REPRODUCTIVE ECOLOGY

OF SAGE GROUSE

IN CANADA

1999 Final Project Report For:

1998 and 1999 Sage Grouse Funding Partners

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December 1999

ABSTRACT

Sage Grouse (*Centrocercus urophasianus*) are the largest of all North American grouse and depend on sagebrush (*Artemisia spp*.) for diet and protective cover. This association with sagebrush limits the range of the Sage Grouse to the range of sagebrush. In Canada, Sage Grouse are at the northern edge of the species' range, occurring only in extreme southeastern Alberta and southwestern Saskatchewan. Lek counts indicate that Canadian Sage Grouse have experienced a 90% decrease from their numbers of the mid 1980s. In this study, I investigated the reproductive ecology of Sage Grouse (*Centrocercus urophasianus*) in southeastern Alberta. Radio telemetry was used to monitor reproductive events and nesting habitat selection, as well as survival and summer habitat use by both male and female Sage Grouse. Nest data was gathered for 20 different females and 28 nests. Clutch size averaged 7.8 eggs per nest. Nest success was 46.1% for 26 nests, and 100% of all females attempted to nest. Breeding success (percent of hens that hatched ∃1egg during a single breeding season) averaged 54.5% for 22 females, however the number of chicks that survived to fledge (50 days) was between 13.6% and 22.7% for 88 chicks. Estimated survival rate for females was about 56.5%, while male survival was estimated at about 30%. A basic population model developed from these data suggest that the Alberta Sage Grouse population may fall to below 300 individuals in 2004, which may not be enough individuals to maintain the viability of the population. Considerations for future research and guidelines for the management of Sage Grouse in Canada are presented that should aid in preventing the extirpation of this species from the Canadian prairies.

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INTRODUCTION

Sage Grouse (*Centrocercus urophasianus*) are strongly associated with sagebrush (*Artemisia spp.*) habitats within the prairie ecozone. Historically, Sage Grouse occurred in British Columbia, Alberta, Saskatchewan and 16 U.S. states, but today they have been extirpated from British Columbia and five states (Braun 1998, Schroeder *et al.* 1999; see Fig. 1). The long-term decline seen in Sage Grouse populations across their range was originally due to the direct loss of sagebrush steppe associated with grassland habitats. This habitat has been reduced by more than 50 percent (2.5 million ha) since the early 1900s (Patterson 1952, Eng and Schladweiler 1972, Braun 1995; Fig. 1). The eastern subspecies (*C. u. urophasianus*) is found at the northern edge of its range in extreme southeastern Alberta and southwestern Saskatchewan (Fig. 2). Historically, Sage Grouse occupied approximately 100,000 km^2 within the two provinces, but today occupy a maximum of 6,000 km^2 (Fig. 2). The range contraction within Canada is also related to habitat loss.

Both Alberta and Saskatchewan still support reproductively active Sage Grouse populations, yet springtime lek counts indicate that Canadian population has experienced a 90% decrease since the mid 1980s, and was reduced to between 549 to 813 individuals in 1997 (Aldridge 1998). Consequently, Alberta closed the Sage Grouse hunting season in 1996 for the first time since 1967 (Aldridge 1998). Further, in 1997, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) listed Sage Grouse as a 'Threatened' species, and in 1998 this listing was upgraded to 'Endangered,' reflecting the imminent threat of extinction of the Canadian Sage Grouse population.

Figure 1. Current and known historic distribution of Sage Grouse. 'E' represents the eastern subspecies (*Centrocercus urophasianius urophasianus*) and 'W' represents the western subspecies (*C. u. phaios*). The current distribution is not continuous and is more fragmented than indicated. (Adapted from Johnsgard 1983).

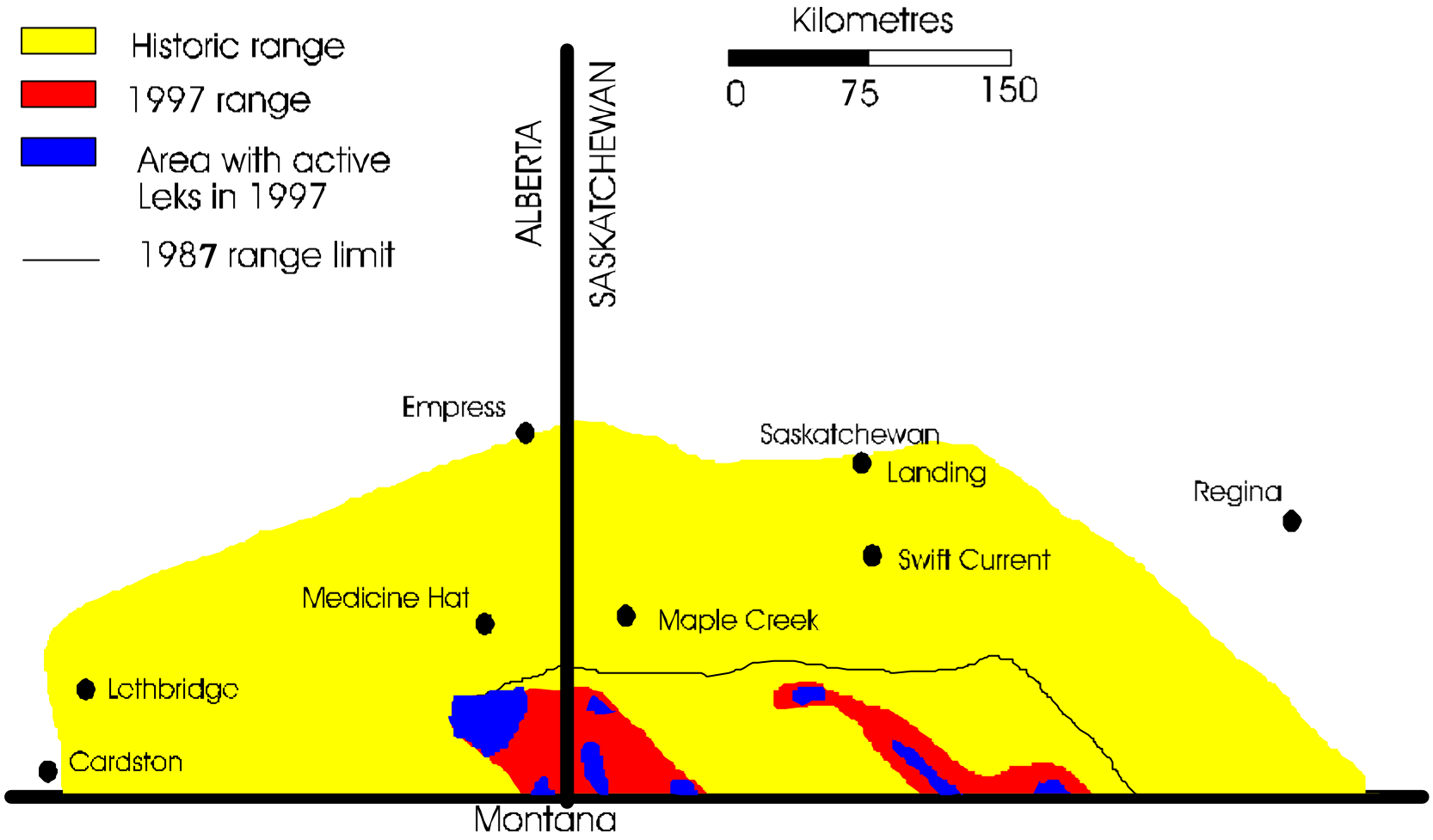

Figure 2. Range of Sage Grouse in Canada. Historical range is based on anecdotal sightings of birds prior to the 1960s. The present (1997) range is based on the locations of known active leks in 1997. The 1987 range limits are shown to illustrate the range contraction.

Many factors may be contributing to the Canadian Sage Grouse population decline, including 1) reduced reproductive success, and 2) reduced survival of post-fledged young and/or adults. Habitat degradation or fragmentation, disturbance, predation pressure, reduced nest success, and climatic change all influence reproduction and survival. Several studies have found that adult hens have greater reproductive success than yearlings (Wallestad and Pyrah 1974, Connelly *et al.* 1993) and yearlings are less likely to nest than adults (Connelly *et al.* 1993, Schroeder 1999). However, Schroeder (1997) found no age-related differences in nesting attempts or nest success, or reproductive success. In his north-central Washington study, Schroeder (1997) found that clutch size was considerably higher than had been previously reported for other areas, and hens were also more likely to renest if their first nest was destroyed. Despite their high reproductive efforts, the Washington Sage Grouse population continues to decline, and the trend may reflect the fact that the habitat of highly fragmented (Schroeder 1997).

OBJECTIVES

The overall objective of my study was to collect data on the population dynamics and ecology of Sage Grouse in Canada; specifically Alberta. The goal of this research was to determine, from a proximate perspective, why the Canadian Sage Grouse population is declining so that the problem can be addressed. The primary focus of this research was to be on hens, assessing their reproductive success, and the survival of hens and their broods, in an attempt to understand the reasons for the decline in population numbers. Habitat use by Sage Grouse at various life history stages throughout the various seasons was also documented in an attempt to determine the importance of specific habitat regimes. Specifically, the objectives were to:

1) determine reproductive success of females as adults and young of the year. i.e. clutch size, nest success, breeding success, fledging success, chick survival etc.

2) determine rates of survival for post fledged young and adults.
3) monitor movements of hens and cocks to assess habitat selection and thus determine the importance of certain habitats throughout different life history stages and different seasons; specifically nesting habitat and brood rearing habitats, summer foraging sites, and winter habitat.
4) compare the life history strategies of Canadian Sage Grouse with southern conspecifics i.e. Colorado, Idaho, Washington, and Wyoming.

OBJECTIVES ACHIEVED

Due to limited number of Sage Grouse in Saskatchewan, and the size of the range of Sage Grouse within Canada, my study area was limited to Alberta, where Sage Grouse are more concentrated. Annual lek counts were performed in Alberta. All historically active leks were monitored at least twice for signs of activity during the breeding period, with all active leks being monitored weekly. Birds were captured and radio transmitters were successfully fitted to both hens and cocks. Provincial authorities had concerns about the potential disturbance that actively trapping at and around leks would have, and thus trapping began cautiously in 1998. This combined with an early spring meant earlier than normal breeding activities, and thus fewer hens were captured in 1998 than anticipated. Trapping in 1999 was very successful. With respect to my four previously listed objectives, the following was accomplished:

1) data were gathered on clutch size, nest success, and breeding success; fledging success; chick survival
2) survival rates were determined for male and females, as well as chicks (fledging success
3) habitat selection at nest sites, and summer roosting sites for both hens and cocks was identified *
4) movements of birds were recorded *

* Data on movements and habitat use have not yet been analyzed.

STUDY AREA

The study area is about 3,000 km^2 in size and is located in the southeastern corner of Alberta, south of the Cypress Hills and east to the Saskatchewan border (Fig. 2). This area

represents the core range of Sage Grouse in Canada and is composed of semi-arid mixed-grass prairie, with an abundance of silver sage (Aldridge 1997). The prairie in this region is essentially flat, often interrupted by vast coulees that lead to numerous small creeks and river tributaries.

METHODS

Lek counts were conducted from March to May at all previously known Sage Grouse leks to obtain population estimates. Both hens and cocks were trapped by spotlighting with a long handled hoop net (Giesen, *et al.*1982) or in walk-in traps (Schroeder and Braun 1991). Necklace style radio transmitters (Holohil Systems Inc., Carp, Ontario) were affixed to both hens and cocks.

Once released, Sage Grouse were tracked using a 5-element Yagi antenna and Telonics scanning receiver (Telonics Inc. Mesa Arizona). Birds were located using triangulation techniques until visually observed. Attendance of cocks at leks was monitored, and once they began leaving the leks in late May/early June, they were relocated weekly and habitat measurements were performed (see below). Hens were located and observed every other day during the nesting period (Musil *et al*. 1994, Schroeder 1997) in order to estimate the date of nest initiation and incubation, and allow for nest fate to be determined. When approaching a nest, observers remained at least 30 m from the nest site (see Schroeder 1997). Nest locations were recorded in Universal transverse Mercator coordinates (UTMs). Nest fate was determined and various measures of reproductive success were estimated based on Schroeder (1997). Nest success was estimated as the percent of all nests that hatched ∃1 egg. Breeding success was estimated as percent of hens that hatched ∃ 1 egg during a single breeding season (first or renest). Fledging success was estimated as the percent of hens that produced a brood ∃ 50 days. Lastly,

chick survival was estimated as the percent of hatched chicks that lived ∃ 50 days. Dates of nest success or failure were estimated as the midpoint between the last observation in which the hen was on her nest, and the first observation in which she was off her nest.

After nesting efforts ceased, nest site characteristics were measured (see Commons 1997; Klebenow 1969, Wallestad and Pyrah 1974, Musil *et al.* 1994). At each nest site, the percent sagebrush canopy coverage, as well as the percent coverage of grasses, forbs, non-palatable forbs (to Sage Grouse), other shrubs and bare ground/dead materials was estimated within a 1 m^2 quadrat similar to Daubenmire's method (1959). The mean maximum height of the aforementioned variables was also calculated for each plot. To determine if habitat characteristics near nest sites are important, eight additional dependent non-random 1 m squared plots were placed at 7.5 and 15 m in each of the four ordinal directions and the same measurements were performed. A modification of Canfield's (1941) line intercept method was used to estimate the live sagebrush canopy coverage along four 15 m transects radiating from the nest site in each ordinal direction (see Commons, 1997). A similar set of habitat characteristics were also taken at a set of plots at a randomly related site, 100 to 500 m in a random direction from the nest site (dependent random plots). The dependent non-random plots represent non-nest site characteristics within the same 'stand', and the dependent random plots represent non-nest site characteristics from different 'stands'.

An artificial nest predation experiment was performed in 1998 to identify key habitat features associated with nesting success as part of Tammy Seida's B.Sc. honours research. Eighty nests containing one brown plasticine egg and two unmarked brown chicken eggs were placed around four active Sage Grouse leks. Similar habitat measurements to those described for actual nests were performed at artificial nests. A similar experiment was performed in 1999, but

grass was clipped surrounding some nests to determine how grass height affected nest success. These results are presently being analyzed by Megan Watters as part of her B.Sc. honours research.

Radio-collared birds were followed throughout the spring and summer to determine habitat use. Each week, hens, with or without broods, and cocks were triangulated until observed (Musil *et al.* 1994, Schroeder 1997) and the same habitat measurements described for nest sites were performed. Brooding hens were not intentionally flushed until chicks were at least three weeks of age, and then brood flush counts were performed when hens were located to estimate chick survival.

Analyses of timing of nesting activities and clutch size was done using an Analysis of Variance. A Chi Squared test was used to analyses nest success and fledging success. All analyses were conducted using an $\forall = 0.05$.

RESULTS

Lek counts were conducted from 11 April, 1998 to 21 May 1998, and 5 March 1999 to 31 May 1999. High counts over the strutting period resulted in a maximum number of 147 cocks on 8 active leks in 1998 and 140 cocks on 8 leks in 1999 (Fig. 3). A similar trend was seen in Saskatchewan, where a maximum of 144 cocks were counted on 12 active leks in 1998, compared to 61 cocks on 10 leks in 1997 (Wayne Harris pers. comm., Fig. 3). Despite the decrease in population numbers from the mid 1980's, counts have remained relatively stable over the last six years (Fig. 3,).

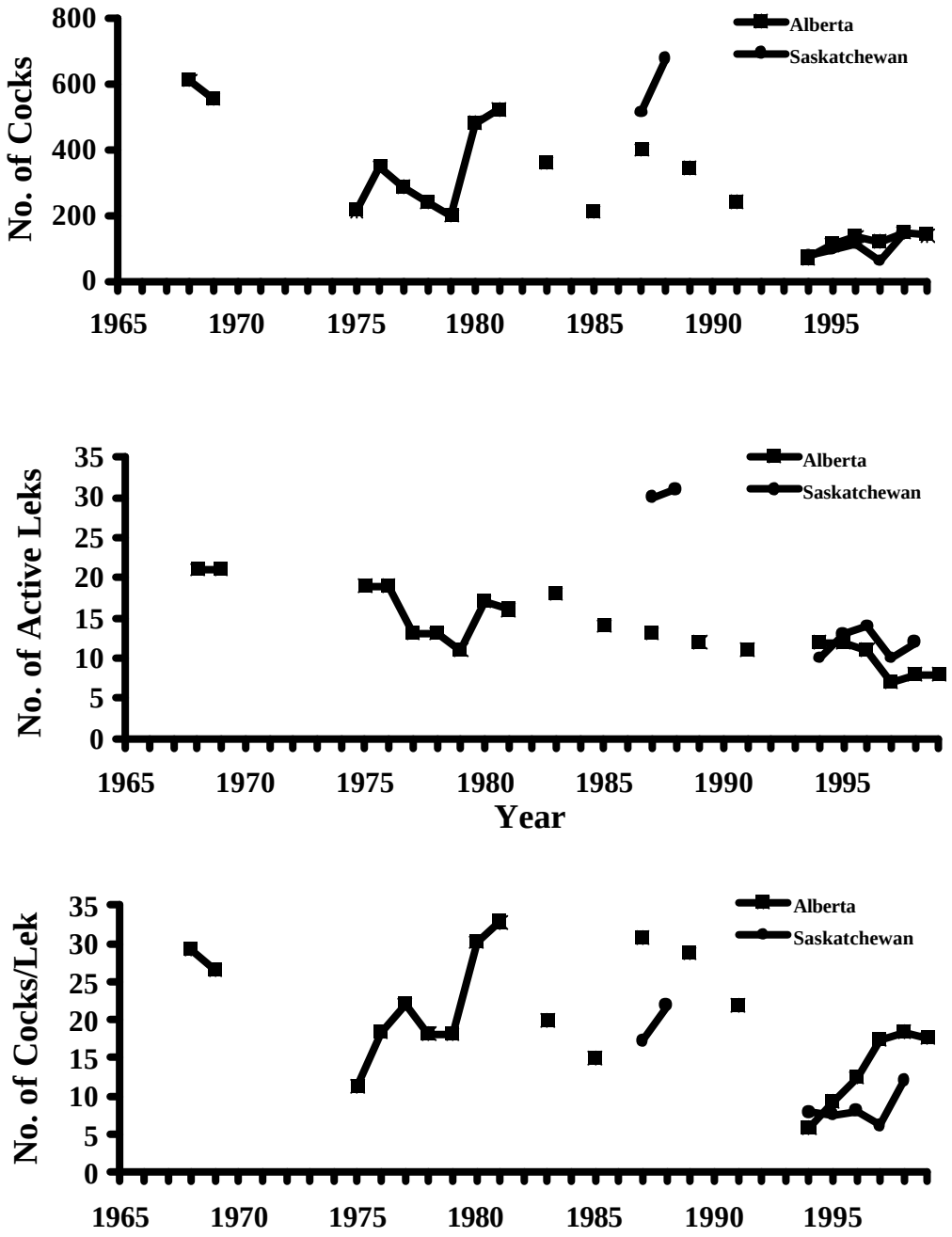

Figure 3. Population trends for Sage Grouse in Alberta and Saskatchewan over the past 30 years. Shown as the number of cocks, number of cocks per lek, and number of active leks. Years when sampling efforts consisted of less than eight surveyed leks were not included.

Trapping during the breeding season resulted in a total of 96 Sage Grouse being captured. Only 25% (24/96) of the birds captured were yearlings (Table 1). Mass of captured birds was significantly different between sexes and age classes (Age * Sex Interaction; $F_{1,92} = 16.0$, $P < 0.0001$; Two-way ANOVA). However, yearling females were not significantly different in mass than adult females ($P = 0.17$; Tukey's Test).

Table 1. Breeding body mass for captured birds and the number of birds that received radio transmitters in Alberta in 1998 and 1999. Standard Error is shown in brackets. Number of radios for yearling females is greater than captures because four additional radios were placed three adult females and one yearling captured after the breeding season.

	Adults		Yearlings	
	Males	Female	Male	Female
Captures	48	24	12	12
Mass	3122 (29.5)	1668 (29.3)	2623 (77.0)	1531 (23.2)
Radios	21	27	3	13

Radio transmitters were affixed to 64 Sage Grouse in 1998 and 1999 (Table 1); 4 adult and 3 yearling females and 20 adult and 3 yearling males in 1998; 23 adult and 11 yearling females and 1 adult male in 1999. Due to the unknown fate of 7 adult males and transmitter difficulties with radios on 2 adults and 1 yearling male, these individuals are excluded from further analyses. Thus male mortality from 1998 to 1999 was 69.2% (9/13); 1/2 yearlings and 8/11 adults. However, in 1999, the single yearling male and 4/5 adults with radios all died shortly after the 1999-breeding season. The fifth adult male disappeared after the breeding season.

Two of seven (28.6%) females outfitted with transmitters in 1998 died before the 1999 breeding season; 1/3 (33.3%) yearlings and 1/4 (25%) adults, although the fate of two of these birds (1 adult and 1 yearling) is unknown. Thus mortality five females from 1998 whose fate was known was 40% (2/5). By the end of August 1999, 27.3% (9/33) females (6/23 adults and 3/10 yearlings) had died. However, this does not take into account the unknown fates of 10 females; 3 adults and 1 yearling who disappeared shortly after their spring capture; 3 adults and 2 yearlings that disappeared shortly after loosing their nest or brood and 1 adult whose radio fell off. Thus, it is more appropriate to only consider birds of known fate when analyzing mortality. Female mortality was 43.5% (10/23) from the 1999-breeding season to the end of August; 7/17 adults and 3/6 yearlings. It is likely that many of these 'lost' birds died and had damaged transmitters that didn't allow me to relocate them. These female estimates also don't include overwinter mortality. Thus, these are minimum mortality rates and are estimates are conservative.

Based on feather remains and tooth marks on transmitters, canids, especially coyotes (*Canis latrans*) appear to be the major predator on Sage Grouse. In a couple of cases, remains suggested a raptorial predator, likely great horned owls (*Bubo virginianus).*

Reproductive Activities

Nest data were gathered for 20 different females. Data for two females was gathered in both years. Nesting data was not gathered for nine of 40 radio-collared females due to transmitter difficulties with five radios, and four females that died prior to the breeding season. Eleven females could not be relocated during the breeding season; 4 were found dead with damaged transmitters in the late spring/early summer and likely didn't nest; 1 was captured with

chicks after nesting; 1 was recaptured 23 July with a brood patch but was broodless; the fate of 5 females is unknown. The mean date of capture for 36 females captured during the breeding season was 8 April +/- 1.91 days (SE), while the mean date of maximum attendance of females at 7 leks in 1999 was 5 April +/- .91 days, suggesting that the peak in breeding occurred during the first week of April (1999 data was only used for lek attendance due to limited counts at leks prior to 11 April in 1998). Due to a limited sample sizes for nesting activities in 1998, I did not test for between year effects on reproductive activities.

Initiation of Incubation

Average date of initiation of incubation for 25 Sage Grouse nests was 10 May (range 23 April to 18 June). Initiation dates were based on localized movements of females, or the continued observation of a hen under the same shrub on repeated relocations. Age ($F_{1,23} = 0.004$, $P = 0.95$) did not explain a significant amount of variation within the dates of initiation of incubation (one-way ANOVA). Incubation of first nests began approximately 35 days earlier that renesting attempts ($F_{1,23} = 113.45$, $P < 00001$; one-way ANOVA). For first nesting attempts only, age explained a significant amount of the variation in initiation dates ($F_{1,18} = 7.34$, $P = 0.01$). Average date of incubation for adults was May 1 (range 23 April to 10 May), which was about 9 days earlier that the average date for yearlings; May 10 (range 5 May to 14 May).

Incubation times for Sage Grouse in this study ranged from 23 to 29 days (0 = 27 +/- 0.62 days (SE), n=10) and was similar for both first nest and renesting attempts ($F_{1,8} = 0.97$, $P = 0.35$). Hatch date for successful nests was significantly earlier (33 days) for first nests (0 = 28 May +/- 1.58 days, n=9) when compared to renesting attempts (0 = 30 June, +/- 5.36 days, n=3; $F_{1,10} = 68.97$, $P < 0.00001$), as was expected.

Clutch Size

Clutch size was variable, ranging from 4 to 11 eggs for 28 nests. Clutch size (0 = 7.75 +/- 0.34 eggs; n=28) was independent of nest success ($F_{1,26} = 0.46$, $P = 0.50$), allowing unsuccessful and unsuccessful nests to be pooled for analyses. Clutch size was dependent on the nesting attempt ($F_{1,26} = 12.38$, $P < 0.0016$) with first nests (0 = 8.2 +/- 0.2377 eggs; n=23) having larger clutches than renesting attempts (0 = 5.6 +/- 0.70 eggs; n=5; Fig. 4). Embryo viability (% of all eggs laid in successful nests that hatched (Schroeder 1997)) was 92% (96 of 104 eggs).

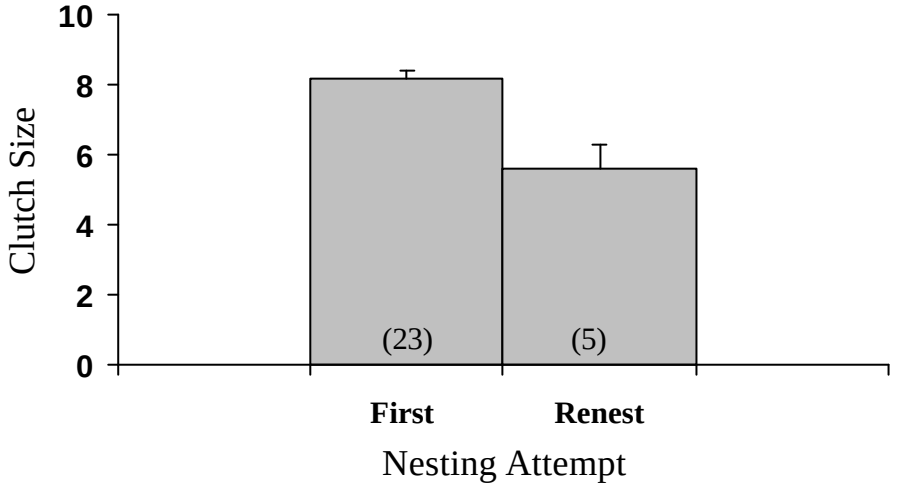

Figure 4. Clutch size shown for first and second nesting attempts for Sage Grouse in southeastern Alberta in 1998-99. Values are shown as means +/- SE. Number of nests indicated in brackets.

Nesting Likelihood

As mentioned, only 20 females were tracked through the breeding season with two tracked through both years. Thus, annual nesting efforts are based on data gathered for the

breeding seasons of 22 females. In all cases in which a hen displayed localized movements within an area, a nest was eventually located after a successful hatch or a predation event. 100% of 22 females attempted to nest.

Nest Success

Overall nest success was estimated at 46.1% for 26 nests; 1/3 nests in 1998; 11/ 23 nests in 1999. This is actual nest success, as all females that were tracked attempted to nest. Nest success was independent of female age ($X^2_1 = 0.46$, $P = 0.50$) and nest order ($X^2_1 = 0.26$, $P = 0.61$). Nest failure was dependent on the stage of incubation ($X^2_3 = 9.43$, $P = 0.02$), with the majority of nest failures occurring between eight and 21 days of incubation (86%; 12/14; Fig. 5).

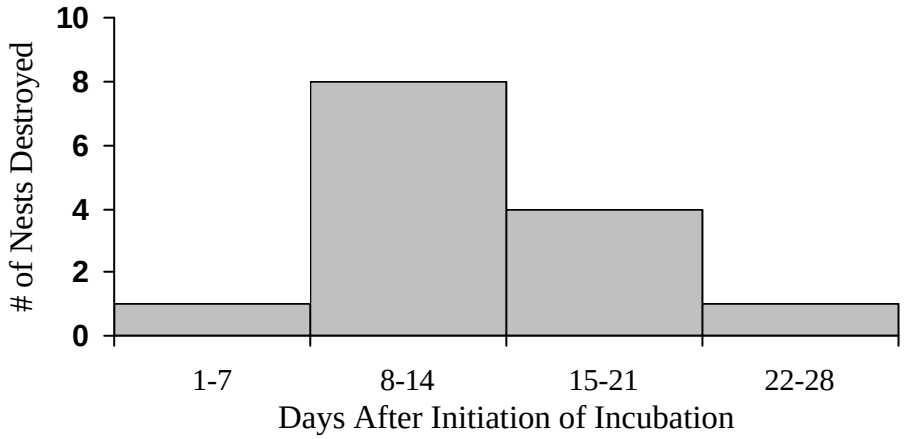

Figure 5. Number of days between nest initiation and nest failure for 14 unsuccessful Sage Grouse nests in southeastern Alberta in 1998-99.

Renesting Likelihood

One female was capture late in the breeding season on a lek in 1998 (22 May) with a well developed brood patch and was assumed to have failed at her first nesting attempt. She did initiate a second nesting attempt that year. Only four of 13 females that were unsuccessful first nesters, attempted to renest (4 of 10 adults and 0 of 3 yearlings). Despite the fact that no yearlings attempted to renest, there was no age effect on renesting likelihood ($X^2_1 = 1.20$, $P = 0.27$).

Breeding Success

Breeding success was estimated at 54.5% for 22 females monitored throughout a single breeding season. Breeding success was independent of age ($X^2_1 = 0.78$, $P = 0.38$; adults = 61%, n = 18; yearlings = 25%, n = 4) although adults appeared to be more successful breeders.

Fledging Success

Fledging success was estimated as 27.8% for 22 females monitored throughout a single breeding season. Fledging success was independent of age ($X^2_1 = 0.91$, $P = 0.34$; adults = 27.77%, n = 18; yearlings = 0%, n = 4) despite the fact that no yearlings successfully fledged chicks.

Chick Survival

Due to the difficulty in locating all chicks when a brooding hen was flushed, chick survival was estimated as range (a maximum and minimum). Chick survival was estimated as

the % of chicks that survived to at least 50 days of age (Schroeder 1997) and ranged from 13.6% to 22.72% for 88 chicks.

Population Predictions

Based on lek counts, I estimate the 1998 Canadian Sage Grouse spring population at 873 to 1293 individuals (Fig. 3). The Alberta population for 1999 is estimated at 420 to 622 individuals and I have also estimated the population for all years when at least 8 leks were checked for occupancy (Fig. 6). Low population estimates are based on a 2:1 female:male sex ratio. High estimates are based on a 2:1 sex ratio, the assumption that only 90% of all leks were located, and that only 75% of all males attend leks.

Using data gathered on survival, I developed a basic population model to predict the future Sage Grouse population trends within Alberta from 2000 to 2030 (Fig. 6). This model could also be applied to the whole Canadian population by combining Alberta lek counts with the most recent lek counts in Saskatchewan. Predicted population numbers are based on 31% male survival; 56.5% female survival, 54.5% breeding success for females, and an average clutch size of 7.75 eggs, 18% chick survival to fledge; an assumed 100% juvenile overwinter survival. Overall, the Canadian-wide population is still as much as 80% below levels maintained in the early to mid 1980s (Fig. 3, 6). As the model predicts, the Alberta population will fall to below 300 individuals by the year 2004. This model assumes a constant proportion of yearlings in the population, (based on 1999 reproduction data; 49%). As mentioned, only 25% of the birds captured in this study were yearlings, which doesn't fit with the predicted model. There are some discrepancies that need to be addressed, such as the accuracy of both adult and chick survival. I have also assumed that juvenile overwinter survival is 100%, which is unlikely. If all the parameters remain constant, and juvenile overwinter survival is entered into the model at a

lower rate, which may be the case, 40% juvenile overwinter survival would result in a yearling to adult ratio close to that indicated by capture records (1:3; 25%).

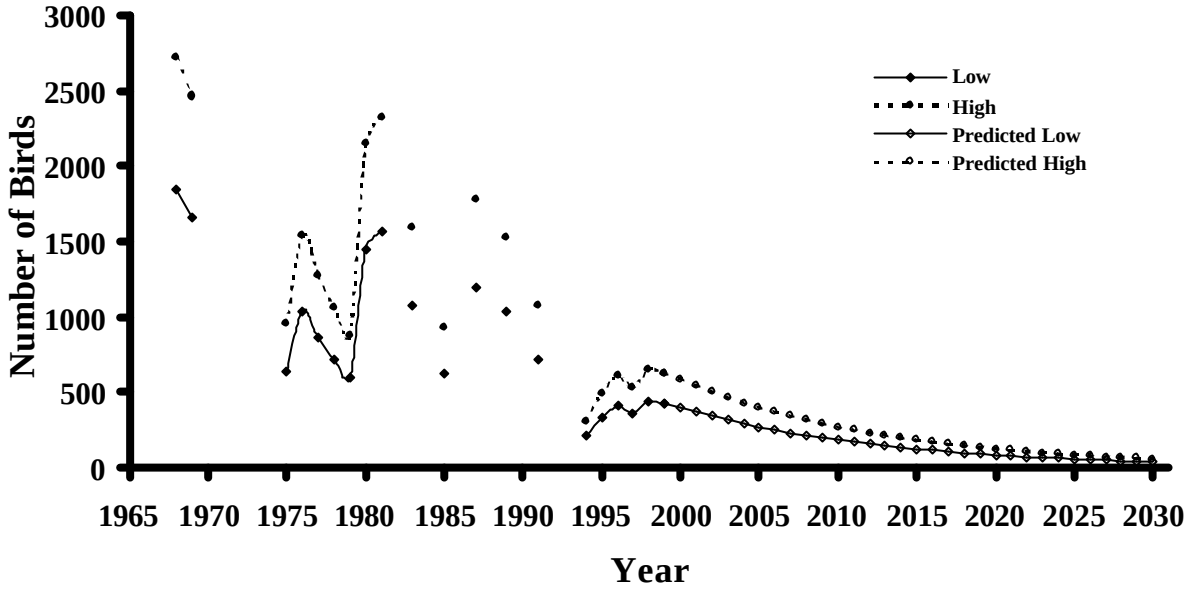

Figure 6. Estimated Alberta Sage Grouse population for 1965 through 1999 and predicted population from 2000 to 2030.

In addition to the data for actual Sage Grouse nests, Seida (1998) found that only 17 of 80 artificial Sage Grouse nests (21%) were successful. Grass height was the strongest variable contributing to the model and was positively correlated with nest success (Seida 1998).

Paired vegetation measurements were made at all Sage Grouse nests to identify key habitat characteristics. Measurements were also made once a week for each brooding hen to identify brood rearing habitat. Broodless hens and males were also located weekly and vegetation measurements were taken to identify summer habitat for Sage Grouse. These data are

currently being analyzed. Movement data was also recorded for each radio collared Sage Grouse.

DISCUSSION

It has been suggested that Sage Grouse populations cycle, although these cycles tend to be irregular at best, if they do exist (Braun 1998). After the Alberta population declined by about 80% to between 210 and 311 individuals in 1994 (Fig. 6), lek counts in both Alberta and Saskatchewan show that the Canadian population has remained relatively stable, but at low numbers (Fig. 3, 6). The reason(s) for the sharp decline from population numbers maintained in the early to mid 1980s are not clearly understood. The fact that the population appears to have stabilized may simply be due to intensified lek count efforts from 1996-1999 in both provinces. Although Sage Grouse were not heavily hunted in Alberta in the early 1990's (K. J. Lungle pers. comm.), the season on Sage Grouse has been closed since 1996. It is possible that the removal of hunting pressure has allowed the declining population to stabilize.

Clutch size for Sage Grouse typically ranges from 7-9 eggs (Patterson 1952, Connelly *et. al.* 1993, Anonymous 1997, Schroeder 1997, Schroeder *et al.* 1999). Clutch size in my study (7.75 eggs) was within the normal range. In a recent review of Sage Grouse literature, Schroeder *et al.* (1999) found that nesting success for Sage Grouse throughout their range in between 15-86%; typically between 40-60%. Overall breeding success ranges from 15-70% (Schroeder *et al.* 1999). In my study, nesting success (46.1%) and breeding success (56.4%) were relatively high when compared to other populations, and reproductive effort and success are likely not the cause of the observed population decline. However, of the 26 nests located in this study, 3 were from 1998 and 23 were from 1999. The spring and summer of 1999 were extremely moist, and as a

result, grass and forb growth in the area was above average. This could have resulted in above average nesting and breeding success, masking the potential reason for the population decline.

Sage Grouse nest almost exclusively under sagebrush plants, with a dense sagebrush canopy coverage (20 to 50%; Patterson 1952, Klebenow 1969, Wallestad and Pyrah 1974, Schroeder *et al.* 1999). Taller shrubs with heights ranging from 17 to 79 cm are preferred (Patterson 1952, Klebenow 1969, Wallestad and Pyrah 1974, Schroeder *et al.* 1999). While Sage Grouse may be selecting the more dense sagebrush to nest under, the overall density of sagebrush within the vicinity of nests may not be sufficient enough to obscure nests from predators. Gregg *et al.* (1994) found that tall grass (≥ 18 cm) was also important for Sage Grouse nests to be successful.

In Sedia's (1998) nest predation experiment, grass height was the most important variable affecting nest success. Height and percent coverage of sagebrush did not affect nest success, as has been found in other areas for both artificial and natural Sage Grouse nests (Wallestad and Pyrah 1974, Gregg *et al.* 1994, DeLong *et al.* 1995,). *A. cana* shrubs are fairly ubiquitous throughout the Canadian range, and thus other variables such as grasses and forbs may become more important for protection from predators. It appears that the lack of residual cover to obscure nests from predators may contribute to decreased Sage Grouse nesting success in Canada, but the excellent grass growth in 1999 may have masked those effects.

Sage Grouse are the largest of all North American grouse (Johnsgard 1983), with adult males throughout their range averaging 2100g to 3200g during the breeding season (Patterson 1952, Dalke *et al.* 1963, Eng 1963, Beck and Braun 1978, Schroeder *et al.* 1999). At 3122 g, birds in Alberta are larger than most other Sage Grouse. Sage Grouse are at the northern extent

of their range in Canada, and it may be necessary for birds to put on more mass to survive the extreme conditions they encounter.

Very little is understood about the survival and life history requirements of Sage Grouse chicks due to the difficulty in relocating chicks and the inability to attach radio transmitters to them. June (1963) banded 2,196 juvenile Sage Grouse in Wyoming and 38% of them survived from hatch to the autumn, for a population that was stable at the time. Brood counts have been performed in many areas, and the low survival of juveniles is reflected in the 18.4-68.4% decline in brood size over the summer (Schroeder *et al.* 1999). Thus, chick survival from hatch to the end of the summer (fledging) ranges from 31.6-81.6%. Chick survival for 1998-99 in Alberta was as high 23%, and possibly as low as 14%. With such low chick survival, it would be expected that annual recruitment of yearlings would also be low. Only 24 of 96 Sage Grouse captured in 1998 and 1999 were yearlings (Table 1), suggesting that recruitment was about 25%. Many other long-term research projects on stable or slightly declining Sage Grouse populations have found that approximately 50% of captured birds are yearlings (Dalke *et al.* 1963, Eng 1963, Jenni and Hartzler 1978), suggesting that recruitment is low for the Alberta population. Low chick survival may be related to reduced recruitment and may be responsible for the population decline. Low juvenile overwinter survival may also contribute to reduce recruitment.

Mortality rates for males are considerably higher than for females likely due to the physically demanding costs associated with displaying at leks during the breeding season (Schroeder *et al.* 1999). Female mortality ranges from 30 to 50% and male mortality is between 50 and 60% (Schroeder *et al.* 1999). While female mortality in Alberta ($\exists$ 40% from March to August) was within the expected range, annual mortality rates may actually be higher if

overwinter female mortality is considered. Male mortality was high at 70%. Low adult survival may also be contributing to the population decline.

Even though the cause(s) for the population decline are not known definitively, it is likely that the problem lies in recruitment and is directly related to chick survival. Adult survival may also confound the problem. Under the present population parameters, the Alberta Sage Grouse population may decline to less than 300 individuals by 2004 (Fig. 6). By 2018 the Alberta population will decline to less than 100 individuals. In either of these cases, there may not be enough individuals to maintain genetic diversity, and it needs to be determined if we have already fallen below a minimum viable population size. This is a very crude model and it should be pointed out that as the current model predicts that the yearling to adult ratio next spring will be about 1:1. However, capture data clearly shows that the yearling to adult ratio is closer to 1:3. More data need to be gathered to improve the model.

CONTINUED RESEARCH

The focus of my current research is to understand the factors regulating Sage Grouse abundance at the northern edge of the specie's range. This will help to address the population decline and to develop management strategies for the continued existence of the species in Canada. Continued monitoring of the Canadian population must be maintained, and efforts must be made to better understand the reasons for such poor chick survival, resulting in low recruitment.

It is my intention to continue to do research on Sage Grouse as part of my Doctoral project. My goal is to assess chick survival from hatch until fledging, and then monitor overwinter survival of juvenile Sage Grouse. To collect data, nests will be located and nesting

success monitored using standard radio telemetry techniques. Broods will be captured and chicks will be fitted with transmitters. These chicks/juvenile Sage Grouse will be tracked through the following year's breeding season, allowing me to assess recruitment rates, and how chick survival in conjunction with other measures of reproductive success (nest success, breeding success) relate to the population decline. For the population to remain stable, recruitment must equal adult mortality.

Habitat quality and fragmentation will be compared to the measures of reproductive success. Areas with greater fragmentation of native prairie have been suggested to reduce reproductive success of many bird species. Grass height is positively correlated with Sage Grouse nesting success. I propose to work with the Alberta government and local landowners to reduce grazing intensity in some areas of the current Sage Grouse range to increase grass height and cover. I hypothesize that Sage Grouse nesting in these areas will have increased nesting success compared to unmanaged areas with shorter grass. Similarly, I predict that chick survival rates will increase in areas where grazing intensity has been reduced.

Intuitively, Grazing patterns have changed since the time of the Bison and European settlement. I will implement a rigorous experimental design that would ideally include a minimum of ten 640-acre sections in which a grazing rotation structure is set up with the complete removal of grazing. This will allow me to develop landscape models using habitat characteristics and energy practices in combination with population models. I will then be able to predict Sage Grouse population trends based on current land use practices and energy developments.

As with any declining population, genetic variability and inbreeding becomes a potential problem. Limited data available suggests that Sage Grouse chicks return to breed on the lek at

which they were conceived the previous year. However, adult Sage Grouse also display lek fidelity and inbreeding resulting from parent offspring matings may be a problem. At a Sage Grouse lek there is typically one master cock that obtains the majority (*ca*. 75%*)* of the matings, and one or two guard cocks that perform the rest of the matings. It may be that males at each lek are more closely related to each other, and thus, there are genetic benefits for males to return to the same lek year after year. If genetic relatedness of males is greater within leks, then yearling females should not display natal lek fidelity. I will take blood samples from a large percentage of grouse at each lek to determine the genetic relatedness within and between leks. This will allow me to determine if lek choice by females avoids potential inbreeding problems. I hypothesize that genetic relatedness will be higher within leks than between leks. Hens with higher indices of inbreeding will have decreased reproductive success and decreased brood survival.

Once I have captured chicks by locating nests and broods of radio collared hens; I will follow these chicks through the next breeding season and determine if they return to the lek at which they were conceived. Blood samples from chicks will be taken to determine their genetic relatedness to males at the lek they attend the following breeding season. If genetic relatedness of males is greater within leks, then juvenile Sage Grouse should not return to the ground at which they were conceived, contrary to what some previous research indicates.

I will begin this research in the spring and summer of 2000 as a pilot year to my Doctoral research. I will continue to monitor the population, gather data on survival, reproductive events, and begin radio telemetry and survival analyses of chick and juvenile Sage Grouse, as well as begin to gather genetic samples and behavioural data for minimum viable population analyses.

RECOMMENDATIONS

Cattle grazing is a common land use practice throughout the Canadian Prairies. However, intensive grazing reduces the height and percent cover of both grasses and forbs. Effective but cooperative management strategies with land owners need to be devised to increase the residual grass and forb cover in areas where Sage Grouse nest. Approximately 90% of all Sage Grouse nests occur within 3.2 km of a lek (Braun, *et al.* 1977). Thus, working with landowners to limit grazing during the breeding season within a 3.2 km radius surrounding all leks would greatly benefit Sage Grouse in Canada. These strategies are being successfully undertaken in some areas of the United States and have resulted in three fold increase for a population in Colorado over a three year period (Clait Braun pers. comm.).

Sage Grouse are extremely sensitive to disturbance, and once these birds are flushed off of a lek, they will not return to resume breeding activities until the next day. Continual disturbance can result in birds abandoning traditional mating grounds. Due to the association of nests with lek sites, disruption of breeding activities may also detrimentally affect nesting Sage Grouse. Therefore access to leks by naturalist and for energy development needs to be controlled. Very little suitable habitat for Sage Grouse remains, and these areas need to be protected from disturbance and fragmentation.

Oil and gas extraction is extremely active within the range of Sage Grouse on the Canadian Prairies. Even though sensitive wildlife areas have been identified to the government, the financial gain of placing an oil well on top of these sensitive areas can to outweigh the cost of disturbing the habitat and the associated wildlife. Since Sage Grouse are a non-migratory species in Canada, they fall under provincial authority. However, Provincial Wildlife Agencies are only able to "recommend" against activities that will ultimately harm Endangered species.

The catch is that land owners also gain financially from oil and gas activities, and biologists need to maintain good land owner relations to allow them to continue research on private and crown leased lands, and to work with land owners for the benefit of the sensitive wildlife. With as few as 873 individuals, the Canadian Sage Grouse population is extremely sensitive to any stochastic event. The longer it takes to begin working with land owners to project habitat surrounding the remaining active Sage Grouse leks, the more likely that Sage Grouse will become extirpated from Canada.

MANAGEMENT RECOMMENDATIONS

I have developed some management recommendations, which can be used as a guide to help protect Sage Grouse and their habitat. All of these suggestions are developed current research on current Sage Grouse research throughout North America, including results from my M.Sc. research.

1) Protect all remaining active Sage Grouse leks from disturbances:
   A) *Breeding Season* - No disturbances
   i) Oil and Gas – No new drilling or seismic activities within 3.2 km of active leks. Also, no activities at current well sites from 1 March to 31 May each year. Preferably not until after July 15th (Nesting period).
   ii) Naturalists – set aside a designated SG viewing area with a blind, set viewing rules, and publish a pamphlet to advertise the location, and the viewing guidelines, so that the Sage Grouse breeding activities are not continually disturbed. Monitor these activities and by all means, market them.
   iii) Utilities Companies - work with them to 'cap' all existing power poles in the area to reduce the number of perching site for raptors around leks. Have any future lines be buried to reduce the number of perching sites available, and reduce to number of Sage Grouse collisions with power lines. Burry all existing lines (<3.2 km) of all active leks (during the non-breeding/nesting periods = July 15th to February 28th).
   iv) Vehicular traffic – Vehicle travel on roads/trails close to leks (<3.2 km) should be minimized during the breeding, nesting and brood rearing seasons, to minimize collisions with Sage Grouse. Work with landowners and Energy Companies to regulate these activities during the breeding/nesting periods.
   B) *Nesting period* (April – July) – Any human activities/disturbances in the vicinity of leks (<3.2 km) need to be carefully scrutinized, as these will likely contain the highest density of Sage Grouse leks.
   C) *Post-nesting* – Hens will be rearing their chick in the sagebrush flats associated with active leks, and disturbances should be minimized in these areas throughout the summer

(until the end of August). Throughout the remainder of the year, Sage Grouse may still be using the area, but the concern lies primarily in disturbing the habitat at or near leks (<2 miles) prior to the next breeding season. Commercial activities may take place at this time, however all leks still need to be protected, and no developments should take place within the 3.2 km buffer around leks.

2) Habitat Protection

A) Sage Grouse are sagebrush obligates, which means that they are essentially found only in native prairie habitats, as they contain sagebrush. All measures necessary should be taken to prevent cultivation, disturbance, destruction, and/or fragmentation of the remaining native prairie within the present Canadian range of Sage Grouse. Many other native prairie species in Canada that have experienced recent declines will also benefit from the protection of native praire. e.g. Burrowing Owl (*Athene cuniculaia)*; swift fox (*Vulpes velox*); Sage Thrasher (*oreoscoptes montanus*); Sprague's Pipit (*Anthus spragueii*); and Mountain Plover (*Chandrius montanus*).

B) As previously mentioned, habitat surrounding Sage Grouse leks needs to be protected from disturbances such as oil and gas developments, cultivation, road development and vehicular traffic (including off road vehicles). Sagebrush flats also need to be protected from destruction throughout the range of Sage Grouse, however areas with 20-50% sagebrush cover are particularly important surrounding leks and must be maintained <3.2 km of leks if leks are to remain active.

C) Manage Grazing – Grazing needs to be actively managed in collaboration with the landowners, government agencies, and grazing associations in conjunction with ongoing research to provide suitable cover for Sage Grouse to nest under, to escape from predators, and for roosting. This will result in increased nesting success, brood survival, and adult survival, which will ultimately result in stable population numbers. Lek surveys and monitoring of reproductive ecology needs to be maintained while these grazing strategies are implemented.

3) Control/eliminate the training of hunting dogs within the range of Sage Grouse in Alberta/ Canada –

Sage Grouse are a non-migratory bird species in Canada, and therefore are only protected by provincial wildlife laws and regulations. The Alberta Wildlife Act does not prevent the training of hunting dogs on endangered species within the province. The Wildlife Act may however come into play if the dogs are considered as an extension of humans under wildlife harassment. However, it is difficult to charge someone with harassing wildlife. A person may also be charged if he/the dogs actually harm/kill an endangered species such as Sage Grouse, but this is also difficult to prove and would be easier to simply prevent the possibility of it occurring. The other complication lies in the fact that Sage Grouse are not yet an endangered species in Alberta. The Wildlife Act does offer some protection for Provincially listed endangered species, but only for the nest or den site of the endangered species. This is by far too weak, and more rigorous guidelines/laws are needed to protect endangered species and the vital habitats that they inhabit and require to survive.

4) Research – Maintain long term Sage Grouse population data:

A) perform lek counts over a minimum of a four week period in the spring, following the recommended Sage Grouse guidelines (Braun *et al.*, 1977).
B) continue to monitor all measures of reproductive success through the use of telemetry studies. This will allow the effects of various management strategies as well as climatic effects to be monitored along with survival and reproductive success.
C) continue to capture Sage Grouse, so as to determine rates of survival for Sage Grouse, especially brood survival and overwinter survival of juveniles to address overall annual reproductive success; in 1999 SG appeared to have relatively high nesting success, but this can only be evaluated through long term reproductive studies, and through the monitoring of the population through the following spring.
D) bring Alberta Environmental Protection, researchers, and Sage Grouse land owners together to actively and cooperatively manage grazing in known Sage Grouse nesting brood habitat. Grazing should be limited in the late fall to allow for some residual grass cover to remain available for Sage Grouse nesting cover the following spring. Grazing should also be limited in these areas during the breeding and nesting season (1 March to 15 July). This will help to increase nesting success, and thus, reproductive success and eventually increase population numbers. Similar efforts in a declining Sage Grouse population in Colorado resulted in a tripling of population numbers over 3 years of reduced grazing pressure.

ACKNOWLEDGEMENTS

I thank Clait Braun for all of his assistance in the field, and guidance since the onset of this project. His genuine interest in my research and my career has been encouraging. Mark Brigham has had a great influence on my development as a biologist and I thank him for his guidance and keeping me focused, and for his assistance in the field and in life. I thank all of my field assistants who were an invaluable part of this research, beginning with Tammy Seida, Craig Cullins, Megan Watters, Erin Urton and Angela Gooliaff. There were also many others who assisted me in the field and showed and interested in my research, some of which include Mark Brigham, Ray Poulin, Danielle Todd, Tyler Cobb, Duane Peltzer, Janna Foster, John Taggart, and Dale Eslinger. I am also grateful to all of the landowners who allowed me access to their land and thank these landowners and the people of Manyberries for their genuine hospitality. I thank Wayne Harris for data on Saskatchewan lek counts. Lastly, this research would not have been possible without the financial and/or logistical support from all of the organizations that contributed to Sage Grouse research in 1998 and 1999. These organizations included: Alberta Conservation Association, Alberta Environmental Protection, Alberta Sport Recreation Parks & Wildlife Foundation, Cactus Communications (Medicine Hat, AB), Canada Trust Friends of the Environment Community Fund, Canadian Wildlife Foundation, Ducks Unlimited Canada (North American Waterfowl Management Plan), Endangered Species Recovery Fund (World Wildlife Fund, Canadian Wildlife Service, and the Government of Canada's Millennium Partnership Program), Esso Imperial Oil (Jack Schacher, Manyberries), Mountain Equipment Co-op, Murray Chevrolet (Medicine Hat), Nature Saskatchewan, Saskatchewan Environment and Resource Management, Saskatchewan Stock Growers Association, Saskatchewan Wildlife Federation, Trans Canada Pipelines Ltd., and the University of Regina. C. L. Aldridge was partially

supported through a Macnaughton Conservation Scholarship, a Dennis Pattinson Memorial Scholarship, and an Edgar A. Wahn Scholarship.

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APPENDIX A

A detailed list of all press releases related to Sage Grouse research in 1998 and 1999.

1998 and 1999 Press Releases Related to
Cameron L. Aldridge's M.Sc. Thesis Work on Sage Grouse in Canada

DATE	PRESS RELEASE	AUTHOR	TITLE
November 1999	Edmonton Journal	Ed Struzik	Wildlife Under Siege
Sept., 1999	Recovery: An Endangered Species Newsletter	Cameron L. Aldridge	Sage grouse continue to decline
Spring, 1999	PICA; The Calgary Field Naturalist's Society	Cameron L. Aldridge	Status of Sage Grouse in Canada
Feb., 1999	CBC Radio Saskatchewan	Peter Dick	Sage Grouse
Dec., 1998	Nature Views; Nature Sask. Newsletter	Cameron L. Aldridge	Status of sage grouse in Canada
Spring, 1998	The Third Degree; U of R Alumni Magazine	Erika Smishek	Research aims to reverse sage grouse saga
May 7, 1998	The Western Producer	Michael Raine	Sage grouse listed as endangered
May 3, 1998	Lethbridge Herald		Future uncertain for once-vibrant population of sage grouse
May, 1998	QR77 Radio; Calgary & Edmonton		Sage grouse
May, 1998	CBC Radio		Sage grouse
May, 1998	CBC News (T.V.) Alberta & Saskatchewan	Gary Sieb	Sage Grouse
May, 1998	Regina Sunday Sun	Frank Flegel	Getting Closer to the Vision
April 17, 1998	Calgary Herald	Monte Stewart	Researcher gets funding to track nesting sage grouse
April 9, 1998	The Regina Leader-Post		Sage grouse population in rapid decline
April 1998	CBC NewsWorld (T.V.)		Sage Grouse
March 27, 1998	The Saskatoon StarPhoenix	Colette Derworiz	Shrinking ranks of sage grouse baffles researchers

APPENDIX B

A list of all Publications, Presentation, and Conference Proceedings Emanating from Sage Grouse Research.

Publications, Presentation, and Conference Proceedings Emanating from Cameron L. Aldridge's M.Sc. Thesis Research on Sage Grouse

a) Articles under preparation for submission to refereed journals

Aldridge, C.L., S.J. Oyler-McCance, and R.M. Brigham. (1999) Occurrence of two sage X sharp-tailed grouse hybrids in Alberta. Condor.

Sedia, T.L., **C.L. Aldridge**, R.M. Brigham, and G.C. Sutter. (1999) Vegetation characteristics affecting artificial Sage Grouse nests: patterns for a northern population. J. Wildl. Manage.

b) Other refereed contributions

Aldridge, C.L. 1998. Status of the Sage Grouse in Canada. *In* Proceedings of the Fifth Prairie Conservation and Endangered Species Conference. Saskatoon, SK. 23 pp. *In Press* (Feb. 1998).

c) Non-refereed contributions
Publications

Aldridge, C.L. (1998) Status of the Sage Grouse (*Centrocercus urophasianus urophasianus*) in Alberta. Alberta Environmental Protection, Wildlife Management Division, and Alberta Conservation Association, Wildlife Status Report No. 13, Edmonton, AB. 23 pp. (Prior to M.Sc.)

Aldridge, C.L. (1997) 1997 Sage Grouse inventory: A comparison of two techniques used to monitor Sage Grouse in southeastern Alberta. Unpub. report. Alberta Environmental Protection, Fish and Wildlife Division, Edmonton AB. 39 pp. (Prior to M.Sc.)

d) Presentations

Aldridge, C. L. (1999) A drastic decline in a northern Sage Grouse (*Centrocercus urophasianus*) population: Is recruitment the problem? 23rd Prairie Grouse Technical Council Meeting. Gimli, Manitoba.

Aldridge, C.L. (1999) Conservation ecology of Sage Grouse in Canada. The Wildlife Society's 6th Annual Conference. Austin, TX.

Aldridge, C.L. (1999) A drastic decline in a northern Sage Grouse (*Centrocercus urophasianus*) population: Is recruitment the problem? 32nd Annual Prairie Universities Biological Symposium (PUBS). Saskatoon, SK.

Aldridge, C.L. (1998) The status of Sage Grouse (*Centrocercus urophasianus*) in Alberta. 22nd Western States Sage and Columbian Sharp-tailed Grouse Workshop. Billings, Montana.

Aldridge, C.L. (1998) Status of the Sage Grouse in Canada. 5th Prairie Conservation And Endangered Species Conference (PCAES). Saskatoon, SK.

e) Invited Seminars

Lecture Biology 150, University of Regina- Biological Concepts - "Conservation Biology on the Prairies" Nov. 1999

Regina Natural History Society – "Sage Grouse" Nov. 1999

Sacred Hearts Elementary School – Sask. Innovation in Science Series – "Endangered Species" Oct. 1999

Cypress Hills Interpretive Center: Invited Lecture Series - "The Sage Grouse" Aug. 1999

Grasslands Naturalists, Medicine Hat - "The Status of Sage Grouse in Canada." May 1999

Southern Saskatchewan Old Timers and Naturalists - "The Status of Sage Grouse in Canada." Feb. 1999