# **Breeding Ecology of Wild and Captive-released Burrowing Owls (*Athene cunicularia*) in Southwestern Manitoba.**

By

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## ABSTRACT

Burrowing Owls (*Athene cunicularia*) once occupied grassland ecosystems in the western Provinces of Canada, as far east as Winnipeg, Manitoba, and west into the southern interior of British Columbia (B.C.). No single factor has been identified as causing the decline of the Burrowing Owl in Manitoba nor in Canada, however, multiple, inter-related factors are thought to be responsible for its gradual and persistent decline over the last century. These factors include habitat loss, fragmentation and degradation; considerable changes in land use practices; anthropogenic changes to the prairie ecosystem resulting in the loss of species like America bison (*Bison bison*), Rocky Mountain locust (*Melanoplus spretus*), Black-tailed prairie dog (*Cynomys ludovicianus*); roads and vehicular traffic contributing to increased mortality on summer, migration, and winter ranges; increased mortality and reduced nesting success from increased predation rates; and decreased prey abundance and availability that has lowered productivity and survival. Burrowing Owl population declines have been most noticeable the extremes of their range in both B.C. and Manitoba where precipitous declines have been evident over the last 50 years. Large-scale reintroductions have taken place in B.C. resulting in small numbers of released owls returning annually. Reintroductions of Burrowing Owls were also conducted in Manitoba from 1987-1996, but low overall return rates, combined with continued declines in wild populations eventually led to the program being discontinued. Few Burrowing Owls were detected in Manitoba for the next decade, but a rather sudden and unexpected return of breeding pairs was noticed after 2005 with a resurgence totaling 35 nesting pairs (cumulative total) through 2006-2009. This prompted the development of a current reintroduction and breeding ecology/diet comparison study of wild and captive-released owls in southwestern Manitoba.

In this three year (2010-2012) study, I compared post-emergence/pre-fledging foraging ecology of male adult captive-released and wild owls and related it to clutch size, hatching, and fledging success. I also collected data on adult and post-fledging mortality, burrow re-occupancy and return rates, home-range size and diet. I hypothesized that wild Burrowing Owls would have larger clutches, hatch and fledge more young, have larger home-ranges, and have more of a variety of prey items in their

diet than captive-released owls. First clutches were 37% larger for wild Burrowing Owls than for released owls. Overall, wild owls raised 77% more young than captive-released owls in the first two seasons (2010-2011). Hatching success (number of eggs that hatched in each nest) was variable for captive-released owls from 22% in 2010 to 70% in 2012. Fledging success (young between 35-42 days) was 100% for both groups in all three seasons. Low adult and juvenile post-fledging mortality rates were observed with only three captive-released owl deaths recorded (3 of 47 owls). Wild and captive-released male Burrowing Owls concentrated their movements during the post-emergence/pre-fledging stage near the nest burrow and nearby favoured roosting spots (i.e., fence line posts near roadside ditches and satellite burrow mounds). Diet varied between groups in both biomass and frequency. Captive-released owl pairs had lower frequency of vertebrate prey in their pellets compared to wild owls. Even with less vertebrate remains observed in their diet, biomass percentages were similar to other studies. The greatest threat to both wild and captive-released Burrowing Owl nests during my study was extreme summer storms resulting in the flooding of nests. Eight of 23 first and replacement clutches (35%) containing 62 eggs were lost from flooding.

Despite the small numbers of captive-released and wild owls that were monitored during this study in Manitoba, several results point to captive-released owls readily adapting to the wild and in many respects behaving like wild owls.

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# DEDICATION

This thesis work is dedicated to my husband Colin who has been a constant source of support and encouragement during the challenges of field work and graduate school life. Colin volunteered many hours helping set up release pens, digging burrows, and collecting owl pellets, etc. The list is infinite with what he has done to help me complete my studies and thesis. He is my biggest cheerleader, and I am truly grateful to have him in my life.

This work is also dedicated to my son, Kellan. Kellan is 16 months old and already a mini-ornithologist spending many hours conducting owl surveys and supervising burrow installations for Burrowing Owls in southwestern Manitoba. It is wonderful to see his eyes light up while watching a flock of birds fly by and making "Caa-Caa" noises when he sees a crow. One of Kellan's first words was "Koko" who is the education ambassador Burrowing Owl for the Manitoba Burrowing Owl Recovery Program (a program that I have continued to develop after completing the three field seasons in this study). Koko lives with us full-time and is definitely more than an education owl to us, she is a big part of our family and Kellan absolutely adores her. My hope for Kellan as he grows into a young boy (and man), is that his appreciation of nature and all wild things will continue to flourish.

And last but not least, a big thank you to my parents Raymond and Lorraine Montague who have supported me in all ways since the very beginning of my life and my studies.

# INTRODUCTION TO RESEARCH TOPIC

The short-term goals of this study was to experiment with methods to increase Burrowing Owl populations in Manitoba through reintroductions, to collect data on nesting and foraging ecology, and to identify factors that affect nesting success, productivity, and survival of captive-released and wild Burrowing Owls in Manitoba.

Aspects of nesting that were compared during this study included clutch initiation (timing), clutch size, hatching and fledging success, dispersal patterns, adult and post-fledging mortality during the nesting season, home-range size, foraging movements, post-fledging movements, and diet.

The long-term goal of this study was to evaluate a reintroduction project for Manitoba using recent release techniques to aid in the re-establishment of a self-sustaining Burrowing Owl breeding population in southwestern Manitoba. Data collected during this study will also help facilitate monitoring and recovery for Burrowing Owls beyond the period of the study in both Manitoba and Canada.

# CHAPTER ONE. Introduction

## 1.1 Species Description and Status

The Burrowing Owl (*Athene cunicularia*) is a small (19.5-25.0 cm, 150-180 g), ground dwelling owl, with brown and buff coloured barring on their chests (adults only, young after first year). The Burrowing Owl has long legs, a rounded head with no ear tufts, bright yellow eyes, and is the only owl in North America to nest under the ground. A common misconception is that the species is able to dig their own burrows. They rely upon fossorial mammals, such as ground squirrels, prairie dogs, badgers, and foxes to excavate burrows which the owls modify and use for nesting.

The Burrowing Owl is listed as a species at risk in nine states and in all four western Canadian provinces (Appendix A). The Burrowing Owl was designated as an Endangered species under the Canadian Federal Species at Risk Act in 2003, and its status was confirmed as Endangered upon re-assessment in April 2006 by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) due to severe and ongoing population declines (Environment Canada 2012).

Burrowing Owls once occupied grassland ecosystems in the western provinces as far east as Winnipeg, Manitoba and west into the southern interior of British Columbia (B.C.). The wild Burrowing Owl population in B.C. was extirpated by the early 1980s. Presently, large-scale reintroductions continue at three locations in the southern interior in B.C. Many of the captive-released owls have successfully hatched and fledged young with several returning from migration in subsequent years. With this said, the Burrowing Owl population in B.C is yet to be self-sustained (Mitchell et al. 2011).

The furthest eastern extent of the Burrowing Owl range in Canada is in Manitoba. In recent decades, the species range has contracted from southeastern Manitoba and near Winnipeg to the southwestern corner of the province (De Smet 1992, 2003). Currently, the largest Canadian concentration of Burrowing Owls are found in Alberta and Saskatchewan, but here too they have greatly declined in numbers and range (Appendix B) (COSEWIC 2006).

## 1.2 Distribution and Population Trends

### *Canadian Trends*

It has been difficult to measure the population size and precise trends for the Burrowing Owl in Canada (Environment Canada 2012). Though substantial declines are evident based on historical nesting numbers, the methods used to estimate the total owl population have varied from early reports to present day and have varied from province to province (Environment Canada 2012). Large-scale standardized surveys are difficult to complete for such a rare and rather difficult species to survey. However, localized survey efforts have occurred across all three Prairie Provinces since the 1980s (Environment Canada 2012).

The Canadian Burrowing Owl population was estimated at approximately 3,000 pairs when the species was initially assessed as Threatened in 1970 (Wedgwood 1979). In 1995, concerted landowner surveys estimated the population of Burrowing Owls in Canada at 1,015-1,695 individuals which resulted in the species being reclassified as Endangered under COSEWIC (Wellicome & Haug 1995). Widespread surveys in all western provinces during 2004 detected a further decline to 795 individuals (288 Alberta, 498 Saskatchewan, 9 B.C., and 0 in Manitoba). These counts, however, are likely all minimum estimates. It is difficult to quantify numbers of undetected or unknown owls (Environment Canada 2012). There are several factors that may limit the numbers of Burrowing Owls located during surveys, including limited or no access to some of the suitable habitat where owls roost or nest, and a general reluctance of landowners to report nesting Burrowing Owls in fear of land-use restrictions or land expropriation associated with species at risk. Landowners also tend to distrust researchers and often hold mistaken beliefs that Burrowing Owls that do not return in subsequent years have been negatively affected by surveys and research, whereas return rates for undisturbed pairs are low as well (Wellicome et al. 2014). Overall, the Burrowing Owl population in Canada has declined by approximately 63% since the early 1970's and the breeding range has contracted substantially along its northern extremes, but particularly in its western and eastern extent (B.C. and Manitoba) (Environment Canada 2012).

### *Western Canadian Studies*

Burrowing Owls disappeared from B.C. in the early 1980's (Leupin & Low 2001). Reintroduction efforts occurred from 1982-1988. Adult owls were captured and translocated from stable populations in Washington and Oregon and hard-released[1] in the Okanagan region (Leupin & Low 2001). This reintroduction showed little success with no owls returning after migration. Through an improved soft-release[2] methodology, 1,031 adult owls have been released and have successfully fledged over 1,880 young from 2005-2015 (Mitchell 2008; Lauren Meads, personal communication, 2015). The B.C. population of Burrowing Owls has yet to recover to pre-1980 levels and continued releases are required to sustain the recovery; 219 released owls have returned after migration to release sites from 2005-2015 (a return rate of 7.5%) and reintroduction efforts are continuing throughout this region (Lauren Meads, personal communication, 2015).

Large-scale studies have examined challenges facing the Burrowing Owl population in both Saskatchewan and Alberta (Haug 1985, Wellicome 1997, Shyry et al. 2001, Sissons et al. 2001, Sissons 2003, Poulin & Todd 2003, Poulin et al. 2006). Haug's 1982-83 observations on the Burrowing Owl's breeding ecology south of Saskatoon, Saskatchewan, was the first major insight into breeding activities and productivity in Canada. Since then, there have been several studies focused on limiting factors contributing to Burrowing Owl trends in Saskatchewan including Wellicome's 1994-1996 study on the effects of predator exclusion and food supplementation. The Regina Plains study area (near Moose Jaw and Regina) is one of the longest running, continuously monitored sites in Canada for Burrowing Owl observations which have

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[1]Hard-release method: Animals receive no aid prior to or after release and are expected to adjust to the wild environment immediately.

[2] Soft–release method: Animal receive some assistance with adjusting to post-release conditions. This assistance may include pre-release training, supplemental feeding, or temporary housing at the release site (Mitchell 2008).

included studies on the effects of habitat fragmentation (Warnock 1995), post-fledging survival of young (Todd et al. 2003), and assessment of feasibility for reintroductions from 1997-2002 (Poulin et al. 2006).

Recent research in both Saskatchewan and Alberta has included studies on the influence of vegetation and anthropogenic development (petroleum) on foraging behaviours, the role of temperature and precipitation on survival, and the effects of climate change on present and future Burrowing Owl populations (Scobie et al. 2013, Fisher & Bayne 2014, Marsh et al. 2014, Fisher et al. 2015). Presently, most wild Canadian Burrowing Owl occurrences and breeding takes place in southern Alberta and Saskatchewan, with small, highly fragmented populations persisting in southern Manitoba.

### *Manitoba Trends and Studies*

Historical records for Burrowing Owls are limited in Manitoba. The species historically occurred east of Winnipeg (De Smet 1997, 2003). Ongoing declines since the 1930's have been attributed to habitat loss and fragmentation due to the expansion of agriculture and a trend towards larger farms. During the mid-1970s, an initial status report for Canada came up with a rough estimate of 110 pairs of Burrowing Owls in Manitoba (Wedgwood 1979). Increased public awareness and requests for reports from landowners by the Department of Natural Resources led to the detection of 76 pairs in 1982, but within two years that number dropped to 35 known nesting pairs (Ratcliffe 1986).

More widespread and extensive surveys for Burrowing Owls in southwestern Manitoba began in 1987, with only 14 pairs and 6 individual wild Burrowing Owls detected (De Smet 1992). This year also saw initial attempts to release Burrowing Owls in Manitoba with juveniles from the Owl Research and Rehabilitation Foundation in Ontario being released north of Winnipeg, near Oak Hammock Marsh. During these initial years, the program focused on expanding overall surveys and monitoring of suitable habitat at former nesting locations throughout southern Manitoba, installation of over 200 artificial nest burrows (ANBs), and expanded public/landowner education and involvement in monitoring and management efforts (De Smet 1992, 1997).

After 1988, releases of juvenile and some adult owls were expanded to include locations in southwestern Manitoba near Lyleton and Broomhill. From 1988-1991, owls for release were obtained from the Owl Research and Rehabilitation Foundation in Ontario and roadside burrows near Regina, Saskatchewan (until 1990), and from larger family groups in prairie dog colonies in southwestern North Dakota (1991) (De Smet 1992, 1997). Releases involved holding the owls in release pens for approximately 7 days until they were familiarized with the release area (De Smet 1992, 1997). Despite successful releases, only one juvenile returned to nest in the study area during these five years. In 1992, the program was modified and one-year old owls, all from the Owl Research and Rehabilitation Foundation in Ontario were released (De Smet 1997). As before, a soft-release technique was employed in all but one year (1995) when a few owls were hard-released and all disappeared the day after release. No returns of young or adults from the release sites in following seasons combined with poor nesting success and low return rates of wild pairs in later years led to the discontinuation of releases after 1996 (De Smet 1997).

Artificial nest burrows (ANBs) reduce predation of young and nesting adults (De Smet 1997, Wellicome et al. 1997). Over 200 ANBs were installed in suitable pastures in southwestern Manitoba from 1987-1996 (De Smet 1997). ANBs during these years consisted of a 19 l buried plastic bucket (the nesting chamber), a 3-4 m section of 15 cm diameter weeping tile attached through a hole in the side of the bucket (which served as the burrow entrance), and a post or mound at the entrance. After 1993, several wild nests in Manitoba were carefully dug up and transferred during egg-laying to an ANB with no abandonments and all nests produced young. Several adult owls that returned to Manitoba selected ANBs over hundreds of available natural burrows in these same pastures. Much higher rates of nest re-occupancy of ANBs (n=27; 44%) were noted than for natural nests during these years (n=152; 13%), emphasizing a preference for ANBs over natural nests (De Smet 1997).

Extensive monitoring efforts, surveys, and enhanced public awareness, which included a mail-out of a brochure and insecticide alert, newspaper articles, several TV and radio appearances, involvement of local interest groups and landowners, and information booths throughout 1987-1996 increased landowner interest, reports of owls, and detections on surveys. Target survey results were encouraging from 1989-1992 with 103 nests located including one released juvenile male from 1990 observed nesting in 1991 (De Smet 1992). By 1993, the nesting population stabilized somewhat at 23 wild pairs; however, severe summer storms and cool temperatures that year resulted in unusually low nesting success (see also Fisher et al. 2015). A decline was anticipated in 1994 due to wet conditions and poor breeding success in 1993, however the observed decline from 23 pairs to 8 was much greater than expected. With additional wet summer conditions and low productivity in 1994 and 1995, Manitoba's Burrowing Owl populations continued to plummet; by 1996 the species had been virtually extirpated from the area (De Smet 1997).

Though the overall goal of recovery for Manitoba's population of Burrowing Owls was not achieved through the 1987-1996 monitoring and management efforts, a great deal of valuable information and data were collected on nesting success, limiting factors, territory re-occupancy rates, movements, and return rates of banded adults and juveniles which informed population models (De Smet 1997, Wellicome et al. 2014). For instance, it was revealed that successful wild nest sites were more than three times as likely to be re-occupied the following year (28 of 122) as unsuccessful wild nest sites (4 of 57). Adult males were also noted to return more often to the general study area and also displayed a much greater tendency to return to the same nest (51%) or to within 1 km of their former nest site (94%), as opposed to females (33% and 56% returned to the same nest or within 1 km, respectively). However, only 3.5% of 538 banded juveniles from wild nests returned to the study area, and none returned to their natal territories. Thus, there was no evidence of juvenile (male and female) natal fidelity.

Although surveys of former nesting areas and follow-up on all Burrowing Owl reports in Manitoba were continued after 1996, research and management efforts were largely discontinued (K. De Smet, personal communication, 2010). After the resurgence of 35 nesting pairs in southwestern Manitoba from 2006-2009, the present study was initiated in 2010 to gain further insight into existing and emerging threats for wild pairs, and to explore alternative reintroduction techniques that could augment Manitoba's wild Burrowing Owl population.

## 1.3 Limiting Factors and Threats

No single factor has been identified as causing the decline of the Burrowing Owl in Manitoba or elsewhere in Canada; however, multiple, inter-related factors are thought to be responsible for its rapid decline.

The ultimate cause for Burrowing Owl declines is likely related to habitat loss and degradation. Housing and farming expansion, road development and energy exploration have eliminated much suitable habitat for Burrowing Owls throughout its nesting, migratory, and winter range. Habitat changes and fragmentation have also allowed for predators to move into areas where they once were not as common (Environment Canada 2012).

Unlike other North American owls, the Burrowing Owl is ground dwelling, making the owls susceptible to a variety of mammalian predators. Burrowing Owls use abandoned burrows from various fossorial mammals, like Prairie Dogs (*Cynomys)***,** Ground Squirrels (*Sciuridae*), Badgers (*Taxidea taxus*), Red Fox (*Vulpes vulpes*) and Coyote (*Canis latrans*). Though Burrowing Owls rely heavily on these burrowing animals for breeding sites, some of these same animals are major predators (i.e., badgers, foxes). In recent years, reduced ground squirrel and prairie dog populations, caused by both disease and pest management/poisoning, has also contributed to reduced availability of burrows for the owls (Environment Canada 2012)

The proliferation of roads throughout the range of the Burrowing Owl also poses a hazard to the species. Roads reduce the quantity and quality of habitat and increase mortality rates (through vehicle collisions) of Burrowing Owls that favour the use of burrows and fence posts along roadside ditches to hunt where prey items occur at higher frequencies (Haug 1985, Ratcliff 1986, Clayton & Schmutz 1999, Sissons 2001, Todd 2003).

Increased predation and periodic or long-term food shortages are two other key factors that limit survival of many birds and other animals (Martin 1992, Wellicome

1997, Rosenberg & Haley 2004). Proximate factors such as prey availability and habitat fragmentation have also been noted to affect survival rates of young and adults returning in subsequent seasons (Haug 1985, Wellicome et al. 1997, Rosenberg & Haley 2004, Wellicome et al. 2013). The Burrowing Owls diet consists of both vertebrate and invertebrate prey (Green et al. 1993, Gervais et al. 2000, Haug et al. 2003, Poulin 2003). Analysis of pellets regurgitated by Burrowing Owls during the breeding season reveal that insects, such as grasshoppers and beetles, outnumber vertebrate prey eaten by adults, nestlings, and recently fledged juveniles (Leupin & Low 2001, Poulin 2003, Sissons 2003, Shyry 2005, Mitchell 2008, Floate et al. 2008).The use of insecticides and farming activities (i.e., plowing and irrigation) reduces insects. Prior to first noted declines in Burrowing Owl populations in Canada (1930s), the Rocky Mountain locust was rapidly eradicated from the Great Plains and is now extinct (Lockwood 2004). Grasshoppers, when available, compose a large part of the Burrowing Owl's diet. There are no known records of pellet dissections for Burrowing Owls during the years the Rocky Mountain locust were ubiquitous, however, because Burrowing Owls consume thousands of insects annually, are generalists (eat a variety of prey (Environment Canada 2012), and are known to consume grasshoppers, it would be reasonable to suggest that the loss of the Rocky Mountain locust would have negatively impact Burrowing Owl populations.

Migration and winter mortality is difficult to measure for long-distance migrants with low nest-site fidelity. As a result, Burrowing Owl migration has not been thoroughly studied. The added stress of attaching a tracking device on small animals like the Burrowing Owl has limited research of this nature. Select migrations studies using geolocator devices have recently focused on Burrowing Owls from Washington State, Oregon, and Saskatchewan (D. Johnson, unpublished data). Geolocators are less than 4% of an adult Burrowing Owl's body mass. These small devices measure and stores ambient light level data in a time series in their internal memory. Such data allows estimates of the time of sunrise and sunset, which by conversion, can be translated to latitude and longitude, on a daily basis. The devices must be retrieved from the marked owls to collect this data. Though research on migration has been successful using satellite markers on larger birds and raptors, including Osprey (*Pandion haliaetus*), Bald Eagles *(Haliaeetus leucocephalus),* and Peregrine Falcons (*Falco peregrinus*), the size and the weight of the

Burrowing Owl limits this type of tracking (Martell et al. 2001,Gahbauer 2008, Mandernack et al. 2012).

Data on migration and movements for Manitoba Burrowing Owls is based on recoveries and recaptures of banded Burrowing Owls. De Smet (1997) found that only 3.5% of banded wild young ever returned to his southwestern Manitoba study area, whereas 32.7% of wild adults returned. Return rates were higher for wild adult males (40.2%) than wild adult females (24.4%). Returning male owls were also much more inclined to use the same nesting location than returning female owls. Young of the year showed very little natal fidelity, as the average post-migration summer home-range for 18 returning juveniles was 32 km from their natal site (range 1-77 km) during 1987-1996 (De Smet 1997, Wellicome et al. 2014).

Low overall return rates for both wild and reintroduced adult and juvenile owls in Manitoba (1987-1996) suggested that low nesting-area fidelity or increased year-round mortality of young and adults may have been a factor in the decline of the species in Manitoba.

## 1.4 Knowledge Gaps

The following items have been identified as important knowledge gaps needed to conserve or recover Burrowing Owls in Canada (Environment Canada 2012).

1. Locations of the majority of Burrowing Owl nests in Canada;
2. Survival rates of Burrowing Owls at life stages for which adequate data currently do not exist (i.e., juveniles during migration, adults during all seasons);
3. Extent and impact of between-year dispersal by juveniles and adults;
4. Quantitative habitat associations of Burrowing Owls, at multiple scales, during all seasons;
5. Quantitative assessments of any relationships between habitat loss and population decreases;
6. Best methods, numbers, and distribution for release of captive-bred owls to establish a self-perpetuating population in British Columbia and Manitoba;

7. Effects of a variety of environmental contaminants on reproduction and survival during breeding and non-breeding seasons;
8. Migratory routes used and winter range of “Canadian” owls; and
9. Improved survey methods for both breeding and wintering populations.

A collaboration of private, government, and university biologists and researchers across the species year-round range (breeding, migratory, and winter) is needed to better understand how and why these factors limit the species overall survival.

## 1.5 Legislation

Both federal and provincial legislation protects Burrowing Owls and other species at risk across Canada. Two main components of the federal species at risk process includes an assessment by the Committee of the Status of Endangered Wildlife in Canada (COSEWIC) and then listing under the Species at Risk Act (SARA) when warranted.

The Burrowing Owl was officially listed as Endangered under the SARA in June 2003, and its status was confirmed as Endangered upon re-assessment in April 2006, largely due to significant population declines. The national recovery strategy for the Burrowing Owls in Canada lists several long-term and short-term recovery goals and a list of objectives focused to conserve Burrowing Owl populations across Canada (Environment Canada 2012).

The long-term recovery goal for the Burrowing Owl is to reverse the population decline in Canada and maintain a self-perpetuating, well-distributed population of at least 3,000 breeding pairs within the four western provinces. The short-term (i.e., 5-year) population and distribution objectives for this Recovery Strategy is to achieve the 2004 estimated population size (800 pairs) and distribution including:

1. Developing an improved understanding of environmental and demographic factors associated with annual changes in Burrowing Owl population size;
2. Identifying and implement protocols that mitigate factors contributing to population declines;

3. Identifying, maintaining, enhancing, and increasing breeding and foraging habitat;
4. Optimizing nesting success, fledging rate, and survival on the Canadian breeding grounds;
5. Assessing feasibility to re-establish wild breeding populations of Burrowing Owls within their historical range in British Columbia and their 1993 range in Manitoba;
6. Encouraging management, conservation, and research of Burrowing Owls and the habitats they use, during each season, in the United States and Mexico; and
7. Engaging with land holders and land managers about conservation actions to assist in in the recovery of Burrowing Owls.

The Manitoba Endangered Species and Ecosystems Act and SARA work in collaboration with each other. The purpose of the Manitoba act is to protect and to enhance the survival of endangered and threatened species and ecosystems in the province, enable the reintroduction of extirpated species into the province, and to use the best available data to designate species and ecosystems as Endangered, Threatened, or Extirpated. The Burrowing Owl was listed as Endangered in 1992 by regulation under Manitoba's Endangered Species Act (Province of Manitoba).

Recovery strategies and action plans are drafted, under SARA and the Manitoba act, to outline long-term and short-term goals at both national and provincial levels. Goals for Manitoba include re-establishing wild breeding populations within the species historical range and 1993 Burrowing Owl population levels; approximately 23 pairs (Environment Canada 2012). Further work and research directed to knowledge gaps are relevant to all provinces and are extremely important to address and understand the species limitations in all jurisdictions as we cannot assume limitations are equal in all areas where the species occurs.

### 1.6 Recovery and Conservation

The grasslands of North America have been largely degraded by human development and are among the most imperiled ecosystems in the world. The Mixed

Grass Prairie biome extends to the southwestern corner of Manitoba. This unique habitat supports a variety of grassland species that are, for the most part, only observed in the extreme southwest corner of the province (Lindgren & De Smet 2001). The loss, fragmentation, and degradation of the Mixed Grass Prairie over time coincides with decreases in many grassland dependant species and in some cases, imminent threat of extirpation from the province. The Burrowing Owl is indeed among the most endangered of grassland birds in Manitoba.

Recovery of species at risk can be a slow process but reintroductions have shown success for several species including the Peregrine Falcon (*Falco peregrinus*) and Whooping Crane (*Grus americana*). Reintroductions alone cannot recover a species threatened by extirpation or extinction. There are numerous factors that need to be addressed with endangered species recovery work. At a minimum, basic ecological requirements would need to be met to allow for a reintroduced species to thrive. This would include available habitat and prey, protection from predators or opportunities for predator avoidance, and suitable and available nest burrows.

**1.7 Thesis Overview**

My study had three main goals. First, I assessed the feasibility of a modified reintroduction method in Manitoba using recent successful release and food supplementation techniques employed elsewhere in Canada (Wellicome 2000, Poulin et al. 2006, Mitchell 2008, Mitchell et al. 2011) to promote nesting success, recruitment, survival, and return rates of Burrowing Owls.

Earlier research in Manitoba noted much higher return rates and nest re-occupancy for successful wild Burrowing Owl pairs than for unsuccessful pairs (De Smet 1997). This was the basis for encouraging released owls to nest and releasing successful breeders at the end of the season to increase nest-site philopatry during my study. My reintroduction research also took additional steps to encourage overall nesting success by using a soft-release technique to increase the overall success of pairs and nests (De Smet 1997, Poulin et al. 2006, Mitchell 2008, Mitchell et al. 2011), removing the release pens only after a nest was established with three or more eggs to promote a pair bond and reduce abandonments (Poulin et al. 2006), and by providing food supplementation until the young had emerged from the nests (Wellicome 2000, Rosenberg & Haley 2004, Wellicome et al. 2013).

A second aspect of my research was to collect data on the current breeding ecology for both captive-released and wild owl populations in Manitoba. This enabled me to compare and contrast these two groups and provided up-to-date information for future recovery and mitigation efforts. Data collected included nest initiation, clutch size, hatching and fledging success, home-range size, adult and juvenile mortality rates on the breeding grounds, and natal and post-breeding dispersal timing and rates.

Third, I collected data on activity bursts and movements around the burrow, foraging behaviours, and habitat use for wild and captive-released nesting male Burrowing Owls. I also collected data on diet (based on pellet dissections) for both adult and juvenile owls. Home-range and prey use have not been previously examined in Manitoba.

### 1.8 Thesis Predictions and Implications

The current project collected data on nesting, foraging behaviour, diet, home-range, survival, dispersal, return rates, and evaluated the feasibility of a long-term captive-release program to re-establish a healthy, self-sustained population of Burrowing Owls in Manitoba.

I predicted that captive-released owls that were held for an extended time (until a three-egg clutch was observed) in soft-release pens would be more likely to continue egg-laying after release and have increased success of young hatching and fledging during the breeding season. This, in turn, would increase the likelihood of adults returning to Manitoba in subsequent years, thus, increasing Burrowing Owl populations.

Captive-released owls were overwintered (held back from migration) and provided with supplemental food until young emerged from the burrow at approximately 10-14 days, I predicted they may be less motivated to forage further away from their burrow than wild owls. Therefore, captive-released owls would have smaller home-ranges and less diversity in observed prey items in pellets. Both diet and home-range have been researched elsewhere in Canada but not in Manitoba previously. The information gathered in my study has important implications for future reintroduction efforts in Manitoba and throughout the historical range of the Burrowing Owl. Assessing a modified release technique and collecting current breeding ecology data from wild and captive-released populations will allow for a better understanding of current and emerging threats Burrowing Owls are facing in Manitoba. This will aid in their recovery and will provide guidelines for continued Burrowing Owl and other recovery reintroduction programs.

**CHAPTER TWO. Breeding ecology and diet of captive-released and wild Burrowing Owls (*Athene cunicularia*) in southwestern Manitoba, Canada.**

## 1) INTRODUCTION

The Burrowing Owl (*Athene cunicularia*) is listed as Endangered in Canada and provincially across the western provinces. There is no single factor that explains the decline of this species, but five limiting factors appear to most profoundly affect their status and survival. These limiting factors include: 1) habitat loss, fragmentation, and degradation; 2) loss of burrows; 3) road development (including increased mortality due to vehicle collisions); 4) increased predation; and 5) overall decreases in prey abundance or availability (Environment Canada 2012).

Burrowing Owl populations in Canada, but particularly in British Columbia (B.C.) and Manitoba have declined sharply in the last 50 years, with B.C. being at the northwestern limit and Manitoba at the northeastern extent of their range in Canada. In Manitoba, Burrowing Owls formerly occurred as far north as Dauphin and east of Beausejour. They regularly nested near Winnipeg until the 1980s (De Smet 1997, 2003). In recent years, the species Manitoba range has contracted to the southwestern corner of the province with very few reports outside of this area.

Reintroduction of Burrowing Owls has taken place in B.C. since the early 1980s when the species was extirpated from the province. This effort has three release facilities currently conducting captive breeding and release programs. The success of these programs is evidenced by the return of captive-released owls to B.C. after migration (Burrowing Owl Conservation Society of B.C., Mitchell et al. 2011).

In Manitoba, reintroductions conducted from 1987-1996 included releases of both young owls (owls born in that season) and one-year old owls (born in the previous season) obtained from the Owl Research and Rehabilitation Foundation in Ontario, and young transplanted from Saskatchewan, and North Dakota (De Smet 1992, 1997). Owls were generally held in pens and released after 7 days using a soft-release technique. Hard-releases were employed during only one year and were found to be largely unsuccessful. Weekly and bi-weekly monitoring of nesting pairs was conducted by provincial government staff and by landowners. Reintroductions in Manitoba were part of a larger monitoring and recovery effort which examined the limiting factors affecting nesting success and survival, nest and territory re-occupancy, return rates, and movements of banded adults and juveniles (De Smet 1997). Reintroductions were discontinued in 1996 due to poor overall return rates of owls to Manitoba after migration, but limited monitoring and management efforts for the species were continued. From 1997-2006, few Burrowing Owls were observed and the population was believed to be on the verge of extirpation from Manitoba until nesting populations inexplicably rebounded in 2006.

One of the biggest proximate factors that lead to a noticeable decrease of Burrowing Owls during the above study were decreased nesting success and productivity associated with increased mid-summer precipitation from 1992 (De Smet 1997). Although conditions were still slightly wetter than normal in 2006-2009, 35 nesting pairs were located during these four years. Typical productivity was observed, with successful pairs rearing an average of 4-6 young (K. De Smet, unpublished data). This resurgence of Burrowing Owls in southwestern Manitoba prompted the development of the present study designed to compare the breeding ecology and diet of the wild owl population to a captive-released owl population.

## 2) METHODS

### *Release Site Selection*

Five sites (Figure 1) were selected on private land for reintroduction of Burrowing Owl pairs and individuals in southwestern Manitoba between 2010 and 2012. All release sites were pastureland (native and tame) and were grazed by cattle throughout the late spring and summer months. Sites were selected based on proximity to recent Burrowing Owl observations and nests in recent seasons (2006-2009) and availability of suitable habitat for Burrowing Owls (i.e., open pasture, no trees or shrubs, and land with ample ground squirrel populations or burrows). Permission for property access, to release owls, and to observe wild owls throughout the nesting season was granted from all landowners.


**Figure 1.** Release and nesting sites for captive-released Burrowing Owls (*Athene cunicularia*) in southwestern Manitoba (2010 to 2012)**.**

Orange: Used in 2010 through 2012; Blue: Used for releases in 2010; Purple: Used in 2012.

### *Captive-released Burrowing Owls*

The founding population consisted of 2009 hatch-year juveniles which included four wild-hatched juvenile owls removed from two larger family groups in southwestern Manitoba (two females and two males); two captive-hatched juvenile owls produced by a non-releasable pair from the Assiniboine Park Zoo (one female and one male); and four captive-hatched juvenile owls from the Alberta Birds of Prey Centre in Coaldale, Alberta (two females and two males). Founding owls were transferred to release sites in mid-May, placed in release pens, and paired for nesting. Owls were intermixed and paired according to where they originated (i.e., Manitoba wild, Birds of Prey Centre (AB), or

Assiniboine Park Zoo (MB)) to avoid breeding related owls (Appendix C1). All founding owls were released if they fledged at least one young.

### *Artificial Nest Burrow Installation and Release Site Preparation*

In mid-May of each season, 2.4 m x 2.4 m release pens were set up at release sites. Pens were constructed of a wooden frame with chicken wire (outside) and mesh/bird netting (inside) (Figure 2). Pens were fenced off with a small section of electric fencing so that grazing cattle would not rub against the pens. In 2010, half of the top of each pen was covered with a section of plastic fencing and the other half with a section of plywood to allow for some shade. The plywood was replaced with plastic fencing in 2011 and 2012 as it was suspected that the plywood contributed to the collapse of two release pens during strong winds (>100 km/h) in 2010. Anchor ropes were also added in 2011 and 2012 to further secure the pens from extreme winds and storms. Each pen was equipped with an artificial nest burrow (ANB), 60 cm high wooden post for perching, and a Reconyx wildlife camera that recorded activities at the nest entrance 24 hours per day (Figure 3).

ANBs used at release sites consisted of a 2.5-3 m length of 15 cm wide, corrugated weeping tile leading to a 19 l plastic bucket that served as the nest chamber. A large section of chicken wire was attached below and around the sides of the nesting bucket to protect the nest from potential fossorial predators. I used two additional buckets placed above the main nesting bucket to permit easier access to the nest chamber (Figure 4). A perching post was installed inside the pen at the entrance to the nest burrow, and access to the nesting bucket (nesting chamber) was 1 m outside the enclosure. An adaptation to Poulin et al.'s (2006) design was the addition of a 61 cm long section of 0.05 m diameter PVC piping that extended from the top bucket down into the nesting bucket, allowing access to the nest chamber for regular observations of egg-laying and hatching (Figure 5) through a fiber optic cable and camera (Peeper 2.0, Sandpiper Industries, California).

**Figure 2**. Release pens for captive-released Burrowing Owls (*Athene cunicularia*) in southwestern Manitoba (2010-2012).

**Figure 3.** Artificial Burrowing Owl (*Athene cunicularia*) nest burrow entrance and fence post for roosting inside pen.

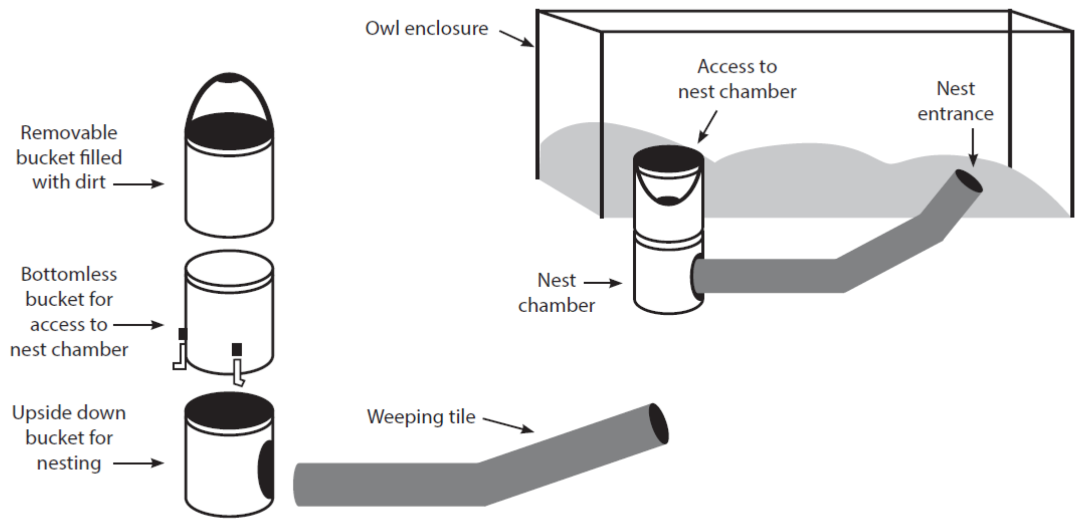


**Figure 4.** Three-bucket artificial nest burrow for Burrowing Owls (*Athene cunicularia*) allowed for easier access to the nest chamber, via removable bucket system located outside the enclosure (adapted from Poulin et al. 2006).

**Figure 5.** PVC piping inserted in the top of third bucket allowed for access to the Burrowing Owl (*Athene cunicularia*) nest chamber with a fiber optic camera.

A soft-release technique was used to house paired owls until a partial clutch was observed (Poulin et al. 2006, Mitchell et al. 2011). To encourage nest success and reduce potential for nest abandonment pairs were held in pens until at least 3 eggs were laid in nests (Poulin et al. 2006). If a nest was not established within 6 weeks or if a later nest failed (replacement clutches occasionally occurred with early nest failures), owls were recaptured and returned to the Assiniboine Park Zoo for overwintering. A few unpaired owls were also released utilizing soft-release techniques (generally released after they had been in the pens for 10 days). In this study, nesting or nest establishment was defined as clutch initiation (one egg observed in the nest). Nesting success was when at least one young fledged from a nest.

Prior to transfer and pairing for nesting, all release owls received live prey training at the Assiniboine Park Zoo six weeks prior to transfer to release pens in southwestern Manitoba . During training, two owls were placed in a training enclosure which had a variety of perches at different heights, two Reconyx cameras to monitor activities, and a clear, 30 cm high basin (30 cm x 60 cm) where live prey (house mouse – *Mus musculus*) were provided once daily for three days. Owls received no other food during their training periods. Each owl's weights were recorded prior to and after the three-day training exercise. Assiniboine Park Zoo keeper staff kept a daily log of live prey eaten and camera images were reviewed on a weekly basis.

Once transferred to the release sites, three frozen-thawed house mice were provided to pairs daily. This daily ration was reduced to two mice per pair after the pens were removed to encourage adult owls to forage for food. Adult owl foraging activities were monitored after release daily through personal observations and by reviewing camera images every four days. Once all young emerged from the burrow (generally between 10 and 14 days old) the supplement was stopped. Young at this stage are still dependent on their parents for food, but they are capable of foraging for insects from in and around the burrow. Fledging age of nestlings (generally at 5-6 weeks of age) was determined based on their abilities for sustained flight (greater than 30 meters) and greater independence from their parents (i.e., movements away from natal burrow to satellite burrows).

Release sites were monitored daily and nests were checked regularly for clutch initiation every 4 days after owls were paired in pens for 10 days. During egg-laying, nests were examined every second day with the fiber optic camera. The nest chamber was only accessed directly (by removing the upper bucket) if a predator event was captured on the cameras, to check if nests had been affected by inclement weather (i.e. signs of imminent flooding), and for banding of young prior to fledging.

In each year, I was permitted to recapture some young from all family groups (captive-released and wild) from which at least two young fledged (artificial brood reduction). Young were transferred back to the Assiniboine Park Zoo to be overwintered and would be paired and released in the following year's reintroduction. In 2012, all young were blood sexed at four weeks of age allowing for the recapture of an equal sex ratio of owls for overwintering at the Assiniboine Park Zoo. There were several advantages to this artificial brood reduction, specifically for this project and for the enhanced survival of the remaining young. Brood reduction allowed for a sex-balanced captive-release breeding group that was genetically diverse for the next reintroduction season. Also, young remaining in the wild had greater access to prey likely resulting in increased body condition and would increase survival prior to migration.

***Owl Surveys and Landowner Reports***

Roadside Burrowing Owl surveys took place from May 10 to June 30 annually (2010-2012) in southwestern Manitoba (Figure 6). Roadside surveys were conducted when Burrowing Owls tend to be most active (at dawn and dusk) and under optimal weather conditions (i.e. little to no wind and no precipitation) (Shyry et al. 2001). A Burrowing Owl male territorial call (Cornell Lab of Ornithology) was used at each stop along a survey route (Haug & Didiuk 1991). The call was amplified using a small portable speaker and played three times at 30-second intervals. Observations were conducted with binoculars and a spotting scope during the playback period and for at least 5 minutes afterwards. Observers also listened for any response to the playback call.

Grasslands deemed suitable for surveys were grazed or mowed native and tame pasture that was less than 0.5 meters tall, and mowed timothy and alfalfa haylands

(Uhmann 2001, Poulin et al. 2005). Other criteria used to assess grasslands for suitability included: 1) presence of ground squirrels and available burrows; 2) previously installed ANB's; 3) grasslands with few or no trees or tall shrubs (flat topography); and 4) sites that have had or were within 5 km of recent owl nests or sightings (2000-2009). Every surveyed site was mapped, categorized as either: a) previous nesting or owl observation sites (blue); b) suitable habitat (green); c) potentially suitable habitat (yellow); or d) not suitable habitat (red). Colour coding was used to mark each survey location on township, section, and range maps during each season and to assess if a site was worthy of revisiting later in the season and in subsequent years (Figure 6). A survey site would be considered suitable for nesting if it contained an area larger than 20 hectares with shorter grass (less than 0.5m tall) and had at least two of the three suitability criteria (see above). A site was not suitable if it failed to have any of the criteria. The township, section, and range maps used to map survey sites were habitat coded Forestry Resource Inventory maps created by the Province of Manitoba Forestry Branch. These maps outlined areas of pastureland (habitat coded as 813 on maps) and haylands (habitat code 811). All 813 and a sampling of the better 811 areas which have traditionally supported Burrowing Owls in Manitoba (1987-present) were surveyed. Surveys were also conducted on any additional grasslands that we encountered during the surveys which were not identified as 813 or 811 on the maps but where land use had changed and these sites now appeared suitable based on one or more of the suitability criteria listed above.

Landowners or other observers who reported owl sightings were contacted, and a thorough survey of any suitable habitat surrounding the location of the owl observation was conducted. If an owl was observed at a burrow during a follow-up survey, a Reconyx motion sensitive trail camera was installed near the burrow to collect more information on the owl and potential nest.

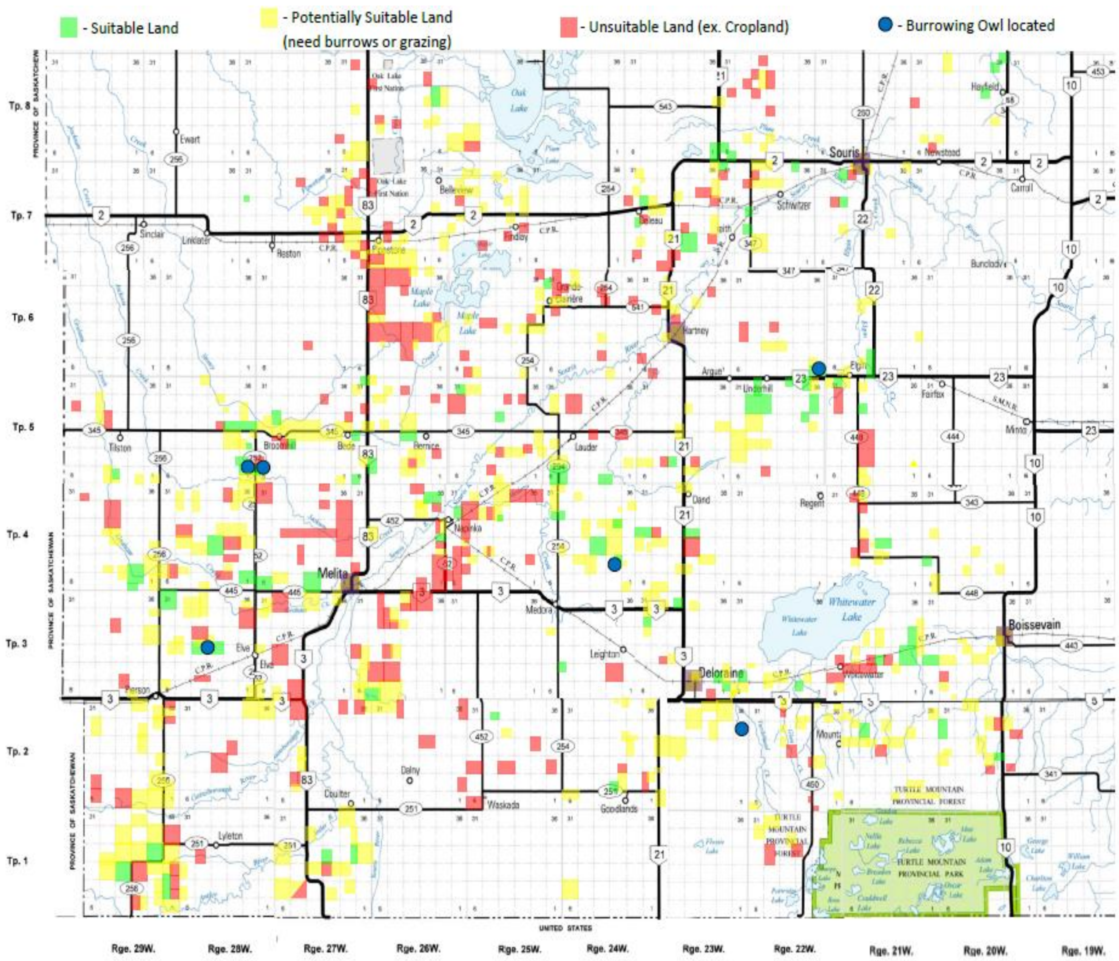


**Figure 6.** Areas surveyed during 2010-2012 for Burrowing Owl (*Athene cunicularia*) habitat and recent Burrowing Owls in southwestern Manitoba.

*Reported and verified Cartwright and Treesbank wild owl sightings not included (outside of annual survey area).

### *Banding*

All captive-released owls in Manitoba were leg banded with a bi-coloured red/blue anodized aluminum alpha-numeric band (A-Craft; Edmonton, Alberta) on a specific leg (i.e., right leg in 2010, left in 2011, right in 2012) and a Canadian Wildlife Service (CWS) aluminum band on the opposite leg from the coloured band. Wild owls in Manitoba were banded if captured with the same type of CWS band as captive-released owls and a black alpha-numeric band. All owls were weighed, and wing chord and tail length were measured when they were handled.

### *Trapping Techniques*

A variety of trapping techniques were used to trap both captive-released and wild owls, including a bow-net trap, walk-in trap with decoy and audio lure, a one-way burrow entrance trap (ground burrow trap), and a mist nest (Bloom et al. 2007). The most efficient trap to capture adult male owls was the walk-in trap with decoy owl and audio lure (A. Froese, unpublished data). This trap is a circular cage design with a suspended door that closes once the trap is triggered (owl enters). A Burrowing Owl decoy was placed inside the trap with a dead mouse and a small recorder that played the male territorial call. This trap had an 83% success rate for trapping both wild and captive-released adult Burrowing Owls (Appendix E).

The most efficient trap (72% success rate when left for one hour or less) to capture wild female and young owls was the one-way burrow-entrance trap. This trap was installed in the opening of the burrow with a one-way door closest to the burrow entrance (Winchell 1999). Owls would collect in the 0.5 meter rectangular box which was made of wood, mesh, and chicken wire. The end of the wooden box is covered with chicken wire so the young owls cannot escape. Traps were observed from a distance to see if young had started to collect in the trap and were checked every hour. Wild-hatched young of captive-released pairs (prior to fledging) were most successfully contained for banding in the nesting bucket of an artificial burrow with the use of a section of clear vinyl reinforced hose (2 cm in diameter and 2.4 meter long) with a towel duct-taped to one end forming a ball. This hose was gently pushed down the weeping tile piping thereby herding the young into the nest chamber.

### *Pellet Collection and Dissection*

Pellets were opportunistically collected every 10 to 14 days at or within 5 m of nests and roosts for both captive-released and wild owls in 2010 and 2011. Pellets of captive-released owls were only collected after the pens had been removed and the owls released. Pellets were collected once or twice for pairs later in the season.

Pellets were manually separated into vertebrate and invertebrate components for analysis. Vertebrates were generally identified to species; invertebrates to family. Vertebrate remains were sorted and identified by Dr. Ray Poulin, Curator of Vertebrate Zoology at the Royal Saskatchewan Museum. A 10% sodium hydroxide solution was used to dissolve fur in the pellets to provide clean bones and teeth for identification. Vertebrate prey remains were identified through unique skeletal and dental traits using reference collection when needed. I identified invertebrate remains with the help of Dr. Terry Galloway, Entomologist from the University of Manitoba. Invertebrate parts were separated, fine combed, and observed under a microscope for identification. Total parts were counted and number of individuals were estimated based on parts examined. For grasshoppers (*Caelifera*) and field crickets (*Gryllidae*), femurs were counted to arrive at conservative totals for each (one or two femurs in a pellet representing one individual; three or four representing two individuals). Heads and wings of beetles used for minimum beetle counts. Weevils (*Curculionoidea)*, Hister beetles (*Histeridae*), and Dung beetles (*Scarabidae*) were conservatively estimated by number of snouts and or bodies found.

Prey in pellets from captive-released and wild Burrowing Owls were categorized in three ways: 1) variety of species found; 2) number of each species found; and 3) species most consumed (invertebrate and vertebrate). Both biomass and frequency (number of occurrences of species found) were estimated for all prey remains in pellets each year (2010-2012).

Total prey biomass was calculated for each year and each group by adding total vertebrate biomass and total invertebrate biomass. Further, vertebrate and invertebrate remains were divided by total biomass to provide percent biomass for overall diet for each group (total vertebrate/total biomass x 100 and total invertebrate/total biomass x100). All biomass weights for vertebrates and invertebrates used in my analysis were found in Marti (1974), Tyler & Jensen (1977), Gleason & Craig (1979), and Mitchell (2008).

### *Extreme Spring and Summer Weather*

Historical precipitation and owl occurrences in Manitoba were examined with descriptive statistics to see whether spring precipitation rates corresponded to low numbers of owls in the following season. I predicted that high precipitation rates in summer (April-June) would negatively affect Burrowing Owl reproductive success and subsequently reduce future adult Burrowing Owl returns.

To test this prediction I conducted a Pearson correlation between precipitation and owl occurrence in the following year and a linear regression analysis with the dependent variable being the number of Burrowing Owl pairs and precipitation as the independent variable.

## 3) RESULTS

### *Captive-released Owls: Nesting Activities (2010-2012)*

Ten adult owls (see Captive-release owls in methods for founding population) were placed in release pens on 14 May 2010. Three of the five pairs produced a first clutch (clutch initiation dates ranged from May 23- June 9), producing a total of 20 eggs (Table 1). Two of three clutches (13 eggs) failed on June 28 from burrows flooding after increased precipitation (>200 mm April to June) events. Pairs that failed did not replace their first clutch in 2010. The only successful pair hatched two of seven eggs and raised both young to fledging (clutch initiation to hatching June 9-July 14). One young was released and the other was transferred to the zoo for overwintering and for breeding in 2011. Due to poor overall nesting success in 2010, owls that did not hatch or fledge young, or that were released early were transferred back to the Assiniboine Park Zoo for the winter. (Table 1).

Extremely wet summer conditions in most of southwestern Manitoba in 2010 and 2011 resulted in most of the reintroduced and wild nests failing from flooding. Pairs were therefore relocated to our driest release site location (Broomhill site) in 2011.

Thirteen adult owls were placed in release pens on 19 May 2011. Ten of 13 owls were paired and placed in five separate pens; three individual owls were placed in three separate pens. (Appendix C2). The paired owls consisted of five owls that did not fledge young in 2010, three one-year old wild-hatched and one one-year old captive-released wild-hatched young from nests in 2010, and one seven-year old female from the Assiniboine Park Zoo. Three of five pairs produced a first clutch (clutch initiation date range was from June 10-16) producing a total of 20 eggs. Two first clutches (13 eggs) failed due to flooding from severe rain storms on June 19, but both pairs produced a replacement clutch (replacement clutch date range was July 9-13) that were smaller than first clutches. One of the females with a replacement clutch incurred a fatal wing injury (probable predation attempt) that resulted in the failure of the replacement clutch. The two successful pairs in 2011 hatched and fledged 6 young (6 young from 11 eggs). Three of the 6 young were removed for overwintering and for breeding in 2012.

Three unpaired second-year male owls were also released after 10 days in soft-release pens in 2011. It was hoped that these male owls might encounter or attract a wild female owl to the area and nest. They did not attract a mate but remained at the release sites occasionally observed calling for a mate at dusk; by late June all three had dispersed from the release site.

Due to continued wet conditions in southwestern Manitoba, I discontinued reintroductions at the Lyleton and Pierson release sites in 2012. Two elevated sites near Medora and Deloraine were selected for release sites in 2012.

Eleven adults were placed in release pens on 17 May 2012; eight of the 11 owls were paired for nesting and release (Appendix C4); the three unpaired owls were released from separate pens after 10 days. The paired owls included one 3-year old female owl, one second-year male owl that had been unsuccessful in 2011, two 2011 wild-hatched and two captive-released wild-hatched young, and two hatch-year 2011 female owls from the Saskatchewan Burrowing Owl Interpretive Centre. All four pairs initiated a first clutch (initiation clutch date range was May 23-30). One nest with 4 eggs was abandoned one day after release for unknown reasons. The pair remained at the release site, however, the female nested with one of the lone released males (replacement clutch date was June 10) approximately 11 days after abandoning her initial nest. This pair successfully raised three young from 6 eggs. Overall, four pairs in 2012 successfully hatched 19 of 27 eggs and fledged all 19 young.

***Summary of Captive-released Burrowing Owl Reproduction (2010-2012)***

Over the three study years, 14 pairs of captive-released owls and 7 single males were placed in release pens. Ten of 14 pairs successfully initiated a first clutch (71%); seven of ten pairs (70%) successfully fledged young (including two replacement clutches). Of 13 total nests produced by captive-released pairs (10 first and three replacement clutches), six failed. Failures were caused by flooding of the burrow (4 nests), abandonment (1 nest), and a probable predation attempt resulting in the death of the female (1 nest). Excluding one first clutch that was abandoned soon after the release (with only a one egg), average clutch size for first clutches during this study averaged 6.5 (n=9, range 5-8 eggs). Replacement clutches were smaller averaging at 5.0 eggs (n=3, range 4-6 eggs). Including all 13 first and replacement clutches, seven clutches were successful (54%) fledging a total of 27 young (3.86 young/successful nest). Overall, 60% (27 of 45) of eggs that were laid hatched. Nestling survival (post-hatching to fledging; n=27) was 100%. Nests in 2012 were the most successful with 19 hatchlings from 27 eggs (70%), including one particularly successful pair that hatched and fledged all 8 of their eggs/young. One of 19 young in 2012 was preyed upon six weeks after hatching at the burrow entrance by a Great Horned Owl (the only known instance of predation of a young prior to dispersal at the release site during this study). Young were considered fledged at 5-6 weeks of age so predation after 6 weeks of age did not affect estimates of fledging success. Twenty-one adults and 15 fledglings were released and dispersed from the release sites during the three-year study period. An additional 12 captive-released juveniles were removed from nests for breeding for the following season.

**Table 1.** Nesting results for captive-released Burrowing Owls (*Athene cunicularia*) in southwestern Manitoba 2010-2012.

| | 2010 | 2011 | 2012 |
|---|---|---|---|
| No. of adult pairs | 5 | 5 | 4 |
| No. of individuals adults released | 0 | 3 | 3 |
| No. of first clutches | 3 | 3 | 4 |
| No. of failed first clutches | 2 | 2 | 1 |
| No. of replacement clutches | 0 | 2 | 1 |
| No. of failed replacement clutches | - | 1 | 0 |
| Mean clutch size (first, n=10) | 6.6 (n=3, 5-8 eggs) | 6.6 (n=3, 6-7 eggs) | 6.25 (n=4, 4-8 eggs) |
| Mean clutch size (replacement clutches, n=3) | - | 4 (n=2, 4 eggs each) | 6 (n=1, 6 eggs) |
| No. total of eggs (first and replacement) | 20 | 28 | 31 |
| No. of eggs in nests that hatched | 7 | 11 | 27 |
| Hatching success (%)[1] | 29% | 55% | 70% |
| Total number of hatchlings in nests | 2 | 6 | 19 |
| No. of hatchlings lost or dead | 0 | 0 | 0 |
| Fledging success | 100% | 100% | 100% |
| Fledglings recruited | 2 | 6 | 19 |
| No. of fledglings removed for overwintering | 1 | 3 | 8 |
| No. of fledglings released | 1 | 3 | 11 |

[1]Based on young observed and # of eggs confirmed in successful nests.

*Wild Owls: Nesting Activities (2010-2012)*

Five wild pairs and two single males were observed during 2010, either by surveys or voluntary landowner reports (Appendix D1). Only four of the five pairs were monitored throughout the nesting season. The fifth pair was reported late in the season when two fledged young (about 6 weeks old) were already present. Of the four monitored pairs (three near Pierson and one near Treesbank, MB), all initiated a first clutch (first clutch date range was April 28-May 12) producing 35 eggs. One nest failed due to flooding and one for unknown reasons on May 18 (19 eggs lost). Both pairs where nests failed produced a replacement clutch (replacement clutch date range was May 27-28) but had smaller clutches (6 and 7 eggs). One replacement clutch failed due to flooding on June 20 resulting in the loss of 7 eggs. Three of four monitored pair (three of six nests) successfully fledged 15 young. Six young were removed from three broods in August and held over at the zoo for breeding.

Two additional single male owls were observed during the 2010 breeding season. One male was observed in pastureland across the road from the Broomhill release site (in the vicinity of a successful 2009 nesting site) from April 28-May 23. The other male was observed near the two other wild owl pairs at Pierson. It appeared that he had secured a burrow and breeding territory and was frequently observed calling for a mate in early in May. However, no other females showed up and he left the area by May 23 (Appendix D2).

Three pairs and four individual Burrowing Owls were observed in 2011 (Appendix D3). Two of the 10 owls observed were returning banded males from successful 2010 nest sites (the successful Treesbank male from 2010 and one of the Pierson males which successfully fledged young in 2010).

Only two of the three nests were monitored throughout the nesting season. The third nest was found late in the season on August 4 near Elgin, when both adults and four fledged young were observed in the area; these dispersed from the area on September 1. Both of the pairs initiated a first clutch (first clutch date range was May 7-15) producing a total of 18 eggs, both nests failed from flooding on May 31 and pairs produced replacement clutches (replacement clutch date range was June 10-11) with less eggs (7 in each nest). One replacement clutch failed from depredation on June 4; the other nest successfully fledged 5 young. Overall, the two pairs in 2011 raised nine young to fledging. Three young were removed from the one monitored nest in August and were held over at the zoo for breeding in 2012.

Four additional Burrowing Owls were observed during the 2011 breeding season (Appendix D4). Two brief observations of individual males were observed at the Broomhill release site on May 15 and July 8. The latter male had a red and tan colour band on his right leg, this colour-coding scheme was not recognizable (forwarded to the Canadian Wildlife Service but they were unable to determine where the owl originated). One banded male owl returned to his nest site from 2010 near Treesbank and stayed near the burrow until June 13, however, a female was not observed at this site. On July 8, an unbanded female was observed at the Broomhill release site with a captive-released male that had recently lost his mate and nest. Copulation was observed on camera several times and this pair were observed together until September 14 but a nest was never produced as it was likely too late in the breeding season (Table 3.4).

No wild nesting pairs were observed or reported in 2012. Four individual owls were detected on surveys or reported by landowners (Table 3.5). The male owl from 2010 and 2011 was again found near Treesbank returning to this site briefly for the third year in a row. A report by a landowner near Deloraine, Manitoba led to the observation of male owl found near a large fox den from early May until mid-June. A camera was installed to observe activities by the burrow but no female was ever observed. Two wild owls (one male and one unknown) were observed at our release sites. The male was observed interacting with a nesting captive-released pair at the Medora site in mid-July. The unknown owl was only detected once on May 11 at the Broomhill release site and was an owl of great interest as red/blue band indicated it was a returning captive-released owl from Manitoba. Although the band number was not identified within the short period of time the owl was observed, based on the leg banded (left), and colour combination, this owl could have only been one of two young hatched and released at this site in 2011.

### *Summary of Wild Burrowing Owl Reproduction (2010-2012)*

Of eight wild pairs located during 2010-2012, two pairs (6 young) were excluded from the monitored pairs as they were located too late in the nesting season to assess breeding ecology (after young had already fledged). For the six monitored pairs, overall clutch size for first and replacement clutches combined was 8.0 eggs/nest, ranging from 8.83 for six first clutches to 6.75 for four replacement clutches. Only two of the six monitored wild pairs were successful with a first clutch, but all four pairs where nests failed did produce a replacement clutch and two of these fledged young. Twenty of 29 eggs in successful wild nests hatched (69%); all 20 young survived to fledging. Four of ten monitored nests (40%) and four of six monitored pairs (67%) successfully raised young to fledging. Nine young were removed from nests in 2010 and 2011 to diversify the gene pool of the captive-released breeding population and for breeding in the next season. (Table 2).

**Table 2.** Nesting results for wild Burrowing Owls (*Athene cunicularia*) in southwestern Manitoba 2010-2012.

| | 2010 | 2011 | 2012 |
|---|---|---|---|
| No. of adult pairs | 5 | 3 | 0 |
| No. of individual/additional adults observed | 2 | 4 | 4 |
| No. of first clutches | 5 | 3 | - |
| No. of monitored first clutches | 4 | 2 | - |
| No. of failed first clutches | 2 | 2 | - |
| No. of replacement clutches | 2 | 2 | - |
| No. of failed replacement clutches | 1 | 1 | - |
| Mean clutch size (first clutches, n=6)* | 8.8 (n=4, 8-11 eggs) | 9.0 (n=2, 9eggs each) | - |
| Mean clutch size (replacement clutches, n=4) | 6.5 (n=2, 6-7 eggs) | 7.0 (n=2, 7eggs each) | - |
| No. total of eggs (first & replacement)[1] | 48 | 32 | - |
| No. of eggs in nests that hatched | 22 | 7 | - |
| Hatching success (%) | 68% | 71% | - |
| Total number of hatchlings | 15 | 5 | - |
| No. of hatchlings lost or dead | - | - | - |
| Fledging Success | 100% | 100% | |
| Fledglings recruited | 15 | 5 | - |
| No. of fledglings removed for overwintering | 6 | 3 | - |

[1]Only confirmed eggs in all nests. Cartwright (2010) and Elgin (2011) eggs were not counted as pairs/young were found later in the season.

### *Owl Surveys and Landowner Reports*

One hundred and seventy-one potential nesting pastureland and hayland sites were surveyed and assessed for suitability during roadside surveys through the 2010-2012 breeding seasons (51 in 2010, 65 in 2011, and 55 in 2012). Some duplication of numbers is included in this total as suitable sites found in 2010 were revisited and included in 2011 and 2012 totals as well. Nineteen reported owl sightings were followed up and all suitable grasslands in these areas were surveyed through 2010-2012. These reports led to the observation of two pairs/nests and one individual owl. Landowner reports detected owls in areas where they have not been observed in the last two decades including areas near Treesbank, Deloraine, and Cartwright, Manitoba.

### *Banding*

Forty-seven captive-released owls were banded as a part of the reintroduction project in 2010-2012; 7 paired adults, 6 individuals, and 27 young. Thirty wild owls (10 adults and 20 young) were banded throughout 2010-2012.

Attempts were made to trap and band all wild owls, however, some trapping attempts repeatedly failed. When nests failed, adults departed from the area before banding was attempted and several individual owls were only detected once or twice and no captures were attempted.

### *Adult Mortality*

Two adult captive-released owls, a male and a female, were found dead as result of predation or predation attempt (2/34 =6%). The female incurred a fatal wing injury and died overnight in the nest burrow. The remains of the male were found 200 meters from his nest burrow (legs with bands). There were no observations of wild adult owl mortality through the duration of the study. Both mammalian and avian predators such as fox, badger, coyote, hawks (*Buteo jamaicensis* & *Buteo swainsoni*), and Great Horned Owls (*Bubo virginianus*) were observed on camera several times at nest sites for both groups.

On one occasion, I observed a wild male owl attacking and driving a badger away from its nest burrow.

### *Post-fledging Mortality*

Only one known death was recorded on camera during my study. A juvenile (captive-released nest), over 6 weeks of age, was observed being taken by a Great Horned Owl at its natal burrow site. For the duration of observations (weekly until the end of October) no other young went missing under circumstances that would may have suggested predation. The resulting known post-fledging mortality for my study was 2% (1 of 52 young of the year, from both groups).

### *Dispersal*

Dispersal of wild Burrowing Owls in 2010 occurred from September 1-9. At this time, most of the young were approximately 7-8 weeks in age. In 2011, all wild owls dispersed from September 14-16, again when young were approximately 7-8 weeks in age. No wild pairs were recorded in 2012.

Captive-released owls dispersed later than wild owls. In 2010, all captive-released owls dispersed from September 19-26. At this time, the lone young released was 8-9 weeks of age. In 2011, young owls dispersed from September 17- October 1, again around 8-9 weeks of age. Adult dispersal dates varied: One left between September 17-28, two from September 28 - October 17. One adult female adult remained until October 26 when she was recaptured and returned to the Assiniboine Park Zoo for the winter. In 2012, all but four adult owls dispersed by September 28. The remaining four left between September 28 and October 13.

### *Re-occupancy and Annual Returns*

Re-occupancy rate of nest site burrows (or at least the general burrow area, within 400 m) were calculated for both groups. Re-occupancy for wild banded adult owls that successfully fledged young in 2010 was 66% for banded males and 0% for banded females in 2011. In 2012, one of the males that returned in 2011 returned again to the same burrow even though he did not have a nest at this site in 2011. He was the only returning banded wild owl observed in 2012. Re-occupancy rates for 16 captive-released adult owls was zero in both 2011 and 2012.

During this study, 47 additional nest and satellite ANBs were installed at all release sites (14 at Broomhill, 7 at Lyleton, 10 at Pierson, 7 at Medora, and 9 at Deloraine). In 2011, three wild adults (two unbanded and one banded with red/tan coloured band) were observed at ANBs at the Broomhill release site. In 2012, one unbanded wild adult was detected at the Medora release site using an artificial nest burrow as a roost site and a wild-hatched captive-released owl returned briefly to the natal burrow/release site.

Four of 26 wild adult observations were banded owls (15%); two wild males returning after migration in 2011 and 2012 to their successful 2010 nest sites and the aforementioned released hatch-year owl from 2011 that returned briefly as an adult to its natal site in 2012. Sixty-five wild and captive-released adults and young were banded and were allowed to migrate during my study. Four of these 65 returned after migration for an overall return rate of 6%.

### *Pellet Collection and Dissection*

Pellets were collected from May 31 through September at 11 wild and captive-released nesting and roosting sites in 2010. In 2011, pellets were collected from May 7 through September at 12 wild and captive-released owl nesting and roosting sites (Table 3).

**Table 3.** Pellet collection sites for captive-released and wild Burrowing Owls (*Athene cunicularia*) in southwestern Manitoba (2010 and 2011).

| **Captive-released collection site 2010** | **Wild collection site 2010** | **Captive-released collection site 2011** | **Wild collection site 2011** |
|---|---|---|---|
| Broomhill West (BHW) | Cartwright | Broomhill Central East (BHC-E) | Pierson North |
| Broomhill East (BHE) | Pierson East (E) | Broomhill South (BHS) | Pierson South |
| Lyleton | Pierson West (W) | Broomhill Central West (BHC-W) | Elgin |
| Pierson North | Pierson South (S) | Broomhill South (single male) BHS ANB | Treesbank (single male) |
| Pierson South | Treesbank | Broomhill West (BHW) | |
| | Broomhill single male (Single Male BH) | Broomhill North (BHN) | |
| | | Broomhill South (single male-natural burrow) BHS natural | |
| | | Broomhill East (BHE) | |

In 2010, almost no vertebrate remains were found in the pellets of captive-released owls. In 2011, vertebrate prey remains were found at 10 times the biomass in pellets than in 2010, which was about half the amount represented in wild owl pellets (2,412 g compared to 5,079 g). There was greater prey species diversity in pellets in 2011 for the captive-released owls (16 species compared to 7 in 2010). Low total invertebrate prey biomass percentages for invertebrate remains were observed for wild owl pellet collections in both seasons with 6% and 1%, respectively. Most of the biomass for both groups was vertebrate (Table 4). Invertebrate prey biomass in both groups showed some similarities in 2010 (Table 4). Though prey biomasses were similar in both groups for invertebrates (a difference of 6.7g), the percentage of invertebrates relative to vertebrates in each group was different (17% for captive-released owls versus 4% wild owls).

The most frequently consumed invertebrates in 2010 and 2011 for both captive-released and wild owls were ground beetles (*Carabidae*). In 2010, both captive-released and wild owls frequently consumed the Olive-backed Pocket Mouse (*Perognathus fasciatus*). In 2011, the most frequently eaten vertebrate for captive-released owls were frogs (*Anura*) and for wild owls were toads (*Bufo*). (Appendix F and G).

Captive-released owls were provided with a supplemental diet of house mouse until young emerged from the burrow at approximately 10-14 days. Wild owls did not receive this supplement. This supplement was not included in the number of total vertebrates counted or in the number of individual species counted per collection.

**Table 4.** Vertebrate and invertebrate prey biomass by year for captive-released and wild Burrowing Owls (*Athene cunicularia*) in southwestern Manitoba (2010 and 2011).

| | 2010 | | 2011 | |
|---|---|---|---|---|
| | Captive-released | Wild | Captive-released | Wild |
| Vertebrate (g) | 271 | 1,519 | 2,412 | 5,079 |
| Invertebrate (g) | 54.4 | 61.1 | 141.6 | 50.8 |
| Total biomass | 325.4 | 1,652.1 | 2,553.5 | 5,129.8 |
| Percent total vertebrate biomass | 83% | 96% | 94% | 99% |
| Percent total invertebrate biomass | 17% | 4% | 6% | 1% |

*Extreme Spring and Summer Weather*

Precipitation from April to June was uncorrelated with Burrowing Owls population trends (Table 5: p=0.6268). It appears that the analysis is confounded by an overall decline in Burrowing Owl populations making it impossible to assess the link between rainfall and subsequent breeding season Burrowing Owl occurrences in Manitoba from these data. (Appendix I).

**Table 5.** Precipitation (rainfall) rates and Burrowing Owl (*Athene cunicularia*) numbers in southwestern Manitoba during annual early egg-laying and nestling stage (April- June) from 1991-2012.

| Year | Total precipitation (mm) April-June | No. of owl pairs observed | No. of individual owls observed |
|---|---|---|---|
| 1991 | 215.9 | 23 | 10 |
| 1992 | 123.4 | 27 | 5 |
| 1993 | 97.5 | 23 | 5 |
| 1994 | 161 | 8 | 5 |
| 1995 | 128.8 | 4 | 0 |
| 1996 | 131.1 | 1 | 2 |
| 1997 | 70.9 | 0 | 1 |
| 1998 | 150 | 1 | 1 |
| 1999 | 259.7 | 3 | 2 |
| 2000 | 171.2 | 0 | 1 |
| 2001 | 145.4 | 1 | 0 |
| 2002 | 95.7 | 0 | 0 |
| 2003 | 105.5 | 0 | 0 |
| 2004 | 198.6 | 0 | 0 |
| 2005 | 345.4 | 0 | 0 |
| 2006 | 130.6 | 9 | 0 |
| 2007 | 129.6 | 4 | 0 |
| 2008 | 145.1 | 13 | 10 |
| 2009 | 100.2 | 9 | 1 |
| 2010 | 215.3 | 5 | 1 |
| 2011 | 261.1 | 3 | 4 |
| 2012 | 128.3 | 0 | 4 |

Source: Precipitation rates adapted from Environment Canada climate data (www. http://climate.weather.gc.ca/); Owl occurrences 1991-2009 Manitoba Conservation Data Centre.

## 4) DISCUSSION

### *Clutch Size, Nesting, and Hatching Success (Captive-released and Wild Burrowing Owls)*

During this study, the average clutch size for wild first clutches (8.9 eggs) was higher than for captive-released first clutches (6.5 eggs). Part of this difference may be attributed to the fact that wild pairs initiated first clutches much earlier (April 28-May 15) than captive-released owls (May 24- June 10). Wellicome (2000) found that wild Burrowing Owls show a seasonal decline in clutch size as earlier initiated clutches are generally larger than those laid later in the season. The difference in clutch sizes of first clutches (8.9 and 6.5) versus replacement clutches (6.75 and 5) in the present study also reflects that later clutches are generally smaller.

Hatching success in this study was defined as number of young that hatched from eggs in either a first clutch or replacement clutch. Hatching success for wild owl nests was high in 2010 and 2011 (68% and 71%) relative to more variable captive-released nest success (22% in 2010, 55% in 2011, and 70% in 2012). Overall, hatching success for wild owls was 69% (2010 and 2011) and captive-released owls was 60% (2010- 2012). Mitchell (2008) saw a similar hatching success rate of 57% in her 2005 and 2006 study in B.C. when reintroducing captive-bred pairs through a soft-release technique. During the course of my study, conditions in 2012 were the most suitable for breeding Burrowing Owls, with lower rainfall during the nesting period reducing damp or wet conditions in the burrow. All captive-released pairs were provided with the same supplemental diet in all three seasons for the same duration (up until all young emerged from the burrow). Male captive-released owls in 2011 and 2012 were observed to be well-adapted hunters bringing back a variety of prey items daily to nest burrows. In 2011, there was an increase in frog and toad populations, which benefited both wild and captive-released pairs (noted in pellet dissection remains). This increased food and more suitable nesting conditions may explain the increase in hatching success for captive-released pairs in 2011 and 2012.

The greatest cause of first clutch failure for both captive-released and wild owls during my study was nest flooding due to heavy rainfall. Seven of nine first clutches failed from flooding (7 of 18 nests, 39%) and two from unknown abandonments (2 of 18 nests, 11%). Seven replacement clutches were established (4 wild and 3 captive-released) and three of these failed from either flooding (1) or predation (2). Catlin et al. (2004) noted that resident Burrowing Owls in California were able to replace a clutch quickly after a nest failure and could have up to three or four replacement clutches in a season, generally with smaller clutch sizes produced after each failure. During this study, most pairs where first clutches failed produced replacement clutches within 10. Multiple breeding attempts in a single season are common among many birds, however, replacement clutches have not been observed for Burrowing Owls in Manitoba prior to this study (K. De Smet, personal communication, 2010).

Overall, 12 of 23 monitored Burrowing Owl nests from 2010-2012 failed (52%); failures were attributed to two main factors, flooding (35%) and predation (9%), with the remainder as unknown caused abandonments (9%). Both captive-released and wild owls responded to nest failures by producing a replacement clutch albeit with smaller clutch sizes.

### *Fledging Success*

Fledging success in this study was defined as young that were between the ages of 5-6 weeks (35-42 days after hatching) and were observed flying (i.e., could sustain flight). Fledging success was 100% for captive-released and monitored wild nests during this study. Nests near Cartwright and Elgin were found later in the season (post-fledging) and I was unable to assess hatching or fledging success for either of these nests therefore excluding them from my nesting analysis. However, with this said, I documented considerably higher fledging rates for captive-released than the 1987-1996 Manitoba reintroduction study and similar efforts in Saskatchewan and B.C (De Smet 1997, Poulin et al. 2006, Mitchell 2008).

One explanation for my observed high fledging rate in this study may be due to reducing brood size prior to fledging. In my study, I reduced family groups prior to fledging age which helped increase survival of young for both wild and captive-released owls. Removal of young from larger families meant that the remaining hatchlings would likely have greater access to prey resulting in increased body condition and survival prior to migration. It also meant that adults had fewer hatchlings to care for and feed, thus their hunting activities would be less taxing, potentially increasing the fitness levels of adults as well.

Based on the observations during my study, I would suggest that extended time periods of confinement prior to release are necessary to instill site-fidelity in released owls similar to Poulin et al. (2006) and Mitchell (2008). The soft-release technique paired with and initial extended confinement timeframe and food supplementation increased nesting success and productivity of captive-released pairs.

### *Adult and Post-fledging Mortality*

Post-fledging in this study was defined as young that were over 6 weeks of age (42 day and older). Although post-fledging mortality is often hard to quantify without radio-marking owls, rates for both observed adult and young appeared low in my study with only 6% of captive-released adults (2 of 34 adults) and 2% of post-fledglings (1 of 27 young) mortality recorded. Higher rates of captive-released adult and post-fledged young mortality were noted through the use of radio-tagging in Saskatchewan; adults (19%), wild juveniles (31.6%) and captive-released juveniles (37.5%) (Poulin et al. 2006). In B.C., post-fledged young mortality was even higher: 58% of captive-released juveniles died before migration (Mitchell 2008).

Both Poulin et al. (2006) and Mitchell (2008) noted that most young were killed by avian predators within 1 km of the nest burrow. In my study, only one fledgling was killed by an avian predator at the nest burrow. While both avian and mammalian predators were recorded by cameras at nest entrances, adults thwarted most predator attempts at the nest sites monitored.

No owls were radio-tagged my study, however, they were observed on a daily basis in both groups (wild and captive-released) until young fledged (at 35 to 42 days old) and twice a week post-fledging (from 42 days to dispersal). After fledging, families were monitored twice a week until for 2-3 weeks (until early September), and weekly thereafter until they dispersed from the release site or nesting burrow area. Although predators were observed regularly on camera and during daily visits to nesting sites, it is possible that my study area had a) fewer predators than release sites in Saskatchewan and B.C.; b) adult owls in my study were more vigilant near their nest burrow avoiding predation attempts and this predator-avoidance behaviour was learned by their young; or c) some young may have been killed after they departed from the nesting area (not personally observed nor detected on camera).

In Saskatchewan, high rates of mortality for captive-released adults was attributed to time spent in captivity which could have limited the owl's ability to recognize and avoid hazards, like predators (Poulin et al. 2006). Captive-released adults in my study appeared to be extremely vigilant to potential avian and mammalian predators when they were in near nesting burrows, and there were few indications that captive-released adults who had been held in captivity for winter were less aware of predators around their nest burrow than wild owls.

***Dispersal***

In my study, captive-released owls dispersed later than wild owls. All wild adults owls and fledglings dispersed from the breeding area no later than September 9 in 2010 and 2011, whereas, captive-released pairs and juveniles left the area anywhere from mid-September to the end of October. This variation and later dispersal from the breeding site may be related to a later nest establishment, nesting, and fledging dates for captive-released pairs and fledglings. In all years, captive-released owls were transferred and paired in pens after the arrival of wild owls at the breeding grounds and after wild owls had established territories and nests in southwestern Manitoba.

Research on White Storks (*Ciconia ciconia*) suggests that holding a species captive for their first winter may hinder their ability to migrate in subsequent years (Mata et al. 2001). While captive-released owls dispersed later than wild owls. One adult female captive-release owl (1 of 34 captive-release adults released) did not disperse from the release site at the end of October. The female was recaptured and held for another winter at the Assiniboine Park Zoo. Reintroductions in B.C., Saskatchewan, and Washington have shown higher rates (5-12%) of Burrowing Owls attempting to overwinter or not dispersing from release sites (Conway et al. 2005, Poulin et al. 2006, Mitchell 2008). Overwintering is not a viable option for Burrowing Owls in Manitoba as below zero temperatures and snow cover would reduce or eliminate prey availability. In my study, there was no evidence that owls attempted to overwinter and there was no ability to assess if holding one year old or juvenile owls overwinter hindered their ability to disperse from the release site for migration.

***Return Rates***

There were 26 adult wild Burrowing Owl observations during my study. Of these 26, 10 were banded. Of the 10 banded adults two adults returned after migration to a successful nest site in the following season (20% for banded, and 8% for all observed wild adults). Both wild adults that returned were male. Seven pairs (14 captive-released owls) that successfully fledged young were allowed to migrate. No captive-released adults returned during the three seasons of my study (20 adults, 7 pairs and 6 unmated adults). Based on a similar wild rate of return as wild owls (8% return rate), I expected to find 1-2 captive-released adults return after migration to the release site or nearby suitable sites in southwestern Manitoba. De Smet (1997) and Poulin et al. (2006) experienced similar results with wild and captive-released returns. In Manitoba from 1987-1966, 33% of 165 banded wild adults and 3.5% of 538 banded wild juveniles returned to Manitoba after migration. Much lower return rates were recorded for captive-released owls during these years with no released adults (87 adults) and only 1 of 169 young returning after migration. In Saskatchewan, nineteen of 101 wild banded owls (19%) and zero of 42 captive-released adults returned after migration.

In my study, one captive-released young (hatch-year 2011) returned briefly to its natal site in 2012 (1 of 14 captive release young released). No wild banded young from 2010 or 2011 were observed near their natal sites or detected on surveys during my study (0 of 20). Again, De Smet (1997) and Poulin et al. (2006) observed one captive-released young return after migration, however, in both of their studies more juveniles were released (169 in Manitoba and 74 in Saskatchewan) compared to 14 (15 released; one young died post-fledging prior to migration) in my study. My return rate for young from captive-released nests was much higher as a result at 7% compared to De Smet's (1997) at 0.6% and Poulin et al.'s (2006) at 1.4%. As I did observe at least one young from a captive-released nest return during my study, this shows that captive-released wild-hatched juveniles have the potential to contribute to the following season's breeding population.

There are many possible explanations as to why so few released adult or juvenile owls were detected in subsequent years during this and other studies. It is possible that released owls, although dispersing from the release site, were unable to migrate successfully (i.e. mortality or lost ability to migrate due to being held overwinter). It is also possible that they migrated south for the winter but then were unable or unwilling to navigate all the way back to Manitoba. As few young returned, this may be an indication that both wild and captive-released owls, especially young in their first year migration, are facing challenges that are limiting their survival along their migration route to and from their breeding range and may be experiencing higher mortality in their wintering range. Currently, there are very few studies on the between-year dispersal of Burrowing Owls and no current satellite tracking data on owls migrating from Manitoba. Further studies need to be conducted to provide answers to these questions.

### ***Pellet Dissection***

The Burrowing Owl's main diet consists of insects, small mammals, amphibians, and small birds (Environment Canada 2012). In wet and cool years, prey shortages can occur resulting in the loss of nests and young (Fisher et al. 2015). In 2011, both groups of Burrowing Owls consumed more vertebrate prey (Table 4). Increased frog and toad populations due to wet conditions in southwestern Manitoba in 2011 were observed and may explain why vertebrate remains were higher in both groups pellet collections than in 2010.

In this study, total biomass percentage for both captive-released and wild owls appears to be similar for both seasons. However, the frequency and amount of remains in pellets were different for both groups. Both small sample sizes and the supplemental feeding of captive-released pairs may have confounded the ability to compare diet of the two groups.

Though I cannot draw any conclusions about foraging behaviour for either captive-released or wild owls based on the small numbers observed in my study, it did appear that captive-released owls were able to capture and consumed both invertebrate and vertebrate prey consistent (specifically in 2011 in my study) with other Burrowing Owl release studies (Leupin & Low 2001, Poulin 2003, Sissons 2003, Shyry 2005, Mitchell 2008). This study documented that in relatively wet and cool years owls are able to provide for their broods by opportunistically adapting to hunt alternate prey when it becomes abundant (i.e., increased  use or switch to frogs and toads for both groups in 2011). This is also consistent with other studies in both Saskatchewan and California (Haug & Oliphant 1990, Gervais 2003). The similarities in the diet of both groups suggests that hunting and foraging abilities of captive-released Burrowing Owls did not hinder the reproductive success of owls reintroduced in this study.

***Extreme Spring and Summer Weather***

Heavy rainfall combined with elevated ground water levels resulted in extensive flooding of both natural and artificial nest burrows during 2010 and 2011 and the loss of five captive-released nests and three wild nests.

In the last 20 years, southwestern Manitoba has experienced increased summer precipitation with the highest levels recorded in 2005 and 2010-2011 (during this study period). During 2005, no Burrowing Owls were observed and the precipitation total for April to June for Melita was 345.4 mm (Table 5). Similarly, in 2010-2011, over 200 mm of precipitation was recorded during April through June which coincided with nest failures observed during my study and a steep decline in Burrowing Owl populations in following breeding seasons. In 2012, two release sites were moved from flooded sites to higher grounds in Medora and Deloraine. This, along with slightly less rainfall levels (<200 mm), contributed to increased nesting success and no flooding losses for captive-released owls.

Burrowing Owls face many challenges including loss of habitat, reduction of nesting burrows, predation, and stochastic climate extremes. Heavy rain can flood nests and reduce prey availability (Grant & Birney 1979, Reed et al. 2006, Fisher et al. 2015). Reduced food availability along with nest flooding resulted in a decline of Burrowing Owl nests and owlet survival in Saskatchewan and Alberta (Fisher et al. 2015).

Nest failures affect Burrowing Owls within and between nesting seasons and result in low subsequent return rates (Haug 1985, De Smet 1997, Wellicome 2000, Fisher et al. 2015). Both male and female owl return rates decreased with reduced nesting success in previous breeding seasons. Catlin et al. (2004) noted that nesting success appeared to have the greatest effect on dispersal between breeding seasons for both sexes.

Due to the small number of Burrowing Owl occurrences throughout the last two decades it is not possible to measure significance (statistically) of the impact of rainfall on Burrowing Owl populations. However, the impact of historical precipitation rates on owl occurrences in Manitoba, personal observations from this study, and the 1987-1996 study, describe and show evidence that in times of increased precipitation, Burrowing Owls do not fare as well as during drier periods. De Smet (1997) speculated that increased summer rainfall in the early to mid-1990s was a major factor in sudden decline in productivity and nesting number of Burrowing Owls in southwestern Manitoba. He believed that food shortages, nest abandonments, and other factors may have been the major reasons why Burrowing Owl nests were lost or produced few young during that period. My study documented that prolonged wet periods contributing to a higher than normal water table combined with high event rainfall occurrences can have a significant effect on Burrowing Owl nesting success through flooding of a large number of nests. The end results of poor overall nesting success is often reduced return rates of nesting adults to the study area in subsequent years.

## 5) LIMITATIONS

### *Small Sample Size*

Small sample sizes (fewer than 10 nesting pairs in both captive-released and wild groups) limited statistical analysis in the present study. As a result, I was unable to assess statistical significance of reproductive success, diet, and dispersal differences between wild and captive-released owl pairs.

### *Data Collection*

#### Wild Nests

Late reports and observations of owl pairs further limited sample sizes for estimating hatching and fledging success. In both 2010 and 2011, a family group was reported and verified later in the season when hatchlings were near fledging age. These family groups were not included in monitored pairs, however, they were included in total number of pairs observed during the study.

#### Pellet Collections

The supplemental diet provided to captive-released owls limited a true comparison to wild prey remains. It is likely that captive-released owls were less inclined to hunt as extensively as wild pairs as long as they were receiving supplemental food. They might also be more inclined to hunt invertebrates close the nest burrow thereby reducing the amount of vertebrate prey items in their pellet collections. Another confounding factor in the pellet collections is obtaining a representative sample. Owls do not necessarily regurgitate pellets only at the nest burrow and main roost sites, where the majority of pellets were collected in this study. Thus, the pellets collected are likely a biased sample and cannot be interpreted as a complete collection of pellets/diet of both groups.

***Conservation***

Burrowing Owls in Manitoba face a host of significant limiting factors and threats. To stabilize or increase the population, it is necessary to identify and respond to as many of these threats as possible, and to explore means to increase nesting success and overall productivity. A goal of this study was to demonstrate that releases may play a role in conservation efforts by increasing overall numbers of adult and young Burrowing Owls on the landscape. The short-term goal of this study was to experiment with methods to increase Burrowing Owl populations in Manitoba, compare nesting and foraging ecology of wild and captive-released Burrowing Owls in the same general area, and to identify limiting factors that can be modified to enhance Burrowing Owl survival and productivity in Manitoba.

Initially, this study was developed to compare similarities and differences amongst the captive-released and wild groups, however, due to the status of Burrowing Owls in the province, conservation of the species took precedence. For example, if the supplemental diet was completely discontinued after removal of the pens (release), would there have been any successful pairs or hatchling or fledgling survival? Removing the supplement was not considered as it could have resulted in the loss of individual owls, pairs, nests, hatchlings, and fledglings. Continuation of food supplementation for captive-released pairs until hatchlings emerged from the burrow eliminated a true comparison between the wild and captive-released groups during the egg-laying and early-nestling stages.

The long-term goal of this study was to evaluate an alternative reintroduction strategy for Manitoba where successful pairs and some of their progeny are released and some of the progeny are held back and overwintered to serve as stock for subsequent releases. Though this study was limited by low numbers of owls and pairs in both groups, observations and data collected can be used as a starting point for continued research on the Burrowing Owl in Manitoba. Data from this study will also help facilitate monitoring and adaptive management for Burrowing Owls beyond the period of the study in both Manitoba and elsewhere in their Canadian range.

## 6) CONCLUSION

### *Management Implications and Next steps*

Although earlier Burrowing Owl monitoring and management efforts in Manitoba laid the ground work for reintroductions of the species and provided many answers as to why the species was declining in Manitoba, it was not able to stop the decline of the species in Manitoba. With a return of wet conditions in the early to mid-1990s, Burrowing Owl numbers in Manitoba plummeted to where they were on the verge of extirpation and reintroductions and management efforts for Burrowing Owls were discontinued in 1996. Thereafter, research and monitoring shifted west in the prairies to Alberta and Saskatchewan where Burrowing Owls still occurred but in greatly reduced numbers. Species-specific studies are essential as a means of quantifying progress towards achieving recovery objectives and assessing habitat management needs at current, former, or potential nesting sites. Valuable data was collected on the species in Manitoba during the 1987-1996 reintroduction efforts including: nesting success, territory re-occupancy, return rates, and population models (De Smet 1997). However, no data was collected on home-range, foraging behaviour and diet. The present study set out to collect updated information about the species, emerging threats (i.e. climate), and to evaluate new reintroduction techniques. It was expected that this study would assess an alternative release technique that would assist in the recovery of Burrowing Owls in Manitoba. Although sample sizes for both wild and captive release pairs were small during the current project, some inferences can be made.

1) Captive-released owl pairs were able to secure food for themselves and their young. Even with a reduced frequency of vertebrate remains in their diet, biomass percentages were similar to other studies. Burrowing Owls consume thousands of insects every season and this makes up the bulk of their diet. Also, despite the fact that food supplementation of captive release family groups stopped when the hatchlings emerged (at 10-14 days of age), 100% of the hatchlings that emerged

from the burrow all fledged, suggesting that these pairs and their young had learned the skills necessary to hunt, avoid predators, and survive.

2) Captive-released and wild owl pairs and nests face similar threats to survival. The greatest limiting factor experienced by both groups during this study was flooding of nests due to a high water table combined with extreme rainfall.

***Next steps***:

i. Continued surveys and monitoring of the species in the province. This is important to assess whether Burrowing Owls are responding to management efforts here and elsewhere in their Canadian range, to assess changes in trends and distribution of the species (i.e., will their numbers respond positively to drier conditions in the future or will numbers unexpectedly rebound again as they did in 2006). Monitoring will also help define critical habitat areas for Burrowing Owls in Manitoba and assist in habitat securement and habitat protection that will aid the species in its recovery.

ii. As extreme spring and summer weather patterns are expected to continue to occur and may be even more severe in the future due to changes in our climate, ground-dwelling species like the Burrowing Owl will continue to be challenged to locate suitable nesting habitat and finding nesting sites that are not prone to flooding. Engaging landholders in land management practices which positively affect fossorial mammals would increase natural burrows available for returning Burrowing Owls. Also, provisions and maintenance of ANBs in suitable areas is one way to encourage Burrowing Owls to return to these sites. The development of a waterproof ANB should also be considered.

iii. Additional research on limiting factors and species needs along migration and the winter range is increasingly important. As technology improves and tracking devices become lighter, we must explore every avenue to gain further insight into how and where Burrowing Owls migrate, and the survival challenges they face both on migration as well as on their wintering and nesting grounds. Migration and return rate data for adult and juvenile Burrowing Owls from Manitoba is currently limited to recapture and recovery of banded owls. With low band return rates throughout the last three decades, the challenges owls are facing along migratory routes could be the greatest limiting factor impacting their survival.

## CHAPTER THREE. Home-range size, habitat use, and foraging behaviour of wild and captive-released Burrowing Owls (*Athene cunicularia*) in southwestern Manitoba.

### 1) INTRODUCTION

The Burrowing Owl (*Athene cunicularia*) is a small, ground dwelling owl with long legs, bright yellow eyes, and brown and buff coloured barring on their chest. It relies on fossorial mammals to dig burrows for nesting and generally selects nest burrows in short-grass sections of pastures or haylands with longer grass hunting areas nearby. Burrowing Owls are a migratory species breeding in western Canada from March and April through August and migrating south from Canada in the fall (September and October) to the southern United States and Mexico.

Burrowing Owls were once found breeding in all of southern Canada's western provinces. Due to steady and ongoing declines in the population, most Burrowing Owls are currently found today in southern Alberta and Saskatchewan (Recovery Strategy for the Burrowing Owl in Canada 2012). The species has been extirpated from British Columbia (B.C.) since the early 1980's. Manitoba's population declined from nearly 100 pairs in the early 1980's to near extirpation by the late 1990s (De Smet 1997, 2003). No single factor explains the owl's continued decline. Rather, many year-round threats limit the species survival. These include habitat loss, degradation and fragmentation, loss of nesting burrows, vehicle collisions, increased predation, and a decrease in prey availability due changes in habitat and climate, as well as, increased pesticide use.

Few studies have looked at home-range size and habitat use for adult male Burrowing Owls in Canada and none have examined these aspects of their breeding territories in Manitoba. Radio telemetry studies collected home-range data for male owls near Ardath and Bounty, Saskatchewan (Haug & Oliphant 1990) and Brooks and Hanna, Alberta (Sissons et al. 2001, Sissons 2003). Some movement data has been collected for juveniles in Saskatchewan (Todd 2001, Todd et al. 2003) and for captive-bred released owls in B.C. (Mitchell 2008). Studies on nocturnal foraging behaviour, habitat use, and the effects of petroleum development on Burrowing Owls breeding success have been conducted in Alberta with the use of GPS dataloggers (Scobie et al. 2013, Marsh et al.

2014, Scobie et al. 2014). Other post-fledging dispersal research using radio telemetry has been conducted in Idaho, Washington State, and California including data the on effects of radio-transmitters on natal recruitment and assessing exposure risk to pesticides (King & Belthoff 2001, Gervais et al. 2003, Rosenberg & Haley 2004, Conway & Garcia 2005).

Historical records indicated Burrowing Owls in Manitoba were once more widespread than today. The species formerly occurred as far north and east as Dauphin and Beausejour, and regularly nested near Winnipeg until the 1980s (De Smet 1997, 2003). Declines in the population size and range were already evident in the 1930s, but became more evident when monitoring of the species began in the early 1980's (Ratcliff 1986, De Smet 1992). Extensive surveys, monitoring, and reintroductions were conducted in southwestern Manitoba through 1987-1996 (De Smet 1992, 1997). By 1996, due to low return rates and a nesting population that was close to zero, management and reintroductions efforts were discontinued (De Smet 1997). Although grassland bird monitoring, checks of former Burrowing Owl nesting sites, and follow–up of reports continued through the 1990s and early 2000s, it was not until 2006 that Burrowing Owls suddenly re-emerged in southwestern Manitoba with 9-13 nesting pairs monitored during most years from 2006-2009 (K. De Smet, unpublished data). Despite extensive monitoring, management, and research on return rates of Burrowing Owls in Manitoba since the 1980s, there has been no data collected on habitat use, home-range, and foraging behaviours of wild and captive-released owls in the province. Such information may prove critical to preventing further declines in Burrowing Owl populations in Manitoba. To successfully accomplish this, current data on the species status and breeding ecology needs to be updated for Manitoba.

In this study, home-range size was estimated for nesting captive-released males and nesting wild males during the 2010 and 2011 breeding seasons in southwestern Manitoba. A particular interest in this study was to determine whether there was a difference between the movements and habitat use of captive-released and wild male Burrowing Owls during a particularly critical period of development for the young, the post-emergence/pre-fledging stage. Differences in movements of captive-released owls as the season progressed may reveal how well these owls acclimated to the wild after release and how well they have adapted to hunting and providing food for their young. It is also important to affirm that the hunting abilities of captive-released one-year old male owls have not been impeded by being overwintered and to assess the benefits and potential drawbacks of holding over owls during what would be their first winter migration. Ultimately, it is hoped that these assessments will show how best to continue reintroductions to aid in the recovery of the Manitoba Burrowing Owl population.

## 2) METHODS

### *Study Area*

The majority of Burrowing Owl sightings in Manitoba in the last 10 years, and indeed since the late 1980s, have been in the extreme southwestern corner of the province near the towns of Melita, Pierson, Reston, Pipestone, and Lyleton with only a handful of reports outside of this area (De Smet, 1992, 1997, 2003, unpublished data). This area is composed of a mixture of agricultural cropland, haylands, pasturelands, and a few fragments of native grassland prairies, particularly in the Poverty Plains, Souris River Lowlands, and Lyleton-Pierson Prairie areas.

Five sites were selected on private land for the reintroduction of captive pairs in southwestern Manitoba (2010-2012). Release sites were selected based on proximity to recent Burrowing Owl observations and where optimal suitable habitat was available for Burrowing Owls (i.e., open pasturelands and short-grass prairie, abundant ground squirrels and burrows, and few trees or shrubs). Permission for access to release and observe owls throughout the nesting season was granted from all landowners.

Two release sites that also supported some wild male owls in 2010 and 2011 (near Pierson and Broomhill) were used to collect habitat use, foraging, and movement data for this study. Captive-released male owl data was collected at the Broomhill site and all wild male data was collected near the Pierson release site (Figure 1). Both sites were in extensive pastures grazed by livestock and dominated by mixed grass prairie grasses and forbs including, native species like Pasture Sage (*Artemisia frigida)*, Prairie Sage (*Artemisia ludoviciana),* Gaillardia (*Gaillardia aristata),* Crocus (*Pulsatilla patens),* Dotted Blazing Star (*Liatris punctatel*), Goldenrod (*Solidago spp.),* Coneflower, (*Ratibida columnifera)*, Prairie Rose (*Rosa arkansana),* Switch Grass (*Panicum virgatum),* Little Bluestem (*Schizachyrium scoparium)*, and Big Bluestem (*Andropogon gerardii*). There was also a mixture of tame/introduced species in these pastures including: Crested Wheatgrass (*Agropyron cristatum*)**,** Kentucky Bluegrass (*Poa pratensis*), and brome grasses (*Bromus spp.*).


**Figure 1.** Release and foraging data collection sites for captive-released and wild Burrowing Owls (*Athene cunicularia*) in southwestern Manitoba (2010 to 2012)**.** Broomhill (orange): Movement data collected at this site for captive-released male owls in 2010 and 2011; Pierson (blue): Movement data collected at this site for wild owls in 2010 and 2011.

*GPS Datalogger Installation and Data Collection*

Burrowing Owls generally forage for insects by day and make more extensive movements hunting small mammals by night (Poulin & Todd 2006). I collected data on foraging activities during both day and night for both groups.

Data was collected during the post-emergence and pre-fledging stage when young were approximately 10-21 days old. In this study, post-emergence stage was defined as the time when young emerged from the nest burrow (10-14 days of age) and pre-fledging stage was defined as the time between post-emergence and fledging of young (14-35 days). Females were not monitored because they generally remain close to the nest burrow through the early fledgling period. During this period, males provide >90% of the pairs' food (Haug et al.1993, Poulin & Todd 2006).

Home-range in this study was defined as the area used for foraging, roosting, nesting, and raising young during the post-hatch or early nestling stage. Daily foraging paths were measured using GPS dataloggers (Gypsy 4, Technosmart), which recorded locations at defined time intervals (2 fixes/GPS locations every minute). The dataloggers recorded three-dimensional location, i.e., latitude, longitude, and altitude, speed, angle of two-dimensional movement, and degree of precision. The accuracy of the logger was high, with 95% of locations falling within 4.2 m when recorded for 24 hours in a fixed position (Marsh et al. 2014).

GPS dataloggers were temporarily installed on select male owls during the post-emergence/pre-fledging stage, approximately 10-14 days after hatching started, during July and August in 2010 and 2011. All GPS data from captive-released males was collected after the supplemental feeding at the burrows had ended.

Male owls were trapped near the nesting burrow using walk-in traps with a decoy owl and an audio lure (Bloom et al. 2007). Once trapped, males were weighed and outfitted with a lightweight (6.1-6.4 g), vinyl backpack which held the datalogger. The backpack was secured to the owl using half-weave Teflon ribbon (Figure 2). In 2011, the addition of a lightweight plastic zip-tie was added to ensure that the vinyl backpack remained closed. The backpack and harness weighed slightly less than 4% of the male owl's body weight (≤ 150 g). It generally took about 5 minutes to attach the backpack. All males were captured a second and third time, approximately 3-4 days later, to either change the battery or remove the datalogger to collect the spatial data. I provided one extra mouse to all broods after every trapping event to accommodate for the effects of disturbing the male. Each owl's overall body condition was assessed when trapped by visually inspecting the owl's feathers around where the backpack and harness were attached (i.e., around wings, chest, and back) and by recording weight to ensure the backpack was not having a negative effect on its overall health and survival.

**Figure 2.** GPS datalogger secured to wild male Burrowing Owl (*Athene cunicularia*) with vinyl backpack and Teflon tubing near Pierson, Manitoba in 2010.

Additional behavioural observations were recorded throughout the GPS datalogger period. Owls were observed twice daily for at least two hours per visit. During these visits, owls were monitored from a nearby roadside with 8x40 binoculars and a 20x window-mounted spotting scope. Reconyx infrared wildlife trail cameras were also installed at all nests to monitor all activities near the burrow entrance 24 hours a day. Trail camera cards were removed during feeding and checked on a daily basis to verify that the GPS backpacks were still intact, that the backpacks were not impeding hunting activities for the owls, and to record any potential predator near the nest burrow. All images of prey deliveries near the burrow entrance were saved and times were noted. I considered a prey delivery to be when I was able to confirm that the male returned with either insects, amphibians, or small mammals to the nest burrow or transferred the prey item to either the female or young (Figure 3 & 4). Some prey deliveries may not have been recorded as the female and young, on occasion, did move outside the recording area to retrieve prey from the male.


**Figure 3.** Prey delivery from male to female nesting Burrowing Owls (*Athene cunicularia*) during GPS datalogger monitoring period at captive-released nest near Broomhill, Manitoba in 2011.

**Figure 4.** Prey delivery from male to young Burrowing Owl (*Athene cunicularia*) during GPS datalogger monitoring period at captive-released nest near Broomhill, Manitoba in 2011.

Activity patterns were evaluated from GPS datalogger spatial data. Home-range was determined by using the minimum convex polygon (MCP) estimate for each owl (Jennrich & Turner 1969). GPS coordinates were evaluated and probability contour and kernel density estimate maps were created outlining foraging and areas used using ArcGIS programming. Probability contour maps defined the owl's use of the area by total occurrence (50%, 90%, and 95%). Kernel density estimate maps outlined the owl's frequency or regularity of use in areas within the total home-range; these were classified as high to low use. GPS points were used to produce home-range maps and to evaluate frequently used areas during the post-emergence and pre-fledging period.

To compare and contrast foraging activities of nesting captive-released and wild males, I looked at the following parameters:

1) Activity bursts (timing and movements). An activity burst was defined as any movement greater than 1 meter. These did not include any small movements <1

meter around nest burrow or roosting sites. The total distance was calculated for all movements greater than 1 meter (i.e., trigger for activity) from GPS point to GPS point. GPS dataloggers were programmed and collected data for most owls from 1300h-0600h. These times included primary late-evening and overnight hunting times when males travel more extensively during hunting forays. Daytime hunting times were defined as occurring between 0600h-1800h and evening times were defined as 1800h-0600h.

2) Home-range size. Home-range was defined as the entire area or minimum convex polygon (MCP) the owl used while the GPS datalogger was installed. Maximum distance travelled from the burrow was calculated for each owl. This was calculated from the nest burrow GPS location to farthest GPS location from the nest burrow. In addition, home-range size and distance travelled from the nest were calculated and averaged for all owls, by group, and by year.

3) Habitat composition and use within home-ranges. Habitat composition within each home-range was broken down into seven categories: 1) native pastureland (dominated by mixed grass prairie grasses and forbs); 2) tame pasture (some mixed grass prairie but dominated by introduced species); 3) hayland (some native-like portions, but mostly were brome grass or alfalfa mixtures); 4) roadside ditches and roadways; 5) cultivated areas or cropland; 6) riparian borders or wetlands; and 7) grazed hayland (Haug & Oliphant 1990, Mitchell 2008).

In 2010, I installed dataloggers on two wild males and one captive-released male. Data was collected from July 7-16 for the captive-released owl and from July 14-17 for the wild males. Data was collected from 1300h-0600h for the captive-released and one wild male and from 1800h-0300h for the other wild male.

My first attempt to trap and install a datalogger on a wild male owl (Black A04) on July 14, 2010 was unsuccessful as the datalogger fell off or was removed by the owl shortly after being installed and was never recovered. Another datalogger was installed the following day, however, this datalogger was set up to provide a fix once every second draining the battery quickly and collecting only 10 hours of data (see Table 3 in results). This male proved to be very difficult to trap for a third time, outsmarting most of my trap attempts. I finally trapped him on July 20 by luring him back to the cage trap by using one of his young as a lure. Due to the difficulty of recapturing this male and the added disturbance to the nest, I decided not to install another datalogger as I may not have been able to recover the datalogger at a later date. Black A04 and his mate successfully fledged four young which were last observed in the area through September 1-9.

In 2011, one wild male and two captive-released males were outfitted with GPS dataloggers. Data was collected from both captive-released owls 24 hours a day from August 3-11, but the datalogger on the wild male (July 27-31) was programmed for more conservative hours (1300h-0600h) because I was not confident that he could be caught with enough frequency to allow for all day recordings. Despite the disparity in datalogger dates for wild and captive-released males, young were of similar age (10-14 days) when dataloggers were installed on males.

## 3) RESULTS

### *Captive-released Owls (2010 and 2011)*

Home-range and movement data collected on three captive-released Burrowing Owl males (2010 and 2011) is presented in Table 1. GPS readings were taken over a total of 26 days (533 hours) for these three males. A total of 82,449 GPS readings were obtained over this period, 64% of these were collected during nighttime hours (1800h-0600h).

**Table 1.** Movements of captive-released male Burrowing Owls (*Athene cunicularia*) temporarily installed with GPS datalogger during the post-emergence/pre-fledging stage in southwestern Manitoba, in 2010 and 2011.

| Year | Owl band (number) | Dates | No. young fledged | No. hours monitored | No. readings | | Home-range size ($km^2$) | Max distance from burrow (km) | Mean distance from burrow (m) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Day | Night | | | |
| 2010 | Red/Blue AE | July 7-16 | 2 | 224 | 11256 | 21053 | 0.25 | 0.4 | 70.5 |
| 2011 | Black A12 | *August 3-10 | 4 | 145 | 10001 | 22149 | 0.54 | 0.5 | 109.7 |
| 2011 | Black A08 | *August 4-11 | 2 | 164 | 8570 | 9420 | 0.51 | 0.5 | 105.2 |

*Late replacement clutch dates due to flooding of first nests.

Probability contour and kernel density estimate maps showed that male Red/Blue AE (2010) spent 50% of his time within 0.001 $km^2$ of the 0.25 $km^2$ home-range (Figure 5). Table 1 also reveals that this male's home-range was less than half as large as the other two captive-released males that were monitored in 2011. The kernel density estimate shows that this owl frequently used four areas.  The majority of his time was spent near the nest burrow, with considerable time spent at two nearby satellite burrows, and along a fence line adjacent a roadside ditch approximately 300 meters east of his nest burrow (Figure 6). GPS data was collected from this male from July 7-16 when his two young were 11-20 days old.

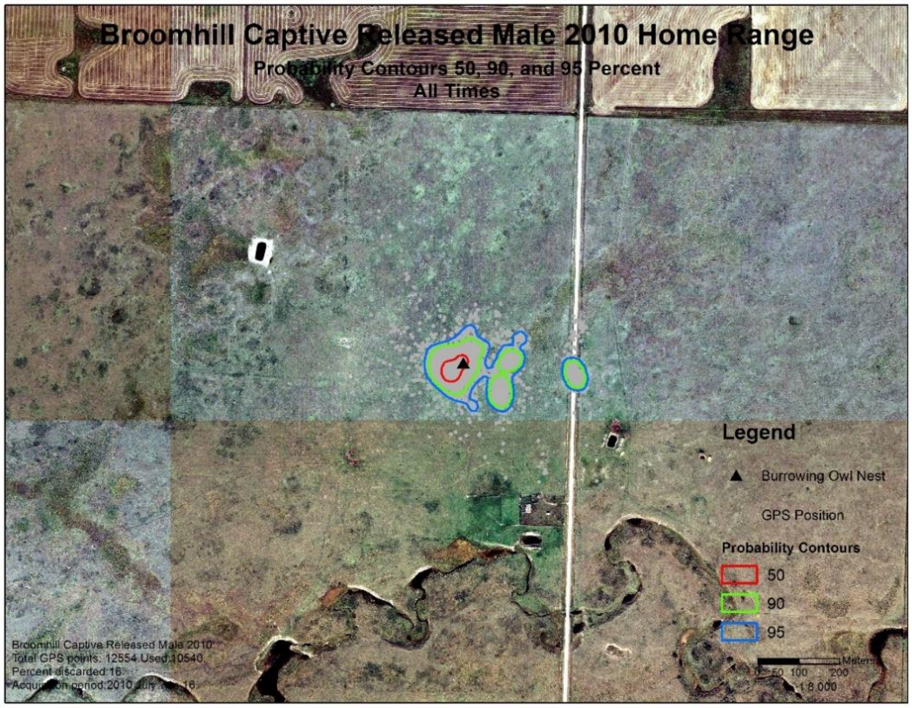


**Figure 5.** Home-range (probability contour) for captive-released male Burrowing Owl (*Athene cunicularia*) (Red/Blue AE) in southwestern Manitoba in 2010.

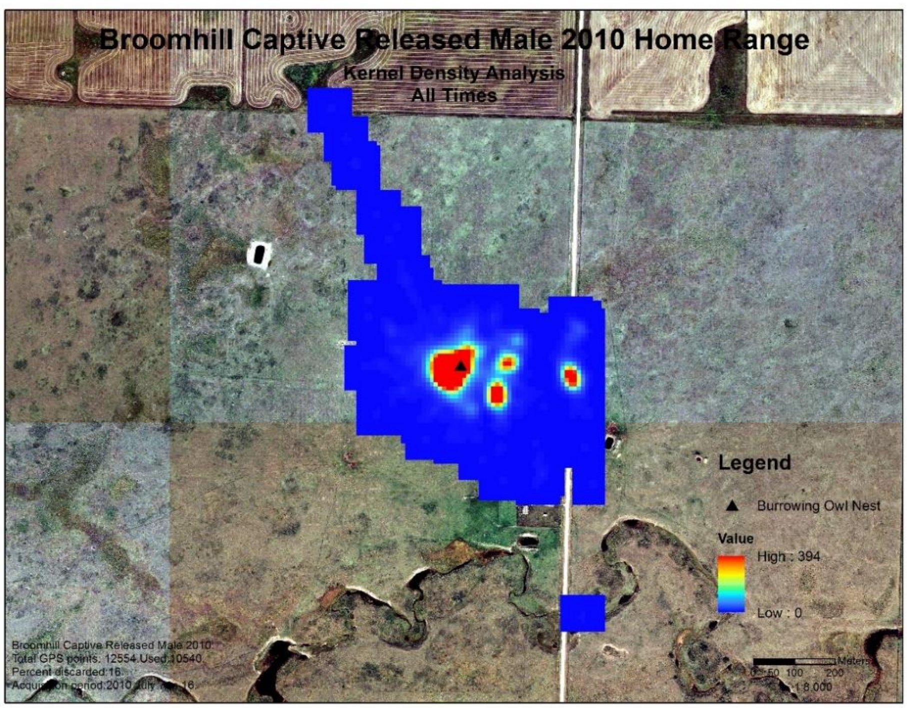


**Figure 6.** Home-range (kernel density estimate) for captive-released male Burrowing Owl (*Athene cunicularia*) (Red/Blue AE) in southwestern Manitoba in 2010.

The other two captive-released males were monitored during 2011. GPS data was collected for Male Black A12 from August 3-10 when his four young were 12-19 days old. This male's probability contour and kernel density estimate maps show that he spent 50% of his time within 0.011 $km^2$ of the 0.54 $km^2$ home-range (Figure 7). The kernel density estimate shows the owl frequently used five areas more regularly (Figure 8). These areas of frequent use were focused around his nest burrow and at four nearby satellite burrows.

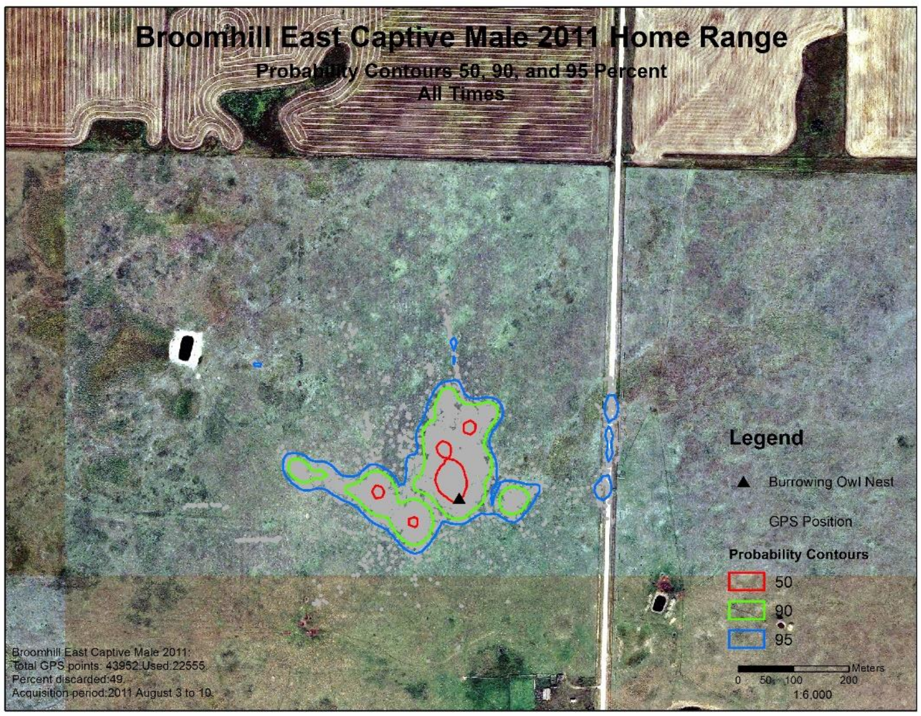


**Figure 7.** Home-range (probability contour) for captive-released male Burrowing Owl (*Athene cunicularia*) (Black A12) in southwestern Manitoba in 2011.

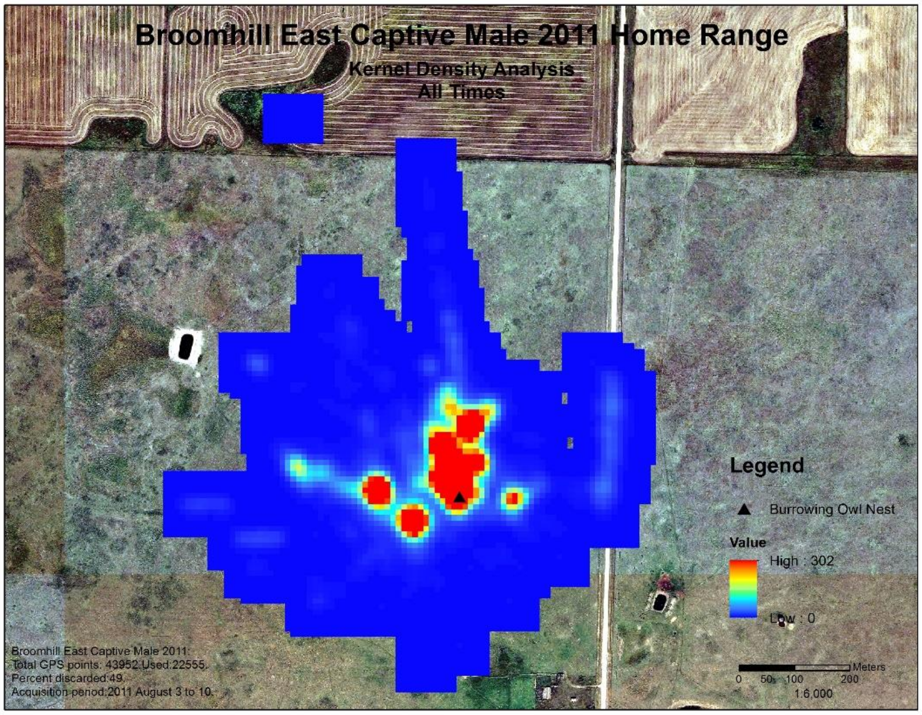


**Figure 8.** Home-range (kernel density estimate) for captive-released male Burrowing Owl (*Athene cunicularia*) (Black A12) in southwestern Manitoba in 2011.

GPS datalogger was collected for Male Black A08 from August 4-11 when his two young were 10-18 days old. His probability contour and kernel density estimate maps show that he spent 50% of his time within 0.014 $km^2$ of the 0.51 $km^2$ home-range (Figure 9). The kernel density estimate shows the owl frequently used three areas (Figure 10). These areas of frequent use surround his nest burrow and nearby satellite burrows, alike Red/Blue AE in the previous season, he also spent a fair amount of time along the fence line adjacent a roadside ditch approximately 300 meters east of the nest.

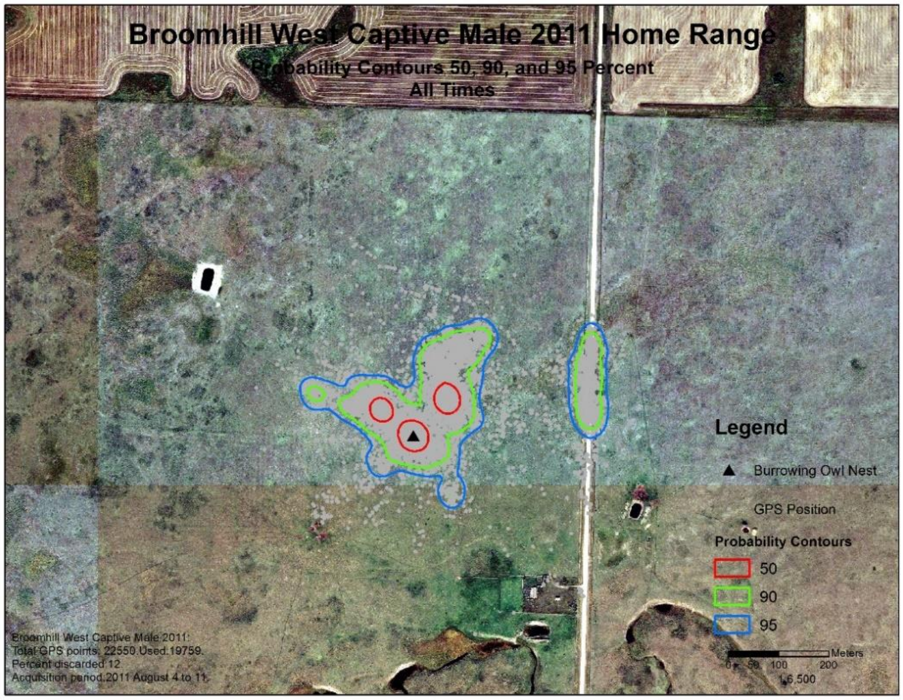


**Figure 9.** Home-range (probability contour) for captive-released male Burrowing Owl (*Athene cunicularia*) (Black A08) in southwestern Manitoba in 2011.

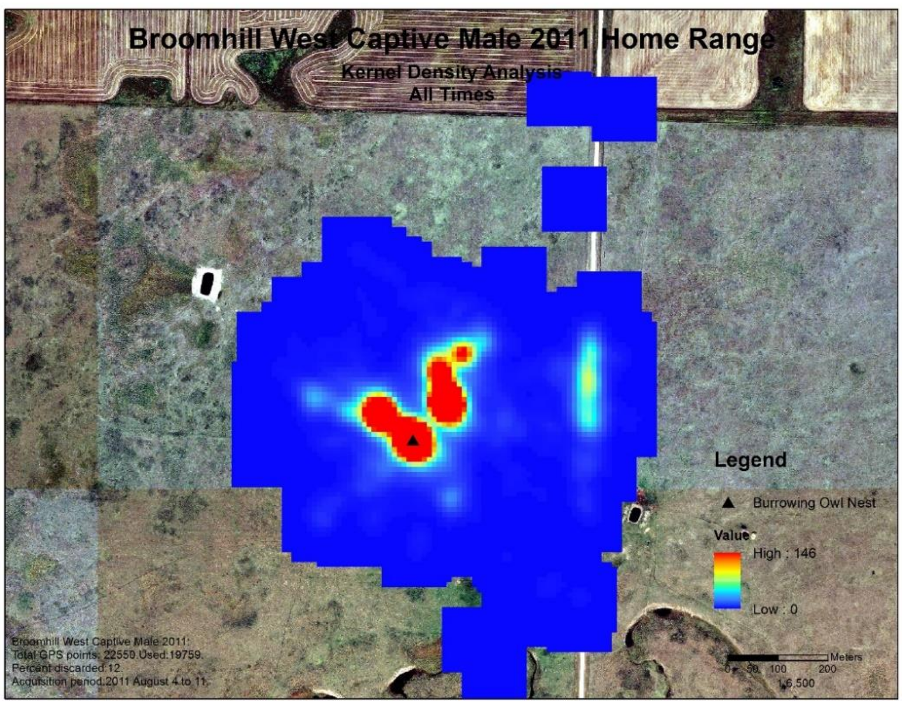


**Figure 10.** Home-range (kernel density estimate) for captive-released male Burrowing Owl (*Athene cunicularia*) (Black A08) in southwestern Manitoba in 2011.

Mean home-range size for the three captive-released owls in both seasons was 0.43 km$^2$, with a range of 0.25 km$^2$ – 0.54 km$^2$ (Table 1). Average distance travelled from the nest by these owls was 95 m. Habitat frequently used by captive-released males for foraging were predominantly grazed pasture dominated by mixed grass prairie and a fence line along a roadway and ditch. Lesser used habitats included cropland edges (canola and sunflower fields) which occurred >600 m north of nest burrows, and a riparian creek area that was located with the pasture but >400 m south of the nests (Table 2).

**Table 2.** Percent habitat used by captive-released and wild Burrowing Owls (*Athene cunicularia*) collected from GPS dataloggers in southwestern Manitoba (2010-2011).

| Year | Captive-released or Wild | Owls | Pasture (%) | Crop/Hayland (%) | Roadway and ditches (%) | Riparian (%) |
|---|---|---|---|---|---|---|
| 2010 | Wild | Black A04 | 100 | 0 | 0 | - |
| 2010 | Wild | Black A02 | 60 | 9 | 31 | - |
| 2010 | Captive-released | R/B AE | 98 | 0 | 2 | 0 |
| 2011 | Wild | Black A04 | 100 | 0 | 0 | - |
| 2011 | Captive-released | Black A12 | 98 | 1 | 1 | 0 |
| 2011 | Captive-released | Black A08 | 93 | 0 | 6 | 1 |

### *Wild Owls (2010 and 2011)*

Home-range and movement data collected on wild Burrowing Owls are presented in Table 3. GPS readings were taken over a total of 11 days (148 hours) for these three males. A total of 6,193 GPS readings were obtained over this period, 78% of these were collected during nighttime hours (1800h-0600h).

**Table 3.** Movements of wild male Burrowing Owls (*Athene cunicularia*) temporarily installed with GPS datalogger during the post-emergence/pre-fledging stage in southwestern, Manitoba through 2010 and 2011.

| Year | Owl band # | Dates | No. young fledged | No. hours monitored | No. readings | | Home-range size ($km^2$) | Max distance from burrow (km) | Mean distance from burrow (m) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | Day | Night | | | |
| 2010 | Black A04 | *July 15-16 | 4 | 10 | - | 950 | 0.14 | 0.8 | 74.3 |
| 2010 | Black A02 | July 14-17 | 7 | 58 | 1233 | 2905 | 1.02 | 0.7 | 135.0 |
| 2011 | Black A04 | *July 27-31 | 5 | 80 | 160 | 945 | 0.10 | 0.4 | 83.5 |

*Replacement clutch due to flooding of first clutch.

GPS data was collected for wild male Black A04 from July 15-16 for ten hours (dusk and overnight period) when his young were approximately 13-14 days old. Because of the earlier addressed datalogger and recapture problems, I had no daytime readings and less than 1000 total GPS readings for this male (Table 3). Probability contour and kernel density estimate maps showed that he spent 50% of his nighttime hours within 0.004 $km^2$ of a 0.14 $km^2$ home-range (Figure 11). This male appeared to spend most of his time at two spots - his nest burrow and a nearby satellite burrow. However, he did spend some time in a lush pasture approximately 600 meters northeast of his nest burrow across a roadway (Figure 12).

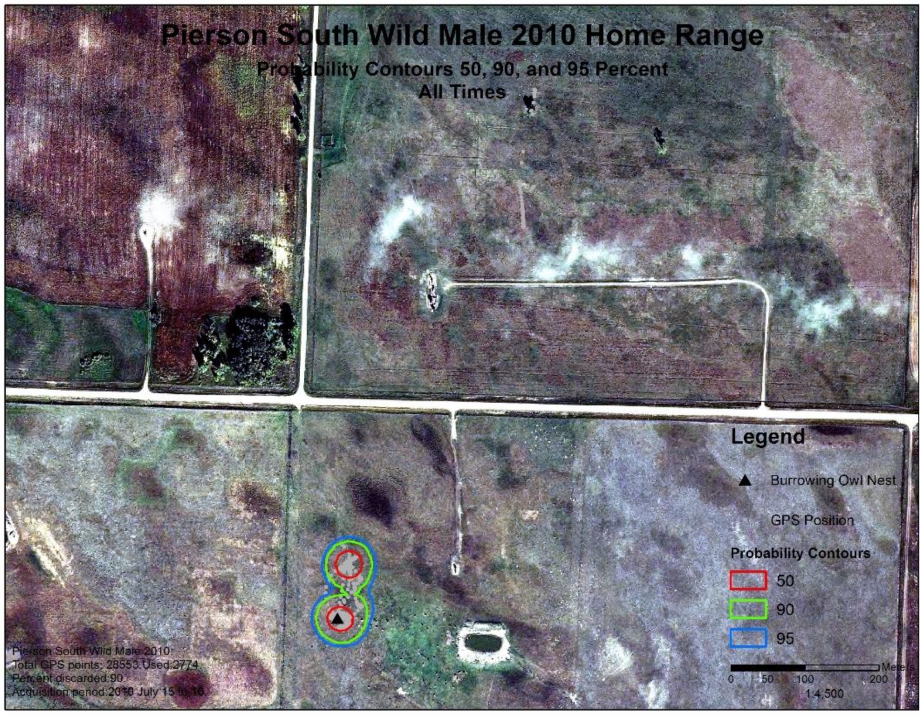


**Figure 11.** Home-range (probability contour) for wild male Burrowing Owl (*Athene cunicularia*) (Black A04) in southwestern Manitoba in 2010.

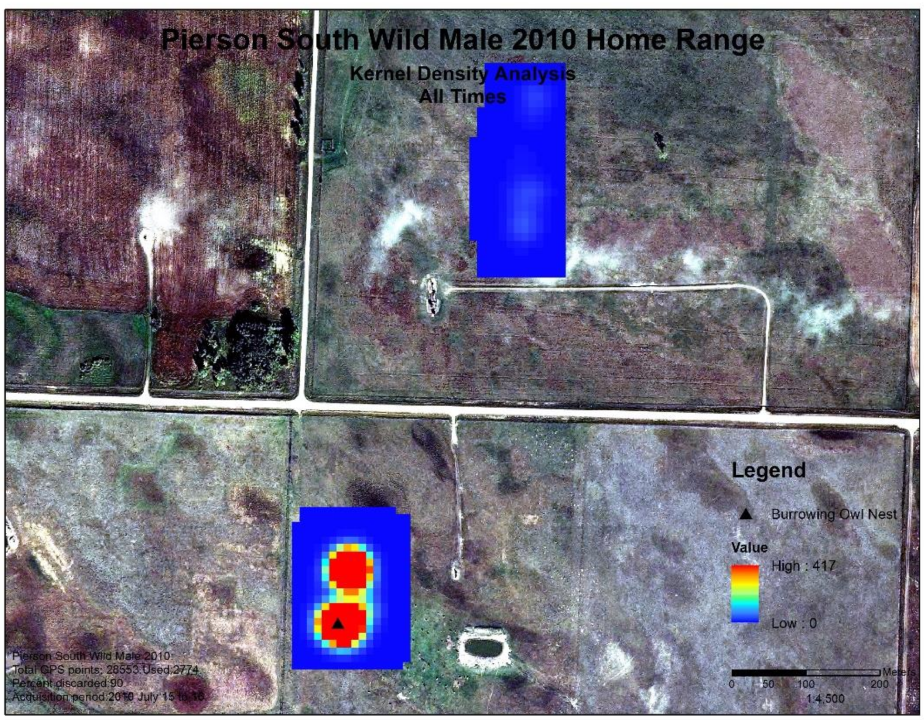


**Figure 12.** Home-range (kernel density) for wild male Burrowing Owl (*Athene cunicularia*) (Black A04) in southwestern Manitoba in 2010.

GPS data was collected from male Black A02 from July 14-17; his seven young were 12-14 days old (at installation) to 15-17 days old (at removal of backpack). Over 4100 GPS readings were taken for this male, considerably more than for Male Black A04 but considerably less than for any of the captive-released males. Overall, this male displayed by far the largest home-range size of any of the monitored males (1.02 $km^2$) and a much larger mean distance travelled from his nest burrow (Table 3). Probability contour and kernel density estimate maps for male Black A02 showed that he spent 50% of his time within 0.007 $km^2$ of his 1.02 $km^2$ home-range (Figure 12). The kernel density estimate shows that this owl frequently occupied a large area around his nest burrow and nearby roosting sites which included the fence line along a roadway (Figure 13). Less used areas included cropland to the northwest and a fence line bordering a tall-grass pasture across the road and to the east of his nest burrow.

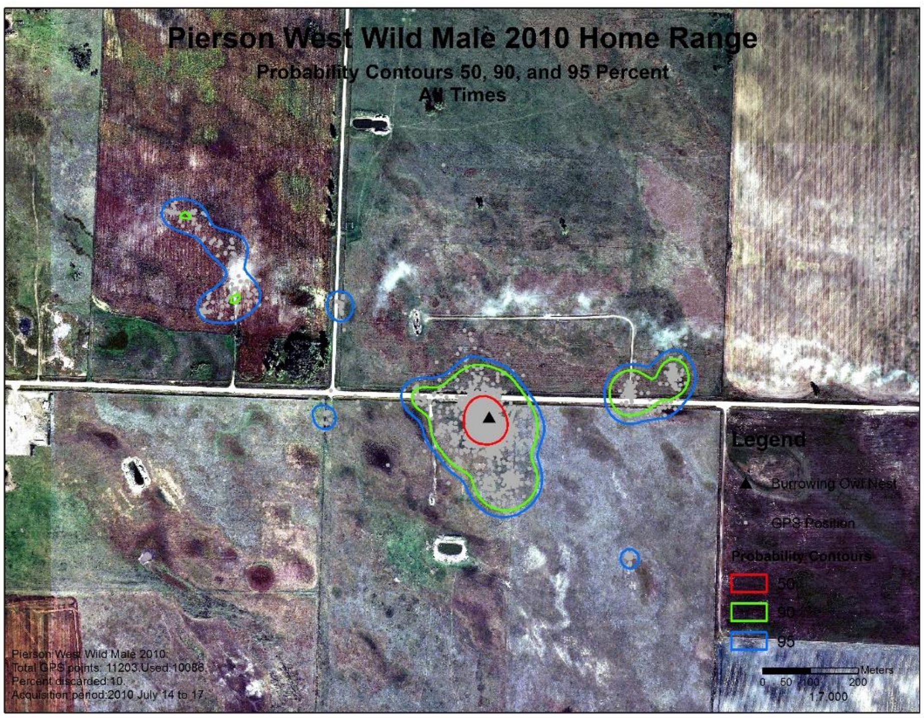


**Figure 13.** Home-range (probability contour) for wild male Burrowing Owl (*Athene cunicularia*) (Black A02) in southwestern Manitoba in 2010.

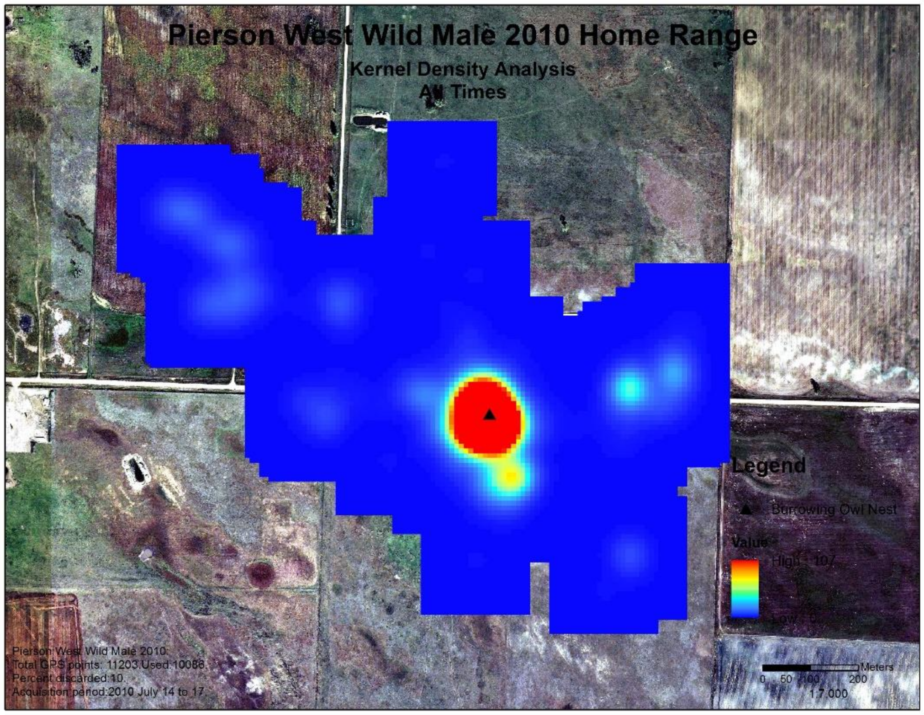


**Figure 14.** Home-range (kernel density) for wild male Burrowing Owl (*Athene cunicularia*) (Black A02) in southwestern Manitoba in 2010.

After the datalogger and capture issues I had with Black A04 in 2010, I was intrigued to see if I would again encounter issues with capturing him and how his foraging behavior might change from one year to the next. His 2011 nest was about 300 m from where he had successfully fledged young in 2010. GPS data was collected from this male from July 27-31 when his five young were 12-14 days old (installation) and 16-18 days old (removal of backpack). Once again in 2011, this male was a challenge to catch, therefore the backpack was not left on when he was recaptured for fear I might not have another opportunity to retrieve the backpack. Consequently, only 1105 total GPS readings were obtained for this male in 2011, more than the previous year but still far less than for any other male during this study. Probability contour and kernel density maps for male Black A04 (2011) showed that he spent 50% of his time within 0.002 $km^2$ of the 0.10 $km^2$ home-range (Figure 15). The kernel density estimate showed this male frequently used three larger and one smaller areas around his nest burrow, nearby satellite burrows, and along a broken fence line between sections of pastureland (Figure 16)

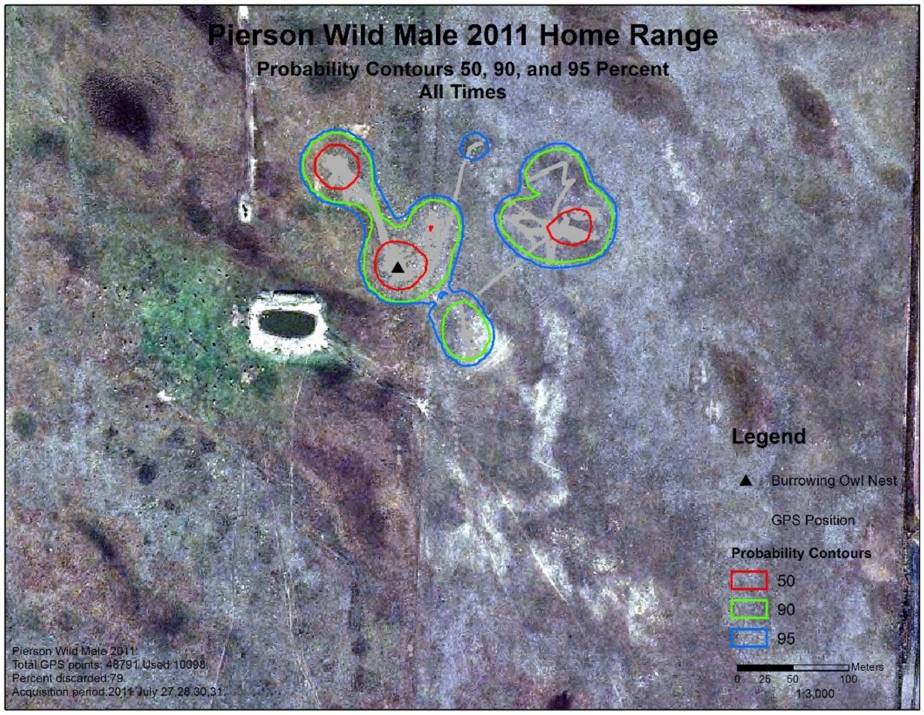


**Figure 15.** Home-range (probability contour) for wild male Burrowing Owl (*Athene cunicularia*) (Black A04) in southwestern Manitoba in 2011.

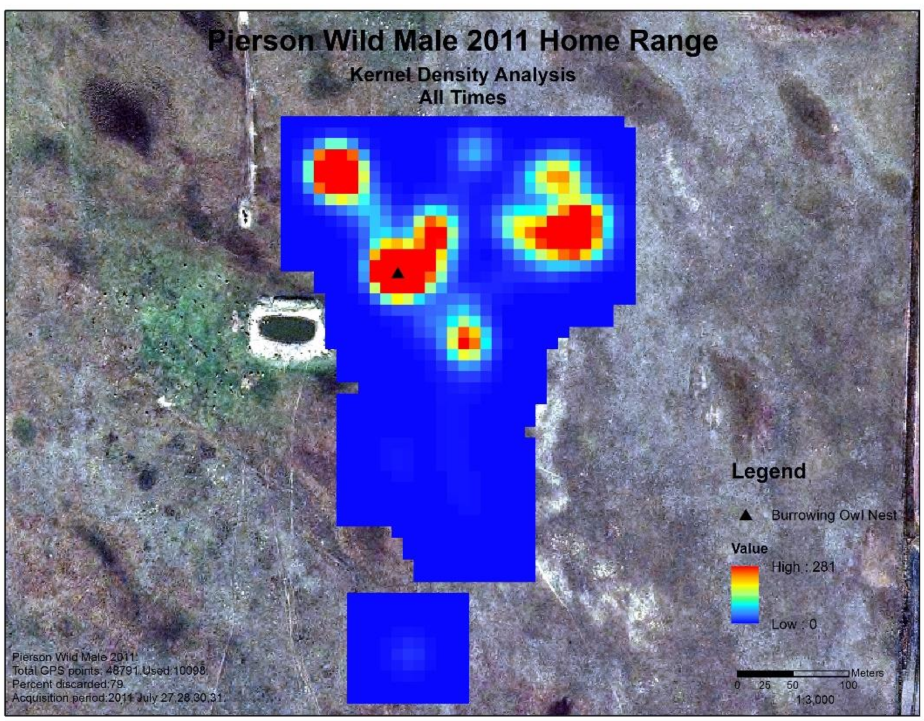


**Figure 16.** Home-range (kernel density) for wild male Burrowing Owl (*Athene cunicularia*) (Black A04) in southwestern Manitoba in 2011.

Mean home-range size for wild owls in both seasons was 0.42 $km^2$, with a range of 0.10 $km^2$ – 1.02 $km^2$.  Average distance travelled from the nest for these males was 121.4 m. Habitats frequently used by wild males for foraging were predominantly grazed, native pasture dominated by mixed grass prairie and grass-forbs areas along roadways and ditches. Lesser used habitats were cropland and tall-grass pasturelands, both of which occurred north of the nest burrows.

### *Activity Bursts and Distance for Captive-released and Wild Owls*

Average activity distance for captive-released male owls was 21.5 meters (range 14.5m-25.9m). Activity distances of captive-released males were, on average, greater than wild males (21.5 m versus 12.1 m), but wild males showed greater variation (Tables 1 and 2). Average distance travelled from the nest was 70% greater for wild owls than captive-released owls (Table 1 and 2). Captive-released owl activity distance between points was greater than wild males. Also, 79% of all captive-released owl movements were >l meter, compared to wild owl movements at 34%.  One wild and two captive-released owls travelled more than 100 meters consistently from the burrow, and the other two owls (three samples) generally stayed closer to the nest with distances < 85 meters. Individual activity distances and activity bursts are presented in figures 17 and 18.

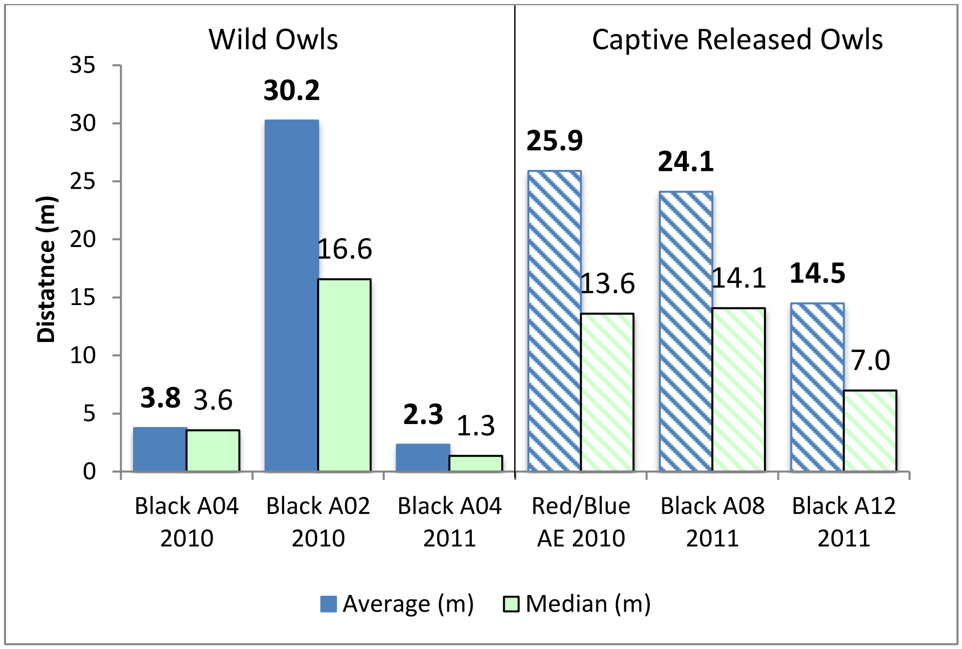


**Figure 17.** Individual average and median activity distance between GPS points for captive-released and wild Burrowing Owls (*Athene cunicularia*) temporarily installed with GPS datalogger during the post-hatch/pre-emergence stage in southwestern Manitoba (2010-2011).

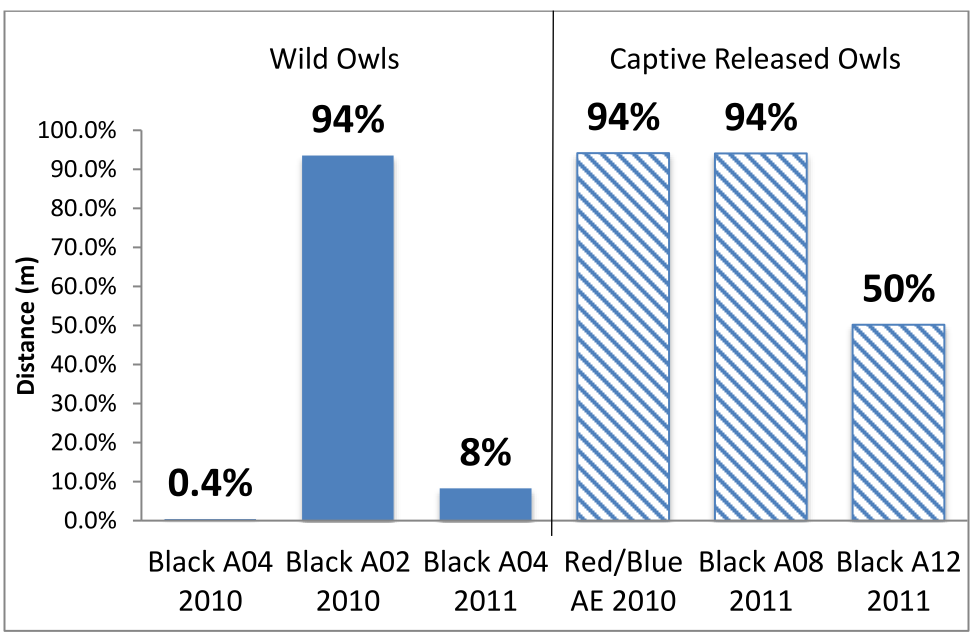


**Figure 18.** Activity bursts (movements >1meter) for captive-released and wild Burrowing Owls (*Athene cunicularia*) temporarily installed with GPS datalogger during the post-hatch/pre-emergence stage in southwestern Manitoba (2010-2011).

## 4) DISCUSSION

### *Captive-released Owls*

The most data points collected during my study were from the Broomhill east male (Red/Blue AE) in 2010 (Table 1). This male also had the smallest home-range (0.25 $km^2$) among the monitored captive-released males. This male spent most of his time near the nest burrow and a nearby fence line (300 m from his burrow) by a gravel roadway and ditch. He mostly foraged along this roadway, in grazed pasture near his release and nest burrow, and on occasion on the border of cropland (canola) north of his nest burrow. This configuration of habitat relative to his nest burrow explained his increased activity distance (25.1 m on average) and bursts results (94% of all his movements were >1 m).

In 2011, both captive-released male owls observed at the Broomhill site (Black A08 (west) and Black A12 (east)) had similar sized home-ranges. They also travelled a similar distance to and from their nests. Both males nested in similar habitat and primarily foraged in the surrounding native pasture (Table 2). Black A12 foraged less regularly to the north (cropland) and east (roadway and ditch). Black A08 frequently foraged south of his nest burrow (near a creek) and east (fence line by roadway). Nest proximity, territory, and competition for food may have influenced habitat used for foraging by both males. Male Black A08's nest was situated further south and closer to a nearby creek than male Black A12's. Black A12's nest was closer to the cropland located north of the release site. Probably most influential in their choice of foraging areas was that these males would have crossed each other's nesting territory to access the south creek or north cropland areas, thus it is possible that they stuck to hunting close to their respective territory to avoid conflict. It is also possible that because they were nesting in the same general area that they foraged in a particular niche due to competition for food. A preferred hunting location in this field was the fence line directly east of Black A12's nest, however, he did not use this fence line to forage as often as Black A08 did. This may have been a territorial exclusion by Black A08. In contrast, the captive-released male (Red/blue AE) in 2010, with a home-range half the size of Black A08 and A12, had no competitors and predominantly used this fence line to roadway ditch to forage daily.

All captive-released nest burrow sites were equipped with a short, 60 cm high wooden post for owls to perch prior to and after release. Wild Burrowing Owls tend to favour slightly elevated perch sites like knolls, large burrow mounds, and fence posts for roosting and hunting. Perches are advantageous as they provide the owls with an elevated location to visually spot predators as well as prey. The short wooden posts that were installed with pens were not removed after release, whereas wild owls were not provided with a similar convenient perch near their burrow. Since Burrowing Owls favour these slightly elevated perches, especially fence posts, it is likely that wild owls would have moved a further distance, on average, from the nest burrow to find elevated perches whereas, captive-released owls did not have to leave the nest burrow area to perch reducing overall activity and travel distance.

***Wild Owls***

Limited data for male Black A04 made it difficult to assess if the results collected were a true representation of his home-range in 2010. This male returned in 2011 to the same pasture but nested in a different burrow about 300 meters east from his 2010 burrow. There was little difference between his home-range size, activity bursts, and distances from 2010 to 2011 (Table 3 and Figure 16), and he had the smallest home-range in both seasons and in both groups (captive-released and wild). In 2010, he travelled further than in he did in 2011 to forage. His longest distance traveled at 0.8 km north of the nest burrow to a tall-grass pastureland across a roadway, north of the nest burrow. In 2011, he foraged closer to the nest burrow and on average traveled half the distance (0.4 km) he did in 2010. In both seasons, his movements between points were the shortest recorded for any of the tagged males at an average of 3 meters between points. In both seasons, he had a similar brood size with four young in 2010 and five young in 2011.

In both 2010 and 2011, the breeding seasons (April through August) in southwestern Manitoba were extremely wet. Increased precipitation created issues with overland flooding in most of the southwest corner of the province (traditionally among the driest of areas in the province). These extremely wet conditions appeared to boost amphibian populations. Based on both personal observation and pellet collection dissection both captive-released and wild owls consumed more frogs and toads in 2011

(Chapter One). The observed difference in foraging activity for Black A04 in 2011, when his home-range was smaller than 2010, could be related to greater abundance of prey available in the immediate vicinity of his nest site.

It is also possible, based on the GPS data that male Black A04 did not respond well to carrying the GPS datalogger attachment. It is difficult to measure whether the datalogger limited his movements during installation as this male's daily activities (based on behavioural observations) prior to and after the datalogger was removed were concentrated around his nest burrow and a nearby fence line. As no other tagged owls showed negative effects while carrying the backpack, and this male's movements without the backpack were small and generally around his nest burrow, I assumed that the foraging data collected from Black A04 was an accurate depiction of his daily activities.

In this study, wild male Black A02 from 2010 had the largest home-range (1.02 $km^2$). Also, 94% of his movements were >1 meter and he had the longest movements between points of all owls at 30.2 meters. This male had the greatest number of young of all monitored males (7 young) which may have increased his need to hunt more actively and greater distances from the burrow. Based on the kernel density estimate and observations, this male maximized the use of a nearby fence line along a ditch and gravel roadway. He also foraged in nearby cropland, grazed hayland, and other nearby grazed pastureland. Observations and camera images also that revealed his mate actively hunted more extensively than other females to help feed the large brood. It would be reasonable to suggest that Black A02 had a larger home-range, used a greater variety of habitat, and moved more frequently and longer distances as a result having a large brood to feed (3 more young than any other male in this study). All young fledged from this nest in early August, dispersing to nearby satellite burrows and were last observed at this site in early September 2010.

### *Captive-released and Wild Owls*

As captive-released owls were overwintered and provided with a supplemental diet prior to and after release I assumed this might impede their ability and motivation to hunt. Based on this, I expected that wild Burrowing Owls would have a larger home-range size, travel greater distances from their nest burrow, have larger movements between points, and use a greater variety of habitat types to forage than captive-released owls. Although I am unable to draw any conclusions about the entire population of Burrowing Owls based on six samples, I was able to provide some qualitative insight on home-range size, movements, foraging behaviours, and habitat use for the small number of male owls observed.

Wild male owls had both the largest and smallest home-range in this study. One wild male had a 1.02 $km^2$ home-range that was 40% larger than all other males in either group. The other wild owl, which was observed in both seasons, had the smallest home-range of all males in both seasons, 0.14 $km^2$ and 0.10 $km^2$, respectively. Wild males travelled farther with an average of 633 m (range 400-800 m) compared to an average of 467 m (range 400-500m) for captive-released males. Mean home-range size was similar for both groups in this study (Table 1 and 2).

Home-range sizes in this study were similar to Sissons et al. (2001) collected from four male owls near Avonlea, Saskatchewan, with average home range sizes of 0.34$km^2$ (range 0.08$km^2$ - 0.47$km^2$). However, both mean home-range and maximum distance travelled were much smaller in my study compared to Haug & Oliphant (1990) in Saskatchewan (2.41 $km^2$) and Sissons (2003) in Alberta (3.95 $km^2$). Gervais (2003) also saw larger home-range sizes (1.28 $km^2$ - 1.34 $km^2$), however, mean distance travelled from nest burrows were lower in her study with 378 m and 409 m where she tracked 33 resident male Burrowing Owls with radio-collars at the Naval Air Station in Fresno, California. The number of owls examined in my study were similar to Haug & Oliphant (1990) with 6 male owls, Sissons et al. (2001) with 4 male owls, and Sissons (2003) with 11 male owls, however, these four studies monitored owls for extended periods of time ranging from one month (Sissons et al. 2001) to over four months (Gervais 2003). My study collected movement data from male owls over a 1-9 day period. Because of the small sample size and short duration of monitoring in my study it is possible that home-range size was not fully represented. Thus, home-range size of the six male owls examined in my study are considered minimum home-range sizes.

The wild male, Black A02, with the largest home-range, had the most young in all nests (total of 7). Haug & Oliphant (1990) also found that two owls in their study with the largest home-range sizes fledged the greatest number of young in that season. Black A04, with the smallest home-range had 2-3 fewer young and in general remained closer to his nest burrow. An increase in both frog and toad populations was observed in 2011, both by personal observation and in pellet collection dissections (Chapter One).

Burrowing Owls are opportunistic foragers that eat a wide variety of vertebrate and invertebrate prey (Green et al. 1993, Gervais et al. 2000, Haug et al. 2003, Poulin 2003).

Haug & Oliphant (1990), Sission et al. (2001), and Gervais (2003) observed owl foraging behaviours, diet, and home-range size shift due to resource availability when grasshopper (Haug & Oliphant 1990) and small mammal (Sisson et al. 2001, Gervais 2003) populations increased. I observed similar phenomena in 2011 when an increase in both frog and toad populations no doubt contributed to an increase in these food items in the diet of wild owls at the Pierson site and may have resulted in male Black A04 foraging closer to his nest.

Activity distances varied for all owls in both years. Two of the three captive-released owls showed similar activity distances to a wild owl with 94% of all movements being >1 meter (Figure 17). Activity distance and bursts have not been evaluated in other studies. However, using similar GPS dataloggers, Marsh et al. (2014) examined vertebrate prey capture sites for male owls during the breeding season in Albert and Saskatchewan. He noted that 47% of all captures occurred at > 800 m from the nest, 17% of captures occurred at > 1600 m from the nest, and fewer than 10% of captures occurred at < 200 m from the nest.  The average home-range size for all owls in my study was 420-430 $m^2$. Based on Marsh et al.'s (2014) observations, owls in my study were foraging a distance from the burrow consistent to distances from the nest where most vertebrate prey captures occur.

## 5) LIMITATIONS

### *Small Sample Size*

Generally, small samples limit statistical analysis. Descriptive statistics were used to interpret data, limiting the ability to make assertions for the entire population of Burrowing Owls in Manitoba. This study was the first of its kind in Manitoba. It collected home-range size, movements, and diet (Chapter One) for the species in Manitoba. Despite the limited sample size this study provides a basis for future research and assists in the stewardship and recovery of the Burrowing Owl in the province.

### *Datalogger Installation and Trapping*

During my study, fewer datalogger data were collected for wild owls than captive-released owls because the former were more difficult to trap. Minimizing disturbance to all owls was a priority, especially at wild nests where trapping attempts failed several times over consecutive days. Behavioural observations suggested that captive-released adult may have been slightly more habituated to humans than wild owls. This could be a result of exposure to humans while they were overwintered, fed, and observed throughout the winter and breeding season. They also had regular contact with humans at the release site during the supplemental feeding period. This may be why captive-released owls were easier to trap and recapture. As a result, less data was collected from wild owls in both years.

Dataloggers captured most readings, however, two were rather sporadic in that they varied from recording normally to capturing one point a minute or even failing to record for 2 minutes. This seemed to occur closer to the end of the collection period and perhaps was an issue with the battery. It could also be a malfunction of the datalogger or poor GPS coverage at the time the datalogger was recording the point.

In conclusion, both the small sample size and variable performance of dataloggers resulted in a limited ability to compare activity distances and movements among and between owls.

# 6) CONCLUSION

## *Management Implications and Next Steps*

Limited information exists regarding home-range and preferred foraging habitat for Burrowing Owls. This study is the first to examine home-range, foraging behaviours, and diet for Burrowing Owls in Manitoba, and to examine and compare foraging ecology between a captive-released and a wild population. Burrowing Owl populations are critically endangered in Manitoba with five or less wild breeding pairs observed annually during my three year study. Despite low occurrences for wild owls, valuable data was collected. Although statistical analyses were limited, descriptive data collected from Manitoba's small population of Burrowing Owls provides a basis for future recovery and research efforts.

My data suggests that male owls, in both groups, concentrate the majority of the foraging efforts near the nest burrow and nearby favoured roosting spots (i.e., fence line near roadway and satellite burrows). There was considerable variability in home-range size estimates and activity distances among individual male owls and groups (captive-released and wild) making it difficult to assess how much habitat a male requires to forage.

Based on my results, it appears that captive-released and wild male owls had similar habitat requirements and movement patterns. Captive-released male owls were capable of securing and providing food for their broods, foraging in a variety of habitat types and capturing an array of prey species. Both wild and captive-released owls appeared to be opportunistic shifting prey use depending on its availability.

Despite the small sample size of both groups in this study, data collected can be a foundation for future research for the species in Manitoba. As the Burrowing Owl population continues to decline throughout Canada continued recovery efforts must be a priority to ensure that the owl does not become extirpated from Manitoba, and Canada.

***Next Steps:*** For Burrowing Owls in southwestern Manitoba

1) Continue surveys based on suitable habitat types and monitor all historic nesting sites (all sites used since 1980s area recorded in the Manitoba Sustainable Development (CDC) with additional importance attached to nesting areas used in the last decade).

2) Whenever possible, work with local communities, landowners, habitat preservation groups (i.e., Nature Conservancy Canada, Manitoba Habitat Heritage Corporation) and local/provincial management agencies (i.e., Manitoba Sustainable Development, Conservation Districts) to preserve and better protect key nesting sites and suitable nesting habitat. Encourage landowners and management agencies to maintain habitat and install artificial nest burrows where needed.

3) Collect more detailed data on home-range, movements, dispersal (both adult and juvenile), and diet on a wider scale and throughout the nesting season, if and when available. Advances in technology may eventually allow more sophisticated techniques and even satellite monitoring to be done on smaller birds like the Burrowing Owl but currently this is still not an option. All of these techniques should be investigated where possible to allow researchers to gain a better understanding of the habitat needs for Burrowing Owls in Manitoba, and as well as on their wintering and migration range.

4) Prepare and implement a new provincial recovery strategy to prevent further declines of the species. This plan should include:

    - A 10 year recovery action plan to promote a self-sustaining population of owls to 1993 levels (23 pairs) – the minimal population goal outlined in the Recovery Strategy for the Burrowing Owl in Canada 2012.
    - Reintroduction options.

- Surveys and monitoring.
- Description and protection of critical nesting habitat.
- Identify gaps and areas for continued research.
- Outreach with landowners and the active involvement of various interest groups and management agencies in communities nearest current wild populations.

# CHAPTER FOUR. Summary and Conclusions

## *Thesis Summary and Conclusion*

Manitoba's small population of Burrowing Owls declined through the last 25 years (1987-2012). When conditions were suitable here, or perhaps less suitable elsewhere in their nesting range, there were small influxes of owls and enhanced nesting success was observed. This study, and data collected during the 1987-1996 management and reintroduction programs, have been unable to pinpoint a single factor contributing to the species ongoing decline in Manitoba and throughout the Northern Great Plains. Instead, multiple limiting factors seem to be operating in conjunction and these can vary drastically from one study area to the next and from one year to the next.

Limiting factors include habitat loss, degradation and fragmentation, loss of burrows, increased use of pesticides, decreased abundance of prey, increased exposure to predation, and an increase in cool wet seasons. These have all reduced the species nesting success and survival. During this three-year study, both wild and captive-released owls were challenged by extreme spring and summer storms which flooded nests and resulted in several nest failures. Surveys in southwestern Manitoba have revealed that anthropogenic changes to the landscape include urban expansion, modern large-scale agricultural practices, increased construction and use of roadways throughout their year-round range, and energy exploration (i.e., installation of oil derricks and associated infrastructure). These have reduced suitable breeding habitat for Burrowing Owls. Several areas where owls historically nested in recent decades have been completely altered from native pastureland to cropland.

My study had three objectives:

- To explore a new reintroduction technique for Burrowing Owls in Manitoba using recent and successful techniques that have been used recently in western Canada to encourage overall productivity and success of captive-released owls and nests.
- To compare aspects of the breeding ecology of captive-released and wild Burrowing Owls in Manitoba. Few studies have assessed reproductive

success (i.e. nesting and fledging success), survival, dispersal, and return rates.

- To gather data on prey use, habitat use, breeding home-range size, movements, and activity for wild and captive-released owls. This information helps to better understand emerging threats and other limiting factors that Burrowing Owls may encounter in Manitoba in an ever changing landscape.

A small number of captive-released and wild owls were studied from 2010-2012. The results suggest that captive-released owls that had been overwintered and then encouraged to nest in the wild adapted well, reproduced successfully, and in many respects behaved like wild owls.

***Future Research***

Continued research and work is needed to facilitate Burrowing Owl recovery in Manitoba. Outlined below are recommendations for future reintroductions and research needs based on the results from my study.

Reintroduction is a feasible option for the recovery of Burrowing Owls in Manitoba. I recommend reintroductions using the soft-release technique (where owls are held in their pens for at least two weeks and encouraged to initiate egg-laying before pens are removed). I also recommend that some food supplementation be considered until young have emerged from the burrow for both captive-released and wild nests. This study and others have shown food supplementation to be very effective for increasing survival of young, particularly in the early nestling stage. During this study, I delayed releasing pairs until at least 3 eggs were observed in nests, similar to a strategy used during successful releases in Saskatchewan (Poulin et al. 2006) and B.C. (Mitchell 2008). The pair bond appeared to be strong for all pairs released after egg-laying and only one of 14 pairs abandoning their nest after release during this study. I contend that providing food supplements to captive-released families greatly promoted fledging success in my study, with 100% of young fledging each season. This, plus the results from Saskatchewan, suggest that providing supplemental food to wild nests should be employed in future to enhance fledging success.

Prior to fledging, a few select young were removed from larger family groups of both wild and captive-released nests for overwintering to serve as breeding/release owls for the following year. During the three-year study, only one of 34 captive-released adult owls that were overwintered was recaptured at the end of October. I also observed one young produced at the Broomhill release site in 2011 return briefly to its natal site in 2012. It was encouraging to see that at least one captive-released young returned after migration as this feat is a rare occurrence for wild juvenile owls. Overwintering in captivity appeared to have very little impact on the owl's ability to adjust to the wild the following season. Overwintering may impact their ability to migrate successfully to normal wintering areas and migrate back still. This still needs to be studied.

Conducting surveys to locate wild owls in Manitoba and monitoring nest success is important to collect annual breeding population data and to identify and secure nesting habitat for the species. Thorough and widespread surveys in the southwestern corner of Manitoba combined with increased public awareness campaigns were identified as instrumental in the monitoring of the species from 1987-1996 (De Smet 1997) and these activities also led to the detection of wild owls during the present study, many in areas where they had not been observed in the last two decades.

Outreach and working with community organizations like Turtle Mountain, Assiniboine Hills, and West Souris River Conservation Districts led to additional landowner reports and the installation of 47 artificial nest burrows near owl observations and historical nesting sites during the course of this study. It is extremely important to learn from and educate landowners about habitat requirements for Burrowing Owls (i.e., availability of burrows) and to encourage them to maintain current management practices or, if needed, alter land use practices to promote nesting success and return rates.

It is equally important to be respectful and transparent with landowners about monitoring and research activities involving Burrowing Owls. In some cases landowners were reluctant to allow land access for owl surveys. For instance, many landowners initially believed that observing and banding owls decreased their survival and returns rates. Discussion with these and other landowners were opportunities to correct misconceptions and to share information about challenges Burrowing Owls encounter in Manitoba, western Canada, and during migration. Surveys in southwestern Manitoba around suitable habitat (see Figure 6, Chapter One) and historical owl nest sites should be conducted annually. Also, following up on all landowners reports is equally important. Landowner and local birder reports during this study resulted in the discovery of two nests outside of the main study and survey areas and documented one additional male owl observation.

Home-range estimates and activity distance among individual male owls and groups (captive-released and wild) varied greatly. Habitat use and foraging appeared to be influenced by distance and availability of suitable habitat in relation to the nest burrow. Habitat type used most often for foraging for both groups was predominantly native and tame pastureland, followed by roadside ditches. Owls frequented elevated perch sites like fence posts, particularly those along ditches and roadways to forage for prey. Burrowing Owls in both groups consumed similar prey based on dissection of pellets, including invertebrate and vertebrate species. Captive-released owls consumed more invertebrate than vertebrate prey (frequency) during both study years, however, they consumed a similar number of small mammal prey species as wild owls in 2011. Encouraging landowners to maintain suitable habitat or enhance land management practices near nest burrows that reduce the use of pesticides, ground squirrel controls, and create habitat for prey used by Burrowing Owls will help the species recover.

Many nests of both captive-released and wild owls in this study failed due to extreme spring and summer storms which resulted in nest flooding and the loss of 62 eggs (2010 and 2011). Some owls produced replacement clutches, though clutch size was consistently smaller for these replacement clutches in both groups. Several studies have shown that Burrowing Owl nest success and productivity declines when exposed to extreme summer precipitation. Nest failure also reduces the likelihood of pairs returning in subsequent years (Haug 1985, De Smet 1997, Wellicome 2000, Fisher et al. 2015). Extreme precipitation events have increased in frequency across North America. From 2000–2012, there were three summers ranked in the top 10 wettest on record since 1948, one of which was 2010 (Fisher et al. 2015). Wet conditions have been shown to directly reduce Burrowing Owl nest success and negatively impact prey availability. Mitigation actions suggested by Fisher et al. (2015) and Marsh et al. (2014) are to increase prey abundance and availability in nearby surrounding habitat in close proximity to Burrowing

Owl nesting areas. This can be done by creating a mosaic of areas with tall vegetation cover for small mammals with abundant edge and shorter vegetation areas, where owls can access prey. Since access to vertebrate prey is especially important to nesting owls during periods of high precipitation, these mosaics will certainly benefit owl fitness and nest success when extended wet periods are incurred during the nesting season. Extreme weather events are expected to increase due to the effects of climate change and flooding is a major concern for both natural and artificial nest burrows. Developing waterproof artificial nest structures and creating suitable nesting habitat in higher, less flood-prone areas should be considered.

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# APPENDICES

## APPENDIX A.

Legal status and natural heritage status of the Burrowing Owl (*Athene cunicularia*) in the United States, Canada, and Mexico.

| Area | Legal Status | Natural Heritage Status[a] |
|---|---|---|
| **United States**[3] | | |
| | **None** | **Apparently Secure** |
| Arizona | None | Vulnerable[br] |
| California | Species of Concern | Imperiled[br] |
| Colorado | Threatened | Apparently Secure |
| Idaho | None | Vulnerable/Apparently Secure |
| Iowa | Accidental breeder | Unranked |
| Kansas | None | Vulnerable |
| Minnesota | Endangered | Critically Imperiled |
| Montana | Species of Concern | Vulnerable |
| Nebraska | None | Vulnerable |
| Nevada | None | Vulnerable[br] |
| New Mexico | None | Apparently Secure[br] |
| North Dakota | None | Unranked |
| Oklahoma | Species of Concern | Vulnerable |
| Oregon | Species of Concern | Imperiled |
| South Dakota | None | Vulnerable |
| Texas | None | Vulnerable[br] |
| Utah | Species of Concern | Vulnerable |
| Washington | Species of Concern | Vulnerable |
| Wyoming | Species of Concern | Vulnerable |
| **Canada**[3] | | |
| | **Endangered** | **Vulnerable** |
| Alberta | Endangered | Vulnerable |
| British Columbia | Endangered | Critically Imperiled |
| Manitoba | Endangered | Critically Imperiled |
| Saskatchewan | Endangered | Imperiled |
| **Mexico** | Threatened | Unranked |

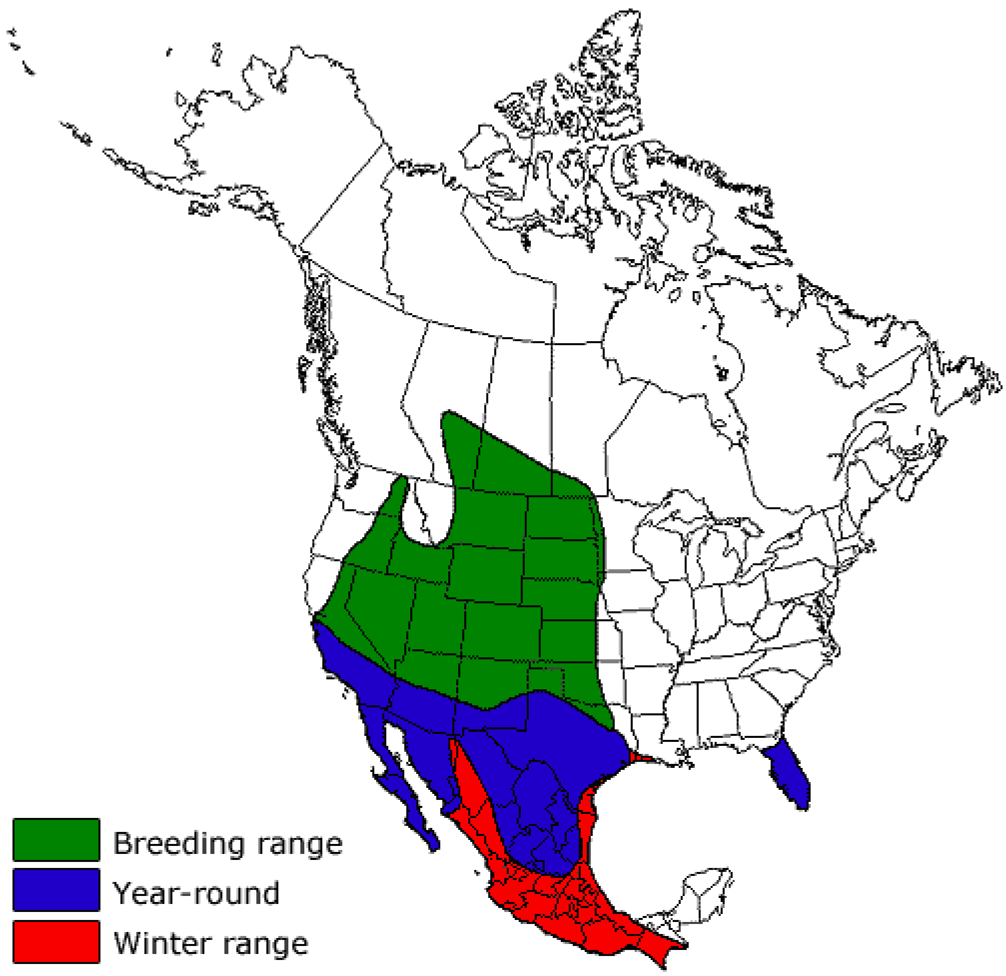
[a] –Global Status = Apparently secure; Global Heritage Status rank of G4 but rare is some parts of its range. (CITES)
[b r]–Breeding range (resident population)

Adapted from the Status Assessment and Conservation Plan for the Western Burrowing Owl in the United States.
http://www.fws.gov/mountainprairie/migbirds/species/birds/wbo/Western%20Burrowing%20Owlrev73003a.pdf

[3] Listed under the United States Fish and Wildlife Service and the Canadian Species at Risk Act

**APPENDIX B.**

Burrowing Owl (*Athene cunicularia)* range map for North America. **(**Adapted from the Recovery Strategy for the Burrowing Owl in Canada 2012**)**



**APPENDIX C.**

Captive-released Burrowing Owl (*Athene cunicularia*) pairs and individuals per year (2010-2012).

**C1.** Captive-released owl pairs 2010.

| **Sex** | **Release site/nest** | **Bands** (CWS aluminum/ colour coded alpha-numeric)[4][5] | **Source** (Wild nest (WN) or Captive-released (CR) | **Nest success** (Yes/No) | **Released** (Yes/No) |
|---|---|---|---|---|---|
| Male | Broomhill #1 | 614-96121/ R/B AB | CR Alberta 2009 | No | No |
| Female | Broomhill #1 | 614-96120/ R/B AA | CR Assiniboine Park Zoo 2009 | No | No |
| Male | Broomhill #2 | 614-96104/ R/B AE | CR Alberta 2009 | Yes | Yes |
| Female | Broomhill #2 | 614-96412/ no colour band | WN Manitoba Broomhill 2009 | Yes | Yes |
| Male | Pierson #1 | 614-96105/ R/B AD | CR Assiniboine Park Zoo 2009 | No | No |
| Female | Pierson #1 | 614-96415/No colour band | WN Manitoba Pipestone 2009 | No | Yes (dispersed after nest failure) |

[4] R/B = Red over blue
[5] AB = Letters on band in white

| | | | | | |
|---|---|---|---|---|---|
| Male | Pierson #2 | 614-96414/ R/B AK | WN Manitoba Pipestone 2009 | No | No |
| Female | Pierson #2 | 614-96115/ R/B AH | CR Alberta 2009 | No | No |
| Male | Lyleton | 614-96413/ no colour band | WN Manitoba Broomhill 2009 | No | Yes (dispersed after pen collapsed) |
| Female | Lyleton | 614-96124/ R/B AC | CR Alberta 2009 | No | No |

**C2.** Captive-released owl pairs 2011.

| **Sex** | **Release site/nest** | **Bands** (CWS aluminum/ colour coded alpha-numeric) | **Source** (Wild nest (WN) or Captive-released (CR)) | **Nest success** (Yes/No) | **Released** (Yes/No) |
|---|---|---|---|---|---|
| Male | Broomhill #1 | 614-96106/ Black A08 | WN Manitoba Treesbank 2010 | Yes | Yes |
| Female | Broomhill #1 | 614-96116/ Black A18 | WN Manitoba Pierson 2010 | Yes | Yes |
| Male | Broomhill #2 | 614-96112/Black A12 | WN Manitoba Pierson 2010 | Yes | Yes |
| Female | Broomhill #2 | 614-96124/ R/B AC | Alberta Birds of Prey 2009 | Yes | No |

| | | | | | |
|---|---|---|---|---|---|
| Male | Broomhill #3 | 614-96110/Black A10 | WN Manitoba Pierson 2010 | No | No |
| Female | Broomhill #3 | 614-96120/ R/B AA | Assiniboine Park Zoo 2009 | No | Yes (dispersed after pen release) |
| Male | Broomhill #4 | 614-96106/ Black A06 | WN Manitoba Treesbank 2010 | No | No |
| Female | Broomhill #4 | 20435390/ Red C 81 | WN Saskatchewan (wild) 2009 | No | No (died as a result of a wing injury) |
| Male | Broomhill #5 | 614-96123/R/B AM | CR nest Broomhill 2010 | No | No |
| Female | Broomhill #5 | Black A18 | WN Manitoba Pierson 2010 | No | No |
| Male | Broomhill #6 | 614-96414/ R/B AK | WN Manitoba (Pipestone) 2009 | No | Yes |
| Female | Broomhill #6 | Alum 234 | CR Assiniboine Park Zoo 2003 | No | Yes |

**C3.** Released single owls 2011.

| **Sex** | **Location** | **Bands** (CWS aluminum/ colour coded alpha-numeric) | **Source** (Wild nest (WN) or Captive-released (CR) |
|---|---|---|---|
| Male | Broomhill | 614-96112/Black A12 | WN Manitoba Pierson 2010 |
| Male | Broomhill | 614-96108/Black A08 | WN Manitoba Treesbank |
| Male | Broomhill | R/B AD | CR Assiniboine Park Zoo 2009 |

**C4.** Captive-released owl pairs 2012.

| **Sex** | **Release site/nest** | **Bands** (CWS aluminum/ colour coded alpha-numeric) | **Source** (Wild nest (WN) or Captive-released (CR)) | **Nest success** (Yes/No) | **Released** (Yes/No) |
|---|---|---|---|---|---|
| Male | Deloraine | 614-96106/ Black A06 | WN Manitoba Treesbank 2010 | Yes | Yes |
| Female | Deloraine | 614-96126/Black A21 | WN Manitoba Pierson 2011 | Yes | Yes |
| Male | Broomhill | 614-96130/ Black A23 | WN Manitoba Pierson 2011 | Yes | Yes |
| Female | Broomhill | 614-96124/ R/B AC | CR Alberta Birds of Prey | Yes | No |
| Male | Medora | 614-96110/Black A10 | WN Manitoba Pierson 2010 | Yes | Predated |
| Female | Medora | 614-96137/ R/B AW | CR SBOIC 2011* | Yes | No |

| | | | | | |
|---|---|---|---|---|---|
| Male | Broomhill | 614-96123/ R/B AM | CR/WN born at Broomhill site 2010 | Yes | Predated |
| Female | Broomhill | 614-96138/ R/B AX | CR SBOIC 2010 | Yes | Yes |

*Saskatchewan Burrowing Owl Interpretive Centre

**C5.** Released single owls 2012.

| **Sex** | **Location** | **Bands** (CWS aluminum/ colour coded alpha-numeric) | **Source** |
|---|---|---|---|
| Male | Medora | 614-96133/ R/B AR | CR/WN Broomhill 2011 |
| Male | Broomhill | 614-96131/ R/B AN | CR/WN Broomhill 2011 |
| Male | Broomhill | 614-96134/ R/B AS | CR/WN Broomhill 2011 |

## APPENDIX D.

Wild Burrowing Owls (*Athene cunicularia*) pairs and individuals observed per year in southwestern Manitoba (2010-2012).

**D1.** Wild pairs observed in Manitoba in 2010

| **Sex** | **Location of pair and nest** | **Bands** (CWS aluminum/ colour coded alpha-numeric) | **Nest success** (Yes/No) |
|---|---|---|---|
| Male | Pierson West burrow | 614-96101/Black A02 | Yes |
| Female | Pierson West burrow | unbanded | Yes |
| Female | Pierson South burrow | 614-96100/Black A00 | Yes |
| Male | Pierson South burrow | 614-96103/ Black A04 | Yes |
| Male | Treesbank | 614-96109/ Black A09 | Yes |
| Female | Treesbank | 614-96102/ Black A05 | Yes |
| Male | Pierson East burrow | unbanded | No |
| Female | Pierson East burrow | unbanded | No |

**D2.** Individual owls observed in Manitoba in 2010

| **Sex** | **Location of individual** | **Bands** (CWS aluminum/ colour coded alpha-numeric) | **Details** |
|---|---|---|---|
| Male | Near Broomhill | Unbanded | Single male owl in pasture from April 28-May 23 (near 2009 nest site) |

**D3.** Wild pairs observed in Manitoba in 2011

| **Sex** | **Location of pair and nest** | **Bands** (CWS aluminum/ colour coded alpha-numeric) | **Nest success** (Yes/No) |
|---|---|---|---|
| Male | Elgin | 614-96129/Black A24 | Yes |
| Female | Elgin | unbanded | Yes |
| Male | Pierson | 614-96103/ Black A04 | Yes |
| Female | Pierson | 614-96128/ Black A01 | Yes |
| Male | Pierson | unbanded | No |
| Female | Pierson | unbanded | No |

**D4.** Individual owls observed in Manitoba in 2011

| **Sex** | **Location of individual** | **Bands** (CWS aluminum/ colour coded alpha-numeric) | **Details** |
|---|---|---|---|
| Male | Treesbank | 614-96109/ Black A09 | Single male owl returned to nest burrow in 2010 observed May 7-June 13. |
| Female | Broomhill release site | No band | Observed at release burrow from July 8-Sept 14. |
| Unknown | Broomhill release site | Red/white/Red band (# unconfirmed) | Observed on July 8-9. |

| | | | |
|---|---|---|---|
| Unknown | Broomhill release site | No band | Observed May 15 only. |

**D5**. Individual owls observed in 2012

| **Sex** | **Location of individual** | **Bands** (CWS aluminum/ colour coded alpha-numeric) | **Details** |
|---|---|---|---|
| Male | Treesbank<br>SE 12-8-17 | 614-96109/ Black A09 | Observed at nest burrow 2010 from May 6-June 8. |
| Male | Near Medora<br>SE 11-4-23 | 614-96160/ Black A27 | Observed at Medora release site using an ANB from August 1-4. |
| Male | Near Deloraine<br>SE 35-2-23 | No band | Observed near Deloraine in pastureland from May 10-June 4. |
| Male | Broomhill release site | Banded (unconfirmed) | Observed using an ANB at release site on May 11. |

**APPENDIX E.**

Techniques used to trap adult and young Burrowing Owls (*Athene cunicularia*) in southwestern Manitoba (2010-2012).
(See page 42 for descriptions)

Trap type, number of attempts with success, and overall trapping success rate (%) for adult wild and captive-released Burrowing Owls in southwestern Manitoba (2010-2012).

| Owls (adult) | Walk-in trap with decoy owl/audio lure | Bownet | Mist-net | One-way burrow entrance trap | Bal-Chatri with live mouse |
|---|---|---|---|---|---|
| Wild | 11/14 (79%) | 4/9 (44%) | 0/4 (0%) | 3/4 (75%)* | 0/4 (0%) |
| Captive | 14/16 (88%) | 0/8 (0%) | - | 3/3 (100%) | 0/7 (0%) |
| Totals: | 25/30 (83%) | 4/17 (24%) | 0% | 6/7 (86%) | 0% |

*all wild adult female Burrowing Owls

Trap type, number of attempts with success and overall trapping success rate (%) for young wild and captive-released Burrowing Owls in southwestern Manitoba (2010-2012).

| Owls (young) | Walk-in trap with decoy owl/audio lure | Bownet | One-way burrow entrance trap | Hose down artificial burrow |
|---|---|---|---|---|
| Wild | 15/27 (56%) | 3/10 (30%) | 13/18 (72%) | - |
| Captive | 21/35 (60%) | 2/5 (40%) | 7/14 (50%) | 21/21 (100%) |
| Totals: | 36/62 (58%) | 5/15 (33%) | 20/32 (63%) | 21/21 (100%) |

**APPENDIX F.**

Prey remains from pellets of captive-released and wild Burrowing Owls (*Athene cunicularia*) in southwestern Manitoba (2010-2012).

**F1.** Breeding season vertebrate prey remains from five sites for captive-released Burrowing Owls (*Athene cunicularia*) during the period from May 31-September 2010.

| Species | Number of individuals | Average adult weight (g)[6] | Estimated biomass (g)[7] | Total Biomass (%) |
|---|---|---|---|---|
| *Peromyscus maniculatus* | 2 | 24 | 48 | 18% |
| *Perognathus fasciatus* | 3 | 14 | 42 | 15% |
| *Sorex cinereus* | 1 | 4 | 4 | 1.5% |
| *Thomomys talpoides* | 1 | 49 | 49 | 18% |
| *Ambystoma tigrinum* | 1 | 55 | 55 | 20% |
| Unidentified bird *(Aves)* | 1 | 30 | 30 | 11% |
| Unidentified frog | 1 | 43.3 | 43 | 16% |
| Totals | 10 | | 271 | |

[6] All biomass weights for vertebrates and invertebrates were either estimated (weighed) or obtained from Marti 1974, Tyler & Jensen 1977, Gleason & Craig 1979, and Mitchell 2008.

[7] Estimated biomass was calculated by average adult weight (g) multiplied by number of individuals.

**F2.** Breeding season invertebrate prey remains from five sites for captive-released Burrowing Owls (*Athene cunicularia*) during the period from May 31-September 2010.

| Species | Number of individuals | Average adult weight (g) | Estimated biomass (g) | Total Biomass (%) |
|---|---|---|---|---|
| *Silphidae* | 33 | 0.3 | 9.9 | 18% |
| *Carabidae* | 86 | 0.2 | 17.2 | 32% |
| *Scarabidae* | 4 | 0.3 | 1.2 | 2% |
| *Histeridae* | 2 | 0.2 | 0.4 | Less than 1% |
| *Gryllidae* | 7 | 2 | 14 | 26% |
| *Caelifera* | 13 | 0.5 | 6.5 | 12% |
| *Curculionoidea* | 11 | 0.2 | 2.2 | 4% |
| *Myrmicinae* | 18 | 0.1 | 1.8 | 3% |
| *Formicinae* | 1 | trace | trace | trace |
| Unknown insect | 4 | 0.3 | 1.2 | 2% |
| Totals | 179 | | 54.4 | |

**F3.** Breeding season vertebrate prey remains from six sites for wild Burrowing Owls (*Athene cunicularia*) during the period from May 31-September 2010.

| Species | Number of individuals | Average adult weight (g) | Estimated biomass (g) | Total Biomass (%) |
|---|---|---|---|---|
| *Peromyscus maniculatus* | 14 | 24 | 336 | 21% |
| *Perognathus fasciatus* | 18 | 14 | 252 | 16% |
| *Oncychomys leucogaster* | 3 | 35 | 105 | 7% |
| *Microtus pennsylvanicus* | 8 | 46 | 368 | 23% |
| *Blarina brevicauda* | 1 | 22 | 22 | 1% |
| *Sorex cinereus* | 1 | 4 | 4 | Less than 1% |
| *Sorex hoyi* | 1 | 3 | 3 | Less than 1% |
| *Sorex hayden* | 2 | 4 | 8 | Less than 1% |
| *Spermophilus richardsonii* | 2 | 75 | 150 | 9% |
| *Zapus hudsonius* | 1 | 18 | 18 | 1% |
| *Spea bombifrons* | 3 | 43.3 | 130 | 8% |
| *Ambystoma tigrinum* | 1 | 55 | 55 | 4% |
| *Rana* (Leopard Frog) | 1 | 48 | 48 | 3% |
| Unidentified vole | 2 | 46 | 92 | 6% |
| Totals | 58 | | 1591 | |

**F4.** Breeding season invertebrate prey remains from six sites for wild Burrowing Owls (*Athene cunicularia*) during the period from May 31 September 2010.

| Species | Number of individuals | Average adult weight (g) | Estimated biomass (g) | Total Biomass (%) |
|---|---|---|---|---|
| *Silphidae* | 41 | 0.3 | 12.3 | 20% |
| *Carabidae* | 144 | 0.2 | 28.8 | 47% |
| *Scarabidae* | 2 | 0.3 | 0.6 | 1% |
| *Histeridae* | 2 | 0.2 | 0.4 | 1% |
| *Gryllidae* | 1 | 2 | 2 | 3% |
| *Caelifera* | 30 | 0.5 | 15 | 25% |
| *Curculionoidea* | 17 | 0.1 | 1.7 | 3% |
| *Myrmicinae* | 4 | trace | trace | trace |
| Unknown insect | 1 | 0.3 | 0.3 | Less than 1% |
| Totals | 242 | | 61.1 | |

**F5.** Breeding season vertebrate prey remains from eight sites for captive-released Burrowing Owls (*Athene cunicularia*) during the period from May 7-September 2011**.**

| Species | Number of individuals | Average adult weight (g) | Estimated biomass (g) | Total Biomass (%) |
|---|---|---|---|---|
| *Peromyscus maniculatus* | 1 | 24 | 24 | Less than 1% |
| *Microtus pennsylvanicus* | 12 | 46 | 552 | 26% |
| *Blarina brevicauda* | 4 | 22 | 88 | 4% |
| *Oncychomys leucogaster* | 1 | 35 | 35 | 1% |
| *Sorex cinereus* | 4 | 4 | 16 | Less than 1% |
| *Spermophilus richardsonii* | 1 | 75 | 75 | 3% |
| *Pseudacris* | 10 | 11 | 110 | 5% |
| *Lithobates sylvaticus* | 3 | 8 | 24 | Less than 1% |
| *Rana* (Leopard Frog) | 1 | 48 | 48 | 2% |
| *Bufo* | 8 | 43.3 | 346.4 | 14% |
| *Anaxyrus cognatus* | 2 | 80 | 160 | 7% |
| *Ambystoma tigrinum* | 5 | 55 | 275 | 11% |
| *Spea bombifrons* | 1 | 43.3 | 43.3 | 2% |
| *Aves* Unidentified bird | 4 | 30 | 120 | 5% |
| Unidentified mouse | 6 | 22 | 132 | 5% |
| *Anura* Unidentified frog | 16 | 22.7 | 363.2 | 15% |
| Totals | 79 | | 2411.9 | |

**F6.** Breeding season invertebrate prey remains from eight sites for captive-released Burrowing Owls (*Athene cunicularia*) during the period from May 7-September 2011.

| Species | Number of individuals | Average adult weight (g) | Estimated biomass (g) | Total Biomass (%) |
|---|---|---|---|---|
| *Silphidae* | 47 | 0.3 | 14.1 | 10% |
| *Carabidae* | 292 | 0.2 | 58.4 | 41% |
| *Scarabidae* | 0 | 0.3 | 0 | 0 |
| *Histeridae* | 0 | 0.2 | 0 | 0 |
| *Gryllidae* | 13 | 2 | 26 | 18% |
| *Caelifera* | 63 | 0.5 | 31.5 | 22% |
| *Curculionoidea* | 8 | 0.1 | 0.8 | Less than 1% |
| Unknown insect | 36 | 0.3 | 10.8 | 8% |
| Totals | 459 | | 141.6 | |

**F7.** Breeding season vertebrate prey remains from four sites for wild Burrowing Owls (*Athene cunicularia*) during the period from May 7-September 2011.

| Species | Number of individuals | Average adult weight (g) | Estimated biomass (g) | Total Biomass (%) |
|---|---|---|---|---|
| *Peromyscus maniculatus* | 9 | 24 | 216 | 5% |
| *Microtus pennsylvanicus* | 19 | 46 | 874 | 17% |
| *Microtus ochrogaste* | 2 | 43 | 86 | 2% |
| *Sorex cinereus* | 1 | 4 | 4 | Less than 1% |
| *Blarina brevicauda* | 2 | 22 | 44 | Less than 1% |
| *Perognathus fasciatus* | 9 | 14 | 126 | 2% |
| *Ambystoma tigrinum* | 3 | 55 | 165 | 4% |
| *Spermophilus richardsonii* | 2 | 75 | 150 | 3% |
| *Spea* | 23 | 2 | 46 | Less than 1% |
| *Pseudacris* | 3 | 11 | 33 | Less than 1% |
| *Lithobates sylvaticus* | 2 | 8 | 16 | Less than 1% |
| *Bufo* | 40 | 50 | 2000 | 39% |
| *Anaxyrus cognatus* | 13 | 80 | 1040 | 20% |
| eggshell | 2 | Trace | Trace | Trace |
| *Aves* Unidentified bird | 4 | 30 | 120 | 2% |

| | | | | |
|---|---|---|---|---|
| *Anura*<br>Unidentified frog | 7 | 22.7 | 159 | 4% |
| Totals | 141 | | 5079 | |

**F8.** Breeding season invertebrate prey remains from four sites for wild Burrowing Owls (*Athene cunicularia*) during the period from May 7-September 2011.

| Species | Number of individuals | Average adult weight (g) | Estimated biomass (g) | Total Biomass (%) |
|---|---|---|---|---|
| *Silphidae* | 43 | 0.3 | 12.9 | 25% |
| *Carabidae* | 172 | 0.2 | 34.4 | 68% |
| *Scarabidae* | 0 | 0.3 | 0 | 0 |
| *Histeridae* | 0 | 0.2 | 0 | 0 |
| *Gryllidae* | 0 | 2 | 0 | 0 |
| *Caelifera* | 4 | 0.5 | 2 | 4% |
| *Curculionoidea* | 1 | 0.1 | 0 | 0 |
| Unknown insect | 5 | 0.3 | 1.5 | 3% |
| Totals | 225 | | 50.8 | |

## APPENDIX G.

Frequency of prey remains from pellets of captive-released and wild Burrowing Owls (*Athene cunicularia*) in southwestern Manitoba 2010-2012

**G1.** Frequency of prey remains in Burrowing Owl (*Athene cunicularia*) pellets by year for captive-released owls.

| | 2010 | | 2011 | |
|---|---|---|---|---|
| | # of individual prey | Percent individuals | # of individual prey | Percent individuals |
| Vertebrate | 10 | 5% | 79 | 14.7% |
| Invertebrate | 179 | 95% | 459 | 85.3% |

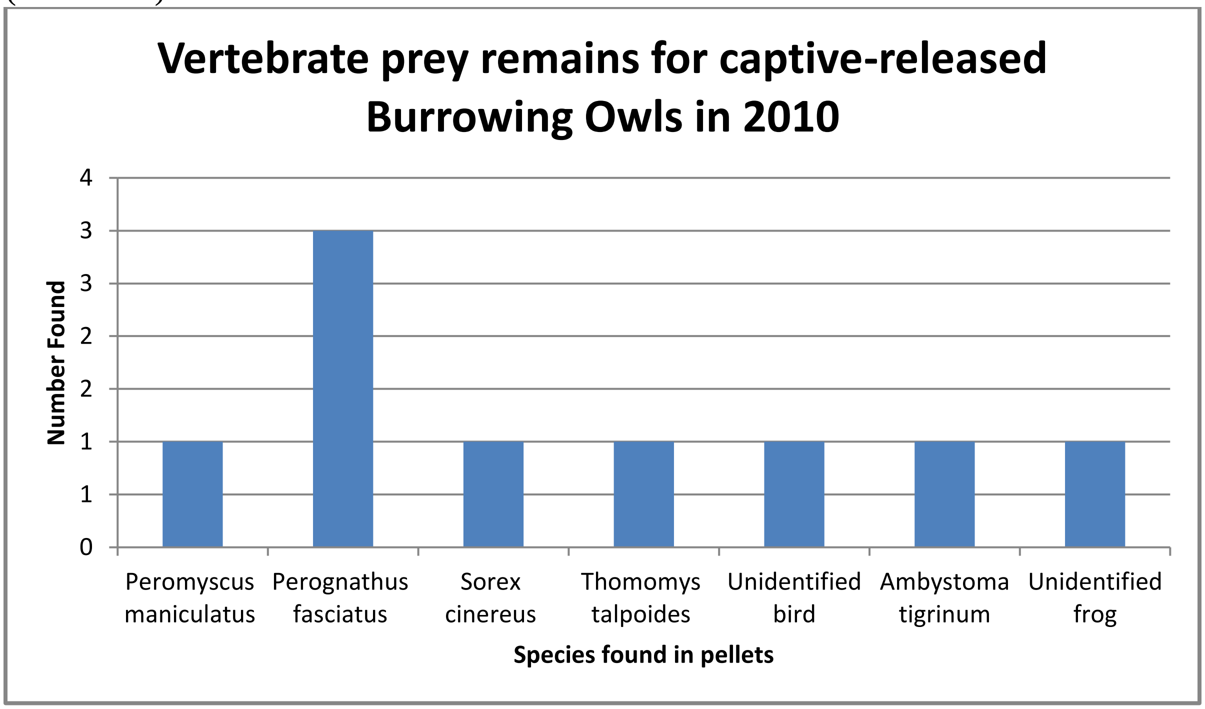
**G2.** Frequency of prey remains in Burrowing Owl (*Athene cunicularia*) pellets by year for wild owls.

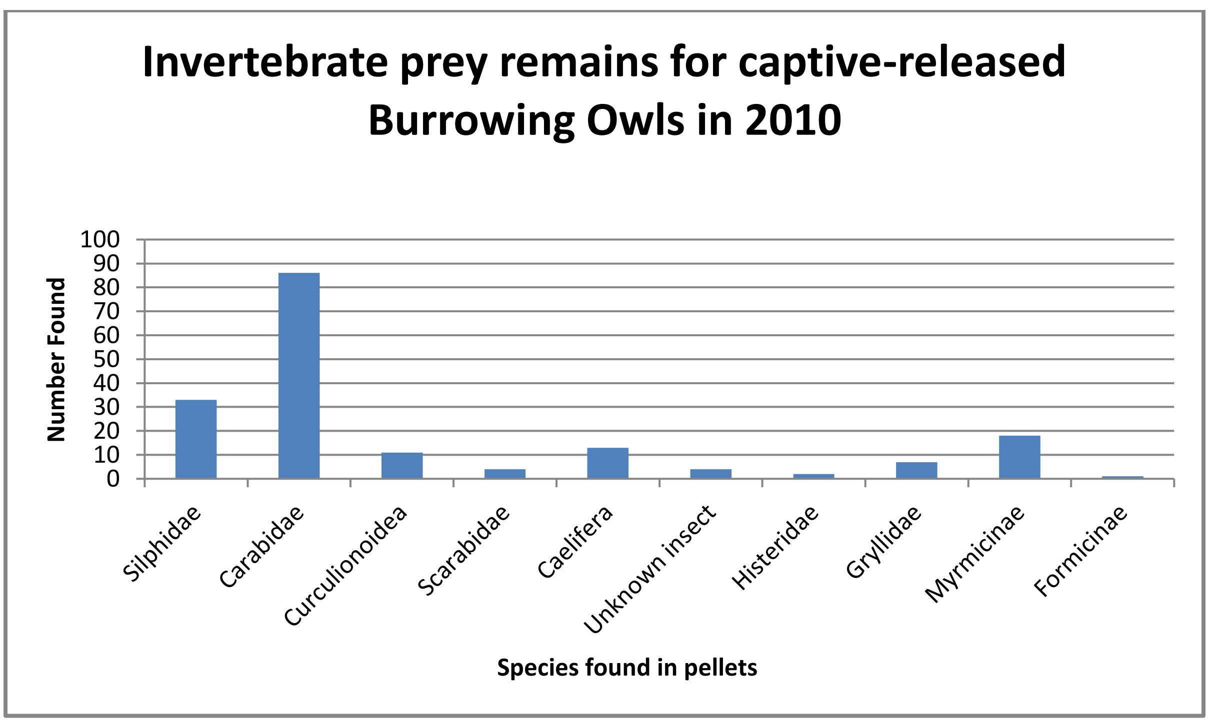
| | 2010 | | 2011 | |
|---|---|---|---|---|
| | # of individual prey | Percent individuals | # of individual prey | Percent individuals |
| Vertebrate | 58 | 19.3% | 141 | 38.5% |
| Invertebrate | 242 | 80.7% | 225 | 61.5% |

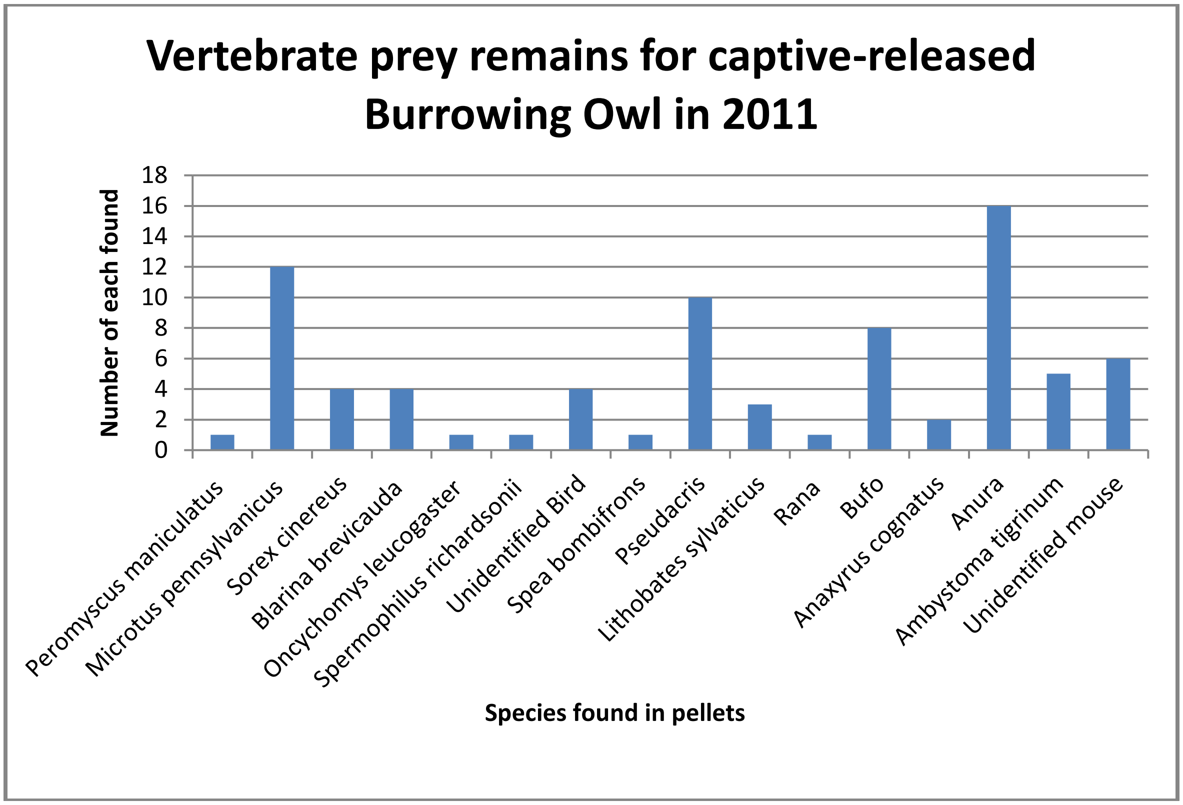
**APPENDIX H.**

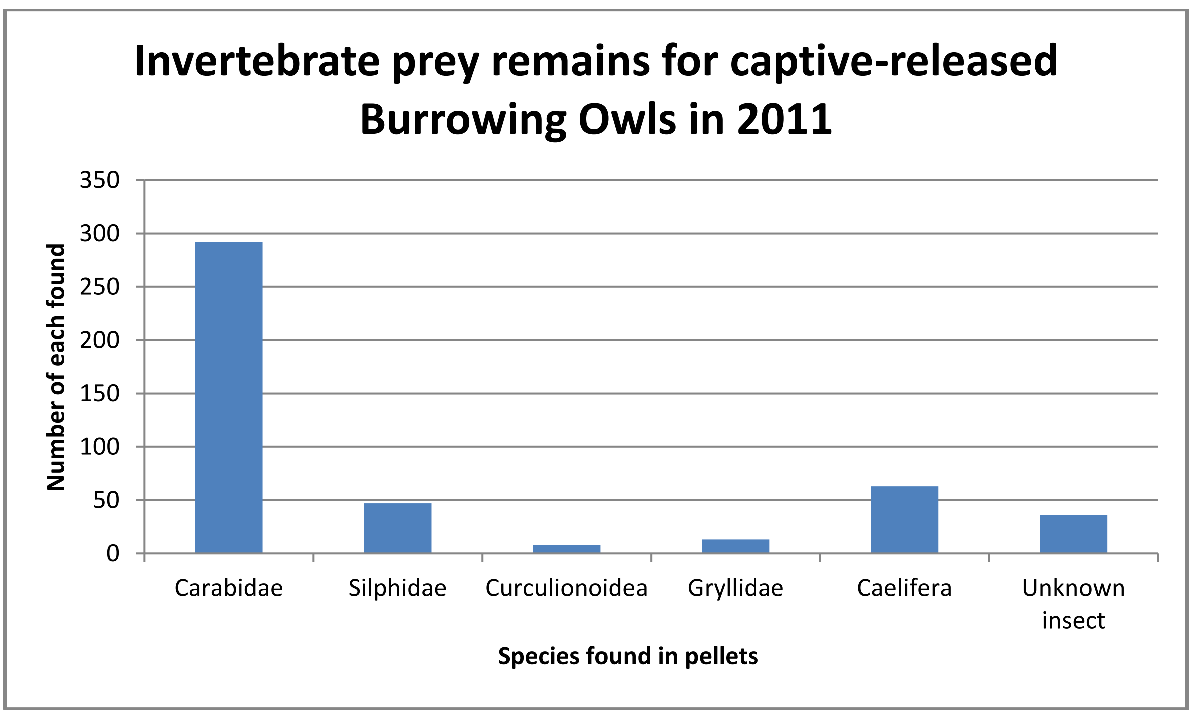
Charts for captive-released and wild Burrowing Owls (*Athene cunicularia*) pellets in southwestern Manitoba (2010-2012).

**H1.** All prey remains for captive-released Burrowing Owl (*Athene cunicularia*) pellets (2010-2011) in southwestern Manitoba.

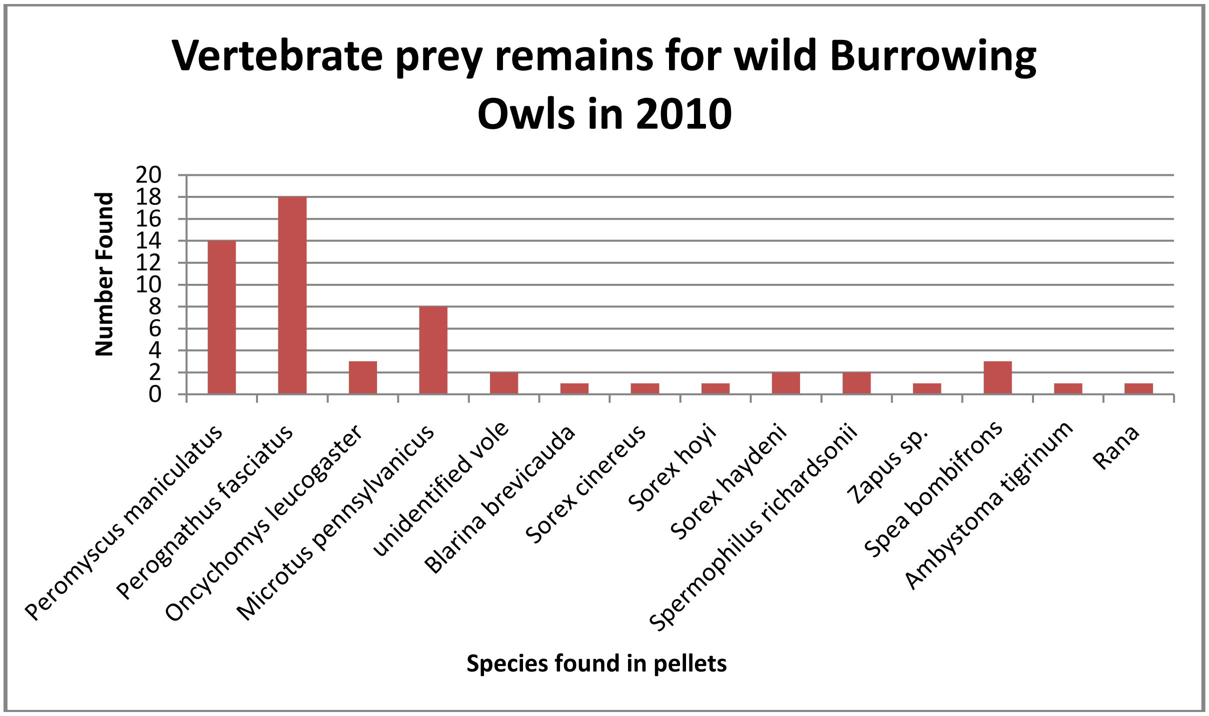


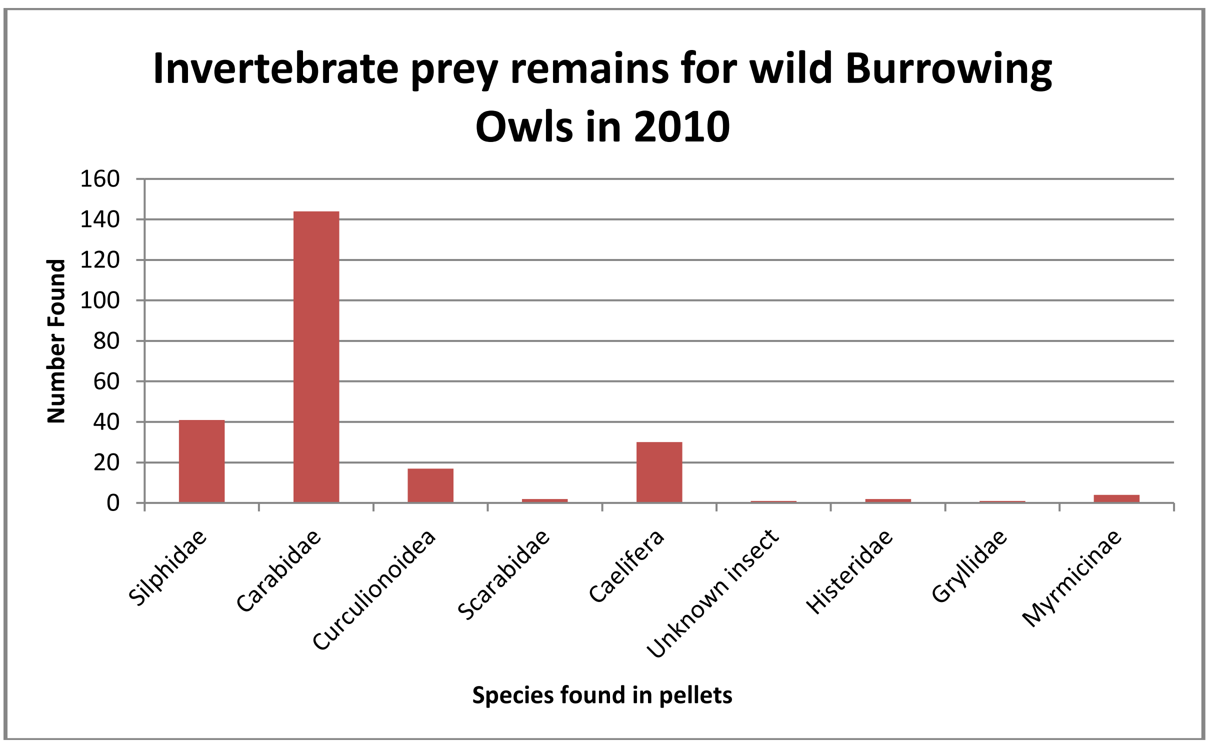



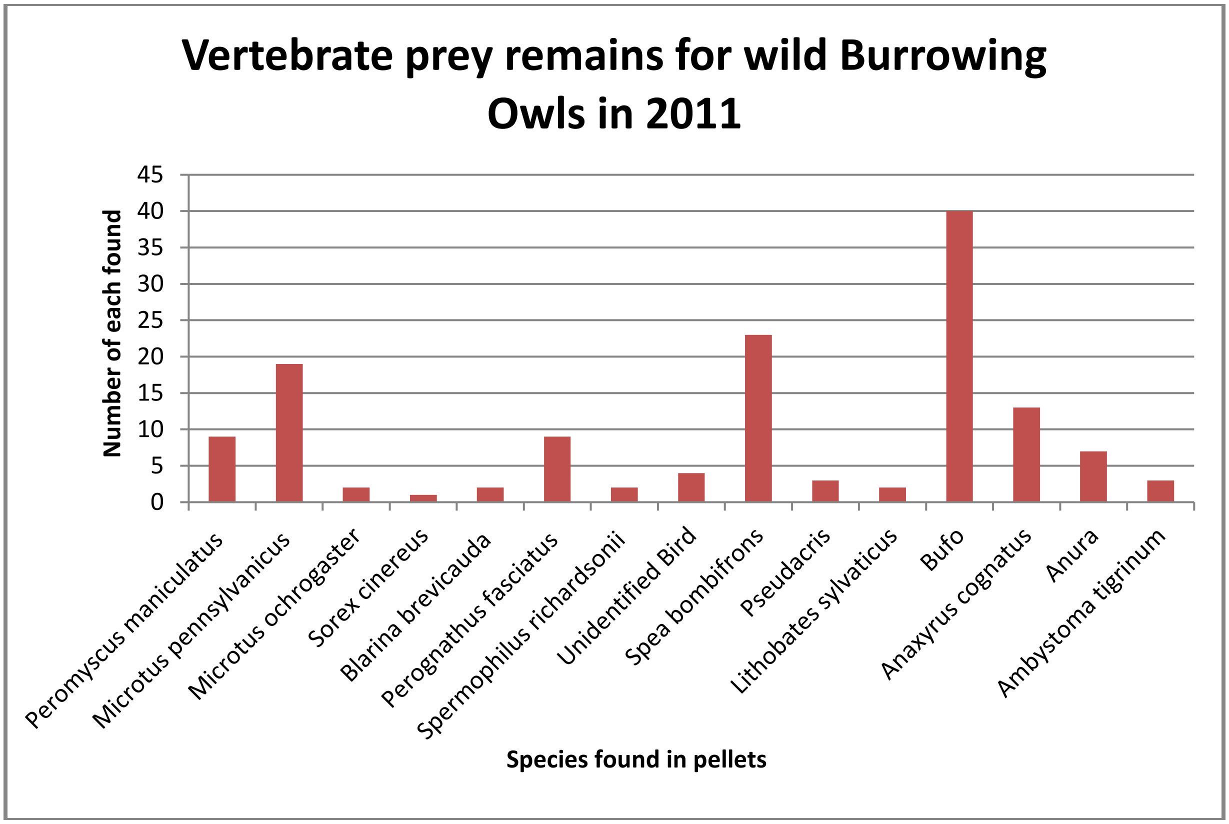

Vertebrate prey remains for captive-released Burrowing Owl in 2011
Number of each found
0
2
4
6
8
10
12
14
16
18
Peromyscus maniculatus
Microtus pennsylvanicus
Sorex cinereus
Blarina brevicauda
Oncychomys leucogaster
Spermophilus richardsonii
Unidentified Bird
Spea bombifrons
Pseudacris
Lithobates sylvaticus
Rana
Bufo
Anaxyrus cognatus
Anura
Ambystoma tigrinum
Unidentified mouse
Species found in pellets

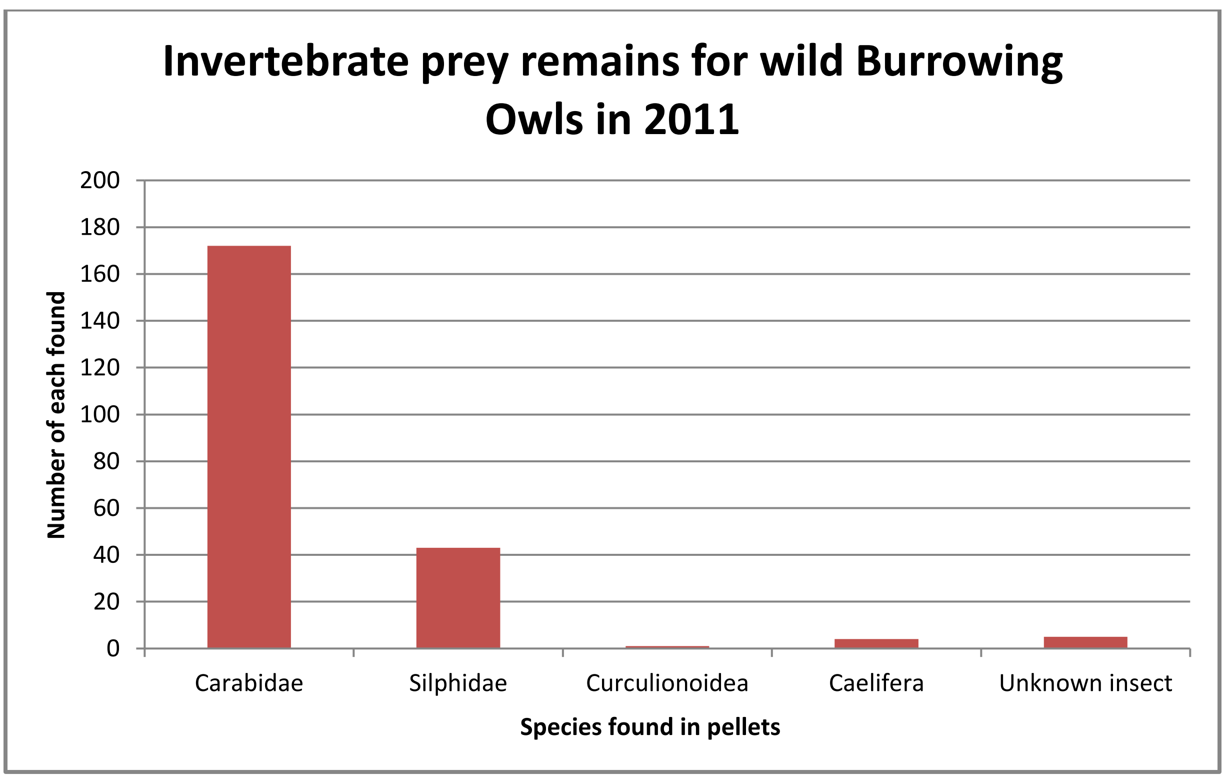

Invertebrate prey remains for captive-released Burrowing Owls in 2011
Number of each found
0
50
100
150
200
250
300
350
Carabidae
Silphidae
Curculionoidea
Gryllidae
Caelifera
Unknown insect
Species found in pellets

**H2**. All prey remains of wild Burrowing Owl (*Athene cunicularia*) pellets (2010-2011) in southwestern Manitoba.

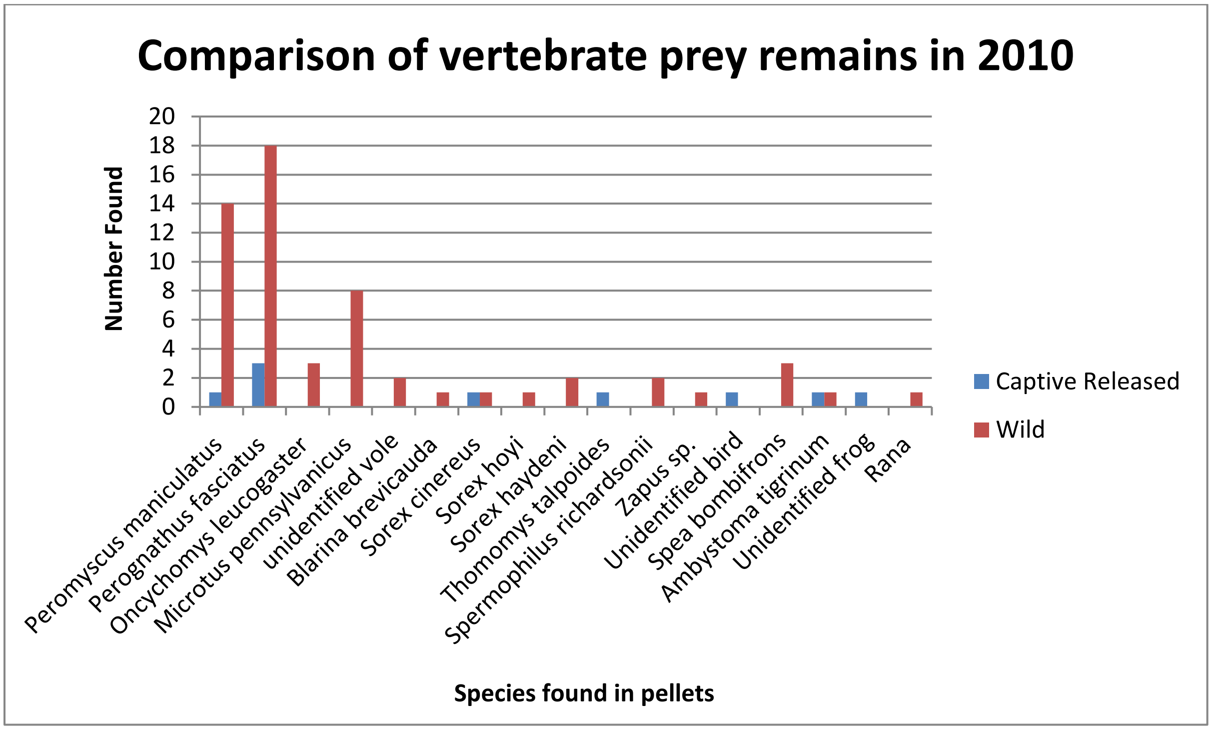


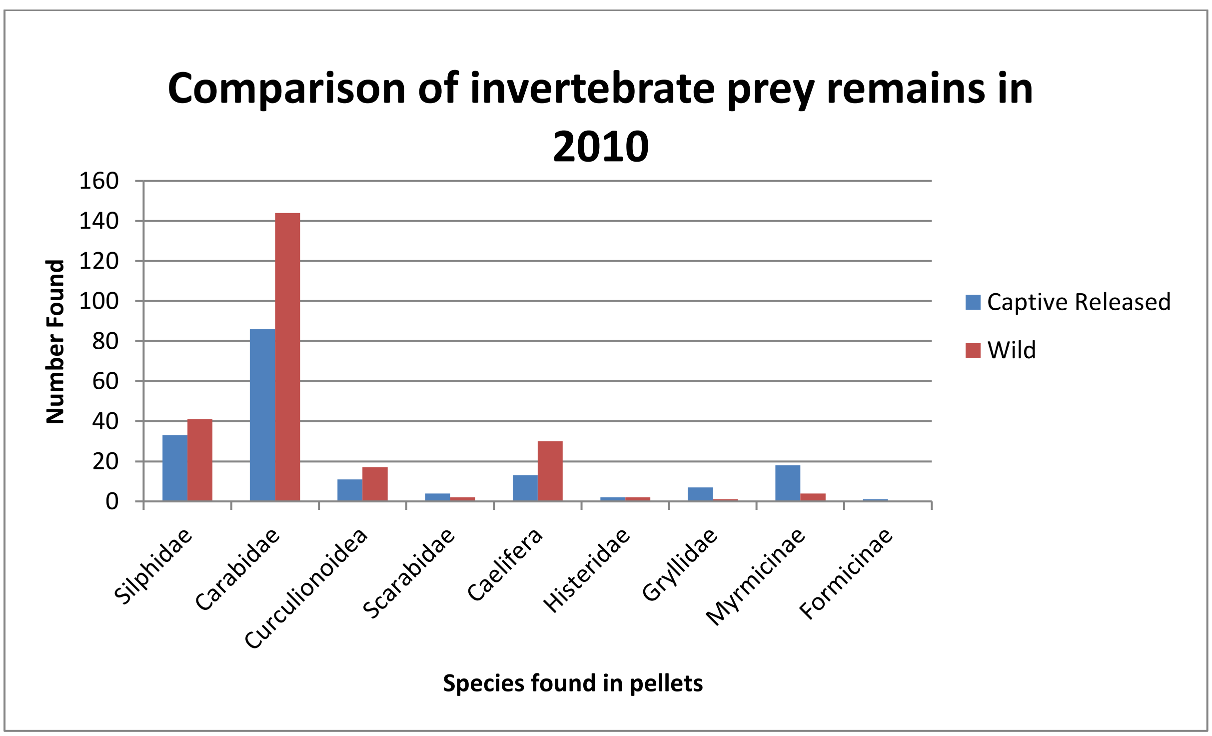



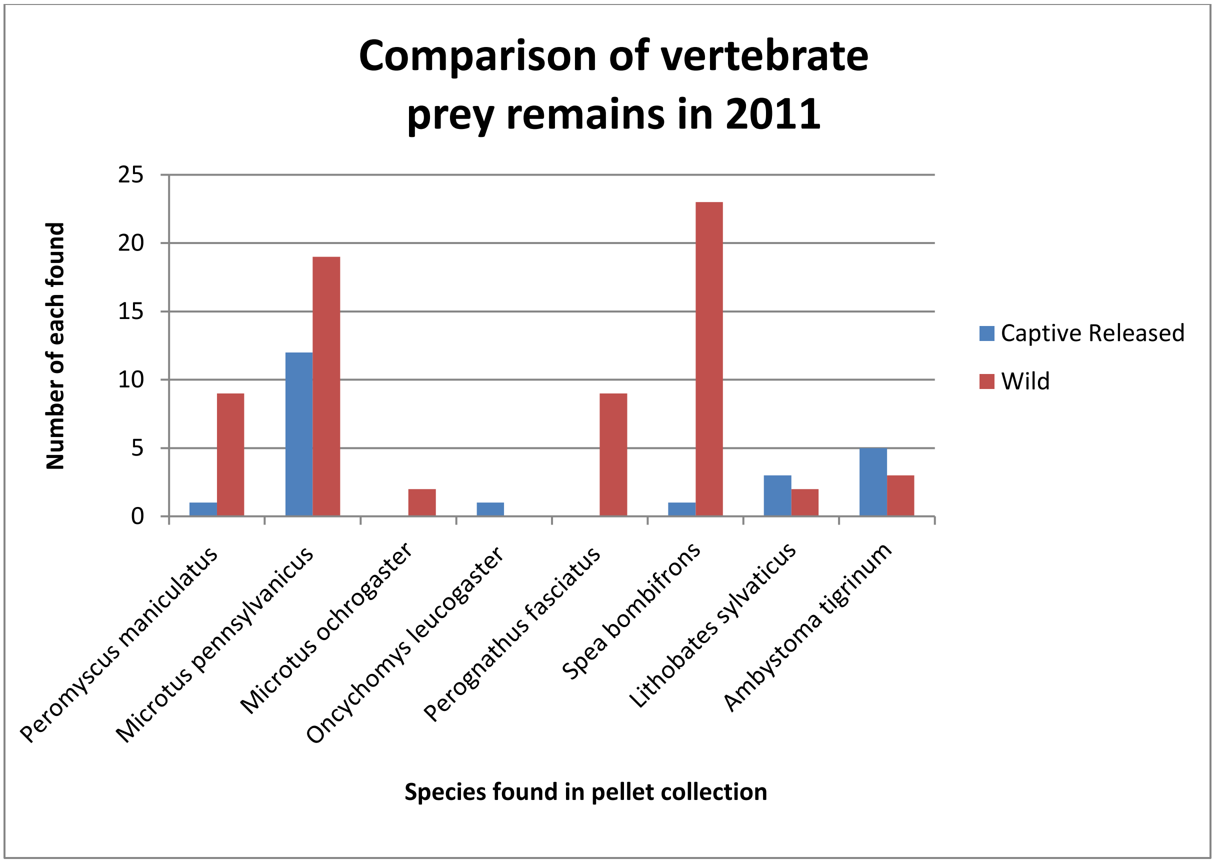

Vertebrate prey remains for wild Burrowing Owls in 2011
Number of each found
45
40
35
30
25
20
15
10
5
0
Peromyscus maniculatus
Microtus pennsylvanicus
Microtus ochrogaster
Sorex cinereus
Blarina brevicauda
Perognathus fasciatus
Spermophilus richardsonii
Unidentified Bird
Spea bombifrons
Pseudacris
Lithobates sylvaticus
Bufo
Anaxyrus cognatus
Anura
Ambystoma tigrinum
Species found in pellets

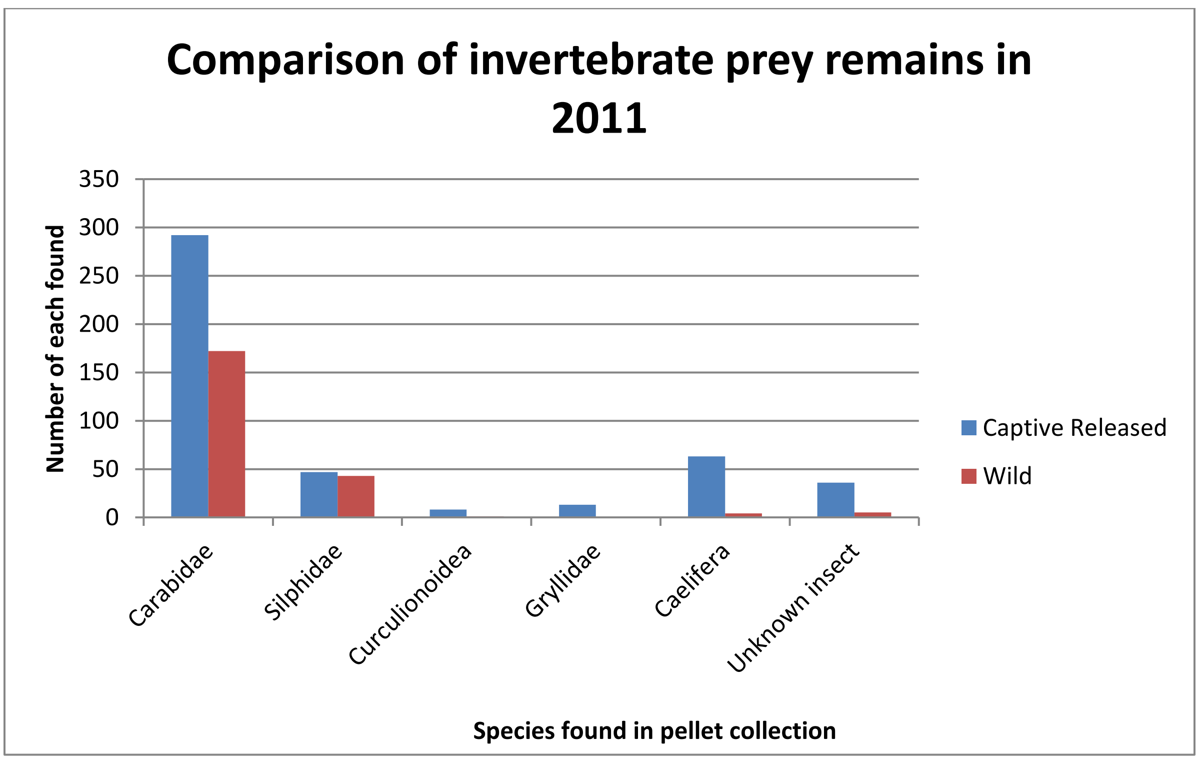

Invertebrate prey remains for wild Burrowing Owls in 2011
Number of each found
200
180
160
140
120
100
80
60
40
20
0
Carabidae
Silphidae
Curculionoidea
Caelifera
Unknown insect
Species found in pellets

**H3.** Comparison of vertebrate and invertebrate remains from both captive-released and wild Burrowing Owl (*Athene cunicularia*) pellets (2010-2011) in southwestern Manitoba.

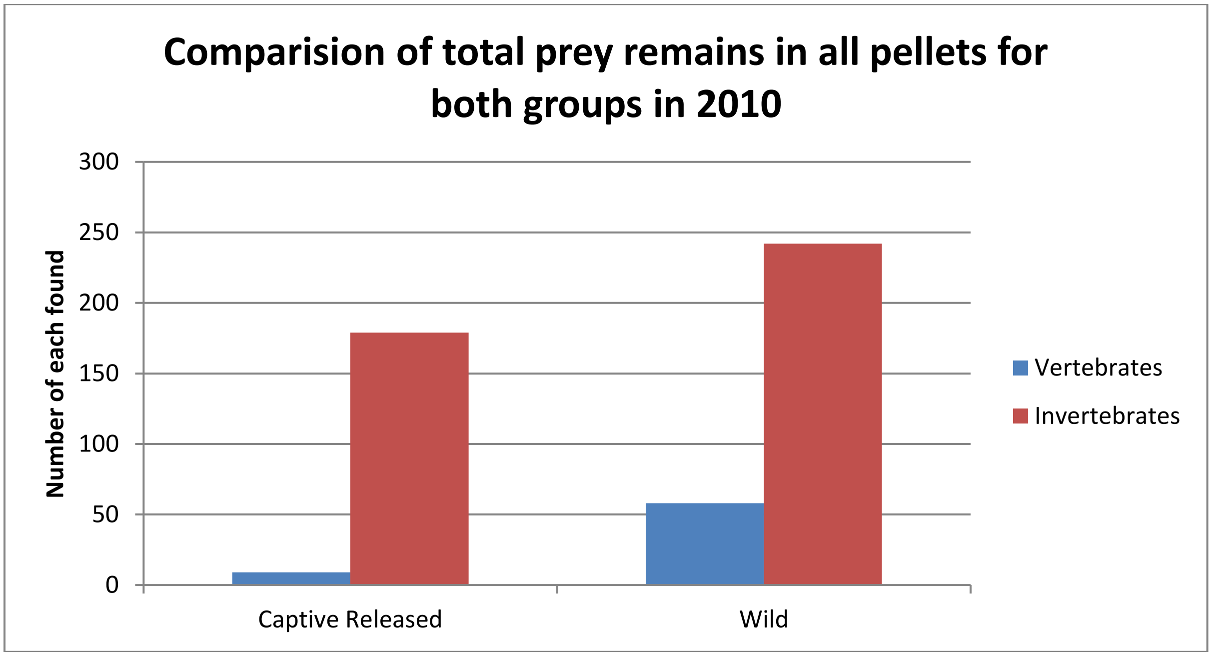


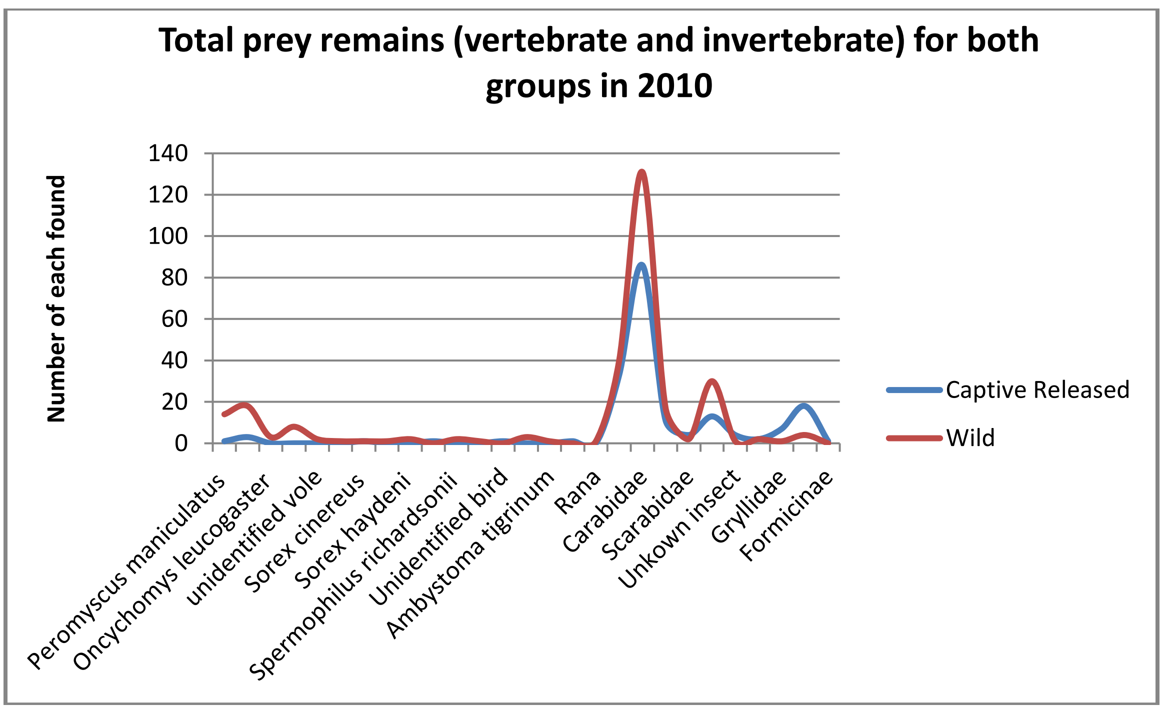



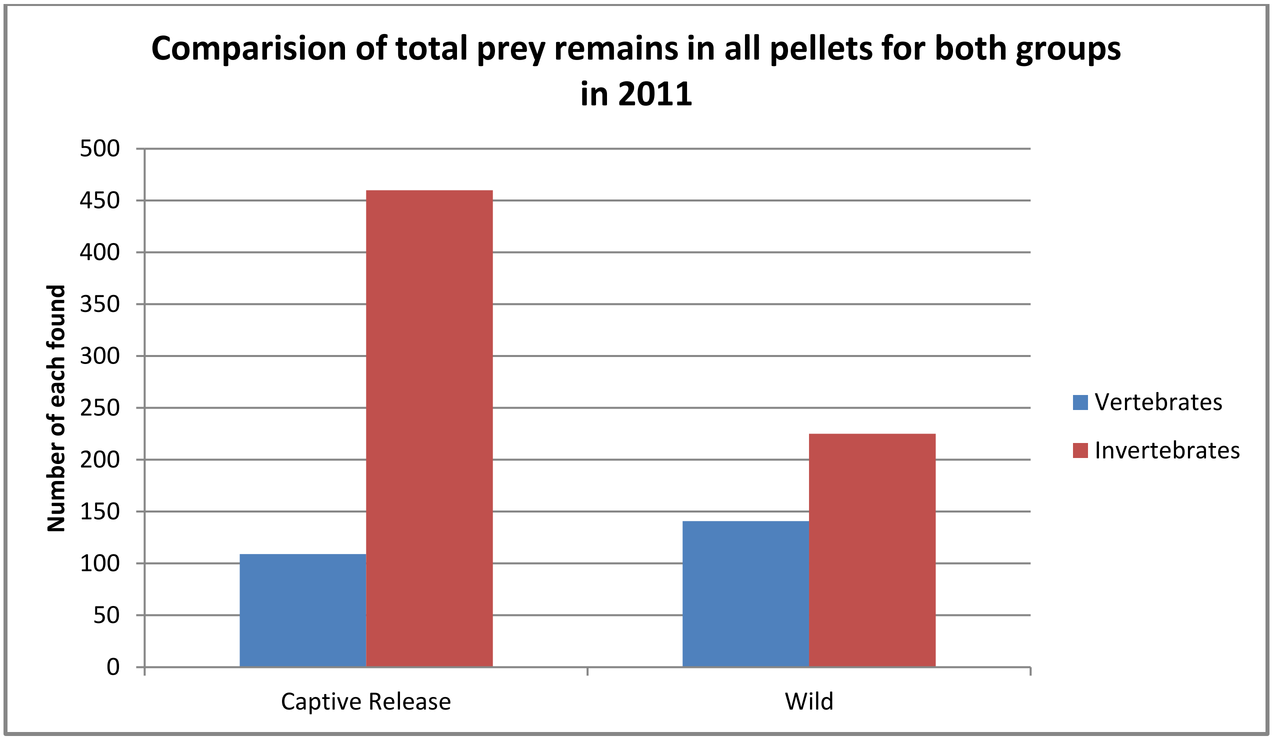

Comparison of vertebrate prey remains in 2011
Number of each found
25
20
15
10
5
0
Peromyscus maniculatus
Microtus pennsylvanicus
Microtus ochrogaster
Oncychomys leucogaster
Perognathus fasciatus
Spea bombifrons
Lithobates sylvaticus
Ambystoma tigrinum
Species found in pellet collection
Captive Released
Wild

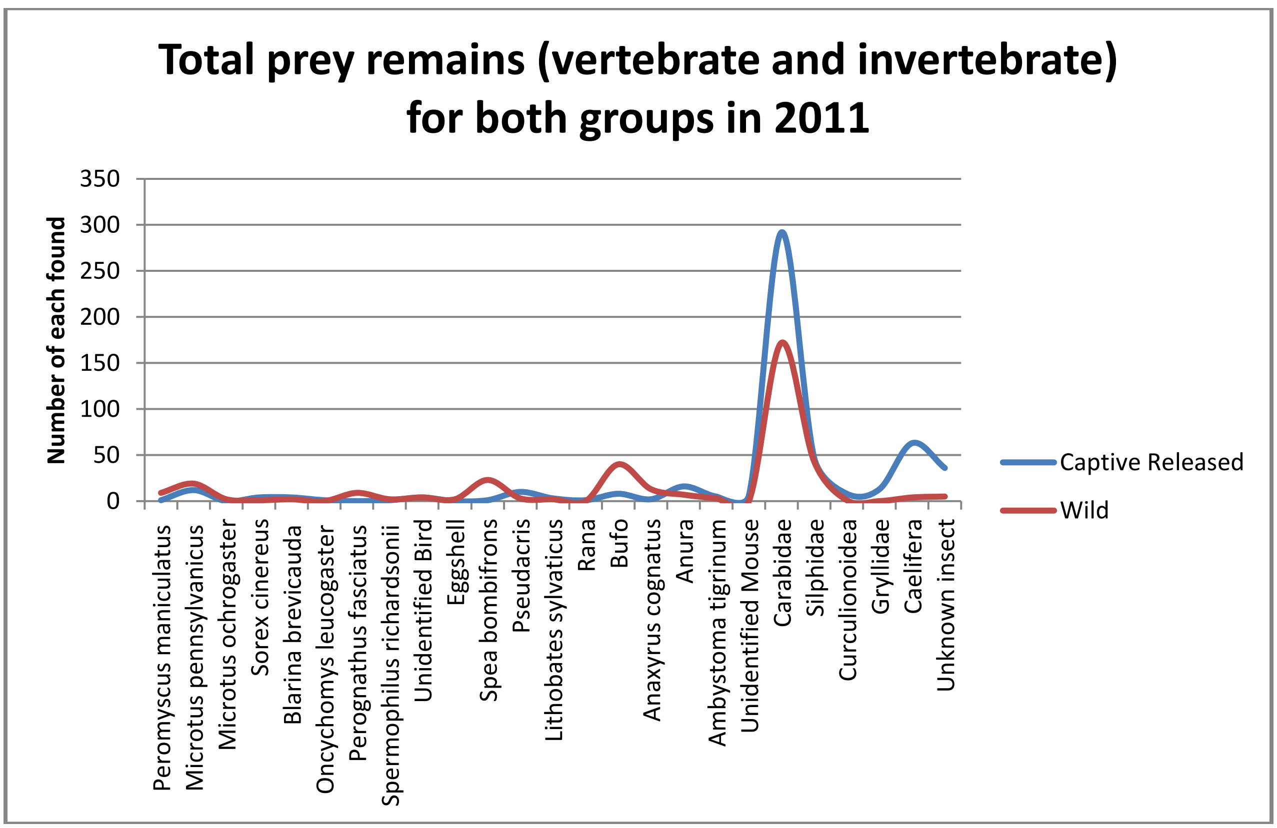

Comparison of invertebrate prey remains in 2011
Number of each found
350
300
250
200
150
100
50
0
Carabidae
Silphidae
Curculionoidea
Gryllidae
Caelifera
Unknown insect
Species found in pellet collection
Captive Released
Wild

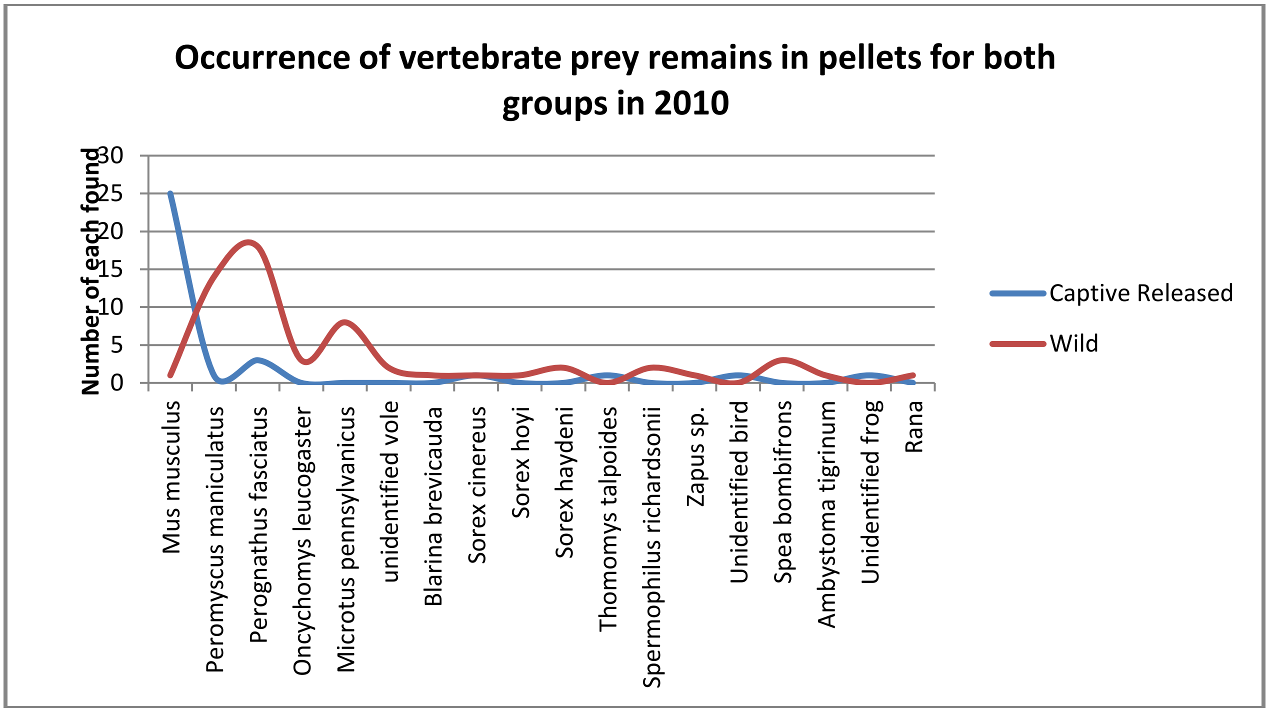
**H4.** Comparison of total prey remains in pellets for both captive-released and wild Burrowing Owl (*Athene cunicularia*) groups (2010-2011) in southwestern Manitoba.

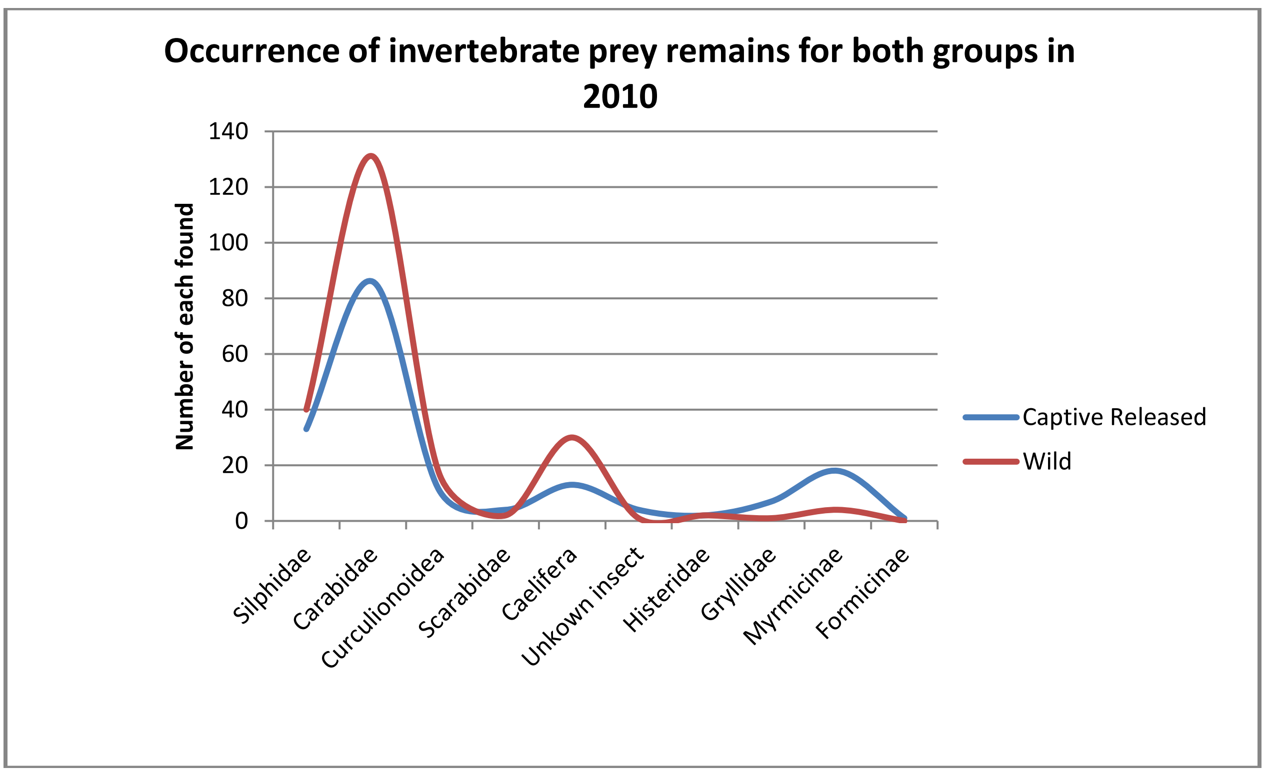


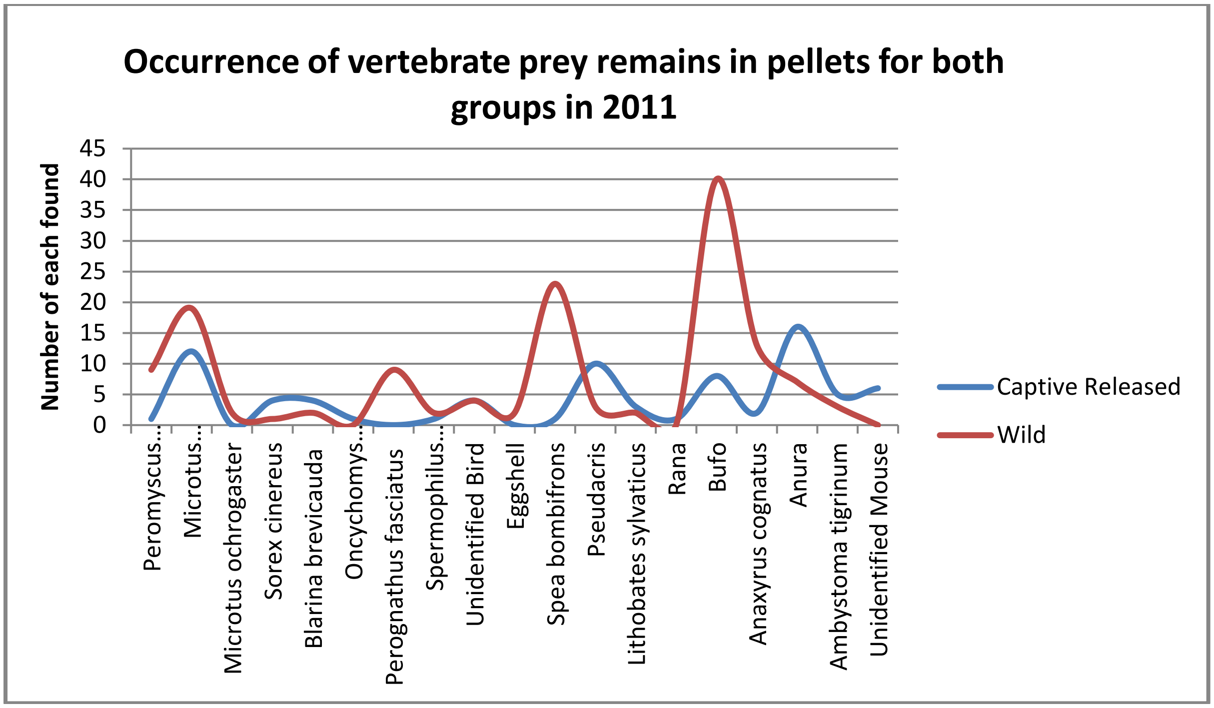




Comparision of total prey remains in all pellets for both groups in 2011
Number of each found
500
450
400
350
300
250
200
150
100
50
0
Captive Release
Wild
Vertebrates
Invertebrates

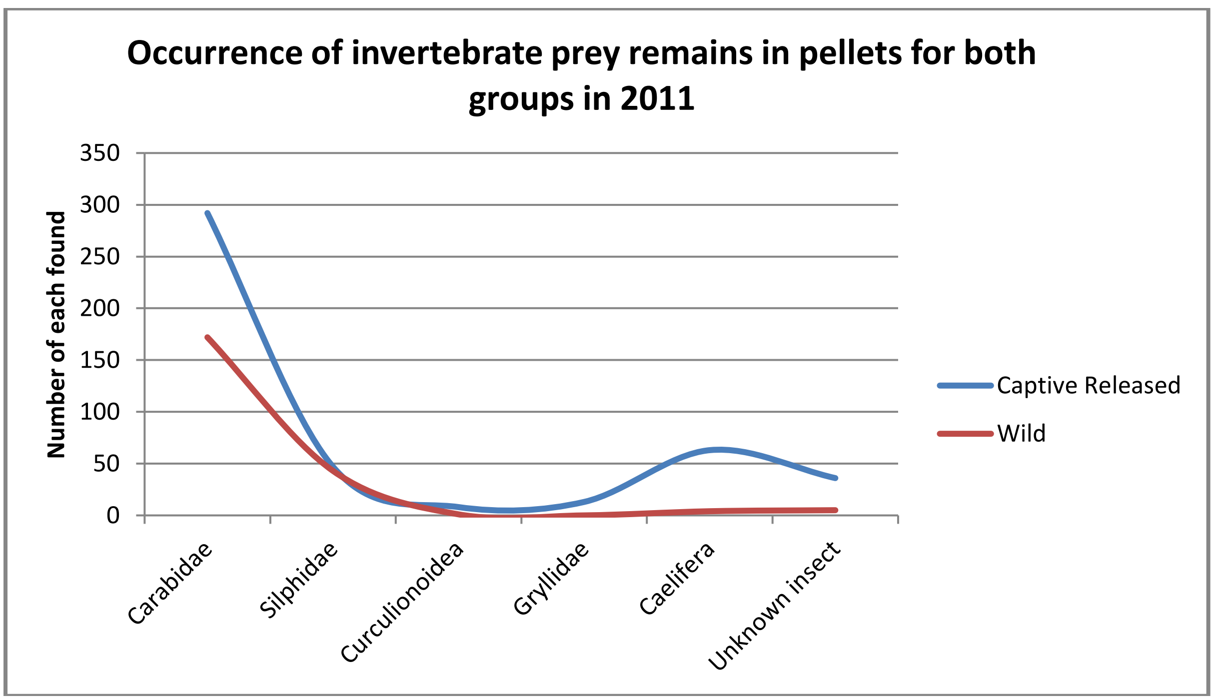

Total prey remains (vertebrate and invertebrate) for both groups in 2011
Number of each found
350
300
250
200
150
100
50
0
Peromyscus maniculatus
Microtus pennsylvanicus
Microtus ochrogaster
Sorex cinereus
Blarina brevicauda
Oncychomys leucogaster
Perognathus fasciatus
Spermophilus richardsonii
Unidentified Bird
Eggshell
Spea bombifrons
Pseudacris
Lithobates sylvaticus
Rana
Bufo
Anaxyrus cognatus
Anura
Ambystoma tigrinum
Unidentified Mouse
Carabidae
Silphidae
Curculionoidea
Gryllidae
Caelifera
Unknown insect
Captive Released
Wild


Occurrence of vertebrate prey remains in pellets for both groups in 2010
Number of each found
30
25
20
15
10
5
0
Mus musculus
Peromyscus maniculatus
Perognathus fasciatus
Oncychomys leucogaster
Microtus pennsylvanicus
unidentified vole
Blarina brevicauda
Sorex cinereus
Sorex hoyi
Sorex haydeni
Thomomys talpoides
Spermophilus richardsonii
Zapus sp.
Unidentified bird
Spea bombifrons
Ambystoma tigrinum
Unidentified frog
Rana
Captive Released
Wild


Occurrence of invertebrate prey remains for both groups in 2010
Number of each found
140
120
100
80
60
40
20
0
Silphidae
Carabidae
Curculionoidea
Scarabidae
Caelifera
Unkown insect
Histeridae
Gryllidae
Myrmicinae
Formicinae
Captive Released
Wild

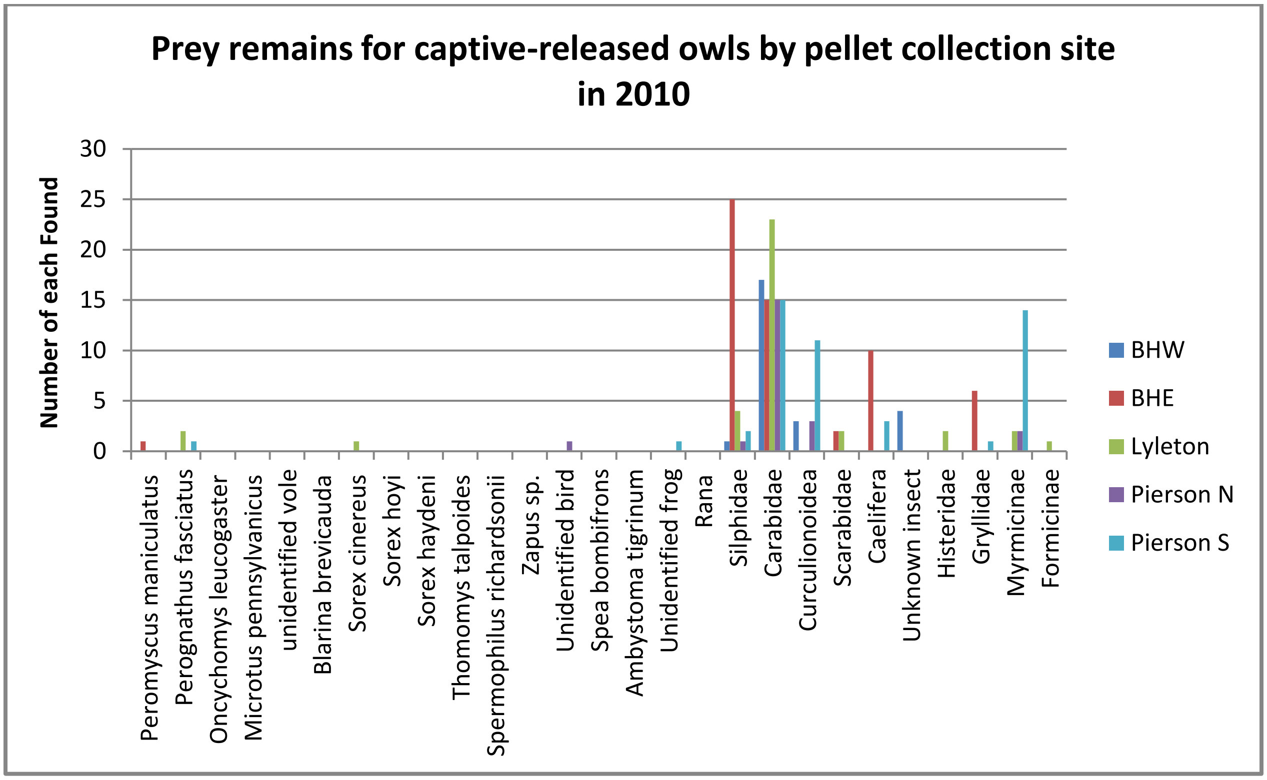


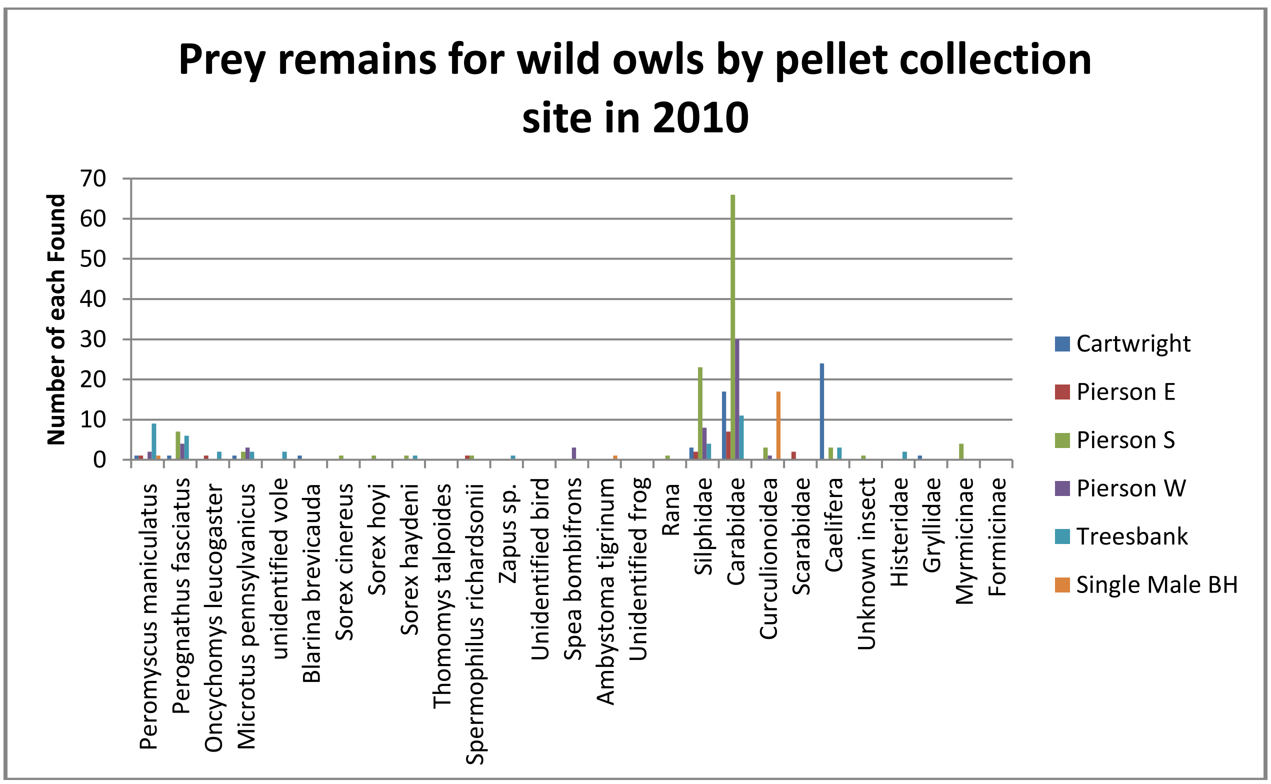
Occurrence of vertebrate prey remains in pellets for both groups in 2011
Number of each found
45
40
35
30
25
20
15
10
5
0
Peromyscus…
Microtus…
Microtus ochrogaster
Sorex cinereus
Blarina brevicauda
Oncychomys…
Perognathus fasciatus
Spermophilus…
Unidentified Bird
Eggshell
Spea bombifrons
Pseudacris
Lithobates sylvaticus
Rana
Bufo
Anaxyrus cognatus
Anura
Ambystoma tigrinum
Unidentified Mouse
Captive Released
Wild

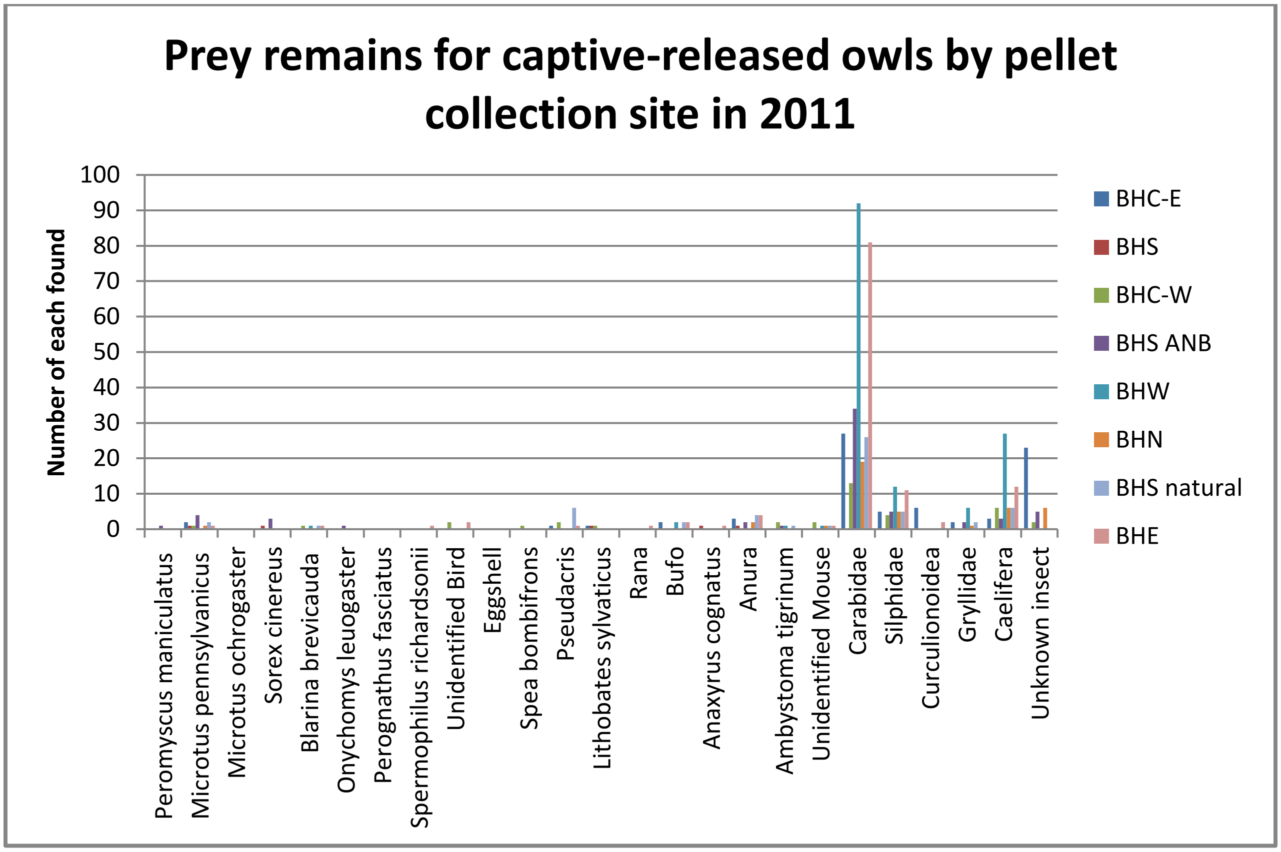



Occurrence of invertebrate prey remains in pellets for both groups in 2011
Number of each found
350
300
250
200
150
100
50
0
Carabidae
Silphidae
Curculionoidea
Gryllidae
Caelifera
Unknown insect
Captive Released
Wild

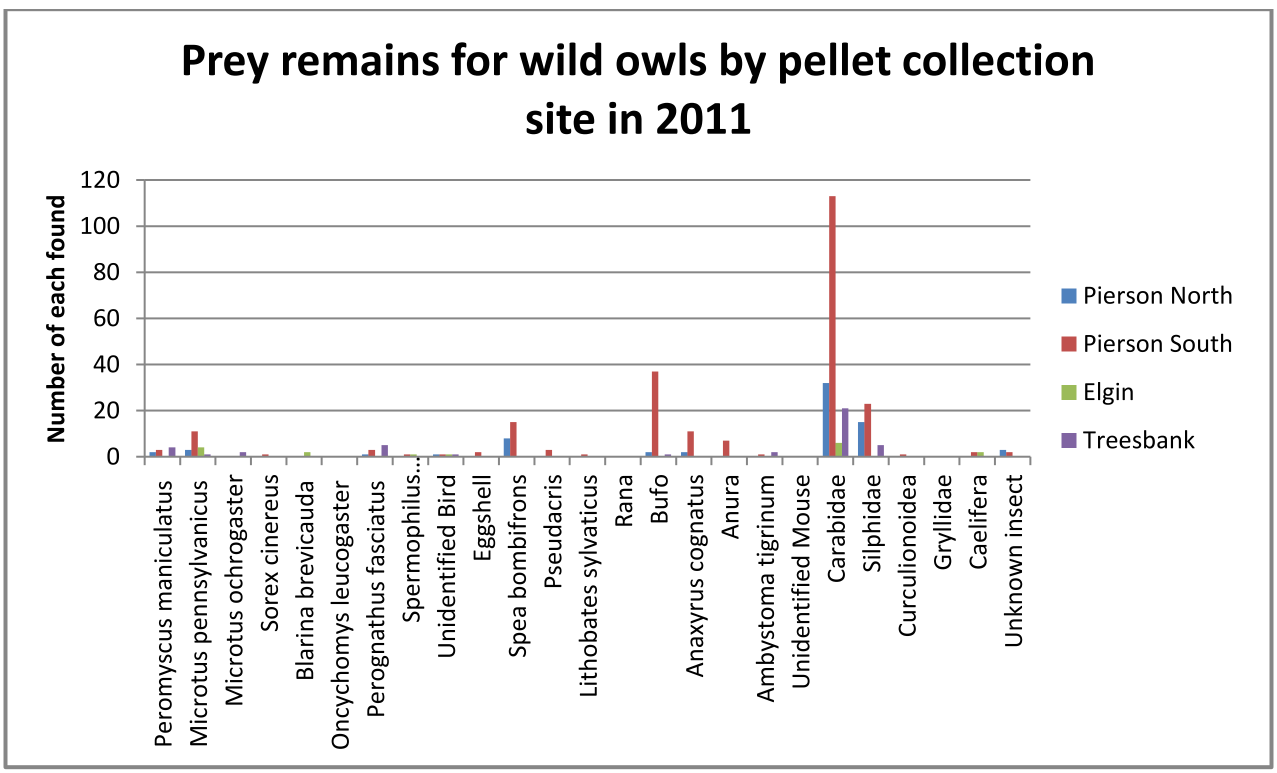
**H5.** Prey remains for both captive-released and wild Burrowing Owls (*Athene cunicularia*) by pellet collection site (2010-2011) in southwestern Manitoba.





Prey remains for captive-released owls by pellet collection site in 2011
Number of each found
100
90
80
70
60
50
40
30
20
10
0
BHC-E
BHS
BHC-W
BHS ANB
BHW
BHN
BHS natural
BHE
Peromyscus maniculatus
Microtus pennsylvanicus
Microtus ochrogaster
Sorex cinereus
Blarina brevicauda
Onychomys leuogaster
Perognathus fasciatus
Spermophilus richardsonii
Unidentified Bird
Eggshell
Spea bombifrons
Pseudacris
Lithobates sylvaticus
Rana
Bufo
Anaxyrus cognatus
Anura
Ambystoma tigrinum
Unidentified Mouse
Carabidae
Silphidae
Curculionoidea
Gryllidae
Caelifera
Unknown insect

Prey remains for wild owls by pellet collection site in 2011
Number of each found
120
100
80
60
40
20
0
Pierson North
Pierson South
Elgin
Treesbank
Peromyscus maniculatus
Microtus pennsylvanicus
Microtus ochrogaster
Sorex cinereus
Blarina brevicauda
Onychomys leucogaster
Perognathus fasciatus
Spermophilus...
Unidentified Bird
Eggshell
Spea bombifrons
Pseudacris
Lithobates sylvaticus
Rana
Bufo
Anaxyrus cognatus
Anura
Ambystoma tigrinum
Unidentified Mouse
Carabidae
Silphidae
Curculionoidea
Gryllidae
Caelifera
Unknown insect

## APPENDIX I.

Descriptive statistics for precipitation rate and Burrowing Owl (*Athene cunicularia*) occurrences in southwestern Manitoba (1991-2012)

| **Variable #1 (Total precipitation (mm) April-June)** | |
|---|---|
| *Count* | 22 |
| *Mean (mm)* | 159.6 |
| *Mean Lower Confidence Limit* | 130.3 |
| *Mean Upper Confidence Limit* | 188.8 |
| *Variance* | 4,349.1 |
| *Standard Deviation* | 65.9 |
| *Mean Standard Error* | 14.1 |
| *Coefficient of Variation* | 0.41331 |
| | |
| *Minimum* | 70.9 |
| *Maximum* | 345.4 |
| *Range* | 274.5 |
| | |
| *Median* | 138.1 |
| *Median Error* | 3.8 |

| **Variable #2 (# of owls)** | |
|---|---|
| *Count* | 22 |
| *Mean* | 14.5 |
| *Mean Lower Confidence Limit* | 6.2 |
| *Mean Upper Confidence Limit* | 22.9 |
| *Variance* | 355.5 |
| *Standard Deviation* | 18.9 |
| *Mean Standard Error* | 4.05 |
| *Coefficient of Variation* | 1.29626 |
| | |
| *Minimum* | 0.0 |
| *Maximum* | 59.0 |
| *Range* | 59.0 |
| | |
| *Median* | 7.5 |
| *Median Error* | 1.1 |

## APPENDIX I. CONTINUED

**Linear Regression**

**Regression Statistics**

| | |
|---|---|
| *R* | 0.10976 |
| *R-square* | 0.01205 |
| *Adjusted R-square* | -0.03735 |
| *S* | 19.20354 |
| *N* | 22 |

**Aggregate # of owls = 19.55243 - 0.03138 * Total precipitation (mm) April-June**

**ANOVA**

| | *d.f.* | *SS* | *MS* | *F* | *p-level* |
|---|---|---|---|---|---|
| *Regression* | 1. | 89.9356 | 89.9356 | 0.24388 | 0.6268 |
| *Residual* | 20. | 7,375.51895 | 368.77595 | | |
| *Total* | 21. | 7,465.45455 | | | |

| | *Coefficient* | *Standard Error* | *LCL* | *UCL* | *t Stat* | *p-level* | *H0 (5%)* |
|---|---|---|---|---|---|---|---|
| **Intercept** | 19.55243 | 10.93435 | -3.25622 | 42.36108 | 1.78817 | 0.08891 | *accepted* |
| **Total precipitation (mm) April-June** | -0.03138 | 0.06354 | -0.16393 | 0.10117 | -0.49384 | 0.6268 | *accepted* |
| *T (5%)* | 2.08596 | | | | | | |

*LCL - Lower value of a reliable interval (LCL)*
*UCL - Upper value of a reliable interval (UCL)*

**Residuals**

| *Observation* | *Aggregate # of owls* | *Predicted Y* | *Residual* |
|---|---|---|---|
| 1 | 56. | 12.77747 | 43.22253 |
| 2 | 59. | 15.68013 | 43.31987 |
| 3 | 51. | 16.49287 | 34.50713 |
| 4 | 21. | 14.50024 | 6.49976 |
| 5 | 10. | 15.51068 | -5.51068 |
| 6 | 3. | 15.4385 | -12.4385 |
| 7 | 1. | 17.32758 | -16.32758 |
| 8 | 4. | 14.84542 | -10.84542 |
| 9 | 7. | 11.40302 | -4.40302 |
| 10 | 0. | 14.18016 | -14.18016 |
| 11 | 2. | 14.98977 | -12.98977 |
| 12 | 0. | 16.54936 | -16.54936 |
| 13 | 0. | 16.24183 | -16.24183 |
| 14 | 0. | 13.32035 | -13.32035 |
| 15 | 0. | 8.71375 | -8.71375 |
| 16 | 18. | 15.45419 | 2.54581 |
| 17 | 8. | 15.48557 | -7.48557 |
| 18 | 36. | 14.99918 | 21.00082 |
| 19 | 19. | 16.40815 | 2.59185 |
| 20 | 11. | 12.7963 | -1.7963 |
| 21 | 10. | 11.35909 | -1.35909 |
| 22 | 4. | 15.52637 | -11.52637 |
| *Minimum* | 0. | 8.71375 | -16.54936 |
| *Maximum* | 59. | 17.32758 | 43.31987 |
| *Mean* | 14.54545 | 14.54545 | 0. |