ASSESSING CHICK SURVIVAL OF SAGE GROUSE

IN CANADA:

FINAL PROJECT REPORT FOR

2000 SAGE GROUSE FUNDING PARTNERS

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ABSTRACT

The Alberta sage grouse population has declined by 66-92% over the last thirty years. Previous research in Alberta suggested that the population has declined as a result of poor recruitment. Low levels of recruitment appear to be linked to poor chick survival as a result of limited mesic sites important for brood rearing habitat. Due to the inaccuracies of brood flushing counts, and the limits of technology to produce transmitters small enough for chicks, it has been difficult to accurately assess and understand chick survival. A population model developed from data gathered in 1998 and 1999 suggested that the population would decrease in 2000, resulting in a decrease in the number of males observed on leks from 140 to 132. I counted 140 males at leks in 2000, suggesting that the population remained relatively stable, at between 420 and 622 individuals. While sample sizes were small, measures of productivity in 2000 were quite low compared to previous years, suggesting a better understanding of the variability in the parameters in the model is needed. I also performed a 2-stage pilot experiment, focusing on attaching transmitters to sage grouse chicks. I first practiced the technique by suturing transmitters to 10 chicken chicks, and then tested the technique on 4 sage grouse chicks in the field. The transmitters did not appear to harm the chicks at all, and none of them showed signs of infection, bleeding, or scaring from the transmitter attachment. This technique appears to be a viable method for assessing chick survival.

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INTRODUCTION

Sage grouse (*Centrocercus urophasianus*) historically 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). Throughout their range, sage grouse have declined by an estimated 45-80% since the 1950s (Braun 1998). The decline has been most severe at the northern fringe of the species range, with the Alberta population experiencing a 66-92% decline over the last 30 years (Aldridge and Brigham 2000a). The reasons for this decline are uncertain, but previous research in Alberta suggests that poor quality habitat has reduce survival, particularly that of chicks (Aldridge and Brigham 2000a). From this research, the population decline appears to be a result of high juvenile mortality leading to poor juvenile recruitment (Aldridge and Brigham 2000b). Chick survival may be limited by available escape cover, due to limited grass cover and sagebrush (*Artemisia cana*) cover in southern Alberta (Aldridge and Brigham 2000c). However, the lack of mesic sites, and thus, lush forbs (Aldridge and Brigham 2000b) that are important in the diet of chicks (Johnson and Boyce 1990, Drut et al. 1994, Sveum et al. 1998) also may have reduced chick survival. My research indicated that nest success was within the normal range for sage grouse, however, above-average spring precipitation over this period likely increased vegetation growth, resulting in above-average nesting success (Aldridge 2000). Grass height was positively correlated with nest success for both artificial and natural sage grouse nests (Aldridge and Brigham 2000c, Watters et al. 2000), suggesting that habitat management could benefit both sage grouse productivity and chick survival (Aldridge 2000).

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).

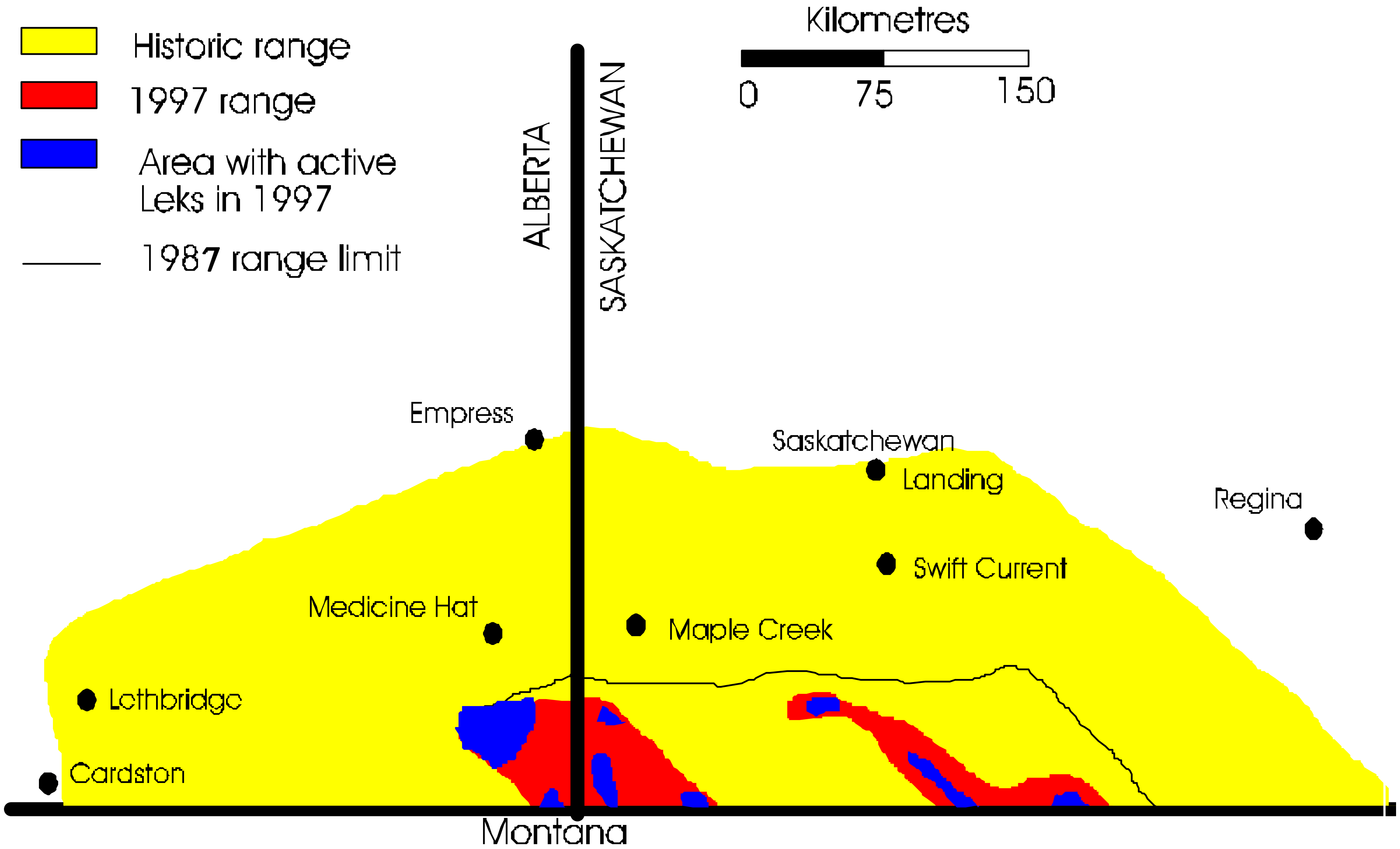

Figure 2. Range of sage grouse in Canada. Historical range is based on anecdotal sightings of birds prior to the 1960s. The present (1997) range is based on the locations of known active leks in 1997. The 1987 range limits are shown to illustrate the range contraction.

OBJECTIVES

The purpose of this research was to continue to gather long-term population data on the sage grouse population in southeastern Alberta. Specifically, the first objective was to monitor the population status through lek counts to evaluate a population model that I developed as part of my M.Sc. thesis research at the University of Regina. I also tracked the females that I had affixed transmitters to in the summer of 1999 to generate an estimate of overwinter survival of females for 1999/2000. The second major objective was to attach additional transmitters to females and assess reproductive activities to obtain a better understanding of the variability inherent in each measure of productivity. The third major objective was to perform a preliminary study to assess the high levels of chick mortality which previous research suggested is a population bottleneck. To accomplish this, I conducted a pilot study that would allo w me to develop a technique to suture micro-transmitters to chicks. I first developed a protocol with chicken chicks. The goal of this experiment was to develop the technique so as to reduce the handling time and risk of complications that could potentially occur using the technique on sage grouse in the field. The intent was also to monitor whether the transmitters imposed any constraints on young birds, and whether any infections, or aggressive behaviours towards whick with transmitters occurred. If the technique proved successful, I would do a pilot project on sage grouse chicks in the field.

STUDY AREA

The study area is about 4,000 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 2000). The prairie in this region is essentially flat although it is interrupted by vast coulees that lead to numerous small creeks and ephemeral water bodies.

METHODS

Lek counts were conducted from 03 April to 31 May at all previously known sage grouse leks to obtain population estimates. Birds 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 only to females.

Once released, sage grouse were tracked using a 5-element Yagi antenna and an R-1000 scanning telemetry receiver (Communications Specialists, Inc. Orange, CA). Birds were located using triangulation techniques until visually observed. Females were located and observed every other day during the nesting period (Musil et al. 1994, Schroeder 1997, Aldridge 2000) in order to allow for nest fate to be determined. When approaching a nest, I remained at least 30 m from the nest site (Aldridge 2000). Nest locations were recorded in Universal transverse Mercator coordinates (UTMs). Nest fate was determined and various measures of reproductive success were estimated (see Aldridge 2000). Nest success was estimated as the percent of all nests that hatched ≥ 1 egg. Breeding success was estimated as percent of females that hatched ≥ 1 egg during a single breeding season (first or renest). Fledging success was estimated as the percent of females that had a brood survive ≥ 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 Aldridge 2000). At each nest site, the percent sagebrush canopy coverage, as well as the percent cover of grasses, forbs, non-palatable forbs (to sage grouse), other shrubs and bare ground/dead materials was estimated within a 1 m^2 quadrat using a method similar to Daubenmire's (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 (Aldridge 2000). 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 (Aldridge 2000). 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'.

I followed radio-collared birds throughout the spring and summer to determine habitat use. Each week, females, with or without broods were tracked (Musil et al. 1994, Schroeder 1997, Aldridge 2000) and the same habitat measurements described for nest sites were performed. Brooding females were not intentionally flushed until chicks were at least three weeks of age, and then brood flush counts were performed to estimate chick survival when females were located. I captured two chicks from each brood and fitted each with a transmitter.

To attach transmitters, I inserted one sterile 20-guage needle perpendicular to the dorsal midline between the wings. A 5-0 non-absorbable sterile surgical suture was fed through the needle and then the needle was removed. I repeated this procedure with a second needle about 1 cm further posterior along the midline. I then fed each suture through the front and rear of the transmitter, respectively. A surgical square knot was tied in each suture. I made sure I did not tie the suture too tight, leaving about 1 cm between the transmitter and the chick, to allow for growth. I applied a small drop of Skin-Bond surgical adhesive (Smith and Nephew Inc., Largo, FL) between the transmitter and the chick's back before tying the sutures to ensure that the transmitter and sutures did not catch on any vegetation. Chicks were triangulated every second day, to determine if they were still together with the hen. If signals were separated, I would locate the chick radio-signal to determine if the chick was still alive. Before the weekly flushing of each brood to estimate chick survival, I moved close enough to observe the radio-collared chicks. I attempted to capture tagged chicks approximately every 2 weeks to inspect the transmitters.

Chicken Experiment

In March, prior to heading to the field, I performed a preliminary pilot study to practice attaching transmitters to chicken chicks under the supervision of the University of Regina's veterinarian. Twenty chicks were randomly selected from 30,000 chicks at O and T Farms (Regina, SK). Ten randomly chosen chicks received transmitters, and 10 were controls. Transmitters were sutured to the 10 treatment chicks, and the each control chick was handled for the same time that the paired treatment chick was handled during the procedure. All chicks were placed in a separate pen in the large holding barn, and provided with food and water. The birds were observed daily by local staff to ensure that food and water did not run out.

RESULTS

Chicken Experiment

The mass of birds in treatment and control groups of chicks was measured every 4-6 days. However, the chicks escaped from their holding pen after approximately 6 days, and joined the other 30,000 chicks in the barn. Since the control chicks were unmarked, they could not be re-measured to compare growth (mass) to chicks with transmitters. The chicks with transmitters were recaptured and weighed at the end of the experiment (16 days). Treatment chicks averaged 463 ± 24.7 g, comparable to the mean growth for all chicken chicks at the farm. None of the chicks showed any signs of infection or bleeding, and the feathers were growing in normally beneath the transmitter. One of the two sutures came untied on two of the first five chicks fitted with transmitters. I had improved my suturing techniques and reattached these two transmitters, and had no problem with the second group of five chicks that I fitted with transmitters. Thus, I was given permission from the University of Regina's Animal Care committee to use the technique on Sage Grouse chicks.

Population Trends

Lek counts in 2000 were conducted from 3 April to 31 May. High counts over the strutting period resulted in a maximum number of 140 males being counted on 8 active leks in 2000 (Fig. 3). This was the same number of males counted in 1999. Despite the decrease in population numbers from the mid 1980's, counts have remained relatively stable over the last seven years (Fig. 3). All historical lek locations were checked for signs of use, and the same 8 leks that were actively used in 1999, were used in 2000. However, at one lek, only one male was ever observed at that lek, suggesting that it may not be active in 2001.

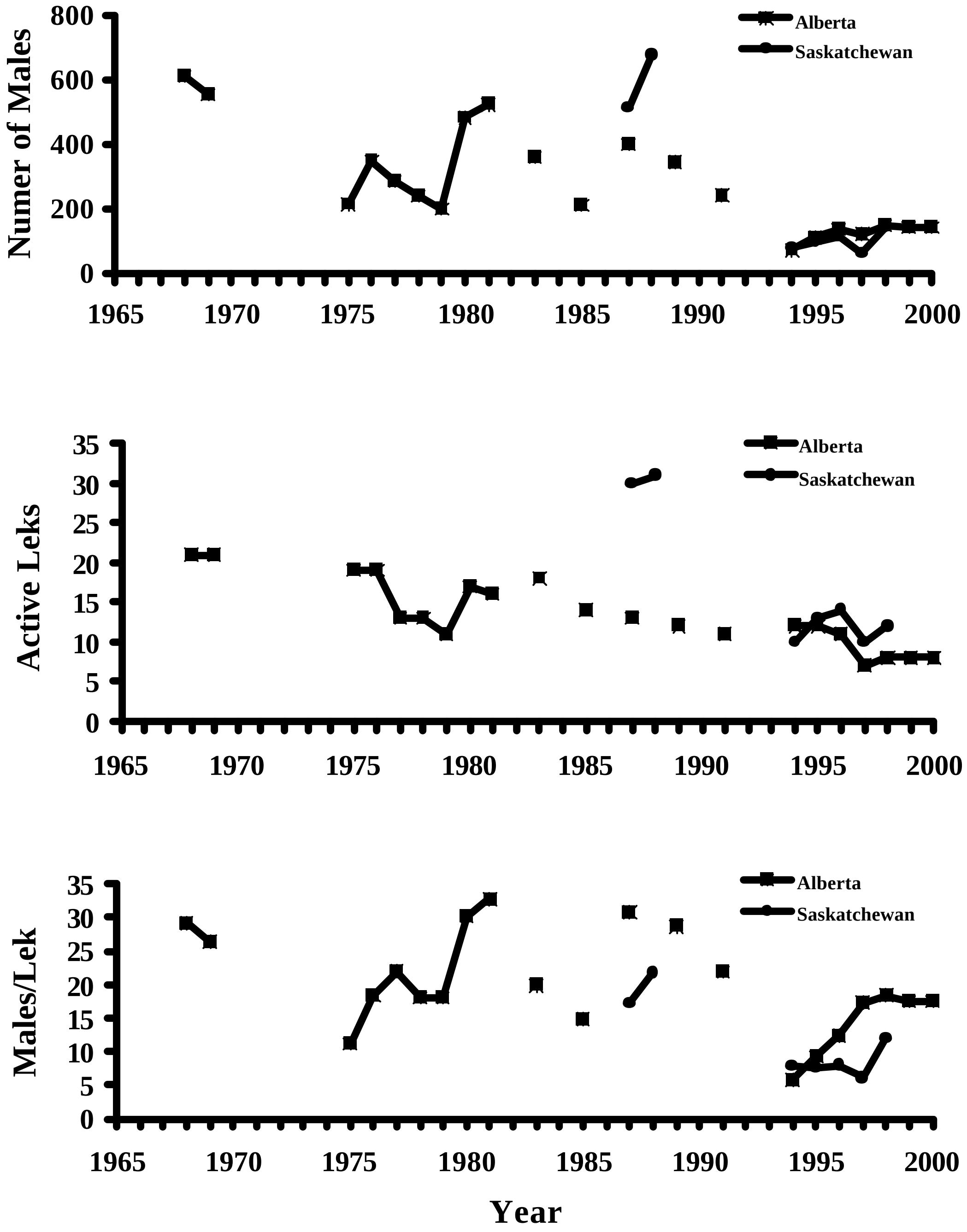

Figure 3. Population trends for sage grouse in Alberta and Saskatchewan over the past 33 years. Shown as the number of males, number of males per lek, and number of active leks. Years when sampling efforts consisted of less than eight surveyed leks were not included.

Captures

I captured a total of 17 males (11 adults and 6 yearlings) and 20 females (17 adults and 3 yearlings) during the 2000 breeding season (Table 1). Of the 37 captures, 24% were yearlings. I affixed radio transmitters to 15/20 captured females (12 adults and 3 yearlings). One additional yearling female captured in mid-summer received a transmitter, but was later killed by a predator. I was able to locate the radio signals of 16 different females that I had radio-collared in 1999. Only 31% of those females 5/12 adults (42%) and 0/4 (0%) yearlings survived over the winter. Survival was not age dependent ($X^2_1 = 1.67$, $P = 0.2$).

Table 1. Body mass for birds captured in the 2000 breeding season in Alberta and the number of birds that received radio transmitters. Standard Error is shown in brackets.

	Adults		Yearlings	
	Males	Female	Male	Female
Captures	11	17	6	3
Mass	3044 (46.9)	1618 (20.8)	2623 (115.0)	1443 (78.4)
Radios	0	12	0	3

Reproductive Activities

Including the 5 females radio-collared in 1999, I tracked 20 females at the beginning of the 2000-breeding season. Forty-five percent of females (3/3 yearlings and 6/17 adults) died prior to or during the breeding. Breeding season mortality was independent of age ($X^2_1 = 2.27$, $P = 0.13$). Of the remaining 11 females, I was able to locate nests for 10 individuals. The one female that I could not find a nest for, did display localized movements, and more than likely initiated a nest that was quickly destroyed.

I was unable to relocate five females after their first failed nesting attempt, four of which were a result of transmitter difficulties. Thus, excluding the two successful females, only 33% of females (1/3) attempted to renest. Nest success was 20% (2/9 first nests and 0/1 renest). Breeding success was 28%, with 2 of 9 females successfully hatching at least one chick. Clutch size (0 = 6.9 eggs ± 3.2; independent of nest order) ranged from 5 to 8 eggs for 10 nests. Of the two successful nests, incubation lasted 27 and 28 days, and 93% (13/14) eggs hatched.

Chick Transmitters

I captured four sage grouse chicks and sutured a transmitter to each; two from each of the two broods that I was tracking. Eggs at these two nests hatched before I had received transmitters, and as a result, I did not put the transmitters on the chicks until about 2 weeks of age (Table 2). Transmitters weighed 1.6 g, and represented 1.54% of the mean mass of 2 week-old chick (Table 2). In the first brood, a canid predator killed one of the radio-collared chicks at 5 weeks of age (3 weeks after capture). The other tagged chick was the last survivor of the brood, but was killed at about 11 weeks of age. Both radio-collared chicks of the second brood survived past the age of independence (50 days) and were still together with the mother and three other siblings at the end of the summer (12 weeks of age). One of these chick's transmitters had failed, but the chick was still observed with the brood and it's transmitter was still attached. Several attempts to recapture this chick failed, due to my inability to locate it. I did manage to capture the second chick, a male, and removed his transmitter and equipped him with a full-sized necklace style radio transmitter. It was difficult to recapture chicks every two weeks to inspect transmitters. I was able to observe the chicks weekly. Transmitters became covered by feathers after approximately two weeks, and the antenna was camouflaged beneath the feathers on the back of the chick. Excluding the chick killed three weeks after capture, I recaptured the other 3 tagged chicks an average of two times. None of the recaptured chicks showed any signs of bleeding, infection, or scaring, due to the transmitters or sutures. The glue appeared to keep the transmitter tight to the chicks' backs for several weeks, preventing the transmitters from snagging on vegetation.

Table 2. Age and mass of the four Sage Grouse chick captured and fitted with micro-transmitters. Standard error is shown in brackets.

Chick	Age (Days)	Mass	Transmitter Mass (g)	Increase in Mass
1	17	112	1.4	1.42 %
2	18	132	1.4	1.21 %
3	14	80	1.4	2.00 %
4	14	104	1.4	1.54 %
Mean	15.8 (1.0)	107 (10.8)	1.4	1.54 % (0.17)

Fledging success based on all females that attempted to nest was 20% (2/10 females). Fledging success calculated for successful breeders only would be 100%, as both females that were successful nesters raised at least one chick to 50 days of age. Chick survival to 50 days of age was 46% (n = 13) but this was only based on chicks from two broods. The single chick from one brood that was alive at 50 days of age was later killed at approximately 11 weeks of age.

I gathered vegetation data at 12 Sage Grouse nest locations. I also gathered habitat information for 23 different brood rearing locations used by the two brooding females throughout the summer. I continued to gather vegetation data for broodless females, and performed 27 vegetation measurements at summer foraging sites for broodless females. This data will supplement previous data that I have gathered on habitat use and will be analyzed in conjunction with future data gathered for my Doctoral research.

DISCUSSION

The population model that I developed based on my M.Sc. research predicted that the Alberta sage grouse population should decline in 2000 (Aldridge 2000). The model suggested that the population should decrease from a spring estimate of 420 to 622 individuals in 1999, to between 397 and 598 individuals in 2000 (Aldridge 2000). Thus, the number of males attending leks in 2000 was predicted to decline from 140 males to 132, respectively. I counted 140 males on leks in 2000, the same number that I counted in 1999. I estimate the 2000 Alberta spring sage grouse population to have remained at between 420 to 622 individuals. Low population estimates are based on a 2:1 female:male sex ratio. High estimates also assume that only 90% of all leks are located, and that only 75% of all males attend leks (Aldridge 2000).

While my model is useful for predicting the general population trends, caution needs to be used when predicting the actual population size, especially when all of the assumptions of lek counts are considered (Braun et al. 1977, Jenni and Hartzler 1978, Aldridge 2000). Each parameter in the model is highly variable, and a better understanding of the variability inherent in each parameter is needed to understand the population variability.

This model assumes that female over winter survival is 100%, as I did not have any data on female overwinter survival at the time. Female survival over the winter is assumed to be relatively high (Schroeder et al. 1999), and thus, estimates for female winter mortalities were considered to be only slightly conservative. However, female overwinter survival from 1999 to the spring of 2000 was only 31% (5/16 females). When combined with the previous spring to fall female survival estimate of 56.5% (Aldridge 2000), annual female survival is estimated at only 17.5%. The reason(s) for this low survival rate are unknown, considering the mild winter, and the fact that the population remained relatively stable in 2000 (Fig. 3). However, sample sizes are low and my survival estimates, based on a limited number of tagged birds, may not be representative of the population.

From 1998 to 1999, 25% of 96 captured birds were yearlings, suggesting that yearlings were under-represented in the population and that low recruitment was related to the population decline (Aldridge 2000). Capture data from the spring of 2000 were similar, with yearlings comprising only 24% of 37 birds (Table 1). Nest success (20%) was lower in 2000 than in previous years (46% for 1998/99, Aldridge 2000). Breeding success ranges from 15-70% for sage grouse throughout their range (Schroeder et al. 1999), but in Alberta, was only 28% in 2000, compared to 56% in 1998/99. However, sample sizes are small, as I was only able to follow 10 nests from 9 different females throughout the 2000-breeding season. Mean clutch size for sage grouse typically ranges from 6-9 eggs (Patterson 1952, Connelly et al. 1993, Anonymous 1997, Schroeder 1997, Schroeder et al. 1999). Clutch size in 2000 was 6.9 eggs per nest, which is lower than previous estimates for Alberta (7.75 eggs, Aldridge 2000). It was an extremely dry winter and early spring, which may have limited food resources that are important to pre-laying hens (Barnett and Crawford 1994), limiting clutch size.

The chicken experiment allowed me to learn the appropriate technique to attach transmitters to sage grouse chicks. The transmitters did not have any visible negative effects on the chicken chicks. There were no complications of using this suture technique on sage grouse chicks in the field. It allowed me track the survival of individual chicks, and locate the remains of chicks when they were killed. I only put 4 transmitters on chicks, due to the limited number of broods. However, the main purpose of this experiment was to validate the technique to understand the factors related to chick survival. I think that the technique was successful, and these transmitters will be useful in the future to help understand factors related to chicks survival.

Overall, although my 2000 data are based on small samples sizes, they illustrate the variability in productivity that may occur within the population. To better understand the Canadian sage grouse population requirements, we need to address the variability in productivity and survival, and understand the factors that may regulate them.

CONTINUED RESEARCH

I will be expanding my project on this research as part of my Ph.D. at the University of Alberta under Dr. Mark S. Boyce. The overall goal of this research is to relate habitat characteristics to measures of productivity and survival, and ultimately, population size. I will use resource selection functions (RSFs) to develop statistically rigorous habitat models (Manly et al. 1993). I will then measure population parameters to link these habitat models to population models and conduct habitat-based population viability analyses (Boyce and McDonald 1999).

Specific Objectives include:

1) Implement experimental grazing manipulations to decrease grazing intensity on native prairie in SE Alberta. These manipulations will be designed to increase the residual grass cover and litter cover, and result in better moisture retention and forb growth.
2) Continue to monitor the population through spring lek counts and trapping efforts.
3) Monitor all aspects of sage grouse life history (reproductive effort, reproductive success, recruitment, and survival, focusing on females and chicks).
4) Model the population based on these parameters.
5) Assess habitat use at various life history stages using RSFs (specifically nesting and brood rearing periods and possibly at wintering areas).
6) Understand the effect of habitat manipulations; how sage grouse respond to/use them (selection of nests/brood sites within manipulations; nest success/chick survival).
7) Assess chick survival (hatch to fledge); overwinter survival (estimate recruitment).
8) Develop habitat use/probability maps to aid in habitat management for sage grouse.
9) Develop a habitat-based population model for sage grouse.

To ensure that the RSF models capture the complete range of vegetation variables that are available for selection by the birds, and for management purposes, I will work with local ranchers, Alberta Environment, and Alberta Agriculture to implement experimental grazing treatments. These manipulations will decrease the grazing intensity, particularly in important mesic habitats, and increase the amount of residual cover while providing added concealment for nests, and escape cover for adults and broods, allowing me to build grazing effects into my habitat models. The design of these treatments will depend on the participation of individual landowners, and site-specific range assessments, which are currently being performed. The link with population viability analysis will allow me to evaluate the consequences of management alternatives on the long-term probability of sage grouse extinction in Alberta.

To understand how habitat quality can affect brood survival and fledging success, we need to better understand chick survival. This has not been monitored for sage grouse previously, and the causes of reduced recruitment in all grouse populations are poorly understood. Each year, I will capture and affix radio transmitters to approximately 40 females from six of eight known leks, and locate their nests using standard radiotelemetry techniques (Aldridge 2000). I will monitor nest success, capture broods of successful females, and fit two chicks from each of 15 broods with micro-transmitters. These chicks will be tracked until they fledge, at which time I will recapture them and attach a full-size transmitter to juvenile sage grouse, tracking them through the following year's breeding season. Depending on chick survival, I might have to capture additional juveniles to obtain suitable sample sizes. This will allow me to estimate recruitment rates, as well as understand how chick survival in conjunction with other measures of reproductive success (nest success, breeding success etc.) relate to observed population declines.

I will use logistic regression to analyse resource selection by sage grouse at several different levels. I will compare fourth order selection (micro-scale level; Manly et al. 1993), using vegetation characteristics at nest sites and brood rearing locations, compared to those available at random sites within the study area. I will also compare third order selection (Manly et al. 1993) using a GIS to investigate habitat characteristics of all nests associated with each lek site compared to random points generated in the GIS surrounding each lek. I will analyse third order selection (Manly et al. 1993) of brood rearing locations by estimating an RSF for each female, comparing brood sites to available sites within each females home range with data from a GIS. Lastly, I will investigate second order selection (macro-level selection; Manly et al. 1993) of both nest and brood rearing sites in a GIS compared with available sites across the whole range of sage grouse in Alberta. From these models, I will be able to generate probability maps based on habitat suitability for sage grouse, which will be used to manage the landscape, and maintain or improve habitat for sage grouse and other species of concern. The effect of the grazing manipulations will be compared across these models using the selection and use, nest success, and survival of sage grouse within the manipulated areas compared with those outside of these areas.

Variables compared in models will include cover and height of vegetation classes, including: sagebrush - important for cover and as a food resource; palatable forbs - limiting for chick survival; grass - important for concealment and protection; as well as litter accumulation and vertical and horizontal obstruction measurements. Density of disturbances such as roads, oil pump stations, pipelines, fences and power lines will also be measured, and I will index the relative density of ground squirrels surrounding nest sites (a common nest predator; Aldridge 2000, Watters et al. 2000). I will also gather data on insect population densities using pitfall traps surrounding brood rearing locations, because insects are extremely important to the survival of young sage grouse (Aldridge and Brigham 2000c, Johnson and Boyce 1990).

A habitat-based population viability model using RSF's (Manly et al. 1993, Boyce and McDonald 1999) will entail modeling habitat selection and suitability, and thus, habitat requirements and population requirements of sage grouse in Canada (Manly et al. 1993). Ultimately, I will be able to evaluate the response of sage grouse to the grazing treatments. This will allow for sagacious management strategies to be undertaken to increase and/or improve important habitats limiting to sage grouse. My goal is to assess the effect of the grazing manipulations on the survival and productivity of sage grouse, and thus the population's status in Canada. Sage grouse are sensitive to disturbances, and thus can be considered an indicator species of the health of the prairie ecosystem. Understanding habitat use by sage grouse and developing management strategies from a landscape approach will benefit many other species at risk. Once I have developed predictive models, I can potentially apply them to sage grouse in other areas, and to other species within similar ecosystems. Other declining and less sensitive prairie species will also benefit from these proposed experimental manipulations.

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LITERATURE CITED

Aldridge, C. L. 2000. Reproduction and habitat use by sage grouse (*Centrocercus urophasianus*) in a northern fringe population. M.Sc. thesis, University of Regina, Regina, SK. 109 pp.

Aldridge, C. L. and R. M. Brigham. 2000a. Status and distribution of sage grouse in Canada. Submitted to Can. Field Nat. 44 pp.

Aldridge, C. L., and R. M. Brigham. 2000b. Nesting and reproductive activities of sage grouse (*Centrocercus urophasianus*) in a Northern Population. Submitted to Condor 29 pp.

Aldridge, C. L., and R. M. Brigham. 2000c. Nesting and brood habitat use by sage grouse (*Centrocercus urophasianus*) in a northern population. Submitted to J. Wildl. Manage. 34 pp.

Anonymous. 1997. Gunnison sage grouse conservation plan. Colorado Division of Wildlife. 108 pp.

Barnett, J. K., and J. A. Crawford. 1994. Pre-laying nutrition of Sage Grouse hens in Oregon. J. Range Manage. 47: 114-118.

Braun, C. E., T. Britt, and R. O. Wallestad. 1977. Guidelines for maintenance of sage grouse habitats. Wildl. Soc. Bull. 5: 99-106.

Braun, C. E. 1998. Sage grouse declines in Western North America: What are the problems? Proc. West. Assoc. State Fish and Wildl. Agencies. 78: 139-156.

Boyce, M. S., and L. L. McDonald. 1999. Relating populations to habitats using resource selection functions. Tree 14: 268-272.

Canfield, R. H. 1941. Application of the line interception method in sampling range vegetation. J. For. 388-394.

Connelly, J. W., R. A. Fischer, A. D. Apa, K. P. Reese, and W. L. Wakkinen. 1993. Renesting by sage grouse in southeastern Idaho. Condor. 95: 1041-1043.

Dalke, P. D., D. B. Pyrah, D. C. Stanton, J. E. Crawford, and E. F. Schlaterer. 1963. Ecology, productivity and management of sage grouse in Idaho. J. Wildl. Manage. 27: 810-841.

Daubenmire, R. F. 1959. A canopy coverage method of vegetational analysis. Northwest Science. 33: 43-46.

Drut, M. S., J. A. Crawford, and M. A. Gregg. 1994. Brood habitat use by Sage Grouse in Oregon. Great Basin Nat. 54: 170-176.

Giesen, K. M., T. J. Schoenberg, and C. E. Braun. 1982. Methods for trapping sage grouse in Colorado. Wildl. Soc. Bull. 10: 223-231.

Jenni, D. A., and J. E. Hartzler. 1978. Attendance at a sage grouse lek: implications for spring census. J. Wildl. Manage. 43: 46-52.

Johnsgard, P. A. 1983. Grouse of the world. University of Nebraska, Lincoln. Nebraska. 413 pp.

Johnson, G. D., and M. S. Boyce. 1990. Feeding trials with insects in the diet of sage grouse chicks. J. Wildl. Manage. 54: 89-91.

Manly, B. F. J., L. L. McDonald, and D. L. Thomas. 1993. Resource selection by animals: statistical design and analysis for field studies. Chapman and Hall, London, UK.

Musil, D. D., K. P. Reese, and J. W. Connelly. 1994. Nesting and summer habitat use by translocated sage grouse (*Centrocercus Urophasianus*) in central Idaho. Great Basin Nat. 54: 228-233.

Patterson, R. L. 1952. The sage grouse in Wyoming. Sage Books, Denver. 341 pp.

Schroeder, M. A. 1997. Unusually high reproductive effort by sage grouse in a fragmented habitat in North-Central Washington. Condor. 99: 933-941.

Schroeder, M. A., and C. E. Braun. 1991. Walk-in traps for capturing greater prairie-chickens on leks. J. Field Ornithol. 62: 378-385.

Schroeder, M. A., J. R. Young, and C. E. Braun. 1999. Sage grouse (*Centrocercus urophasianus*). *In* The Birds of North America, No. 425 (A Pool and F. Gill, eds). The Birds of North America, Inc. Philadelphia, PA. 28 pp.

Sveum, C.M., J.A. Crawford, and W.D. Edge. 1998. Use and selection of brood-rearing habitat by sage grouse in south-central Washington. Great Basin Nat. 58: 344-351.

Watters, M. E., C. L. Aldridge, and R. M. Brigham. 2000. The effect of vegetative characteristics on the fate of artificial sage grouse nests. Submitted to Ecoscience 23 pp.

APPENDIX A

A list of all

Publications, Presentations, Invited Seminars, and Media Stories

Emanating from Sage Grouse Research.

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

Publications

Theses

Aldridge, C.L. 2000. Reproduction and habitat use by sage grouse (*Centrocercus urophasianus*) in a northern fringe population. M.Sc. thesis, University of Regina, Regina, SK. 109 pp.

Watters, M.E. 2000. The effect of Vegetative characteristics on predation of artificial sage grouse (*Centrocercus urophasianus*) nests. B.Sc. Thesis, University of Regina, Regina, SK. 30 pp.

Seida, T.L. 1998. The influence of vegetative characteristics on predation at artificial sage grouse nests. B.Sc. Thesis, University of Regina. Regina, SK. 26 pp.

Articles submitted to refereed journals

Aldridge, C.L. and R.M. Brigham 2000. Status and distribution of sage grouse in Canada. Can. Field Nat. 44 pp. (July 2000).

Aldridge, C.L., S.J. Oyler-McCance, and R.M. Brigham. 2000. Occurrence of two sage X sharp-tailed grouse hybrids in Alberta. Condor 14 pp. (July 2000).

Watters, M.E., **C.L. Aldridge**, and R.M. Brigham. 2000. The effect of vegetative characteristics on the fate of artificial sage grouse nests. Ecoscience 23 pp. (July 2000).

Aldridge, C.L., and R.M. Brigham. 2000. Nesting and reproductive activities of sage grouse (*Centrocercus urophasianus*) in a Northern Population. Condor 29 pp. (Aug. 2000).

Aldridge, C.L., and R.M. Brigham. 2000. Nesting and brood habitat use by sage grouse (*Centrocercus urophasianus*) in a northern population. J. Wildl. Manage. 34 pp. (Oct. 2000).

Other refereed contributions

Aldridge, C.L. 2000. The Status of the sage grouse (*Centrocercus urophasianus urophasianus*) in Canada. Proceedings of the 5th Prairie Conservation and Endangered Species Workshop. J. Thorpe, T.A. Steves, and M. Gollop *eds*. Provincial Museum of Alberta Natural History Occasional Paper. 24:197-205.

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.

Non-refereed contributions

Aldridge, C.L. 1999. Reproductive ecology of sage grouse in Canada. Unpubl. Report. Prepared for 1999 Sage Grouse Funding Partners. Department of Biology, University of Regina, Regina SK. 38 pp.

Aldridge, C.L. 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.

Presentations

Scientific Meetings

Aldridge, C.L. 2000. The decline in the Canadian sage grouse population: Is lack of reproductive effort involved? 23rd Western States Sage and Columbian Sharp-tailed Grouse Workshop. Redmond, Oregon.

Aldridge, C.L. 2000. Conservation ecology of sage grouse in Canada. 34th Prairie Universities Biological Symposium. (PUBS). Regina, SK.

Aldridge, C.L. 2000. Reproductive ecology of sage grouse (*Centrocercus urophasianus*) in Canada. Alberta North American Waterfowl Management Biodiversity Conference. Edmonton, AB.

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. Edmonton, AB.

Invited Seminars

Lecture – ENCS 464 (Endangered Species Conservation and Management) – "Conservation Ecology of Sage Grouse In Canada" Oct. 2000

Guest Speaker – Alberta Chapter of the Wildlife Society – "Conservation Ecology of Sage Grouse In Canada: Understanding the decline of an Endangered Species" Sept. 2000

Cypress Hills Interpretive Center: Invited Lecture Series - "The Strut of the Sage Grouse" June 2000

Lecture – Ornithology and Conservation – University of Calgary – "Sage Grouse; Conservation in Action" Aug. 1999

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

Press Releases Related to
Cameron L. Aldridge's Research on Sage Grouse in Canada

DATE	PRESS RELEASE	AUTHOR	TITLE
Oct., 2000	Discovery Channel Story (on @discovery.ca)	Tom Hince	Sage grouse
Nov., 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	Alberta Report	Les Sillars	Prairie dancers of the sagebrush
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