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A Summary Report on Burrowing Owl (Athene cunicularia) Population Trend Surveys in southern Alberta

Darcy T. Shyry

October 1999

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EXECUTIVE SUMMARY

The Burrowing Owl is listed as an 'endangered' species in Canada by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC 1999). The species is now considered extirpated from both Manitoba and British Columbia, and populations continue to decline in Alberta and Saskatchewan. In Alberta, surveys for Burrowing Owls have been conducted since 1991 near Hanna, and since 1993 near Brooks. These surveys, conducted in permanent blocks, are an ongoing commitment of Alberta Environment to determine the population status of Burrowing Owls in Alberta, in part to fulfil commitments made to the National Recovery Plan for the Burrowing Owl, and to provide information to the Alberta Endangered Species Conservation Committee. Knowledge of the population trend is essential for status designation, and continued population monitoring fundamental to the conservation of Burrowing Owls.

Because of the wide distribution and low density of Burrowing Owls in Alberta, and the large costs and time requirements associated with conducting large scale surveys, the Hanna and Brooks areas were selected to represent the population trend in Alberta. Both the Brooks and Hanna survey areas are within the current distribution of the Burrowing Owl in areas where greater than 50% native prairie habitat remains. The surveys were designed to give a coarse overview of the Burrowing Owl population trend within a scientifically rigorous framework. The number of nests in the Hanna area decreased dramatically from 23 in 1991 to 4 in 1998, while the number of nests in the Brooks area increased from 6 in 1993 to 10 in 1998. When these two data sets are combined for years when the surveys were conducted in the same year, there is an overall decline from 13.03 to 8.04 nests per 100 km^2 between 1993 and 1998. Habitat characteristics such as ground squirrel and badger burrow availability have been incorporated into the survey to try to assess their influence on nesting owls.

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Also, much deserved thanks to all of the landowners that assisted these surveys by allowing access on their land and volunteered their insight. The participation of prairie landowners is, and will continue to be, an essential factor necessary for the conservation of Burrowing Owls in the Canadian prairies.

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INTRODUCTION

Burrowing Owls (Athene cunicularia) show a strong association with native prairie habitat in Canada. This seasonal migrant arrives every spring to the Canadian prairie to breed. Nesting usually occurs in burrows created by ground squirrels (Spermophilus spp.), black-tailed prairie dogs (Cynomys ludovicianus), and badgers (Taxidea taxus). Burrowing owls rely on an abundance of insects, primarily grasshoppers and beetles, and small mammals, primarily deer mice (Peromyscus maniculatus) and meadow voles (Microtus pennsylvanicus), to raise their brood and build up reserves for their long autumn migration. In Alberta, Burrowing Owls reside in the mixed-grass prairie region in the southeast corner of the province.

Conversion of North American native prairie to agricultural cropland or tame pasture has reduced the mixed-grass prairie to 33% of its original extent (World Wildlife Fund 1989). In Alberta, the Mixed Grass Ecoregion comprises almost 12% of the province, of which more than half has been significantly altered by agriculture in the last 100 years (Strong and Leggat 1992). This direct loss of nesting habitat is one of several contributing factors to the decline of the Burrowing Owl in Canada.

Burrowing Owls are declining in every historically occupied province of Canada. In Manitoba and British Columbia, the Burrowing Owl is essentially extirpated (De Smet 1997, Wedgewood 1978, Wellicome 1997). National surveys for the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) show a decline from an estimated 3000 pairs in 1978 (Wedgewood 1978), to 2500 in 1990 (Haug and Didiuk 1991), and 1010-1685 in 1995 (Wellicome and Haug 1995). Although the survey methodology differed in each of these three surveys, the negative trend is supported by other surveys. For example, Operation Burrowing Owl (OBO) in Saskatchewan and Operation Grassland Community (OGC) in Alberta (volunteer private land stewardship programs for the conservation of Burrowing Owl habitat), have provided annual counts of Burrowing Owls on members' land since 1987. Despite a more than 200% increase in the number of OBO members in Saskatchewan, the number of owl pairs has dropped from 721 in 1988 to 88 in 1997 (Operation Burrowing Owl 1997). Although OGC membership has quadrupled in Alberta, the number of owl pairs reported dropped from over 200 in 1989 to less than 100 in 1996 (Wellicome 1997). An analysis of long-term Breeding Bird Survey (BBS) data also indicates there has been a significant (2.19%) annual decline between 1966 and 1994 (Kirk and Hyslop 1998). Finally, three separate derived estimates of the Alberta Burrowing Owl population have indicated a decline that reflects the national and OBO/OGC declines. Estimates of the Alberta population fall from 1500 in 1978 (Wellicome and Haug 1995), to 1000 in 1990 (Haug and Didiuk 1991), and 842 in a census performed on randomly chosen sites in 1994 -1995 (Schmutz 1996).

The Burrowing Owl is now listed as an endangered species in Canada by COSEWIC (Wellicome and Haug 1995) and by the Alberta Wildlife Act as threatened (Province of Alberta 1997). The species has also been given 'Red List' status, noting risk of extirpation in Alberta (Alberta Fish and Wildlife 1991, Alberta Wildlife Management Division 1996). Unless the present trend is halted or reversed, the Burrowing Owl will likely become extinct in Canada within the next two decades (Wellicome and Haug 1995).

The decline of the Burrowing Owl in Canada has stimulated federal and provincial wildlife managers to establish plans to reverse present trends. The Recovery of Nationally Endangered Wildlife (RENEW) Recovery Plan for the Burrowing Owl has seven principal strategies to achieve the goal of establishing 3000 pairs in the Prairie Provinces and a viable population in British Columbia (Hjertaas *et al.* 1995). Strategy Four commits jurisdictions to monitor populations, including the standardization of major data fields between provinces to allow data sharing and the establishment of a system of blocks to monitor population trends biannually using a standardized technique (Hjertaas *et al.* 1995).

Since Alberta and Saskatchewan are the only provinces with viable numbers of owls for recovery, monitoring of the Burrowing Owl population status became the responsibility of these provinces. In Alberta, trend block surveys were developed from previous studies initiated in 1991 (Schmutz and Wood 1991). Trend blocks were established in habitat that contains an excess of 50% native prairie near the Brooks and Hanna districts (see Inset Figure 1). Both survey areas are within the current distribution of the Burrowing Owl in Alberta. Continued monitoring of these standardized survey blocks allows researchers to compare population trends; prior to the implementation of these survey blocks, no standardized survey protocol existed for Burrowing Owls. Five years of survey data from Brooks (1993 to 1998) and Hanna (1991 to 1998) has now been compiled. This report summarizes data from these five years and assesses the consistency of the survey effort within these blocks during that time.

METHODS

A principal problem when conducting population surveys for sparsely and irregularly distributed species is that a large area may be searched and few individuals found. This greatly increases the effort required to gather data on the population status of such species. Counts of individuals may not be the best representation of a population trend for a highly mobile species. Inaccurate trends may be disclosed, as there is always the possibility of recounting individuals. The usual method of ensuring an individual is counted only once is to place separate identification markers on every individual sampled. The intensive effort required to trap Burrowing Owls for individual banding precludes this method of survey. Therefore, the survey protocol was designed to record counts of nests observed in circumscribed quarter sections, although observations of single owls and juvenile owls were also recorded.

1. Trend Blocks - In the Brooks district, survey blocks were comprised of mainly intact native prairie under ownership of the Eastern Irrigation District (EID); 10 survey blocks (K-Block) were located in the northwest and southeast corners of five adjacent townships (Figure 1). These trend blocks were established without prior knowledge of owl presence. Each trend block contains 16 adjacent quarter sections (10.4 km^2) and together incorporate approximately 5% of Wildlife Management Unit 144 (Appendix 1). All 160 quarter sections (103.6 km^2) were surveyed in 1994, 1995, 1997 and 1998. In 1993, 128 quarter sections were surveyed (82.9 km^2).

In Hanna, the 109-quarter sections surveyed were not strictly grouped into survey blocks like Brooks. The Hanna survey blocks were

set up initially as part of an earlier study to evaluate the accuracy of the call playback survey methodology, thus not all sites were selected randomly (Schmutz *et al.* 1993). Of the 109 quarter sections, 32 were chosen because they had supported owls in 1990 and earlier (Schmutz *et al.* 1993). These quarter sections are in Wildlife Management Units 160 and 162. All 109 quarter sections were surveyed in 1991, 1993, 1995 and 1998 (70.6 km^2), while 81 quarter sections were surveyed in 1994 (52.5 km^2) (Appendix 1).

Searches were conducted one quarter section (160 acres = 64.75 ha) at a time by two observers using motorcycles or all-terrain vehicles for transportation. Roadside surveys were previously attempted but only 32% of nests were found whereas motorcycles or quads allowed the observers to locate 92% of the nests (Schmutz and Wood 1991). Quarter sections were chosen because fence lines, roads, and the edges of agricultural fields would delineate some of the quarter section edges.

2. Survey Timing - The timing of the surveys was established to coincide with the highest probability of detecting nesting pairs, or evidence of nesting owls. Burrowing Owls form pair bonds in late April and May. Surveys conducted at this time would be too early in the season to detect established nesting owls. Conversely, surveys conducted after fledging (late July to August) may inflate the number of single owls detected, and give low estimates of nests because some may already be abandoned. Late season surveys are also impeded by decreased visibility because of growth of vegetation during the season. However, the presence of juvenile owls at a nest site enhances the probability of detecting the nest. Personnel planning the surveys considered all potential biases and surveys were conducted in June and July (Table 1).

Table 1. Dates of Surveys.

Year	Hanna	Brooks
1991	July 5 - July 23	No Survey
1993	July 8 - July 23	June 21 - July 20
1994	July 8 - July 15	June 21 - June 28
1995	No Survey	June 19 - July 28
1997	July 14 - July 24	June 7 - June 27
1998	July 2 - July 11	June 17 - June 25

3. Call Playback - Since the cryptically coloured Burrowing Owls nest underground and spend much of their time on the ground, vegetation and landscape features can impede observation during surveys. For this reason the percent visibility between the two observers was approximated at each survey point, and a territorial male Burrowing Owl breeding call (call obtained from the Cornell Laboratory of Ornithology, Ithaca, New York) was used to elicit a response from male owls to enhance the probability of detection. Haug and Didiuk (1993) first showed the effectiveness of call playback for surveying Burrowing Owls. The use of call playback is supported by Schmutz (1994) and Duxbury and Holroyd (1999) who found that 89% and 92% of owl responses could be attributed to the call playback. The pair of observers chose the best elevated vantage-point in the quarter section for observation and a position in the upwind third of the quarter section for call playback of the breeding call. The observers stopped their vehicle at those points and began the survey. With the incorporation of GPS locators, permanent survey points are now being used for each survey. When observers encountered a quarter section that was cultivated, the observers drove the perimeter looking for owls. Approximately 9-10% of the quarter sections surveyed are partially or entirely cultivated, improved pasture, or tame hay.

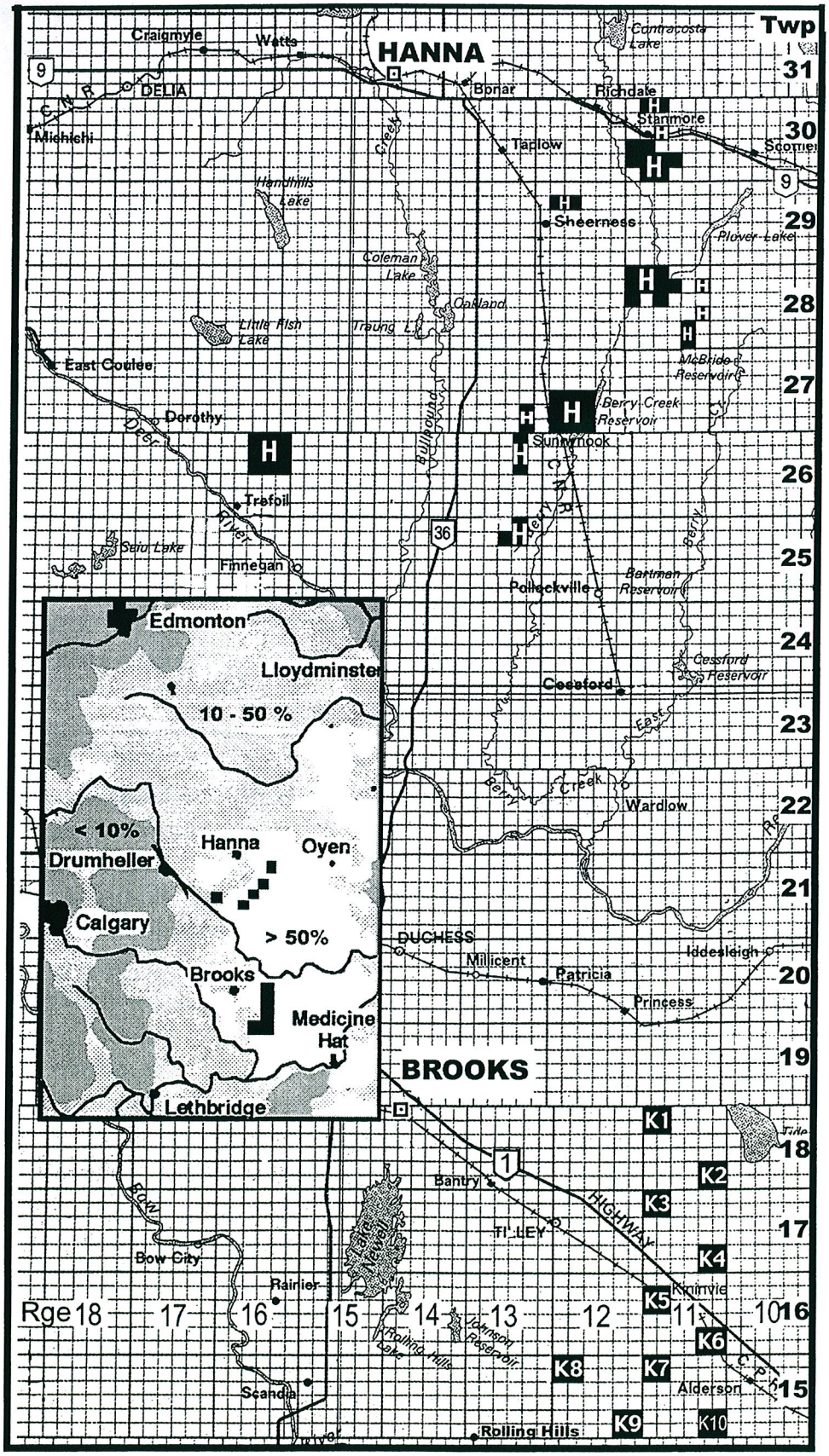

Figure 1. Location of trend blocks in Brooks and Hanna. Inset shows survey areas in respect to remaining native prairie (adapted from Schmutz 1994).

4. Nest Observation - The 15 min observational period was completed in three consecutive 5 min intervals. During the initial 5 min interval, 360° binocular observation allowed for the effect of the vehicle disturbance to recede and for initial observations. The observers then played back a cassette tape with either a repeating breeding call (spaced 20-30 seconds apart) or a continuous call (with breaks to hear responding owls) for the next 5 min while continuing to scan 360°. Continuous call playback may be better at eliciting responses as it reflects the pattern of breeding calls of owls in the wild (D. Scobie, pers. comm.). For the final 5 min interval the observers would continue to scan for possible nests, roosts, and possible sightings. In 1998, the final 5 min scan interval was dropped from the Brooks survey as a time saving measure as most owls were observed in the first two intervals.

Every owl location and potential nest site was recorded and their locations were investigated for evidence of nesting before proceeding to the next quarter section. Ideally, the presence of juvenile owls at a nest burrow was used to indicate an active nest site. Detection of a pair of owls also qualified as a potential nest site as pair bonds usually do not endure unless there is a brood to raise. If only a single owl was observed at a potential nest site, the abundance of nesting material (manure or dung), whitewash, pellets, prey remains present, and the degree to which the soil on the burrow mound was loosened, all qualified the burrow as a nest (Schmutz 1994).

Surveys were not conducted on days with a wind speed greater than approximately 20 km/ hr, since owls stay very low to the ground in the entrance of the burrow under these conditions. Wind also interferes with the breeding call broadcast. The owls tend to exhibit the same behaviour during the hot portions of the day as windy days, so surveys were not conducted during afternoons. It has been suggested that surveys should be limited to mornings between 0600 and 1100, as this is the primary time frame when owls are observed (R. Russell, pers. comm.). Rainy days were excluded from the surveys because the owls are not as observable and access to the sites is limited because of concern for potential damage to roads and native prairie.

5. Burrows - Burrowing Owls in Alberta are dependent on burrows created by fossorial mammals for nesting. To gather data on the availability of burrows, ground squirrel burrow transects were conducted in 1997-1998 in the Hanna survey. The observers followed an 800 m transect line randomly located within the quarter section surveyed, counting burrows 1 m on either side of the line. Information on whether the burrow was currently inhabited by ground squirrels was recorded. It is thought that Burrowing Owls exhibit a preference for ground squirrel burrows that have been excavated by badgers, so additional information on whether the burrow had been excavated by badgers was also recorded.

6. Raptor and Passerine Observations - In order to maximize information gathered during the surveys, incidental observations of several other raptor and passerine species, including potentially threatened species, were recorded in some years. Only records of adults of each species are presented in this report, as juvenile observations are subject to the time of year when they fledge. Baird's Sparrows (Ammodramus bairdii) were recorded visually and acoustically. Because of the subjectivity of the call data in accurately determining the number of individuals, information on Baird's Sparrows is based on presence or absence in each quarter section.

RESULTS

1. Burrowing Owl - Between the first and last year of the survey, the number of nests located in Hanna dramatically decreased while the number of nests found in Brooks increased slightly (Table 2). Since there was less area surveyed in 1994 in Hanna and 1993 in Brooks, estimates based solely on the number of nests located may not accurately reflect the population trend.

Table 2. Number of nests recorded during surveys in Hanna and Brooks.

	1991	1993	1994	1995	1997	1998
Brooks	-	6	2	12	14	10
Hanna	23	14	9	-	2	4

When the number of nests located are adjusted to account for the area surveyed, a trend similar to the changing number of nests is still evident (Figure 2). In Hanna, there is an 82% decrease in nest density from 1991 to 1998, while Brooks shows a 33% increase in nest density from 1993 to 1998. When a linear regression line is added, the nest density in Hanna shows a significant negative trend closely fitting the regression line (P=0.007). Brooks shows a slightly increasing trend, but nest densities do not closely fit the linear regression line, so the population may be stable rather than increasing (P=0.293). Over the five survey years, the average density of nests in Hanna is 15.6 nests per 100 km^2, and 8.8 nests per 100 km^2 in Brooks.

The Hanna and Brooks surveys were combined to give a better indication of the Alberta range-wide population trend. When both surveys were combined for those years when the survey was done in both areas, a negative trend was shown between 1993 and 1998 (P=0.177). The density of nests per 100 km^2 declined 38% over this period, and the average nest density was 9.3 nests per 100 km^2 (Figure 3).

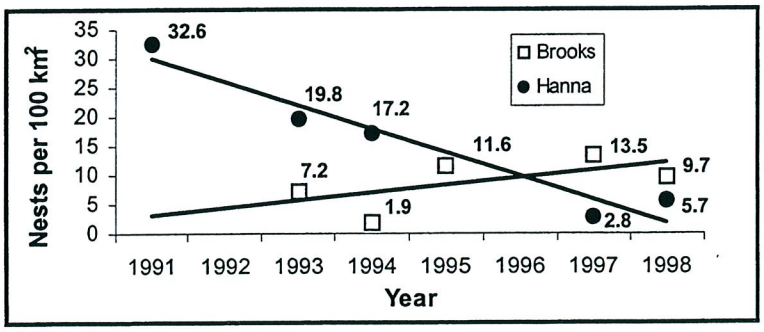

Figure 2. Average number of nests per 100 km^2 with linear regression lines in Hanna (R^2=0.938, P=0.007), and Brooks (R^2=0.351, P=0.293).

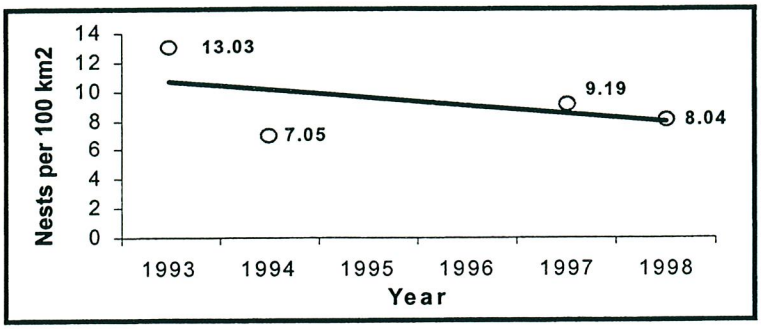

Figure 3. Average number of nests per 100 km^2, with a linear regression line (R^2 =0.677, P=0.177), when Hanna and Brooks are combined for years when both areas were surveyed.

2. Single and Juvenile Owl Observations - The number of single adult owls observed varied between 1 and 3 in Brooks and between 0 and 2 in Hanna for each year. Since every survey year but one has recorded single adult owls there is no clear evidence of a trend. The number of juvenile owls recorded during the survey can only be considered incidental observations because the survey was not designed to quantify reproductive success. To gather reliable information on the number of juvenile owls per nest, it would be necessary to revisit nest burrows for repeated counts as a single observation may miss juvenile owls out of sight in the burrow. Incidental observations of juvenile owls are presented in Table 3. The higher number of juvenile owls observed in Hanna probably resulted from additional visits to confirmed nest sites to recount juvenile owls (T. Wellicome, pers. comm.) and a smaller sample size.

3. Burrows - Since some quarter sections in the survey area are cultivated, and cultivated areas are usually devoid of burrows, not all quarter sections were surveyed for ground squirrel and badger burrows. The number of transects completed in Hanna was 96 in 1997, and 94 in 1998. Although only six nest sites were located in 1997 & 1998, the density of active and enlarged (badger excavated) ground squirrel burrows recorded in the same quarter section as nest sites was more than double the density in all the transects surveyed (Figure 4). This difference may indicate the owls select areas with a higher density of active and enlarged burrows. It is also interesting to note that the two adjacent quarter sections that housed three of four nests in 1998 both had 8 badger enlarged burrows, while the combined average for those two years was 1.2 badger enlarged burrows per transect.

Table 3. Average number of juvenile owls observed per nest site.

	1993	1994	1995	1997	1998
Brooks	1.7 (n=6)	0 (n=2)	1.5 (n=12)	3 (n=14)	1.1 (n=10)
Hanna				5 (n=2)	4.5 (n=4)

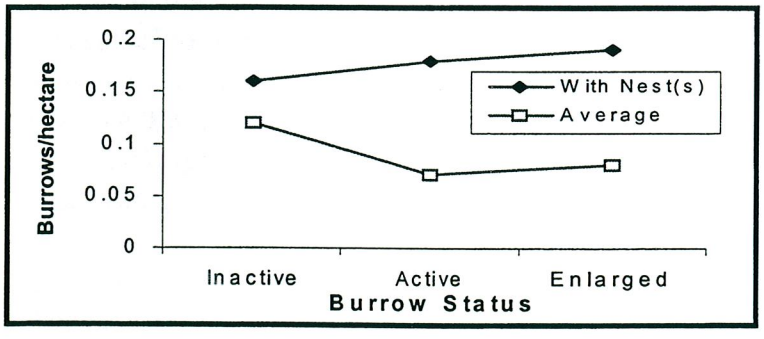

Figure 4. The density of burrows per hectare in Hanna for 1997-1998 for all transects combined (Average), and the density of burrows for transects at the 6 nests sites located in those years (With Nest(s)). Inactive = not currently used by ground squirrels, Active = currently inhabited by ground squirrels, Enlarged = excavated by a badger.

4. Reuse of Nest Burrows - One approach to assist with the recovery of Burrowing Owls is to protect nest burrows especially when the same nest burrow is used from year to year. A nest burrow used over multiple seasons could be considered critical habitat for Burrowing Owls. It is thought that the owls enlarge the nest chamber, which may favour selection of that burrow in future years. In Hanna, nest burrow location data is limited to 1997 and 1998, but no nest burrows recorded in those years were used in multiple years. The low number of nests found in the Hanna survey in 1997 and 1998 reduces the probability of detecting nest reuse. Multi-year use of a nest burrow occurred at four nest burrows in Brooks. One nest burrow was used in 1995 and 1997, another in 1995 and 1998, another in 1997 and 1998, and one burrow was used in 1993, 1994, 1995, and 1998. There are three potential reasons for the reuse of nest burrows. First, the same owl(s) may be using the same burrow in multiple years. Second, the reoccupied burrow is in prime nesting habitat selected for by the Burrowing owls, but used by different individual owls. Finally, it may be a chance occurrence that the same nest burrow was used in multiple years.

5. Raptor and Passerine Observations - There were notable differences shown by the incidental observations of raptors and passerines during the surveys. Short-eared Owls (Asio flammeus) showed more than a ten-fold increase in 1997 in both Brooks and Hanna; a pattern not repeated in 1998. This dramatic increase was probably in response to very high numbers of meadow voles in 1997. Loggerhead Shrikes (Lanius ludovicianus) were not observed in Brooks, while they were observed in Hanna, which may indicate more appropriate habitat in Hanna. Three other interesting observations are that Upland Sandpipers (Bartramia longicauda) and Long-billed Curlews (Numenius americanus) were recorded more often in Hanna as compared to Brooks. Baird's Sparrows were not surveyed during the 1997 and 1998 Brooks survey, as they were downlisted by COSEWIC and are no longer considered a species of concern. As these surveys were primarily designed to record Burrowing Owl nest sites, observations of other species were incidental and should be viewed with discretion. All raptor and passerine observations are summarized in Appendix 3.

DISCUSSION

Accurate estimates of population trends and survey validity result from a standardized survey protocol. The trend block surveys in Hanna and Brooks are some of the first standardized population trend surveys for Burrowing Owls. The results of these surveys can be extrapolated and used to give an estimate of Burrowing Owl densities on a regional basis, and are invaluable for continued monitoring of the population status. Since these two surveys can only be combined for corresponding years, future surveys conducted in the same year for both areas will allow for more accurate population extrapolations within the Burrowing Owl range in Alberta. The trends shown from these surveys are limited by the modest number of years of survey data; five years for Hanna and Brooks individually, four years for the combined surveys. Continual monitoring will increase our understanding of Burrowing Owl population trends and dynamics and the status of Burrowing Owls in Alberta.

It is uncertain if the reduction in the survey area in Brooks in 1993 and in Hanna in 1994 had a substantial effect on the number of nests located during those surveys. Nests had been located in some of the unsurveyed quarter sections during surveys in other years. The 1998 Hanna survey

found three nests in two quarter sections not surveyed in 1994, and so there may be an underestimation in the number of nests for 1994. The two trend blocks not surveyed during the 1993 Brooks survey have not accommodated nests in any other survey year, and so the effect on the number of nests located is probably inconsequential. Although these two blocks are indicative of prairie habitat, they contain low-lying wet areas and improved pasture, and may be less appropriate habitat for nesting owls (R. Russell pers. comm.). Therefore, any underestimation because of decreased survey area is probably limited to the 1994 Hanna survey. Future surveys must make sure all quarter sections are surveyed to ensure comparisons between years are accurate.

It is not believed that eliminating the final five minute interval substantially affected the success of the 1998 Brooks survey. In an assessment of the reliability of roadside surveys using an equivalent three-interval survey with call playback, 96% of owls were detected in the first 10 min (Duxbury and Holroyd 1999). Although there were four fewer nests located in Brooks in 1998 than in 1997, the 4% of owls that may not have been detected would not account for the reduction.

Variation in counts of Burrowing Owls in Alberta occurs because the available habitat is not saturated with owls and the owls are loosely colonial (Schmutz *et al.* 1993). Therefore, there are plots without owls and plots with high numbers of owls. The prevalence of quarter sections where no nests were detected makes analysis of the population trend troublesome at the quarter section level. Additionally, the somewhat colonial nesting nature of the owls increases the variation between trend blocks. In Hanna the nests are fairly well distributed throughout the survey area, but in Brooks, trend blocks K6 through K10 contain 91% of all nests recorded. Even within years the variation is increased because of a large number of nests occurring in one block. For example, in Brooks 1998, one trend block contributed 7 of 13 nests recorded, 6 of which were in a single quarter section. Schmutz *et al.* (1993) found that the variance is minimized when at least 100 quarter section plots are surveyed. Both the Hanna and the Brooks trend survey blocks contain over 100 quarter sections, so trends can be established for each population while attempting to minimize variation.

The dramatic decline in the number of nests located in Hanna between 1991 and 1993 must be viewed cautiously as some quarter sections were initially established with knowledge of owl presence. One can expect that owls will die on the breeding grounds or during migration and disperse outside of the study area, which could initially inflate the estimated decline, but immigration should compensate these losses if the population is stable. It is unlikely that the continued decline in later years results from the biased quarter section selection in 1991. The negative nest density trend is cause for concern because at the current rate of decline Burrowing Owls will disappear from the Hanna survey blocks. The consistently declining nest density may be indicative of the contraction of the northern range of the Burrowing Owl (see Wellicome 1997).

The stable or increasing nest density trend in Brooks is the only population estimate in Canada not showing a negative trend. It is difficult to determine if the density of nests is increasing or stable since the annual nest densities do not closely match the linear regression line. Further investigation and comparison of the population demographics and habitat characteristics of the Brooks area to declining

areas may give clues as to why this population does not appear to be declining while other areas are consistently declining.

Combining the Hanna and Brooks surveys increases the area surveyed, decreases the variability of the population estimates, and gives a better indication of the population trend within the Alberta Burrowing Owl range. As with the 1991 to 1993 Hanna survey, the 1993 combined data may show a greater density of nests than other years because of biased quarter section selection, and could be inflating the rate of decline. Overestimation of the density of nests in 1993 is probably minimal, as two years had passed since the non-randomly selected nests in Hanna were surveyed. The additional area from Brooks would also decrease the impact that biased quarter section selection may have on the nest density estimate by increasing the area surveyed. Although the density of nests does not closely fit the linear regression line, the negative regression trend suggests the nest density will reach zero in fifteen years. The trend evidenced from combining the Brooks and Hanna surveys concurs with negative trends shown by other population estimates such as OBO and OGC. Unless factors contributing to this decline are not halted or reversed, it appears Burrowing Owls may soon be extirpated from Alberta.

As there has not been a substantial change in land use since the start of the survey in either Brooks or Hanna, other reasons for the decline of the Burrowing Owl must be investigated. Increased understanding of productivity and nesting success could be gathered without compromising the current survey protocol. The number of nests that remain active until fledging and the number of juvenile owls at a nest could be compiled from additional visits to nest sites found during the trend block surveys. These additional surveys would increase our understanding of Burrowing Owl population demographics, and would not require the time or expense of the original survey as nest site locations would already be known. The disparity between the average density of ground squirrel and badger burrows near active nest sites and the average density of these features in all survey blocks suggests the density of these features are important to nesting Burrowing Owls. The sample size for this relationship is small (n=6 nests), so additional burrow surveys following the Hanna protocol could resolve the importance of this habitat feature for nesting owls.

Since 10 of 50 nests located during the 1993-1998 Brooks and 1997-1998 Hanna surveys were reused nests, it appears that multi-annual protection of nest burrows may provide some benefit to the conservation of Burrowing Owls. The number of reused nests may be a conservative estimate since the low number of owls returning to nests in Hanna reduces the probability of nest reuse. Protection of nest sites, and the mammals that create them, must be seen as a preliminary step in Burrowing Owl conservation. Nest burrows are a critical factor to ensure nesting sites for the owls, but are a single entity within the required habitat. Preservation of non-nesting Burrowing Owl habitat, such as foraging areas and the elimination of harmful pesticide (e.g., Carbofuran) use near nesting and foraging areas are also crucial to the conservation effort. The validity of these surveys result from the use of qualified personnel who give an equal search effort during every survey. Despite the expertise of the observers, there have been owls found in surveyed areas that were not found during the survey. Owls located after the survey cannot be included in the analysis of the data as they are located outside of the survey protocol and a bias is introduced because of a different search effort.

Therefore, every effort must be made to follow the prescribed protocol every year, for a good survey is not measured by the number of owls located, but by the consistency of the survey between years. Because of the experience of the observers and the difficulty in observing Burrowing Owls, it is more likely that there is an equal probability of missing owls during each survey, and there have been other owls missed that are not known about. Therefore, when the survey protocol is followed, concerns about missed owls or nests are unwarranted, but population extrapolations from the data should be considered a minimum estimate.

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Appendix 1. Land Locations of Quarter Sections Surveyed in Brooks (all West of 4th meridian)

Block	Section	Township	Range	Quarter Sections
K1	29	18	11	NE NW SE SW
	30			NE NW SE SW
	31			NE NW SE SW
	32			NE NW SE SW
K2	1	18	11	NE NW SE SW
	2			NE NW SE SW
	11			NE NW SE SW
	12			NE NW SE SW
K3	29	17	11	NE* NW* SE* SW*
	30			NE* NW* SE* SW*
	31			NE* NW* SE* SW*
	32			NE* NW* SE* SW*
K4	1	17	11	NE* NW* SE* SW*
	2			NE* NW* SE* SW*
	11			NE* NW* SE* SW*
	12			NE* NW* SE* SW*
K5	17	16	11	NE NW SE SW
	18			NE NW SE SW
	19			NE NW SE SW
	20			NE NW SE SW
K6	1	16	11	NE NW SE SW
	2			NE NW SE SW
	11			NE NW SE SW
	12			NE NW SE SW
K7	29	15	11	NE NW SE SW
	30			NE NW SE SW
	31			NE NW SE SW
	32			NE NW SE SW
K8	29	15	12	NE NW SE SW
	30			NE NW SE SW
	31			NE NW SE SW
	32			NE NW SE SW
K9	1	15	12	NE NW SE SW
	2			NE NW SE SW
	11			NE NW SE SW
	12			NE NW SE SW
K10	1	15	11	NE NW SE SW
	2			NE NW SE SW
	11			NE NW SE SW
	12			NE NW SE SW

*Not surveyed in 1993

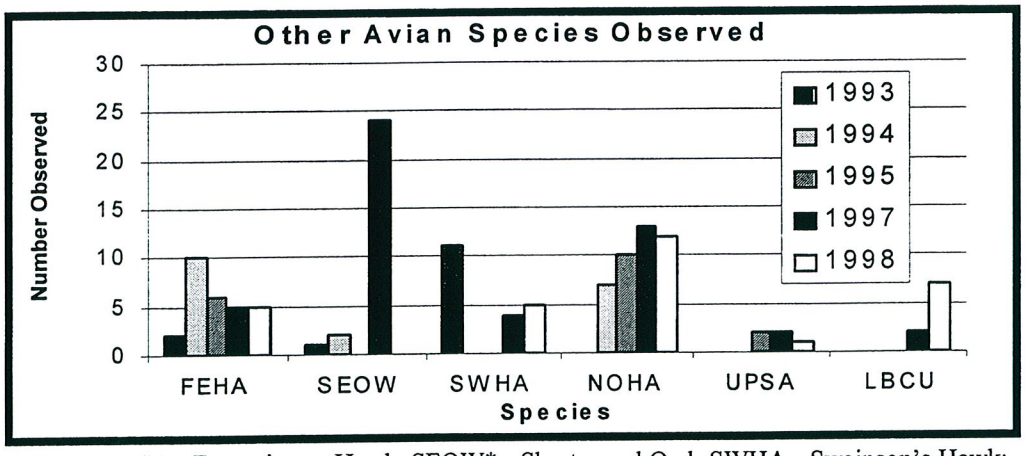
Appendix 2. Land Locations of Quarter Sections Surveyed in Hanna (all West of 4th meridian)

Section	Township	Range	Quarter Sections
26	25	13	NW* SW*
27			NE SE*
35			NW* SW*
23	26	13	NE* NW* SE* SW*
26			NE NW SE SW
35			NE NW SE SW
22	26	16	NE*
23			NE NW*
24			NW
25			SW
26			NW SE SW
27			NE* SE
34			SE
35			NE* NW* SE* SW*
36			NW* SW*
3	27	12	SW*
4			NE NW
5			NE
8			NE SE
9			NE NW SE SW
10			NW SW
15			SW
16			SE SW
17			SE
1	27	13	NE NW
12			SE SW
2	28	11	NE SE
11			NE SE
13			SW
19			NE NW SE
21			SE*
25			NE* SE*
27			SE*
28			NW
29			NE NW SE SW
30			NW SW
31			NE SW*
32			NE NW SE SW
33			NW SW
28	29	12	SE* SW*
29			NW SE SW
4	30	11	NW
5			NE NW SE SW
7			NE SE
8			NE NW SE SW
9			NW* SW*
17			NE NW SE SW
18			NE SE
21			SW
32			NW
33			NW

*Not surveyed in 1994

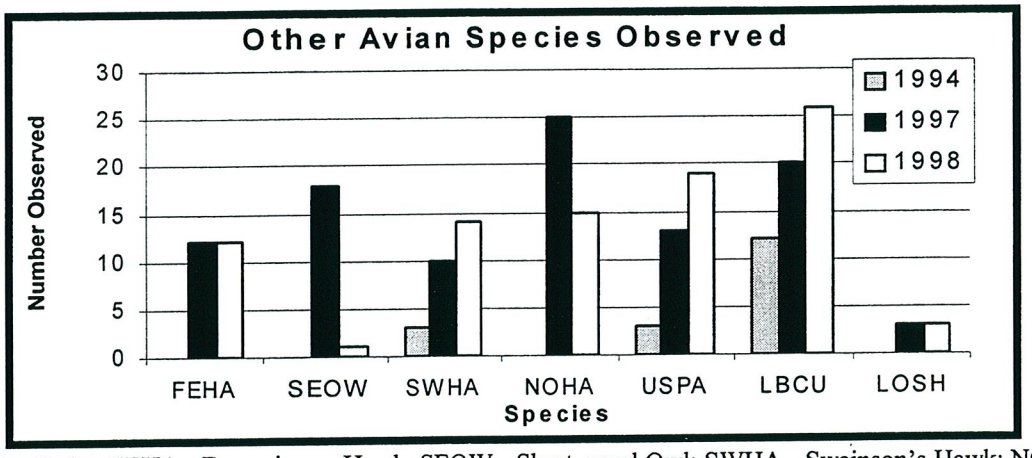
Appendix 3. Incidental Observations of Other Avian Species

A. ***Brooks 1993-1998***



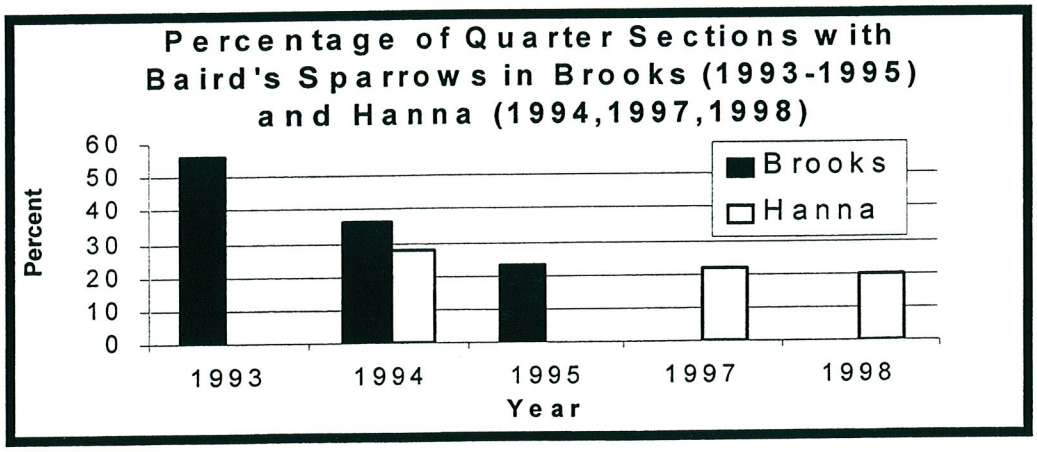
Alpha Codes: FEHA - Ferruginous Hawk; SEOW* - Short-eared Owl; SWHA - Swainson's Hawk; NOHA - Northern Harrier; USPA - Upland Sandpiper; LBCU - Long-billed Curlew

B. ***Hanna 1994-1998***



Alpha Codes: FEHA - Ferruginous Hawk; SEOW - Short-eared Owl; SWHA - Swainson's Hawk; NOHA - Northern Harrier; USPA - Upland Sandpiper; LBCU - Long-billed Curlew; LOSH - Loggerhead Shrike.

C. ***Baird's Sparrow Observed in Brooks and Hanna 1993-1998***



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