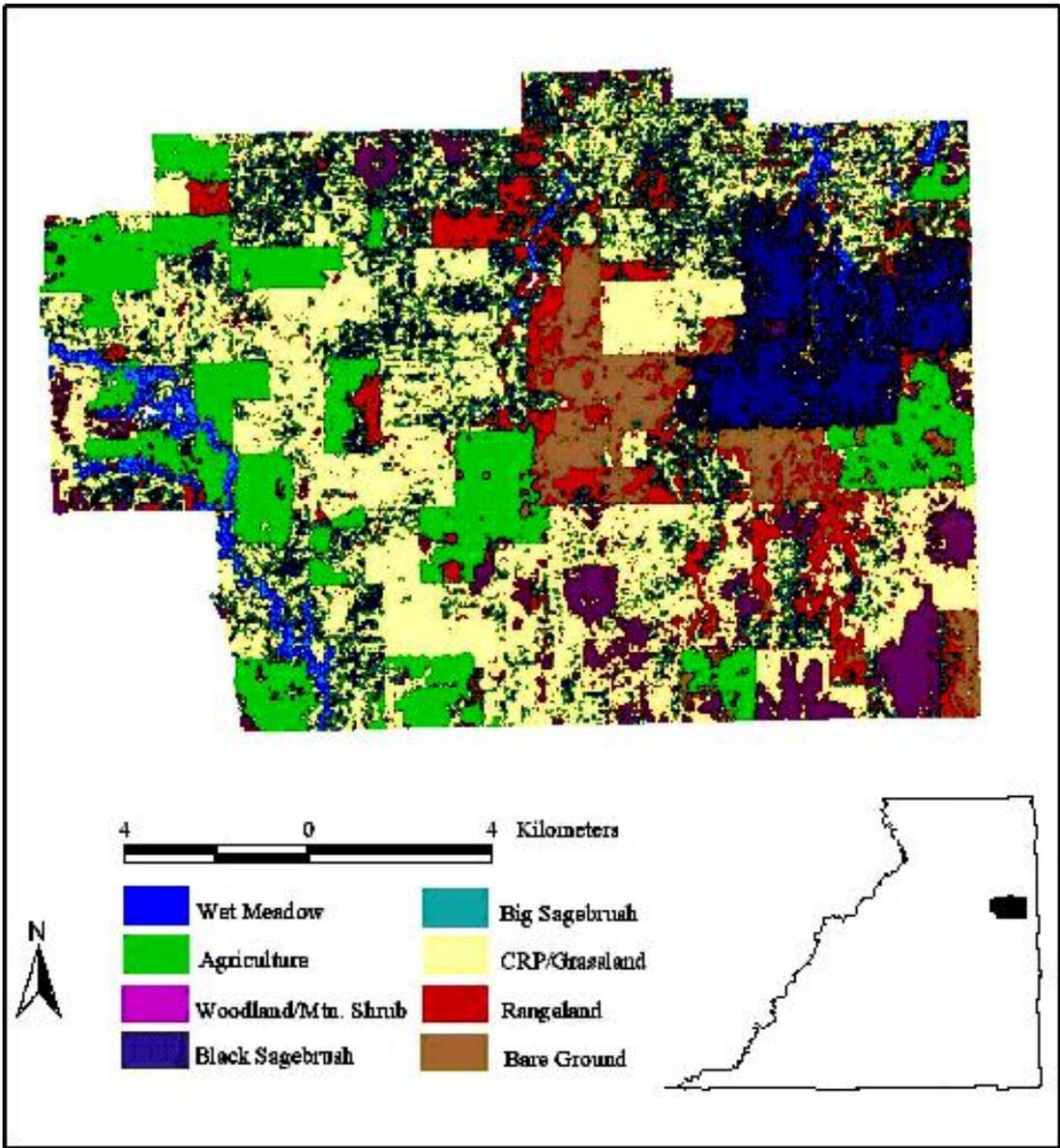


Fig.3.2. Dominant vegetation cover types in the Conservation Study Area, San Juan County, Utah (Lupis 2005).

Table 3.1 Dominant vegetation cover types and percent total available in the Conservation Study Area, San Juan County, Utah, 2004.

Vegetation cover types	Hectares	% total available
Agriculture	3115	12.9
Black Sagebrush	1734	7.2
Big Sagebrush >25% canopy	1739	7.2
Big Sagebrush 15-25% canopy	998	4.1
Big Sagebrush <15% canopy	1460	6.0
CRP >70% canopy	3150	13.0
CRP 41-70% canopy	3444	14.3
CRP 15-40% canopy	1855	7.7
Rangelands	1936	8.0

Table 3.2. Gunnison sage-grouse use by cover type and proportion available for summers 2003-2004 using Goodman's 90% confidence intervals, San Juan County, Utah.

Cover type	Proportion available	2003		2004			
		Lower Observations	Upper Observations	Lower Observations	Upper Observations		
Wet meadow	.020	0	0.000	0.052	0	0.000	0.075
Irrigated agriculture	.002	0	0.000	0.052	0	0.000	0.075
Non-irrigated agriculture	.127	1 ^o	0.000	0.066	7	0.029	0.187
Pinyon/Juniper	.038	0	0.000	0.052	0	0.000	0.075
Black sagebrush	.072	4	0.008	0.100	5	0.017	0.158
Pinyon/Juniper/Mountain shrub	.024	0	0.000	0.052	0	0.000	0.075
Big Sagebrush >25% canopy	.072	12	0.042	0.179	1	0.001	0.094
Big sagebrush 15-25% canopy	.041	11	0.037	0.170	1	0.001	0.094
Big sagebrush <15% canopy	.061	4	0.008	0.100	5	0.017	0.158
Mountain shrub	.003	0	0.000	0.052	0	0.000	0.075
Big sagebrush/CRP	.047	14*	0.051	0.197	1	0.001	0.094
CRP >70% canopy	.131	31*	0.146	0.341	19	0.115	0.342
CRP 41-70% canopy	.143	40*	0.202	0.412	45*	0.353	0.627
CRP 15-40% canopy	.077	15	0.057	0.206	4	0.012	0.143
Rangelands	.080	3	0.005	0.089	2	0.004	0.111
Bare ground	.062	0 ^o	0.000	0.052	2	0.004	0.111

*preferred
^oavoided

Table 3.3. Nesting data for Gunnison sage-grouse hens and vegetation cover types, San Juan County, Utah, 2003-2004.

Date	Hen	# eggs	# hatched	Depredated/Other	Cover type
5/23/2003	FG12	6	6	no	CRP 15-40%
6/2/2003	FG13	8	0	yes	black sagebrush
5/2003	FG14	*	*	*	*
5/2003	FG17	*	*	*	*
5/26/2003	FG24	6	0	yes	black sagebrush
6/10/2004	FG12	6	6	no	big sage 15-25%
5/26/2004	FG14	10	0	abandoned	CRP >70%
6/2004	FG17			mortality	
6/2004	FG18	*	*	*	*
5/26/2004	FG24	6	0	yes	black sagebrush
6/2004	FG27	5-6	0	yes	CRP 15-40%
5/2004	FG28			did not nest	

*unknown

Table 3.4. Mean percent vegetation cover (standard deviation) at nest and random sites, San Juan County, Utah, 2003-2004.

	Nest	Random	P-value
Grass	2.7 (2.0)*	0.7 (0.8)	0.04
Forbs	1.4 (2.9)	0.4 (0.7)	0.43
Shrubs	42.9 (13.4)	36.3 (18.1)	0.47

*differed by multi-response randomized blocked procedure (MRBP).

Table 3.5. Mean percent vegetation cover (standard deviation) at sagebrush and CRP use sites, San Juan County, Utah, 2003-2004.

Site	Year	Mean percent cover			
		grasses	forbs	shrubs	litter
Sagebrush	2003	4.7(5.9)	0.9(1.6)	13.8(8.3)	18.2(9.5)
CRP	2003	1.6(2.6)	4.0(4.6)*	8.8(8.3)	16.5(12.3)
Sagebrush	2004	1.1(1.3)	0.1(0.1)	37.6(15.0)*	4.5(2.3)
CRP	2004	11.7(9.1)*	11.3(13.2)	5.7(10.2)	3.5(1.9)

* Percent canopy cover differed between sagebrush and CRP ($P < 0.05$) by MRPP

Table 3.6. Total number of arthropods collected (percent) from D-vacs and pitfall traps from nest and CRP sites in 2003 and 2004, San Juan County, Utah.

Cover type	Number of insects (%)	
	2003	2004
Sagebrush	991 (39)	1538 (40)
CRP	1579 (61)	2260 (60)
Total	2570(100)	3798(100)

Table 3.7. Abundance of arthropods from non-insect orders collected from sagebrush and CRP lands with pitfall traps and a D-vac, San Juan County, Utah, 2003-2004.

Taxa	2003		2004	
	Sagebrush	CRP	Sagebrush	CRP
Acarina	25	21	39	22
Araneida	52	112	63	102
Chilopoda	2	13	0	0
Scorpionid	1	0	0	0
Sulpugidia	5	17	8	47
Total:	85	163	110	171

Table 3.8. Abundance of insects from taxa collected from sagebrush and CRP lands with pitfall traps and a D-vac (number of families identified within the specific taxa), San Juan County, Utah, 2003-2004.

Taxa	Number	2003		2004	
		Sagebrush	CRP	Sagebrush	CRP
Coleoptera		354	616	214	310
Families	9	9		7	10
Diptera		71	229	62	88
Families	13	17		12	13
Heteroptera		204	264	254	1291
Families	8	11		9	14
Hymenoptera		202	427	83	208
Families	10	8		11	10
Orthoptera		45	42	30	28
Families	2	2		2	3
Lepidoptera		20	43	12	4
Families	2	3		1	1
Neuroptera		2	0	18	7
Families	2	0		2	2
Thysanoptera		0	3	2	47
Families	0	1		1	1
Raphidioptera		0	1	0	0
Families	0	1		0	0
Total	46	52		45	54

Table 3.9. Most abundant insect and non-insect taxa from sagebrush and CRP lands, San Juan County, Utah, 2003-2004.

Taxa	Year	Cover type	P-value
Coleoptera	2003-2004	sagebrush – CRP	0.146
	2003-2004*	sagebrush – CRP	0.042
Diptera	2003-2004	sagebrush – CRP*	0.000
	2003-2004*	sagebrush – CRP	0.003
Heteroptera	2003-2004	sagebrush – CRP*	0.000
	2003-2004	sagebrush – CRP	0.655
Hymenoptera	2003-2004	sagebrush – CRP	0.717
	2003-2004	sagebrush – CRP	0.651
Lepidoptera	2003-2004	sagebrush – CRP	0.911
	2003-2004*	sagebrush – CRP	0.011
Orthoptera	2003-2004	sagebrush – CRP	0.121
	2003-2004*	sagebrush – CRP	0.007
Thysanoptera	2003-2004	sagebrush – CRP*	0.000
	2003-2004*	sagebrush – CRP	0.000
Acarina	2003-2004	sagebrush – CRP	0.172
	2003-2004	sagebrush – CRP	0.201
Araneida	2003-2004	sagebrush – CRP*	0.000
	2003-2004	sagebrush – CRP	0.738
Sulpugida	2003-2004	sagebrush – CRP*	0.004
	2003-2004*	sagebrush – CRP	0.017

* Differed by year or cover type using negative binomial regression model

CHAPTER 4

CONCLUSIONS

In Utah, the only known population of Gunnison sage-grouse is found in the extreme southeastern portion, in San Juan County. This remnant population may be at risk for extinction because of its isolation from other known populations, the nearest is Dove Creek, Colorado, approximately 20 miles east (Oyler-McCance 1999). The Dove Creek Gunnison sage-grouse population has the lowest genetic diversity among all the populations studied (Oyler-McCance 1999). The San Juan County population also has low genetic diversity from studies conducted in Colorado (G. Wallace, Utah Division of Wildlife Resources, personal communication). Since the initial research began on the Gunnison sage-grouse population in San Juan County, no radio-collared birds have been observed moving out of Utah to Dove Creek, Colorado or other populations.

The San Juan County Gunnison Sage-Grouse Working Group (SWOG) was established in 1996 due to growing concerns regarding the declining sage-grouse population. Because the population depends heavily on private lands for their life-cycle requirements, SWOG recognized the importance of collaborating with and involving the local community (SWOG 2000). Prior to 1996, little or no research had been conducted on this population other than annual lek counts.

Previous research on Gunnison sage-grouse has focused on reproductive ecology (Young 1994, Lupis 2005), genetic studies, landscape habitat requirements (Oyler-McCance 1999), summer habitat use and movement patterns (Commons 1997, Lupis 2005). Lupis' information was lacking on winter ecology and habitat use for Gunnison sage-grouse. Gunnison sage-grouse use of CRP relative to arthropod abundance in

sagebrush cover types and potential brood rearing habitat was unknown. This study was initiated in fall 2002 to provide this information.

The Gunnison sage-grouse population I studied occurs primarily on private lands. Most of this privately owned land is in agricultural production. The major agriculture products produced in the area include livestock, winter wheat and dry-land alfalfa. Gunnison sage-grouse population levels during the 1970's were at historic highs which coincided with peak agricultural production (SWOG 2000).

Land-use changes have occurred in the county over the last 10-15 years. The major changes include declines in agricultural land, black sagebrush and sagebrush habitat with 15% canopy cover (SWOG 2000). Declines in the population of Gunnison sage-grouse also coincided with these land-use changes. In 1997, the Gunnison sage-grouse range in San Juan County, Utah was designated a priority conservation area (SWOG 2000). This designation increased the amount of land that could qualify for the CRP. Consequently, approximately 150 km² of additional land was enrolled in the CRP under the conservation initiative and planted with a wildlife seed mix (Lupis 2005).

I used radio-telemetry to monitor 11 female Gunnison sage-grouse in 2003 and 2004 to determine nesting success. Two hens monitored in 2003 and 2004 exhibited nest fidelity (Berry and Eng 1985, Young 1994). In 2004, they nested in close proximity to their old nest sites from 2003; nests were located <30 and <600 m from their nest sites in 2003, respectively. Chi (2004) recommended that to maintain greater sage-grouse hen nest fidelity, a variety of suitable shrub canopies and herbaceous understory would need to be available. Nest site vegetation structure was similar to other Gunnison sage-grouse nest sites reported previously (Lupis 2005). Nest sites exhibited greater percent

herbaceous canopy cover when compared to random sites (Young 1994). In contrast, Lupis (2005) reported while nests sites in San Juan County, Utah exhibited less grass and forb cover and were shorter in stature, they were still successful.

Gunnison sage-grouse winter habitat use was determined using telemetry locations from radio-collared sage-grouse during 2002-2003 and 2003-2004. This population is considered non-migratory due to the limited movements from summer to winter range during this period. The furthest distance a radio-collared bird moved from summer to winter range was 8.2 km. Commons (1997) also reported minimal movements year-round for male Gunnison sage-grouse in southwest Colorado, the furthest distance traveled by sage-grouse was 14 km. Connelly et al. (2000) defined a non-migratory population as one that does not make long seasonal movements between ranges.

During both winters, radio-collared birds preferred black sagebrush, big sagebrush with 15-25% canopy and big sagebrush mixed with CRP cover types. Between 1984 and 1998 in the San Juan County Gunnison sage-grouse Conservation Area, 32% of the black sagebrush cover type was lost (SWOG 2000). Given the high use of black sagebrush cover types and since most of this cover type is located in the eastern portion of the study area, my results support efforts to protect and enhance black sagebrush habitats mixed with big sagebrush to create more contiguous and varied sagebrush canopy cover for winter habitat.

Conservation Reserve Program grassland cover types constituted approximately 39% of the study area. Over 60% of arthropods I collected were obtained from CRP fields. In addition, more arthropods were collected in 2004 compared with 2003. Greater

arthropod diversity was found in CRP fields as compared to other sagebrush cover types. The greater abundance of arthropods from taxa Coleoptera (beetles), Heteroptera (true bugs), Hymenoptera (ants) and Orthoptera (grasshoppers) in 2004 in CRP lands may be related to a more diverse vegetation structure, including greater grasses and forb cover compared to sagebrush or other cover types. These taxa, with the exception of Heteroptera are the primary sources of insects for Greater sage-grouse chick diets (Patterson 1952, Peterson 1970).

The CRP fields studied in the summer of 2004 had been grazed 2 years previously. The area also received more precipitation during April through August (11.0 cm) when compared to this same period in 2003 (8.4 cm). Braun (1998) suggested that drought can indirectly impact insect populations through decreased forb and herbaceous cover. I believe this combination of factors resulted in increased forb cover and arthropod abundance.

Seventy-five percent of radio-collared bird locations during summers 2003 and 2004 were located in CRP/grassland cover type. This preference was also reported by Lupis (2005). Hays et al. (1998) suggested because CRP lands provide permanent cover, nesting habitat is of higher quality for Greater sage-grouse in eastern Washington. Commons (1997) reported male Gunnison sage-grouse in Dove Creek, Colorado used agricultural fields, including alfalfa, wheat and bean fields during summers. Young (1994) reported Gunnison sage-grouse broods in Colorado used habitats consisting of hay meadows and wet meadows interspersed with sagebrush. In San Juan County, CRP appears to provide this critical seasonal habitat.

In the 1970's and early 1980's when Gunnison sage-grouse populations were at record highs, winter wheat, dry land alfalfa and bean fields may have provided critical brood-rearing areas for Gunnison sage-grouse. Although the Gunnison sage-grouse hens I monitored nested in sagebrush habitats, once they left their nest sites, they moved to CRP fields that were once winter wheat, dry land alfalfa and bean fields.

When these agriculture fields were replaced with CRP, the number of arthropods and amount of forb cover available to Gunnison sage-grouse chicks during the initial establishment period may have been impacted. This could have contributed to the dramatic population declines recorded in the 1970's and 1980's. The CRP fields I studied now provide greater forb cover and arthropod abundance than other cover types available. As these CRP fields continue to mature, grasses may out compete forbs, further impacting habitat suitability.

In Colorado, Huwer (2004) reported an increased growth rate for human-imprinted Greater sage-grouse chicks when forb abundance increased. Blendon et al. (1986) reported in central Missouri arthropod abundance was related to herbaceous biomass. In northern Switzerland, Di Giulion et al. (2001) reported for agricultural lands that were cut less frequently and not fertilized, arthropod diversity was greater than in lands that were more intensively managed.

Because much of the agricultural land has been replaced with CRP in San Juan County, CRP fields appear to be substitute refuges for arthropod populations and should be managed to increase vegetation diversity. Continued enrollment of the current CRP lands, as well as new enrollment into the federal program, should be a priority for land managers and private landowners. Additionally, emphasis should also be directed at

planting Wyoming sagebrush seedlings in CRP cover types to provide seasonal use as well as more diverse herbaceous cover. Lastly, CRP fields should be managed to reduce grass competition with forbs through periodic disturbances. Based on the forb and arthropod response I observed in CRP fields that were grazed, I would recommend periodic, controlled livestock grazing by cattle be considered over mowing or burning. Mowing and burning of CRP may impact efforts to establish sagebrush in the CRP fields in San Juan County, Utah.

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APPENDICES

Appendix A

Vegetation mixture seeded on Conservation Reserve Program lands in the Gunnison sage-grouse Conservation Area, San Juan County, Utah (SWOG 2000).

Vegetation mixture seeded on Conservation Reserve Program lands in the Gunnison sage-grouse Conservation Area, San Juan County, Utah (SWOG 2000).

Species	PLS lbs/acre
Grasses	
Bluebunch wheatgrass	1.0
Thickspike wheatgrass	1.0
Western wheatgrass	1.5
Crested wheatgrass	0.5
Pubescent wheatgrass	1.0
Legumes/Forbs	
Alfalfa (Rambler)	1.0
Alfalfa (Ladak, Normad)	1.5
Western yarrow	0.12
Lewis flax	0.25
Sainfoin	0.5
Small burnet	2.0
Shrubs	
Wyoming big sagebrush	0.5
Forage kochia	0.5
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Total	11.37

Appendix B.

List of arthropods identified from pitfall trap and D-vac samples in San Juan County, Utah, (2003-2004).

List of arthropods identified from pitfall trap and D-vac samples in San Juan County, Utah, (2003-2004).

Non-insect orders

Acarina
 Araneida
 Chilopoda
 Phalangida
 Scorpionida
 Sulpugida

Insect orders

Coleoptera

Family:	Carabidae
Genus:	Pachimachus
Family:	Silphidae
Genus:	Necrophorus
Family:	Scarabaeidae
Family:	Tenebrionidae
Genus:	Eleodes
Family:	Histeridae
Family:	Melyridae
Family:	Anobiidae
Family:	Chrysomelidae
Family:	Coccinellidae
Family:	Elateridae
Family:	Curculionidae
Family:	Nitidulidae
Family:	Mordellidae

Diptera

Family:	Tachinidae
Family:	Calliphoridae
Family:	Anthomyiidae
Family:	Sarcophagidae
Family:	Muscidae
Family:	Bombyllidae
Family:	Syrphidae
Family:	Therevidae
Family:	Dolichopodidae
Family:	Empididae
Family:	Phoridae
Family:	Chloropidae
Family:	Heleomyzidae
Family:	Pipunculidae
Family:	Sciaridae

Family:	Rhagionidae
Family:	Tipulidae
Family:	Chironomidae
Family:	Ceraptogonidae
Family:	Cecidomyiidae
Family:	Tephritidae
Family:	Sessidae
Family:	Scatopsidae
Family:	Stratiomyiidae

Heteroptera

Suborder:	Hemiptera
Family:	Lygaeidae
Family:	Rhopalidae
Family:	Tingidae
Family:	Miridae
Family:	Pentatomidae
Family:	Nabidae
Family:	Berytidae
Family:	Anthocoridae
Family:	Reduviidae
Family:	Cydnidae
Family:	Largidae

Suborder:	Homoptera
Family:	Cicadellidae
Family:	Cercopidae
Family:	Psyllidae
Family:	Dictyopharidae
Family:	Aphidae
Family:	Margarodidae

Hymenoptera

Family:	Formicidae
Family:	Mutillidae
Family:	Pompilidae
Family:	Halictidae
Family:	Megachilidae
Family:	Ichneumonidae
Family:	Brachonidae
Family:	Sphecidae
Family:	Vespidae
Family:	Chrysididae
Family:	Bethylidae
Family:	Tiphidae

Lepidoptera

Family:	Noctuidae
Family:	Arctiidae

Neuroptera

Family:	Chrysopidae
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Orthoptera Family: Hemerobiidae
 Family: Acrididae
 Genus: Xanthippus
 Genus: Trimerotropis
 Genus: Psoloessa
 Genus: Arphia
 Family: Gryllidae
 Family: Gryllacrididae
 Subfamily: Rhabdophorinae
 Subfamily: Stenopelmatinae

Raphidioptera Family: Raphidiida

Thysanoptera Family: Phlaeothripidae
