

# **COSEWIC** **Assessment and Status Report**

on the

## **Ord's Kangaroo Rat** *Dipodomys ordii*

in Canada



**ENDANGERED**  
**2017**

**COSEWIC**  
Committee on the Status  
of Endangered Wildlife  
in Canada



**COSEPAC**  
Comité sur la situation  
des espèces en péril  
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

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COSEWIC 2006. COSEWIC assessment and update status report on the Ord's kangaroo rat *Dipodomys ordii* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 34 pp. ([www.sararegistry.gc.ca/status/status\\_e.cfm](http://www.sararegistry.gc.ca/status/status_e.cfm)).

Gummer, D.L. 1995. COSEWIC status report on the Ord's kangaroo rat *Dipodomys ordii* in Canada. Committee on the Status of Endangered Wildlife in Canada. 1-27 pp.

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## COSEWIC Assessment Summary

### Assessment Summary – April 2017

**Common name**

Ord's Kangaroo Rat

**Scientific name**

*Dipodomys ordii*

**Status**

Endangered

**Reason for designation**

This small, nocturnal rodent is restricted to 12 active sand hill complexes in southeastern Alberta and southwestern Saskatchewan, and is separated from the nearest occurrence of the species in the US by about 270 km. Its small population (fewer than 1,000 mature individuals in most years) varies unpredictably over short periods of time. It is threatened by cumulative human impacts including installation and maintenance of roads and service corridors, energy production, changing land uses, and light and noise pollution. These threats may exacerbate the other limiting factors of vegetation encroachment and stabilization of open sand dune habitats. Standardized annual population monitoring of the species in Alberta has revealed a 72% decline in abundance between 2006 and 2015, likely due to habitat decline and a substantial reduction in distribution. This is assumed to be representative of the entire Canadian population. This species was listed under SARA since 2007, and most of its habitat is unprotected.

**Occurrence**

Alberta, Saskatchewan

**Status history**

Designated Special Concern in April 1995. Status re-examined and designated Endangered in April 2006. Status re-examined and confirmed in April 2017.



## **COSEWIC Executive Summary**

### **Ord's Kangaroo Rat** *Dipodomys ordii*

#### **Wildlife Species Description and Significance**

Ord's Kangaroo Rat (*Dipodomys ordii* Woodhouse 1853) is a small (~70 g), nocturnal rodent that occupies habitats with loose, sandy soils typically associated with actively eroding sand dunes. It is the only kangaroo rat species (genus *Dipodomys*) that occurs in Canada. The Ord's Kangaroo Rat is not closely related to kangaroos or Norway Rats, but has some shared features, including reduced front limbs and large hind legs and feet, which are used for hopping on two legs. It has orange-brown dorsal pelage with distinctive white markings on the head, underbelly, and hips and a long, tufted tail that is more than half the total length of the animal.

Kangaroo rats are often considered a keystone species because of their seed predation and hoarding behaviour, vegetation clipping, and soil disturbance. They are also a common prey item for many species, including species of conservation concern. Kangaroo rats are sensitive to habitat change, particularly sand dune stabilization by vegetation, and the species is commonly used as an indicator or focal species of intact sand dune ecosystems. Animals from the Canadian population contrast with others in the United States and Mexico, from which it is geographically isolated, by their larger size, use of torpor to survive long periods of winter, and more rapid reproduction during the relatively short snow-free season. These may be adaptations that have been favoured by long-term isolation at the extreme northernmost periphery of the species' range.

#### **Distribution**

The species is widely distributed in the interior arid grasslands and deserts of western North America, from the southern Canadian prairies to central Mexico. In Canada, its distribution is restricted to 12 active sand hill complexes in southeastern Alberta and southwestern Saskatchewan. The Ord's Kangaroo Rat in Canada constitutes a disjunct population at the northernmost part of the range, separated by approximately 270 km from the nearest population of the same species in Montana.

## **Habitat**

Ord's Kangaroo Rat is a habitat specialist that is typically associated with the margins of actively eroding sand dunes and requires an open or sparsely vegetated, sandy habitat to facilitate its hopping locomotion and extensive burrowing. Its primary habitats are loose sandy soils associated with actively eroding sand dunes, sand flats, and sandy eroding slopes in sand hill regions. Secondly, kangaroo rats may occupy other sandy areas where the soil has been disturbed by humans (e.g., roads and fireguards), but there is evidence that such habitats may be associated with higher levels of mortality. Actively eroding sand dune habitats have declined in recent decades on the Canadian prairies, due to shifts in climate regimes and changing land use and vegetation disturbance regimes.

Primary habitats in Canada are discretely distributed in space and are embedded within a landscape matrix dominated by agriculture. Thus, existing habitat is highly fragmented, with habitat patches separated from one another by distances that are beyond the typical dispersal distance of the species. Because of this patchiness, the Canadian population functions as a metapopulation with high levels of turnover.

## **Biology**

Ord's Kangaroo Rats spend most of their life below ground in elaborate subterranean burrows that provide shelter from winter conditions or other inclement weather and conceal them from above-ground predators, especially during the daytime. Above-ground activity is almost exclusively nocturnal, and most activities are restricted to nighttime when there is little or no ambient light (e.g., moonlight). The species forages primarily on seeds, which it will attempt to cache below ground in sufficient quantity to sustain individuals through the winter period when cold temperatures and snow cover prevent efficient foraging. Except for mothers rearing offspring, kangaroo rats are highly solitary; they are also aggressively territorial, presumably in defence of their underground residences and seed caches.

Winter starvation and hypothermia appear to be the most common sources of mortality for the species; overwinter mortality rates of up to 90% have been documented. Most Ord's Kangaroo Rats in Canada survive less than 1 year. The Canadian population of Ord's Kangaroo Rat exhibits high rates of reproduction from spring to late summer—a strategy that compensates for high overwinter mortality. Females that survive the winter can rear up to four litters in a single season, and litter size averages about three offspring. Juveniles become reproductively active at the early age of approximately 47 days, so the species has the reproductive capacity to expand quickly under ideal conditions.

## **Population Sizes and Trends**

High rates of overwinter mortality and summer reproduction lead to highly variable population sizes, both within and between years, making it difficult to estimate population size and detect population trends. The most recent estimate of peak population size for Ord's Kangaroo Rat in Canada was 4,957 mature individuals in 1995. Given the range-wide loss of habitat for the species, the current population size is assumed to be much lower.

Estimates of minimum known alive for Alberta (assumed to be about 50% of the population) from 2006 – 2015 suggest strongly that peak population size for Canada is fewer than 1,000 individuals in most years. The Canadian population is lowest in number during early spring. Standardized population monitoring in Alberta (about half the population) from 2006 to 2015 indicates that the number of sites occupied by the species has decreased and that there is a 72% reduction in population size over the past 10 years. Population trend data are not available for Saskatchewan, although trends in Alberta are presumed to be representative of the overall Canadian population because similar threats and limiting factors (below) operate across the entire Canadian range of the species.

## **Threats and Limiting Factors**

Direct threats from individual human activities pose relatively low population-level impacts on their own, but cumulatively represent a high threat to the species in Canada in combination with natural limiting factors. The following threats are recognized to pose risks of direct and indirect impacts and may exacerbate the effects of natural limiting factors: transportation and service corridors (roads, trails, pipelines), energy production, light and noise pollution, invasive and other problematic species (predators and parasites), natural system modifications (fire suppression, absence of Plains Bison; *Bison bison bison*), climate change and severe weather, commercial developments, and agricultural crop and livestock production. Some potential threats, such as military training and livestock grazing, may also have positive benefits under certain conditions.

The primary limiting factor for the persistence of Ord's Kangaroo Rats in Canada is vegetation encroachment and stabilization of open sand dune habitats. This specialized habitat is undergoing a long-term trend of loss that is driven primarily by variation in natural climatic conditions, particularly increased precipitation and growing season length that favours vegetation growth and dune stabilization. Yet, many human threats contribute to this trend and exacerbate its effects. In addition, the combination of a relatively small population that undergoes substantial seasonal fluctuations puts Canadian Ord's Kangaroo Rats at imminent risk of extirpation.

## **Protection, Status and Ranks**

Ord's Kangaroo Rat was originally assessed as Endangered by COSEWIC in 2006 and is listed as such on Schedule 1 of the *Species at Risk Act* (SARA). In April 2017, COSEWIC reassessed this species as Endangered. This species is listed as Endangered under the *Alberta Wildlife Act*, which provides legal protection to individuals and their residences within Alberta. In Saskatchewan, the species is not protected as a designated species (i.e., a species at risk of extirpation or extinction) under Saskatchewan's *Wildlife Act*. The global heritage status rank for the species is G5 (Secure) and the provincial status rank is S2 (Imperilled) in Alberta and Saskatchewan.

The national Recovery Strategy for Ord's Kangaroo Rats identified critical habitat within 178 quarter sections (approximately 115 km<sup>2</sup>) on federal lands in CFB Suffield and immediately adjacent provincial lands in Alberta for protection under SARA, which likely represents about one-quarter of all habitats in Canada. Critical habitat identification has not been completed for the remainder of Ord's Kangaroo Rat range in Alberta and Saskatchewan that falls outside CFB Suffield. In Saskatchewan, a small portion of the species' range has been protected in the Great Sand Hills under the *Representative Areas Ecological Reserves Act*. A portion of the species' range falls within CFB Suffield, most of which is also protected as a National Wildlife Area (NWA) under the *Canada Wildlife Act*.

## TECHNICAL SUMMARY

*Dipodomys ordii*

Ord's Kangaroo Rat

Rat kangourou d'Ord

Range of occurrence in Canada (province/territory/ocean): Alberta, Saskatchewan

### Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used)	< 1 yr
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes, observed (AB) and inferred (SK).  (assuming recent observed declines in AB do not represent a fluctuation and are inferred to be representative of SK range)
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	51% decline within 5 years  (based on 13.2% annual decline)
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Observed/inferred 72% reduction over last 10 years
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Observed/inferred 72% reduction over last 10 years
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. No b. Yes c. No
Are there extreme fluctuations in number of mature individuals?	Yes

### Extent and Occupancy Information

Estimated extent of occurrence	14,200 km <sup>2</sup>
Index of area of occupancy (IAO) (Always report 2x2 grid value).	916 km <sup>2</sup> , based on a 2x2 km grid  (Biological Area of Occupancy: 69 km <sup>2</sup> , based on 250m grid)

Is the population “severely fragmented” i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. Yes b. Yes
Number of “locations” (use plausible range to reflect uncertainty if appropriate)	Unknown, but > 10
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes, observed (AB) and inferred (SK)
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Not in the last 10 years
Is there an [observed, inferred, or projected] decline in number of “locations”**?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, observed and projected declines in area of natural habitats
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of “locations”?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

#### **Number of Mature Individuals (in each subpopulation)**

Subpopulations (give plausible ranges)	Unknown
Total	Cannot be quantified; highly variable, likely falling under 1,000 in many years

#### **Quantitative Analysis**

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	No estimates available for 20-year projection; 40-74% PE within 100 yrs. for the Alberta portion (~50%) of the population.
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#### **Threats (direct, from highest impact to least, as per IUCN Threats Calculator)**

<p>Was a threats calculator completed for this species? Yes</p> <p>The following direct threats from human activities are all estimated as low or medium-low impacts but cumulatively pose a high threat impact, particularly in combination with natural limiting factors.</p> <ul style="list-style-type: none"> <li>•Transportation and service corridors – Roads and trails; pipelines</li> <li>•Energy production – Oil and gas drilling</li> <li>•Pollution – light and noise pollution</li> <li>•Invasive and other problematic species – Predators and parasites</li> </ul>
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- Natural system modifications – Fire suppression, absence of bison
- Climate change and severe weather – Habitat shifting and temperature extremes
- Residential and commercial development – Refineries and compressor stations
- Agriculture – Cropland and livestock production

What additional limiting factors are relevant?

- Habitat loss from vegetation encroachment and stabilization of open sand habitats;
- Small population size and extreme fluctuations in population size.

### Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	USA and Mexico: stable, considered common and widely distributed
Is immigration known or possible?	Not possible
Would immigrants be adapted to survive in Canada?	Not likely
Is there sufficient habitat for immigrants in Canada?	No
Are conditions deteriorating in Canada?	Yes
Are conditions for the source population deteriorating?	Unknown
Is the Canadian population considered to be a sink?	No  (there are some areas that serve as sinks within this population)
Is rescue from outside populations likely?	No

### Data Sensitive Species

Is this a data sensitive species? No (there is no information directly in the report that cannot be released)

### Status History

COSEWIC: Designated Special Concern in April 1995. Status re-examined and designated Endangered in April 2006. Status re-examined and confirmed in April 2017.

### Status and Reasons for Designation:

<b>Status:</b> Endangered	<b>Alpha-numeric codes:</b> A2abc+4abc; C2b
<b>Reasons for designation:</b> This small, nocturnal rodent is restricted to 12 active sand hill complexes in southeastern Alberta and southwestern Saskatchewan, and is separated from the nearest occurrence of the species in the US by about 270 km. Its small population (fewer than 1,000 mature individuals in most years) varies unpredictably over short periods of time. It is threatened by cumulative human impacts including installation and maintenance of roads and service corridors, energy production, changing land uses, and light and noise pollution. These threats may exacerbate the other limiting factors of vegetation encroachment and stabilization of open sand dune habitats. Standardized annual population monitoring of the species in Alberta has revealed a 72% decline in abundance between 2006 and 2015, likely due to habitat decline and a substantial reduction in distribution. This is assumed to be representative of the entire Canadian population. This species was listed under SARA since 2007, and most of its habitat is unprotected.	

### Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals):

Meets Endangered, A2, with ~72% overall decline in the past 10 years, as inferred from direct observation (a), index of abundance (b), and habitat quality decline driving population decline. Also meets A4abc (past and future), because some ongoing decline is predicted based on current situation.

Criterion B (Small Distribution Range and Decline or Fluctuation):

Meets Threatened, B2ab, as AOO is  $< 2,000 \text{ km}^2$ , it is experiencing continuing decline in area, habitat, and mature individuals, and has extreme fluctuations.

Criterion C (Small and Declining Number of Mature Individuals):

Meets Endangered, C2b, because the population is  $< 2,500$  mature individuals and undergoes extreme fluctuations.

Criterion D (Very Small or Restricted Population):

Meets Threatened, D1, because total population of mature individuals  $< 1,000$  in most years.

Criterion E (Quantitative Analysis):

May meet Endangered (with 40-74% probability of extinction within 100 yrs.), but this has been estimated for the Alberta portion (~50%) of the population only.

## PREFACE

This report has been updated with new information collected since the previous Status Update for the Ord's Kangaroo Rat *Dipodomys ordii* in Canada (COSEWIC 2006). Considerable research has been undertaken since 2006 to document population trends for the species in the Alberta portion of the range and to identify habitat and determine ways to improve it so that population declines might be mitigated. This research has been guided by the priority recovery actions and research needs identified in the federal recovery strategy (Environment Canada 2012) and the Alberta recovery plan (Alberta Ord's Kangaroo Rat Recovery Team 2005, Alberta Environment and Sustainable Resource Development 2013).

In 2006, an annual, standardized population monitoring program was implemented in Alberta, annually collecting information on population distribution and trends until 2015. Based on these data, an occurrence-based habitat assessment for Alberta was also conducted. Field validation of the Saskatchewan habitat model was not conducted, but a qualitative field assessment of suitable habitat and habitats occupied within the species' range was completed. This effort expanded knowledge about the Canada-wide distribution of the species and refined estimates of extent of occurrence and area of occupancy. Overall, this work confirmed the restricted and fragmented distribution of Ord's Kangaroo Rat in Canada. While population trends are difficult to assess, there is direct evidence that the species has been continuing to decline in the last decade.

A quantitative assessment of predicted population trends and viability has been implemented for Alberta, demonstrating that the highly fragmented nature of habitat contributes to an elevated risk of local extirpation. In response, research has also been conducted to evaluate the feasibility of conservation tools to mitigate population and habitat decline, such as habitat restoration, facilitating connectivity through "stepping-stone" habitat patch creation, and facilitated dispersal through translocation of free-ranging animals.

Although new information for this species has been collected within Alberta, very little new information has been gathered in Saskatchewan regarding abundance, population trends, distribution, or the quantity and quality of habitat. However, Ord's Kangaroo Rat ranges in Alberta and Saskatchewan are adjacent to one another, and there is little reason to expect that factors affecting population size, trends, or habitats are significantly different between the two provinces, which are estimated to contain similar proportions of suitable habitat for the species. Thus, recent information developed in Alberta since 2006 is extrapolated to the Saskatchewan range in this report.



## COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

## COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

## COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

## DEFINITIONS (2017)

Wildlife Species	A species, subspecies, variety, or geographically or genetically distinct population of animal, plant or other organism, other than a bacterium or virus, that is wild by nature and is either native to Canada or has extended its range into Canada without human intervention and has been present in Canada for at least 50 years.
Extinct (X)	A wildlife species that no longer exists.
Extirpated (XT)	A wildlife species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A wildlife species facing imminent extirpation or extinction.
Threatened (T)	A wildlife species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A wildlife species that may become a threatened or an endangered species because of a combination of biological characteristics and identified threats.
Not at Risk (NAR)**	A wildlife species that has been evaluated and found to be not at risk of extinction given the current circumstances.
Data Deficient (DD)***	A category that applies when the available information is insufficient (a) to resolve a species' eligibility for assessment or (b) to permit an assessment of the species' risk of extinction.

\* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.

\*\* Formerly described as "Not In Any Category", or "No Designation Required."

\*\*\* Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.



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The Canadian Wildlife Service, Environment and Climate Change Canada, provides full administrative and financial support to the COSEWIC Secretariat.

# **COSEWIC Status Report**

on the

## **Ord's Kangaroo Rat**

*Dipodomys ordii*

**in Canada**

2017

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## WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

### Name and Classification

Class: Mammalia; Order: Rodentia; Family: Heteromyidae; Subfamily: Dipodomysinae

Scientific name: *Dipodomys ordii* Woodhouse (1853), subspecies *D. o. terrosus* Hoffmeister (1942)

Common names: Ord's Kangaroo Rat (English); Rat kangourou d'Ord (French)

Ord's Kangaroo Rat is a small, nocturnal rodent endemic to the Americas. It is one of 19 species of kangaroo rats (*Dipodomys*) currently recognized (Patton 2005) that occur exclusively in the arid grasslands and deserts of western North America. It is the only species of *Dipodomys* that occurs in Canada. *Dipodomys* is derived from Greek, meaning "two-footed mouse", referring to its bipedal locomotion. The common name reflects its characteristic hopping style of locomotion and its long tail.

Within the genus, Ord's Kangaroo Rat belongs to the *ordii*-group (Grinnell 1921, Stock 1974). Chromosomal evidence suggests that the species is more closely related to the Gulf Coast Kangaroo Rat (*D. compactus*) of southern Texas than to other congeners (Stock 1974, Patton and Rogers 1993). The species is one of only three heteromyidae species found in Canada, and its closest sympatric relative is the Olive-backed Pocket Mouse (*Perognathus fasciatus*), which has a similar range.

There are 32 recognized subspecies of Ord's Kangaroo Rats (Williams *et al.* 1993). The Canadian population belongs to *D. o. terrosus* (Hoffmeister 1942, Anderson 1946, Setzer 1949, Hall 1981, Williams *et al.* 1993), which ranges from northern Wyoming and South Dakota into southern Alberta and Saskatchewan. The northernmost (Canadian) population is geographically isolated and exhibits distinct life history and physiological traits (Gummer 1997, 2005) that differentiate Canadian Ord's Kangaroo Rats from populations to the south. The original assignment of the Canadian population to *D. o. terrosus* appears to have been made based on an examination of only one specimen (Anderson 1946). Thus, the taxonomic designation of the Canadian population warrants re-evaluation.

### Morphological Description

Ord's Kangaroo Rats have large hind legs and feet that facilitate bipedal, hopping locomotion (Bartholomew and Caswell 1951; see Figure 1). The dorsal pelage is mostly orange-brown but the ventral surface, dorsal surfaces of the feet, markings above the eye and below the ear, forelimbs, hip stripes, lateral stripes of the tail, and base of the tail are white. The species has fur-lined cheek pouches and five toes on each foot. The tail is tufted and long, accounting for more than half of total length (Table 1). Across the species' range, males tend to be slightly larger in some skeletal measurements than females (Kennedy and Schnell 1978, Best 1993). In Canada, overall sexual size dimorphism is not evident (Gummer and Bender unpubl. data), yet males tend to have slightly higher body mass for

their size than females (Teucher 2007). In Canada, adult Ord's Kangaroo Rats (Table 1) are consistently larger (up to 33%) than individuals from the same species in more southern localities (Jones 1985, Best 1993). The skull of Ord's Kangaroo Rat is distinctive from other sympatric rodents in Canada due to its conspicuous, large auditory bullae and grooved upper incisors.



Figure 1. Photograph of Ord's Kangaroo Rat (photograph by D.L. Gummer, courtesy of the Royal Alberta Museum).

**Table 1. Standard measurements of 49 adult Ord's Kangaroo Rats from the collections of the Royal Alberta Museum, Royal Saskatchewan Museum, and University of Alberta Museum of Zoology.**

Measurement	Mean $\pm$ 1 standard error
Body mass (g)	69.2 $\pm$ 0.9
Total length (mm)	261.4 $\pm$ 1.7
Tail length (mm)	143.3 $\pm$ 1.2
Hind foot length (mm)	42.2 $\pm$ 0.2
Ear length (mm)	12.9 $\pm$ 0.2

## Population Spatial Structure and Variability

The Canadian population of Ord's Kangaroo Rats occurs in one region of southeastern Alberta and southwestern Saskatchewan where high aridity and sandy soils provide suitable habitat (see **Habitat**). Within this region, the species is highly aggregated and patchily distributed, typically following the distribution of active sand hills.

There is a high degree of spatial structure within the population, exacerbated by human land uses (e.g., cultivation, roads) that limit movement of Ord's Kangaroo Rats among patches of habitat, and the local distribution of kangaroo rats is dynamic (see **Fluctuations and Trends**). Given the patchy nature of habitat and high turnover rates, the Canadian population of Ord's Kangaroo Rats functions as a metapopulation (*sensu* Levins 1969, Hanski 1999). However, Brands (2016) has examined kangaroo rat dispersal in Alberta and suggested that inter-patch distances likely exceed typical movement capabilities of the species, especially given the high degree to which humans have modified the landscape. The Canadian population may be shifting towards a non-equilibrium metapopulation structure (Harrison 1991) with numerous isolated subpopulations, meaning that rates of local extirpation may exceed rates of dispersal and recolonization because of severe fragmentation.

Population genetics of northern Ord's Kangaroo Rats have not been studied. However, the Canadian population has likely been isolated from the nearest populations to the south since the late Hypsithermal (ca. 6,000 years BP; Kenny 1989, Vance *et al.* 1995, Beaudoin 1999). Isolation, short generation time, and extreme annual population cycles are hypothesized to have favoured genetic drift and adaptations to regional environmental conditions (Gummer 1997, 2005) and genetic differentiation from other populations.

## **Designatable Units**

There is no evidence to indicate that Ord's Kangaroo Rats in Canada should be assessed as more than one designatable unit.

## **Special Significance**

Ord's Kangaroo Rat is a potential focal species for conservation of prairie sand dunes—a rare and declining habitat on which many species depend (Hugenholtz *et al.* 2010).

Kangaroo rats are often considered a keystone species because of their seed predation and hoarding behaviour, vegetation clipping, and soil disturbance (Brown and Heske 1990, Heske *et al.* 1993, Kerley *et al.* 1996). They also represent a valuable prey resource for many predators, including other species of conservation concern, such as Prairie Rattlesnakes (*Crotalus viridis*), Burrowing Owls (*Athene cunicularia*), and American Badgers (*Taxidea taxus*) (Kenny 1989, Gummer and Robertson 2003b, Gummer and Bender unpubl. data). Kangaroo rats rely on open, sparsely vegetated habitats and are sensitive to habitat change, particularly sand dune stabilization by vegetation (Bender *et al.* 2005). Finally, Ord's Kangaroo Rats within Canada exhibit key differences from conspecifics in the United States and Mexico: Canadian Ord's Kangaroo Rats are larger in body size (Gummer 1997; Gummer and Bender unpubl. data); they use torpor to survive prolonged periods of winter (Gummer 2005); and they reproduce more rapidly during the relatively short, snow-free season (Gummer 1997). These characteristics likely represent adaptations that have been driven by long-term isolation at the extreme northernmost periphery of the species' range (Gummer 1997, 2005).

## DISTRIBUTION

### Global Range

Ord's Kangaroo Rat is widely distributed in the interior arid grasslands and deserts of western North America (Figure 2; Hall 1981, Schmidly *et al.* 1993, Williams *et al.* 1993). Its geographic range extends across approximately 3,370,000 km<sup>2</sup> and 31 degrees of latitude from the southern prairies in Canada to central Mexico. There is no evidence of broad-scale, historical changes in the overall geographic distribution.

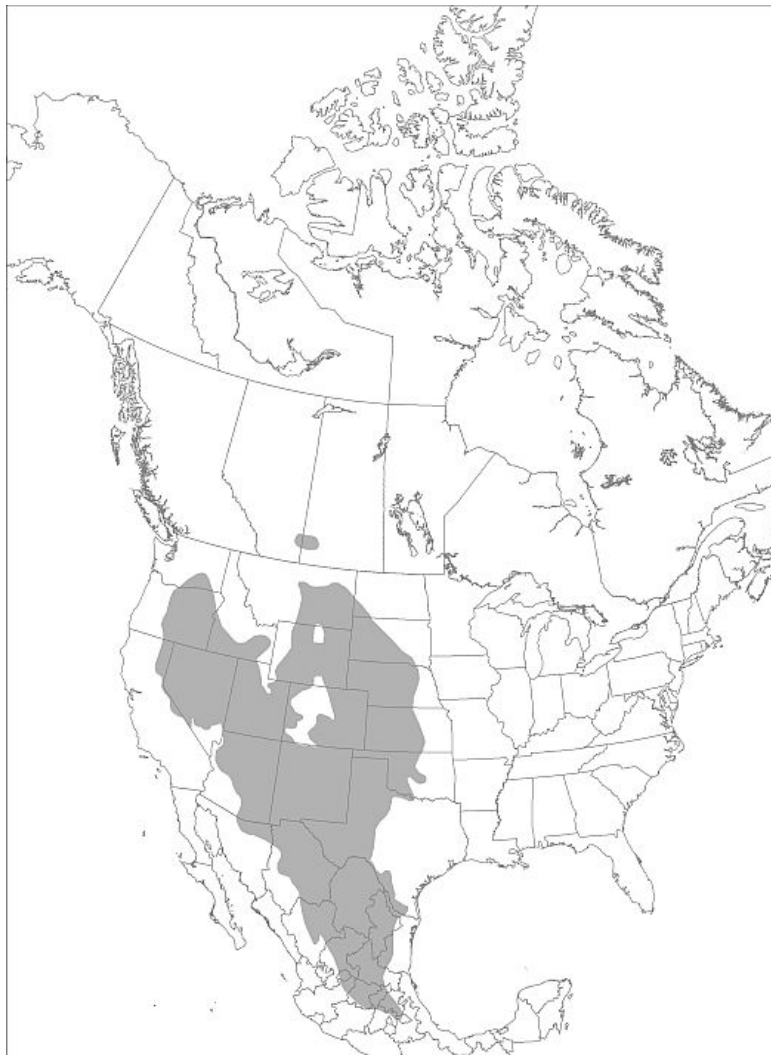


Figure 2. Global range of Ord's Kangaroo Rat. Modified from COSEWIC (2006).

## Canadian Range

In Canada, Ord's Kangaroo Rat is found in one continuous region of southeastern Alberta and southwestern Saskatchewan, which represents less than 1% of the species' global distribution. Canadian Ord's Kangaroo Rats are a disjunct population at the northernmost periphery of the species' range (Kenny 1989, Gummer 1997). The nearest occurrence of Ord's Kangaroo Rats in Montana (Montana Natural Heritage Program 2015) is approximately 270 km to the south.

## Extent of Occurrence and Area of Occupancy

The Canadian range occurs in the mixed grassland ecoregion of the prairie ecozone (Marshall and Shutt 1999) in the vicinities of the Great Sand Hills, Saskatchewan (Nero 1956, Nero and Fyfe 1956, Kenagy 1976, Epp and Waker 1980, Kenny 1989), and the Middle Sand Hills, Alberta (Smith and Hampson 1969, Gummer *et al.* 1997, Gummer 1999, Gummer and Robertson 2003a, b, Bender *et al.* 2010a). This area is composed of a complex of numerous sand hill regions separated by agricultural land that is predominantly cultivated and does not contain sand hills (Wolf 2001; see Figure 3). All confirmed records of Ord's Kangaroo Rat observations in Canada occur within or directly adjacent to sand hills regions, except for two that are presumed to have been accidental or vagrant: (i) an anecdotal observation (Carleton 1956) near Ravenscrag, Saskatchewan (50 km south of the nearest sand hills); and (ii) an undated specimen held by the Royal Ontario Museum from near Val Marie, Saskatchewan (135 km south of the nearest sand hills in unsuitable habitat; Bender and Gummer pers. obs.).

The total extent of occurrence (EOO) for Ord's Kangaroo Rats in Canada is approximately 14,200 km<sup>2</sup>. It should be noted that a previous status update (COSEWIC 2006) estimated the EOO for the species to be considerably smaller (6,030 km<sup>2</sup>), because (i) a different estimation method was used (i.e., two small minimum convex polygons that excluded an interior region of unsuitable habitat instead of one large, encompassing polygon), and (ii) the species was recently observed in the Seward Sand Hills, extending the eastern boundary of its known distribution in Canada (Bender unpubl. data). Thus, the increase in EOO is not likely indicative of a range expansion, rather it is due to methodological differences in estimating EOO and knowledge improvements.

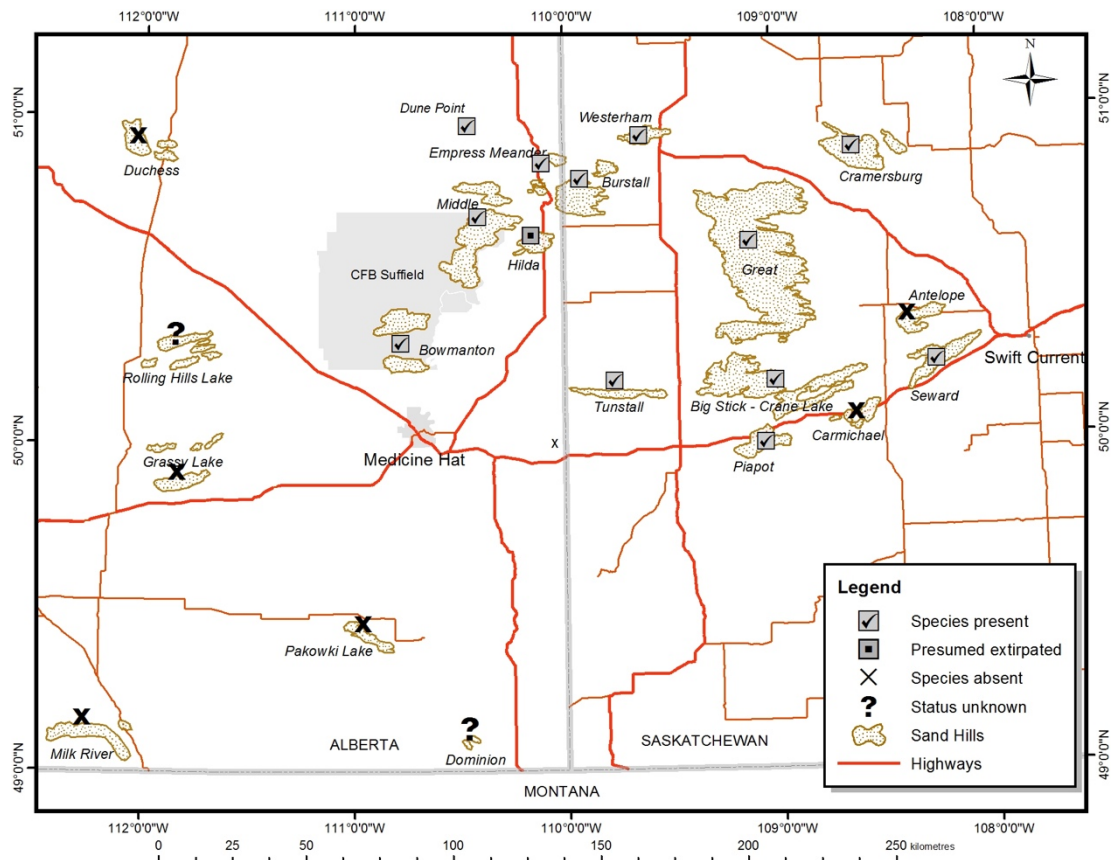


Figure 3. The present distribution of Ord's Kangaroo Rats in the sand hills regions of southwestern Saskatchewan and southeastern Alberta. All recognized sand hill formations (adapted from Wolfe 2001) within and adjacent to the species' range and potentially contain suitable habitat are shown. Also included is the known status of kangaroo rats in each of the sand hill areas (i.e., species present, species historically present but presumed locally extirpated based on surveys, presumed to be absent based on surveys, or undetermined).

The area actually occupied by Ord's Kangaroo Rat in Canada is extremely small due to the specific habitat requirements of this animal (see **Habitat**). In Alberta, Heinrichs *et al.* (2010) estimated the amount of primary habitat associated with active sand dunes to be between 0.7 and 6.2 km<sup>2</sup>. For Saskatchewan, Kenny (1989) estimated approximately 6.8 km<sup>2</sup> for the total area of open, sandy habitats available for Ord's Kangaroo Rats during a drought in the mid-1980s in the Great Sand Hills, Cramersburg Sand Hills, and Burstall Sand Hills (representing about 70% of the Saskatchewan range based on data from Wolfe 2010; see Figure 3). It should be noted, however, that because Kenny (1989) did not distinguish between open sand and sparsely vegetated margins, this likely represents an overestimate of primary habitat in the province. Extrapolating to the entire range in Saskatchewan yields about 9.7 km<sup>2</sup> total habitat. More recently, however, Nielsen (2007) estimated about 5.2 km<sup>2</sup> of total sand dune habitat in Saskatchewan. Taken together, the total primary (sand dune) habitat in Canada ranges from 5.9 to 15.9 km<sup>2</sup>.

Recently, Robbins (2013) attempted to estimate the range-wide amount of primary habitat available to the species in Canada, based on an extrapolation of an occurrence-based habitat model (Bender *et al.* 2010b) developed for Alberta. Using a coarse

approximation from satellite imagery, Robbins estimated that the amount of primary habitat in Canada was between 1.9 and 28.0 km<sup>2</sup>, which contains the estimates above. Depending on the estimation method, Robbins (2013) suggests that about 55 to 75% of the habitat in Canada is within Alberta; however, this percentage does not agree with the estimates extrapolated from Kenny (1989; see above) and expert opinion (D. Bender, pers. obs.), which suggest that the amount of habitat in Saskatchewan is at least as much as in Alberta. Thus, the relative amounts of primary habitat in Alberta and Saskatchewan are probably relatively similar, although this remains to be confirmed.

Estimates for primary habitat presented here do not include secondary (i.e., anthropogenic) habitats, such as sandy roads, trails, and fallow fields (see **Habitat**). These are not consistently occupied by Ord's Kangaroo Rats and may actually function as sink habitats (Teucher 2007, Heinrichs *et al.* 2015). However, using all confirmed habitat patches, including those in anthropogenic habitats, and a block size of 6.25 ha (0.25 x 0.25 km), the total occupied area in Canada would be no greater than about 69 km<sup>2</sup>. While this simple expression of the area does not necessarily include all sites actually occupied by Ord's Kangaroo Rats in Canada (i.e., surveyors will not have detected all animals, particularly in Saskatchewan), it is also a very generous estimate because kangaroo rat home ranges are typically <1 ha (see **Biology**). Thus, this estimate likely represents a reasonable upper limit to an estimate of the biological area of occupancy. A lower estimate is more difficult to obtain, especially because of fluctuations in the population, but it is likely not important given the very low value of the upper estimate. Using a larger block size (2 x 2 km), the index of the area of occupancy for the species is 916 km<sup>2</sup>.

There is some evidence that the biological area of occupancy may have declined in recent decades, at least in Alberta. In 1970 – 1971, Ord's Kangaroo Rats occurred in an area of sand hills 15 km north of Hilda, Alberta, based on four museum specimens collected there (University of Alberta Museum of Zoology, Smith 1972). However, surveys in 1997 and 2001 found no evidence of this species (Gummer and Gummer 1997, Gummer and Robertson 2003a). At Canadian Forces Base Suffield and adjacent lands, sandy roads, trails, and fireguards were often heavily occupied (>10 animals per site) by kangaroo rats in the mid-1990s (Gummer 1997) and early-2000s (Gummer 2007). As of 2014, most of these road sites are now either vacant or support only 1 or 2 animals (Bender unpubl. data; see **Population Sizes and Trends**).

Quantitative evidence indicates that the area of occupancy for the species has declined over the past decade (2006-2015) in Alberta (Figure 4). The observed decline in area of occupancy could underestimate the actual decline because productive, stable habitats are likely over-represented in the underlying survey data (see **Search Effort, Sampling Effort and Methods**). No standardized, repeated surveys have been conducted within Saskatchewan, so trends in occupancy cannot be evaluated in that province. However, the habitats are similar and contiguous, with similar limiting factors (e.g., climate and habitat encroachment), and therefore it is likely that the Alberta distribution trends are representative of the Canadian range.

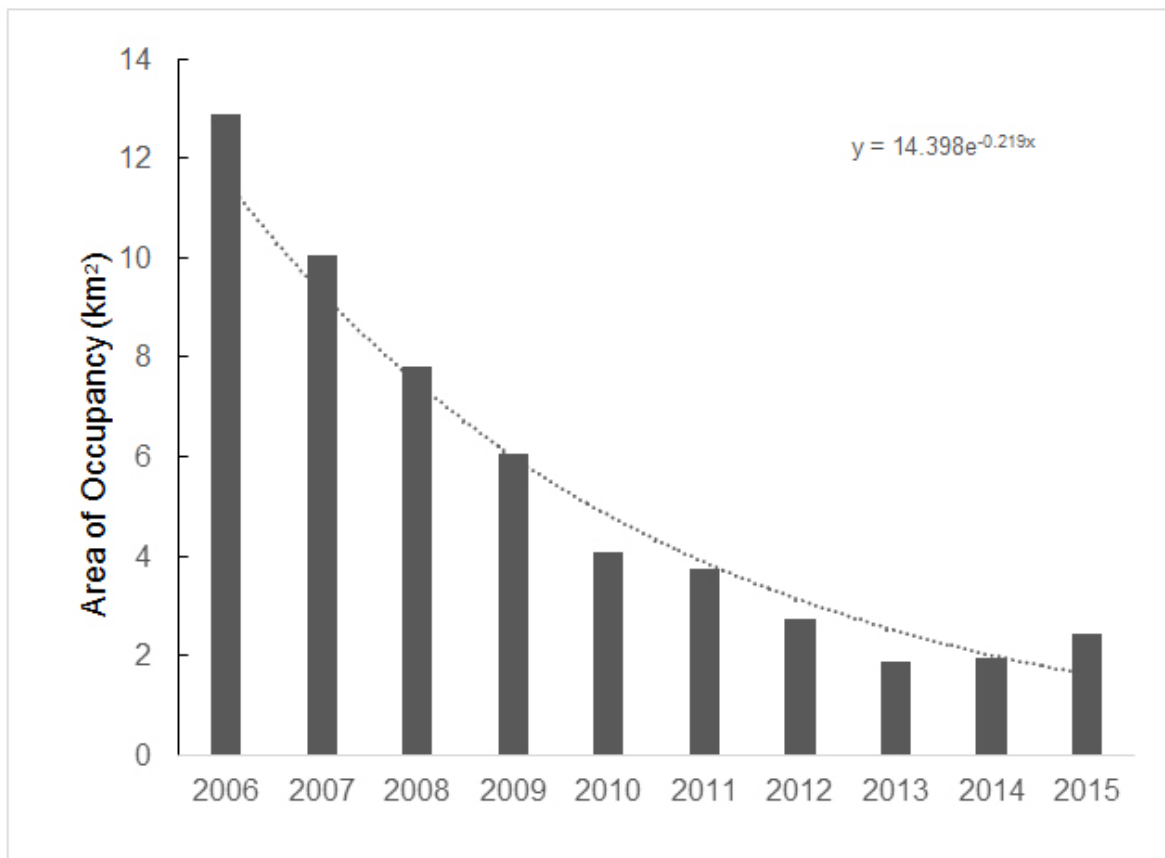


Figure 4. Plot of biological area of occupancy using a 0.25 x 0.25 km block size of occupied habitat for Ord's Kangaroo Rat in Alberta from 2006-2016. The source of data is from the Alberta annual population monitoring program, which uses standardized survey methods each year and approximately equal survey effort. Trend line is an exponential decay curve fitted to the area data, which indicates an average decline of 19.7% per year or an average of about 86% over the 10-year period.

## Search Effort

The Ord's Kangaroo Rat is found in the deserts and arid or semi-arid grasslands of western North America, with the northernmost portion of the range located in southwestern Alberta and southeastern Saskatchewan. In Canada, search effort for the species has been largely restricted to this region, owing largely to the high habitat specificity observed for this species in Canada and the restricted distribution of preferred habitats. Gummer and Robertson (2003a) conducted surveys for the species in all adjacent sand hill regions to the Middle Sand Hills in Alberta, but did not detect the species north of the Red Deer River or south of Medicine Hat. Surveys to the west at Grassy Lake Sand Hills (Gummer and Robertson 2003a) and Duchess Sand Hills (D. Bender unpubl. data) also did not detect the species. D. Bender (unpubl. data) surveyed sand hills complexes nearby the Great Sand Hills in 2009, but did not detect the species east of the Seward Sand Hills, near Swift Current, SK. Suitable habitats do not exist north of the South Saskatchewan River in Saskatchewan, except for one small patch (<100 ha) of potential habitat near Cramersburg, SK (part of the Cramersburg Sand Hills), which has not been surveyed.

There are no records of targeted surveys for Ord's Kangaroo Rats having been conducted outside the semi-arid grasslands in Canada (e.g., none in sand dunes elsewhere in Alberta or Saskatchewan and none in Manitoba). Given the extreme habitat specialization of the species in Canada, it seems unlikely that it would be found at disparate sand dunes in other ecotypes. There are no records of kangaroo rat sightings in other regions of Canada where sandy habitats exist.

The majority of observations of Ord's Kangaroo Rats in Alberta have come from targeted surveys, because the species has been the focus of intensive research and management in Alberta since 1994 (e.g., see Gummer 1999, Gummer and Robertson 2003a, Bender *et al.* 2007). However, little research on the species is available for Saskatchewan, and most observations from that province were opportunistically collected, often obtained from non-targeted surveys. Assuming that approximately equal proportions of habitat exist in Alberta and Saskatchewan (see **Extent of Occurrence and Area of Occupancy**) and similar densities of Ord's Kangaroo Rats in both provinces, it can be assumed that most of the search effort in Canada has only targeted about half of the species' range and population.

Search effort information is not reported for the majority of data sources, precluding direct estimates of absolute abundance. However, sufficient observation records exist, particularly in Alberta, to establish the distribution of the species. Occurrence data derived from opportunistic observations of residences or animal tracks are also available in the source data, but there is high taxonomic uncertainty associated with such records, so they were only considered if submitted by species experts or they occurred in sand hill areas known to have been occupied by the species; otherwise, they were treated as unconfirmed and excluded from analysis.

## HABITAT

### Habitat Requirements

Ord's Kangaroo Rats are habitat specialists, requiring open, sparsely vegetated, sandy habitats to accommodate their hopping style of locomotion and extensive burrowing (Bartholomew and Caswell 1951, Armstrong 1979, Hallett 1982, Kenny 1989, Gummer 1999). Kangaroo rats cannot use their hopping locomotion to evade predators in dense vegetation or dig extensive burrows in fine textured soils. Natural habitats consist of actively eroding sand dunes, sand flats, and exposed sandy slopes of valleys in sand hill areas (Nero 1956, Nero and Fyfe 1956, Epp and Waker 1980, Kenny 1989, Gummer 1999, Reynolds *et al.* 1999, Gummer and Robertson 2003a,c). These habitats are typically associated with sand hills regions where active erosion maintains bare soil, and Ord's Kangaroo Rats occupy the sparsely vegetated margins of these bare areas. Actively eroding sand dune habitats are becoming increasingly rare on the Canadian prairies, most likely due to shifts in climate regimes and recent (post-European settlement) changes to land use and vegetation disturbance regimes (Hugenholtz *et al.* 2010; see Habitat Trends).

Kangaroo rats also use sandy areas where the soil is disturbed by human activities (Nero and Fyfe 1956, Smith and Hampson 1969, Kaufman and Kaufman 1982, Stangl *et al.* 1992, Gummer 1997, 1999, Bender *et al.* 2005) if they are within or adjacent to sand hills regions. These anthropogenic habitats include roads, trails, fireguards, bare ground associated with oil and gas fixtures, heavily grazed pastures or trails, and the margins of cultivated agricultural lands. It appears that anthropogenic habitats represent low-quality habitats that may function as sink habitats where mortality exceeds production in some years (Teucher 2007, Heinrichs *et al.* 2010, 2015; see **Threats and Limiting Factors**). Heinrichs *et al.* (2010) suggested that the occupation of these secondary (anthropogenic) habitats relies on local source populations in primary (sand dune) habitats to persist.

## Habitat Trends

The primary natural habitat of Ord's Kangaroo Rats is typically associated with active-eroding sand dunes, which are characterized by continuously moving wind-blown sand and are sensitive to both climatic change and human land-uses (Wolfe and Nickling 1997, Wolfe *et al.* 2001). Specifically, the species in Canada primarily occupies the sparsely vegetated margins of eroding sand dunes, but expanses of bare sandy soils, like those found within sand dune blow-outs, are generally not occupied (Bender *et al.* 2010a). Sand hills on the southern prairies are becoming increasingly stabilized by vegetation; vegetation growth can reduce or eliminate sand erosion. Climatic factors, particularly precipitation, temperature and wind, are cited as major factors that determine the balance between erosion and stabilization (David 1993, Wolfe *et al.* 1995, 2000, Hugenholtz *et al.* 2010). Increased stabilization of dunes (and thus loss of primary habitat) in this region has been exacerbated by the suppression of natural disturbance regimes (fire, bison grazing) by humans (Hugenholtz *et al.* 2010).

Wolfe *et al.* (1995) analyzed remote sensing imagery and land survey records dating to the late 1800s and found that sand dunes have been stabilizing since European settlement. Recently, Hugenholtz and Wolfe (2005) and Hugenholtz *et al.* (2010) analyzed aerial photographs and satellite imagery and demonstrated that the area of dunes in the Great Sand Hills and other regions has been decreasing since the mid-1900s. Vance and Wolfe (1996) and Muhs and Wolfe (1999) reported significantly less bare sand in the sand hills since the 1930s based on historical photos. Hugenholtz *et al.* (2010) quantified changes in four sand hills regions (Middle, Seward, Tunstall, and Great Sand Hills) across the range of the Ord's Kangaroo Rat in Canada, and showed that habitat declines were as much as 40% per decade on average (Figure 5). The pattern of decline may be non-linear for some sand hills, when localized conditions (e.g., high wind stress and low moisture availability) confer greater resistance to stabilization, and result in a base level of dune erosion. Whether such base levels could support populations of Ord's Kangaroo Rat is not known generally. COSEWIC (2006) projected that, if the trend in stabilization continued at the observed rate in CFB Suffield, all active sand dunes occupied by Ord's Kangaroo Rats in that area would become stabilized by 2014. This projected trend did proceed as predicted until 2008/2009 when two large, high-intensity wildfires burned through the sand hills, temporarily slowing or halting the stabilization process. Despite this temporary

improvement, open sand dune habitats in the Middle Sand Hills have continued to stabilize, and there are only 11 small (< 1 ha) patches of open sand dune habitat left as of 2015 (D. Bender unpubl. data). No estimates of habitat decline due to dune stabilization exist for the period 2005 – 2016, but the trend has likely continued over this period and is probable into the future, because the principal causes are decadal-scale shifts in climate and disturbance regimes (Hugenholtz *et al.* 2010) that are not reversible in the short term.

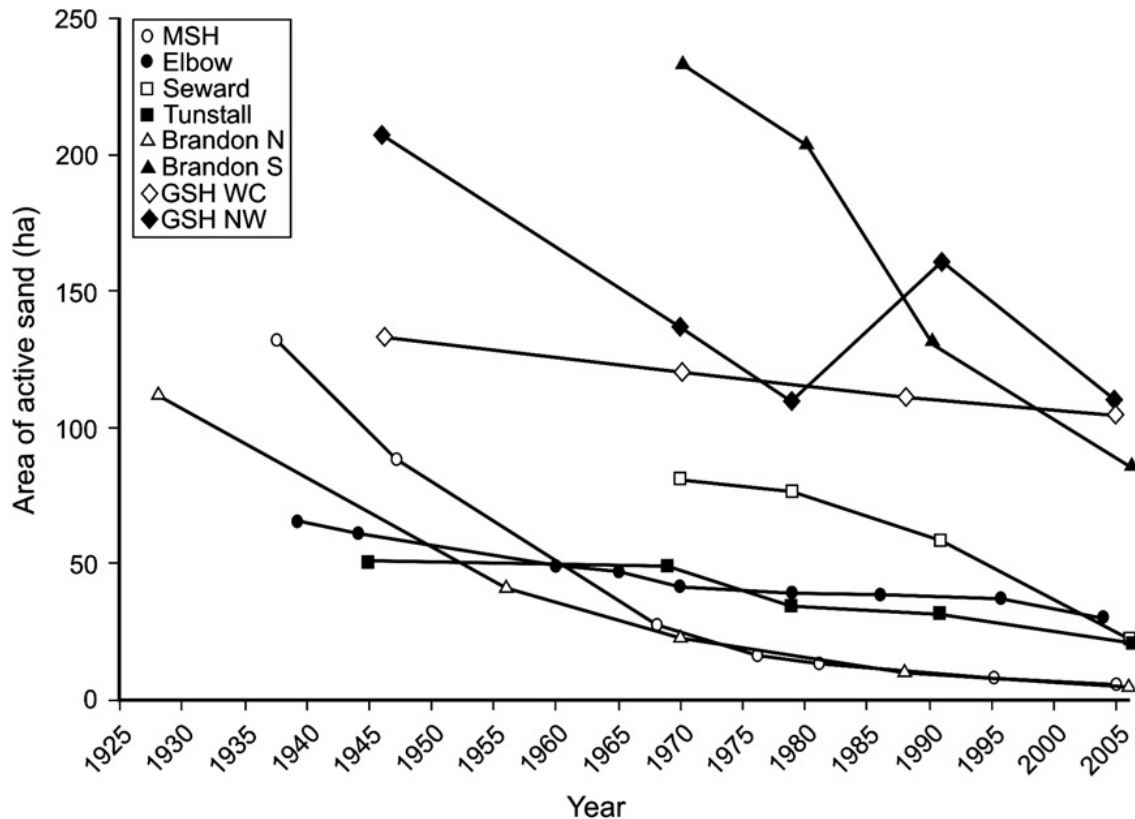


Figure 5. Historical trends of sand dune stabilization across the Canadian prairies, including four sand hills regions within the range of the Ord's Kangaroo Rat: Middle (MSH), Seward, Tunstall, and Great Sand Hills (GSH). Source: Hugenholtz *et al.* (2010). Although the amount of area of active sand is not a reliable indicator of the amount of Ord's Kangaroo Rat primary habitat (i.e., sparsely vegetated, sandy soils associated with actively eroding sand dunes), the decline in active sand dunes does necessarily indicate a loss of primary habitat.

## BIOLOGY

Our knowledge of Ord's Kangaroo Rat biology in Canada is primarily based on research conducted in the Middle Sand Hills of Alberta by D. Gummer and colleagues. Information from more southern localities or other *Dipodomys* species is presented where detailed data on the Canadian population of this species are not available.

## Life Cycle and Reproduction

Desert rodents tend to be relatively long lived and slow to reproduce for their body size (Stearns and Crandall 1981, Kenagy and Bartholomew 1985, Brown and Harney 1993), but Ord's Kangaroo Rats in Canada do not fit this trend (Gummer 1997). Most individuals survive  $<1$  year. Based on mark-recapture studies and minimum numbers known alive from  $> 3,150$  individuals over 11 years in the Middle Sand Hills, overwinter survival is frequently  $\leq 10\%$ , (range 5 to 34%) depending on winter conditions, particularly temperature and snow cover (Kenny 1989, Gummer 1997, Gummer and Robertson 2003b, Teucher 2007, Gummer and Bender unpubl. data). This means that populations reach their lowest levels during early spring. Factors contributing to mortality include predators (Gummer and Robertson 2003c), macroparasites (botfly larvae; Gummer *et al.* 1997, although see Robertson 2007), vehicle traffic, agricultural or industrial equipment crushing animals in their underground burrows, trampling by large grazers such as cattle and Elk (*Cervus canadensis*), hypothermia, and starvation (Gummer 1997). In Alberta, Ord's Kangaroo Rats have been known to survive at least 4 years in the wild (Gummer and Robertson 2003b, Bender unpubl. data), but this is rare and represents less than 0.1% of the population. There are no comparable estimates of maximum longevity in the wild for this species in other regions, although other congeners have been recorded as living at least 5 years in the wild (French *et al.* 1974). In captivity, Ord's Kangaroo Rats from Utah have lived as long as 7 years and 5 months (Egoscue *et al.* 1970).

In most arid regions, kangaroo rats may breed at any time of year when precipitation and new vegetation growth bring favourable conditions for reproduction (Beatley 1969, 1976, Hoditschek and Best 1983, Best and Hoditschek 1986, Kenagy and Bartholomew 1985, Gummer 1997). In Canada, favourable conditions tend to be defined by above-ground temperatures and accessibility of forage. Mating occurs above ground (Engstrom and Dowler 1981), and for the Canadian population of Ord's Kangaroo Rats, reproduction only occurs during the snow-free period, generally from early spring (March or April) to early autumn (September; Kenny 1989, Gummer 1997). However, breeding attempts have been observed during mild mid-winter conditions in one year (Gummer 2005).

Average litter size, according to counts of embryos and placental scars from museum specimens, is 3 (range 1 to 6,  $n = 16$ ; Royal Alberta Museum unpubl. data) and is similar across the species' geographic range (Gummer 1997). Gestation is approximately 29 days (Duke 1944, Day *et al.* 1956, Smith and Jorgensen 1975, Jones 1993) and the lactation period is 14 to 21 days (McCulloch and Inglis 1961). Lactating females appear capable of conceiving before their previous litter is weaned (Nielson 1941, Gummer 1997). The minimum number of juveniles weaned in 98 successful litters in the Middle Sand Hills ranged from 1 to 4 (Gummer 1997).

Adult females in Canada may raise up to 4 litters per year (Gummer 1997), considerably more than for other populations to the south (1 to 2 litters per year; Gummer 1997). Juvenile females attain sexual maturity when they reach approximately 73% of adult body mass, corresponding to an average age at first reproduction of approximately 47 days (Gummer 1997). This is considerably earlier than elsewhere (60 - 90 days; McCulloch and

Inglis 1961, Eisenberg 1963, Smith and Jorgensen 1975, Jones 1985, Best and Hoditschek 1986). Males become reproductive at approximately 79% of adult body mass and 61 days of age (Gummer 1997), although individuals born late in the year may not become reproductively active until the following spring. Given that most Ord's Kangaroo Rats in Canada fail to survive a full year, but produce up to 2 litters during their first year (Gummer 1997), generation length for this population is < 1 year.

## Physiology and Adaptability

Kangaroo rats are adapted to hot and dry desert environments (MacMillen 1983, French 1993, Tracy and Walsberg 2002). Their nocturnal and fossorial nature facilitates heat avoidance and water conservation (Mullen 1971). Kangaroo rats can survive without exogenous water; their metabolic requirements for water are met by eating seeds (Schmidt-Nielsen 1964, MacMillen and Hinds 1983). They select seeds with the highest water content based on feeding tests (Frank 1988), and seeds cached in burrows undergo hygroscopic uptake of water (Reichman *et al.* 1986, Nagy and Gruchacz 1994). Kangaroo rat nasal passages are structured so that moisture condenses by counter-current heat exchange, minimizing water loss (Jackson and Schmidt-Nielsen 1964, Schmidt-Nielsen *et al.* 1970, Collins *et al.* 1971). On average, Ord's Kangaroo Rats have lower metabolism and water loss than other mammals of comparable size (Schmidt-Nielsen 1951, Fairbanks *et al.* 1983, Hinds and MacMillen 1985). Kenny (1989) considered these adaptations as evidence that northern Ord's Kangaroo Rats may be sensitive to drought, although this hypothesis seems inconsistent, given that the species is adapted to dry desert conditions. Cold and snow are more likely to be limiting factors for Ord's Kangaroo Rats in Canada, because these increase energetic requirements and restrict foraging (Gummer 1997, 2005).

Ord's Kangaroo Rats in Canada use daily torpor to conserve energy during winter (Gummer 1997, 2005, Gummer and Robertson 2003c). Individual kangaroo rats carrying radio collars or implanted with temperature data-loggers used torpor exclusively during the winter when the ground was snow covered (Gummer 1997, 2005, Gummer and Robertson 2003c). Torpor was used primarily during daylight hours, with bouts extending up to 17 hours and body temperatures falling to 13.5° C. Animals aroused from torpor during early evening and presumably fed from underground food caches during the night. Individuals generally did not emerge from burrows if there was snow on the ground. Kangaroo rats entered torpor on up to 70 days per winter (Gummer 2005), although some individuals did not exhibit torpor during mild winters (Gummer 2005).

The Canadian population of Ord's Kangaroo Rats is the only one within the genus that is known to use torpor in the wild. Laboratory studies of congeners reveal drastic mass loss and death within several days if they are forced into torpor through starvation and exposure to low temperatures (Dawson 1955, Carpenter 1966, Yousef and Dill 1971, Breyen *et al.* 1973, MacMillen 1983). Likewise, there are reports of captures and observations of Ord's Kangaroo Rats above ground in southern localities throughout the year (Reynolds 1958, Kenagy 1973, O'Farrell 1974, Nagy and Gruchacz 1994), even when air temperature approached -19° C (Kenagy 1973, O'Farrell 1974) and there was up to 40% snow cover (Mullen 1971, Kenagy 1973, O'Farrell 1974). Distinct life history (e.g., age at first

reproduction; Gummer 1997) and physiological traits (e.g., torpor; Gummer 2005) of Canadian Ord's Kangaroo Rats may represent phenotypic plasticity and/or genetic differentiation between individuals in Canada and conspecifics in the USA and Mexico (Gummer 1997, 2005).

Kangaroo rats are territorial and defend burrows and underground food caches (Eisenberg 1963). They are not colonial: individuals are solitary and exhibit little tolerance for conspecifics within their territory (Bartholomew and Caswell 1951, Garner 1974, Daly *et al.* 1984). Some species use foot drumming as a territorial signal (Ward and Randall 1987). Core home ranges of radio-collared Ord's Kangaroo Rats averaged  $1750 \pm 620 \text{ m}^2$  ( $\pm 1 \text{ SE}$ ,  $n = 28$ ; Gummer and Robertson 2003c). However, Ord's Kangaroo Rats occasionally move beyond this range at night, with overall home range size averaging  $7,830 \pm 2,930 \text{ m}^2$  ( $n = 38$ ). The average maximum home range width is  $130 \pm 35 \text{ m}$  ( $n = 38$ ).

Kangaroo rats have a number of behavioural and morphological adaptations that are used for predator avoidance. Their erratic, bipedal locomotion likely evolved in response to selection for predator avoidance, primarily because this style of movement provides fast, energy efficient movements across open surfaces to the safety of burrows (Bartholomew and Caswell 1951, Yousef *et al.* 1970). The middle ear of Ord's Kangaroo Rat is sensitive to the sounds of owl wing beats and the movements of striking snakes (Webster and Webster 1971, 1975). Banner-tailed Kangaroo Rats (*Dipodomys spectabilis*) perform foot drumming as an alarm signal (Randall and Stevens 1987). Ord's Kangaroo Rats may also foot-drum (Brown 1989), which may alert predatory snakes to the fact that they have been detected and cause them to leave rather than investigate (Randall and Stevens 1987). Kangaroo rats avoid or reduce above-ground activity in open habitats when ambient light is present, including bright moonlight or northern lights (*aurora borealis*), presumably to minimize detection by visually orienting predators (O'Farrell 1974, Rosenzweig 1974, Kaufman and Kaufman 1982, Gummer unpubl. data).

## Dispersal and Migration

Juveniles are more likely to disperse than adults. Juvenile dispersal distances do not differ between the sexes and are typically  $< 500 \text{ m}$  (median =  $100 \text{ m}$ ; Gummer 1997). One juvenile male travelled approximately  $10 \text{ km}$  along a sandy fireguard (Gummer unpubl. data), but Ord's Kangaroo Rats are unlikely to disperse such long distances across densely vegetated grasslands because they cannot move inconspicuously through these areas. The longest recorded distance travelled from sand dune to another through vegetated grassland was  $3.2 \text{ km}$  (Brands 2016), although the actual path of travel may have been longer and it is not known whether the animal followed a trail for a portion of the route.

Given the limited dispersal ability of the species relative to distances between neighbouring sand hills complexes (Figure 3), it is unlikely that natural dispersal among all sand hills complexes in Canada occurs. The predominant land use in this area is agriculture, and much of the intervening lands between sand hill regions are cultivated, representing unsuitable habitat for the species. At a finer scale, there is some evidence that individual patches of habitat within sand hills regions may also be isolated from one

another. Brands (2016) looked at inter-patch distances for Ord's Kangaroo Rats in Alberta and noted that most patches of primary habitat were beyond the typical dispersal distances observed from mark-recapture data. Further, most habitat patches in Alberta are small (median = 5.5 ha, quartiles = 3.1, 8.1 ha) and are generally occupied by fewer than 50 individuals (Bender unpubl. data) with high turnover, making it unlikely that they would constitute a self-sustaining population. Brands (2016) also determined that few clusters of connected patches currently exist in Alberta. The largest cluster of medium to large patches of habitat in Alberta occurs in the vicinity of the town of Bindloss, but it is also isolated (>25 km) from the nearest neighbouring patch. Heinrichs (2010) examined the likelihood of Ord's Kangaroo Rats persisting at this isolated site and estimated the probability of extinction in 100 years to be 100%, regardless of the range of plausible parameters used in her population model. This emphasizes the susceptibility of the smaller patches/clusters in Alberta (i.e., nearly all of them). Thus, available evidence suggests that the Ord's Kangaroo Rat population in Alberta meets the IUCN definition of severe fragmentation (IUCN 2016), which is likely the case for the entire Canadian population.

Bender *et al.* (2010a) and Brands (2016) translocated Ord's Kangaroo Rats to investigate the feasibility of using this intervention to enhance natural dispersal. They reported mixed success, in part because there were too few animals remaining in Alberta to experimentally translocate a sufficient sample for statistical analysis ( $n = 16$  over 3 years). Translocations for other species of kangaroo rats in the USA have generally been unsuccessful (see reviews by Bender *et al.* 2010a, Brands 2016).

## Interspecific Interactions

Ord's Kangaroo Rats are primarily granivorous. They collect food items in cheek pouches and store them in underground burrows. In addition to seeds, they collect green vegetation (Best and Hoditschek 1982) and other plant parts (silicles, pods, stems), insects (Johnson 1961, Alcoze and Zimmerman 1973, Flake 1973), bone fragments, and dry grasses for nest material. Members of the Canadian population are known to collect seeds from at least 71 species of plants (Gummer *et al.* 2005), such as the Annual Sunflower (*Helianthus couplandii*), cactus (*Opuntia* spp.), and Scurph Pea (*Psoralea lanceolata*). Their diet includes a high proportion of non-native, weedy plant species, such as Common Knotweed (*Polygonum aviculare*) and Russian Thistle (*Salsola kali*), particularly in anthropogenic habitats.

Kangaroo rats exert ecosystem effects in grassland and desert communities because they remove and eat seeds and grasses and disturb soil (Brown and Heske 1990, Heske *et al.* 1993, Kerley *et al.* 1997, Curtin *et al.* 2000, Brock and Kelt 2004). The low survival rate of northern Ord's Kangaroo Rats (Gummer 1997), combined with their seed collection and caching behaviour, likely leads to a large number of abandoned seed caches for germination or for other granivores to exploit.

Known predators of Ord's Kangaroo Rats in Canada include Great Horned Owls (*Bubo virginianus*; Schowalter *et al.* 2002, Teucher 2007), Burrowing Owls (Gummer unpubl. data, Poulin *et al.* pers. comm. 2005), Short-eared Owls (*Asio flammeus*; Teucher

2007), Prairie Rattlesnakes (Gummer and Robertson 2003c), and American Badgers (Gummer unpubl. data). Domestic cats (an introduced predator) have been observed hunting in Ord's Kangaroo Rat habitat in the Middle Sand Hills (Gummer unpubl. data); both cats and dogs have brought dead kangaroo rats to their owners (Royal Saskatchewan Museum, Gummer unpubl. data). Although diurnal raptors are not generally considered predators of kangaroo rats, they may occasionally take them in the daylight when burrows are disturbed by vehicles or machinery. Other likely predators of Ord's Kangaroo Rats in Canada are Long-eared Owls (*A. otus*), Red Foxes (*Vulpes vulpes*), Swift Foxes (*V. velox*), Coyotes (*Canis latrans*), Bobcats (*Lynx rufus*), Least Weasels (*Mustela nivalis*), Long-tailed Weasels (*M. frenata*), Striped Skunks (*Mephitis mephitis*), Raccoons (*Procyon lotor*), and Bullsnares (*Pituophis catenifer sayi*).

The Canadian population of Ord's Kangaroo Rats is the only one of the genus known to be parasitized by the Botfly (*Cuterebra polita*; Gummer *et al.* 1997). The primary host of *C. polita* is likely the northern pocket gopher (Capelle 1970), but none of 86 northern pocket gophers caught in the Middle Sand Hills from 1994 to 2004 were parasitized (Reynolds *et al.* 1999, Gummer unpubl. data). In this area, *C. polita* may have shifted to Ord's Kangaroo Rats as the primary host, or alternatively the botfly may be a species not previously recognized. Parasitism by botfly larvae compromises survival, reproduction, and growth of some small mammals (Boonstra *et al.* 1980, Burns *et al.* 2005). For Canadian Ord's Kangaroo Rats, botfly parasitism may negatively affect recruitment of juveniles into the population (Robertson 2007; see **Limiting Factors**). Based on 11 years of data (2005 – 2015) from the Alberta annual population monitoring program (Bender unpubl. data), Ord's Kangaroo Rats that inhabit anthropogenic habitats face approximately three times higher prevalence of botfly parasites than those that inhabit natural habitats ( $n = 2366$ ,  $\chi^2 = 73.9$ ,  $p < 0.001$ ). Although the mechanism for this pattern is not fully understood, it is possible that the linear, connected nature of anthropogenic habitats (e.g., roads, trails) may facilitate efficient searching of occupied burrows of kangaroo rats by female botflies for the purpose of oviposition of eggs, in comparison to natural habitats that are relatively isolated and patchily distributed across the landscape (Robertson 2007).

## POPULATION SIZES AND TRENDS

Information about Ord's Kangaroo Rat population sizes and trends is not available for all of Canada. The most recent overall population estimate was from Gummer (1997b) for Alberta and Kenny (1989) for Saskatchewan, and an estimate of the range-wide population based on these sources was reported in COSEWIC (2006) and Environment Canada (2012). Population trend information is available from the Alberta population monitoring program that was implemented from 2005 to 2015, covering about half the Canadian population.

## Sampling Effort and Methods

The Alberta monitoring program took place over 10 years and consisted of annual, standardized surveys occurring over an approximately four-month period starting in May or

early June and ending in late August or mid-September. This yielded the most reliable information for estimating distribution changes and population trends because the data were standardized for search effort to facilitate year-to-year comparison.

There were 22 sites in primary habitat (e.g., naturally eroding sand dunes) and 20 additional sites along sandy roads, trails, fireguards, or other anthropogenic features (e.g., margins of cultivated fields). The sites in primary habitat represented all significant, known natural sites for the population in Alberta. In contrast, the secondary sites included the most significant (e.g., most persistent) anthropogenic sites in Alberta and a sample of secondary site types (i.e., not all secondary habitats are monitored annually: up to 35% were not surveyed in a given year, typically due to logistic constraints or issues with landowner access). Because the Alberta population is small, the monitoring program attempted to survey all known primary habitat (natural) sites annually and a subset of secondary (anthropogenic) low-quality sites. The surveys were biased to sample known, productive sites, which received priority. However, given the high habitat specificity of the species and its well-known distribution (Bender *et al.* 2010b), it is likely that the majority of the Alberta population was directly monitored during this 10-year period.

The Alberta annual population monitoring program collected information about relative abundance, i.e., minimum number alive at all sites, using approximately equivalent survey effort from year to year. Because monitoring was standardized, the number of individuals captured each year (i.e., minimum number alive) provided both a relative index of abundance from year to year, as well as an absolute minimum population size for Alberta. Data were collected during two periods each year: spring/early summer (i.e., when the population size is at its lowest, following the period of high overwinter mortality) and late summer/early fall (when the population size peaked, typically in late August to September). A goal of the program was to visit each site at least once during each of the spring and summer/fall periods, although this was not always possible in every year due to access restrictions (e.g., military training or risk of fire on private land may prohibit access). Search effort at each survey site was either fixed (e.g., fixed length of search along road features) or standardized by survey effort (e.g., by total search time on foot at sand dunes) to yield indices of relative abundance at each of the survey sites.

Surveys were conducted on nights when the species was expected to be most active above ground. This was generally restricted to periods when moonlight was low or absent, typically during the period from one week before to one week after the new moon. Animals were captured by hand, marked, examined, and released at the site of capture. Surveys were conducted at the same sites each year, which allowed for year-to-year comparisons of distribution, habitat patch occupancy, relative abundance, age structure, sex ratio, and prevalence of parasites (especially *C. polita*), plus individual-level information on reproductive status, body size/condition, injuries, and parasite intensity. In years where the population size was lower, there was generally more time available to conduct surveys (due to reduced handling time), resulting in higher confidence in counts. Correspondingly, years with high relative population size may also be slightly underestimated. Full details regarding the procedures and information from the annual Alberta population monitoring protocol can be found in Bender *et al.* (2007).

This monitoring has not yielded overall population estimates for Alberta, due to very low recapture rates, given low annual survival of the species and low population size. Habitats in Saskatchewan have not been monitored systematically in the last 10 years.

## **Abundance**

There have been no range-wide assessments of population size for the Ord's Kangaroo Rat in Canada and no new population estimates since the last status report (COSEWIC 2006). The size of the Canadian kangaroo rat population is difficult to estimate due to the large fluctuations in population size perpetuated by high birth and death rates (Kenny 1989, Gummer 1997a). However, abundance was estimated independently for portions of Saskatchewan (Kenny 1989) and Alberta (Gummer 1997b). Based on these sources, COSEWIC (2006) estimated the peak population size for Canada in 1995 to be 4957 individuals (CI: 3,780 – 6,574). It should also be noted that while these estimates did not distinguish mature individuals from juveniles, the rapid maturation of the species, which largely occurs below ground, means that even young animals captured above ground will be reproductively mature within days or weeks, if they are not already. Thus, the population estimates reported above by Kenny (1989) and Gummer (1997b) are slightly inflated estimates of the number of mature individuals.

Because overwinter mortality is high for this species in Canada, it may be best to evaluate spring population size when assessing the vulnerability of the species. Gummer (1997a) estimated the overwinter survival rate at 10%, which was obtained during particularly cold winter conditions with long periods of snow cover; one decade later, Teucher (2007) estimated overwinter survival rates at 24 to 34%, which were obtained during an exceptionally mild winter. Using the range of 10% and 34% for overwinter survival, and assuming that the current population is likely well below 5,000 individuals, it is apparent that contemporary spring-time population sizes would likely be well below 500 to 1,200 mature individuals. This conclusion is further supported by the documented pattern of ongoing habitat decline for this species since the 1970s (Figure 5; see Habitat Trends).

Recent data from Alberta confirm that the current population size in that province is relatively small compared to the 1995 estimate of 3,000 individuals (Gummer 1997b). The number of individuals observed in Alberta each year from 2006 – 2015, representing the minimum population size at its peak of each year, ranged from at most 549 individuals to as low as 129 individuals (Figure 6). Further, if the Alberta portion of the population represents about half of the Canadian population, it is also unlikely that the peak (late summer) population size in Canada would be much greater than 1,000 individuals. Given that the population is most vulnerable each spring following the annual cycle of high overwinter mortality, and that spring population size could be only 10 – 34% of the peak size, it is very likely that the Canadian population of Ord's Kangaroo Rat falls below 1000 individuals each year from 2006-2015, especially in the most recent years.

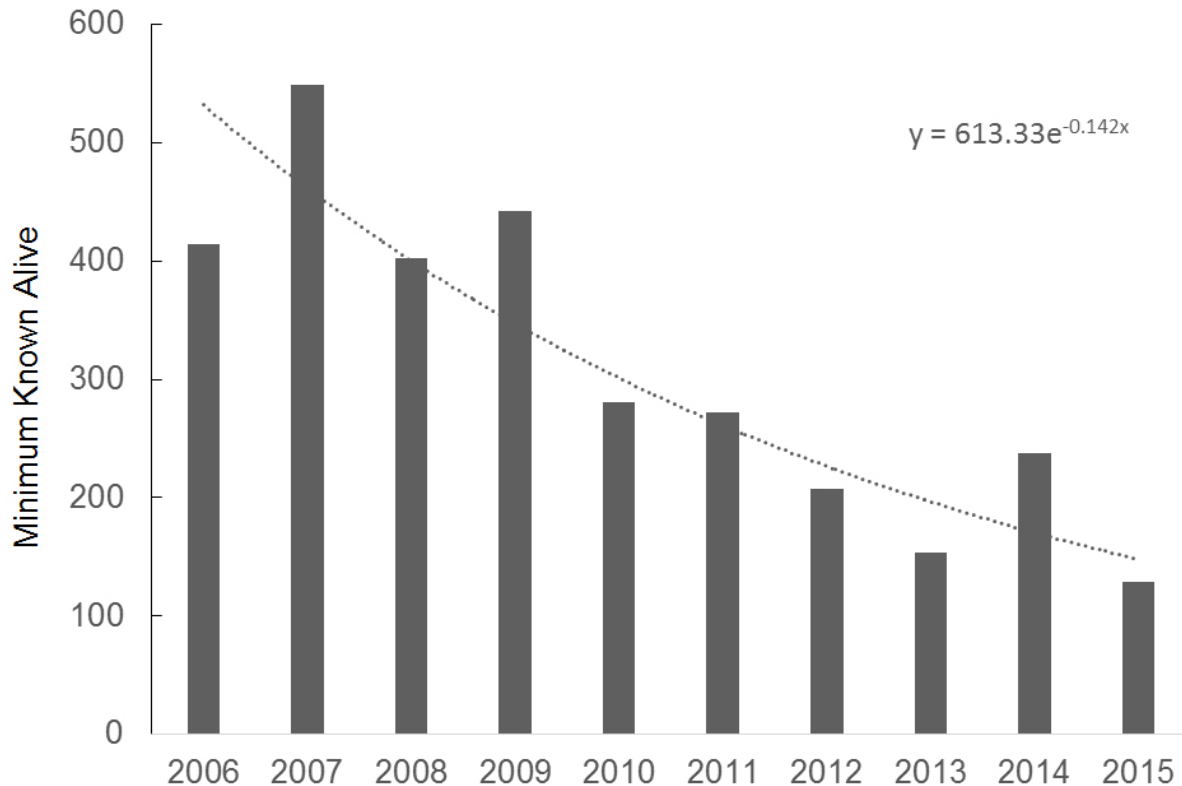


Figure 6. Plot of Ord's Kangaroo Rat counts of mature individuals (minimum known alive) in Alberta using approximately equal survey effort in each year (spring and summer periods combined). Trend line is an exponential decay curve fitted to the counts data, which indicates an apparent decline of 13.2% per year, on average, or 72% reduction over the 10-year period.

## Fluctuations and Trends

No range-wide monitoring of the species has occurred in Canada to assess fluctuations and trends. However, within Alberta, the species exhibits fluctuations in abundance both spatially and temporally, and there is evidence of an apparent population decline in the last 10 years. Given that the range of the species in Canada is largely contiguous across Alberta and Saskatchewan, the climate is similar, the habitats are similar, and land use and threats across the range are generally similar, the fluctuations and trends observed in Alberta are likely representative of the entire Canadian range.

There is evidence that the abundance and distribution of Ord's Kangaroo Rats in Alberta is highly variable in space, exhibiting a metapopulation-like structure whereby patches of habitat support an abundance of animals in some years and then crash or become locally extirpated in other years, often asynchronously from other nearby patches; there is also evidence of dispersal and recolonization (Kenny 1989, Gummer and Robertson 2003b, Gummer and Bender unpubl. data). Kenny (1989) reported that the species was extirpated from 1 of 4 study sites (habitat patches) in the Great Sand Hills in 1985. Gummer and Robertson (2003b) found that 7 of 19 previously occupied sites in the

Middle Sand Hills appeared to be no longer occupied in 2002. More recently, annual population monitoring in Alberta (methods described in Bender *et al.* 2007) from 2005 to 2015 documented three local extirpations and two near extirpations (e.g., population declines to just one female). There is also evidence of recolonization for at least four of these sites (Gummer and Bender unpubl. data).

The Canadian population of Ord's Kangaroo Rat experiences seasonal fluctuations due to high summer reproductive output and loss of individuals over the winter months (Kenny 1989, Gummer 1997, Gummer and Robertson 2003b). The population can decline by an order of magnitude ( $\geq 90\%$  mortality) during the winter period alone (Gummer 1997). There is also a high frequency of local extirpation (i.e., sand dunes, road segments; Kenny 1989, Gummer and Robertson 2003b, Bender, unpubl. data), providing further evidence of the severity of population fluctuations, meeting the IUCN definition of "extreme fluctuations" (IUCN 2016).

The Ord's Kangaroo Rat population in Alberta exhibited an overall declining trend over a ten-year period (2006-2015; Figure 6). An estimate of 72% decline was based on an assumed proportional decline in the population and fitted to an exponential decay function ( $R^2 = 0.823$ ,  $n = 10$ ,  $p < 0.001$ ; exponential decay is  $e^{-0.142 \cdot \text{year}}$ ), translating to an estimated average reduction of 13.2% per year. Additionally, Appendix 2 contains maps depicting the occurrences of all individuals captured for each year of the period, which allows one to visualize the decline in the habitats occupied by the species in Alberta that is associated with the population decline.

Additional strong evidence comes from the amount of primary habitat that has declined in recent decades (e.g., Figure 5; see Habitat Trends) because of vegetation stabilization, which has likely reduced the capacity of the landscape to support the species. It is reasonable to infer that habitat loss has negatively affected the population and played a contributing role in population decline.

Recently, Heinrichs (2010) and Heinrichs *et al.* (2010) developed a spatially explicit individual-based population model to explore the implications of habitat fragmentation and habitat quality on population dynamics and persistence for Ord's Kangaroo Rats in Alberta. Although the goal was not to conduct population viability analysis per se, the model was useful for making predictions about future population trends for kangaroo rats. These were then used to make inferences about the role of habitat features on population growth and persistence. The model was also used as the basis for the identification of critical habitat for Ord's Kangaroo Rat on federal lands in Alberta (Environment Canada 2012). A key finding of the research was that many secondary habitats (e.g., roads) appear to function as attractive sinks in some years (see Habitat Requirements above) and, if linear in shape, may be intercepting Ord's Kangaroo Rats dispersing between patches of primary habitat (e.g., isolated sand dunes), contributing reduced population stability through habitat fragmentation. Heinrichs *et al.* (2010) report that the removal of these secondary habitat features actually improved the stability and persistence of the population in their model, even though they accounted for a large portion (39%) of habitat by area. Conversely, Ord's Kangaroo Rats appear to be highly dependent on primary habitats: the loss of only 1.7 ha

of primary habitat produced a 1% increase in probability of extinction over 100 years or less, although no attempt was made to integrate this finding with contemporary rates of habitat decline. Heinrichs (2010) reported that her model (same model used in Heinrichs *et al.* 2010) predicted a >10% probability of extirpation in Alberta under a scenario of no decline in primary habitat and a 40 - 74% probability of extirpation under scenarios of moderate to intense decline due to vegetation stabilization. Thus, it appears that population stability and persistence, at least in Alberta, are very sensitive to changes in habitat fragmentation and quality (Heinrichs *et al.* 2010).

## **Summary of Population Sizes and Trends**

The most recent estimate of peak population size for Ord's Kangaroo Rat in Canada was 4,957 mature individuals in 1995 (COSEWIC 2006). Given the range-wide loss of habitat for the species (Figure 5; see Habitat Trends), the current population size is assumed to be much lower. Estimates of minimum known alive for Alberta (assumed to be about 50% of the population) from 2006 – 2015 (Figure 6) suggest strongly that peak population size for Canada is fewer than 1,000 individuals in most years. Because the population undergoes reduction annually from severe over-winter mortality (up to 90% mortality), the number of mature individuals each spring may be far fewer than this in some years. However, there is relatively high uncertainty associated with these estimates because there have been no recent population estimates in Saskatchewan and an error assessment of the Alberta estimates has not been performed.

Although estimates of absolute abundance are uncertain, there is strong evidence to demonstrate a declining population trend for the Alberta portion of the range. Standardized population monitoring of the species in Alberta has revealed a substantial reduction in distribution (Figure 4) and relative abundance (Figure 6), likely due to habitat decline, suggesting a 72% decline in abundance between 2006 and 2015, which is assumed to be representative of the entire Canadian population. Quantitative analysis supports the suggestion that habitat loss will contribute significantly to future declines and possible extirpation of the species.

## **Rescue Effect**

There is no likelihood of a rescue effect for the Canadian population of Ord's Kangaroo Rats. The nearest conspecifics from outside Canada occur over 270 km to the south, well beyond the dispersal capabilities of this habitat specialist. Further, rescue is unlikely to mitigate population declines as long as habitat degradation and decline within Canada continue.

## THREATS AND LIMITING FACTORS

### Threats

Direct threats facing Ord's Kangaroo assessed in this report were organized and evaluated based on the IUCN-CMP (World Conservation Union-Conservation Measures Partnership) unified threats classification system (Master *et al.* 2009). Threats are defined as the proximate activities or processes that are known or inferred to directly and negatively affect Ord's Kangaroo Rat population in Canada. While there has been considerable research into the biology and limiting factors for the species in Canada, little research has been conducted to scientifically test and document human-related threats, so many of the threats identified in this section are reported as likely or plausible, along with a brief explanation of the evidence that justifies them. Results on the impact, scope, severity, and timing of threats are presented in tabular form in Appendix 1.

Narrative descriptions of the threats are provided below and for the IUCN-CMP threat categories in order of highest to lowest impact. Each of the following direct threats represents medium-to-low or low impacts on kangaroo rats, but cumulatively pose a high threat in combination with natural limiting factors. The overall calculated and assigned threat impact is high.

### Transportation and Service Corridors

#### Roads

Ord's Kangaroo Rat range in Canada is overlain by an extensive, highly connected network of loose-surface roads and trails that attract individuals by providing open, sparsely vegetated surfaces and eroding banks (see **Habitat**). Kangaroo rats that inhabit roadside habitats are exposed to risks of direct mortality from vehicle traffic and burrows being damaged or destroyed by construction or maintenance activities, which may disturb, displace, kill, or otherwise jeopardize the survival of kangaroo rats. Road signs and fences also serve as artificial perches for owls that prey on kangaroo rats. There is evidence that Ord's Kangaroo Rats that occupy roadside habitats may experience higher predation risk, colder microclimates, and lower body condition than those individuals that inhabit more natural habitats (Teucher 2007). Roads and trails may also predispose Ord's Kangaroo Rats to parasitism by botfly larvae (see **Interspecific Interactions**). Because of these many factors, roads may serve as ecological traps for Ord's Kangaroo Rats (Bender *et al.* 2005). Population simulations based on field estimates of Ord's Kangaroo Rat demographic rates indicate that roadside habitats contribute relatively little to overall population viability, and in many areas, they are predicted to function as population sinks (Heinrichs *et al.* 2010).

## Utility corridors and service lines

There is a dense array of natural gas pipelines and other industrial infrastructure throughout the range of Ord's Kangaroo Rats in Canada. The majority of pipelines coincide with vehicle trails that are developed for installation, access, inspection, and maintenance of pipelines and associated infrastructure. These activities require heavy equipment, vehicles, and excavation, and may therefore damage burrows or disturb, displace, kill, or otherwise reduce the survival of kangaroo rats in the vicinity of the work site. Above-ground infrastructure, such as pipe, valves, and shelters, likely provide artificial perch sites for owls that prey on kangaroo rats. In some areas, gas pipeline construction requires directional drilling, night-time construction activities, artificial illumination, and noise disturbances that may indirectly impose further detrimental effects (see **Pollution**, below). During construction of the North Suffield gas pipeline in late summer 2001, resident Ord's Kangaroo Rats exhibited reduced above-ground activity and smaller home range sizes in response to construction activities and were less likely to use torpor during the subsequent winter, but these differences did not translate into lower survival in comparison with Ord's Kangaroo Rats in an undisturbed area (Gummer and Robertson 2003c). In the years following pipeline construction, Ord's Kangaroo Rats declined at the pipeline study site and were eventually extirpated in 2010 (Bender and Dzenkiw 2010). It is not known, however, whether or not the pipeline and associated habitat modifications contributed to this decline. Power lines and poles also create artificial perches for owls, and some large power lines in Ord's Kangaroo Rat habitat generate audible noise that may affect kangaroo rat behaviour or interfere with predator detection (see **Pollution**).

## **Energy Production**

### Oil and gas drilling

Wellsite developments, predominantly for natural gas, are common and widely distributed across the range of Ord's Kangaroo Rats in Canada. The direct impacts of exploration, drilling, construction, operation, maintenance, and (future) reclamation on this species are uncertain. Heavy vehicles, seismic tests, construction, drilling, fracking, maintenance, and reclamation actions may collapse burrows, and disturb, injure, or kill Ord's Kangaroo Rats in close proximity. However, these direct impacts can be minimized by adopting specific mitigations for kangaroo rats where they are known to occur (Gummer and Robertson 2003b). Any above-ground infrastructure that is installed at well sites, such as pipe, valves, storage tanks, shelters or other structures, may serve as artificial perch sites for owls and promote predation in the immediate vicinity. The specific effects of seismic exploration on Ord's Kangaroo Rats and their burrows have not been investigated.

### Renewable Energy

Wind turbines or solar energy developments may be a threat within the next 10 years in Ord's Kangaroo Rat habitats. The potential scope of this threat is unknown but presumed to be small (<10% of the population). New wind turbines or solar energy projects would likely impose similar severity of impacts as other industrial developments that include new

excavation, construction, and maintenance activities. Renewable energy projects may also promote other associated threats if they necessitate additional access roads, lighting, and noise (see **Pollution**).

## **Pollution**

### Light pollution

Many threats, such as industrial refineries, compressor stations, wellsite drilling, and some military training exercises, generate artificial light at night within Ord's Kangaroo Rat habitats. The specific impacts of artificial light on kangaroo rats have not been directly investigated, but based on their natural anti-predator behaviour, kangaroo rats likely reduce their above-ground activity or shift their microhabitat use to avoid exposure to predators under relatively bright conditions, as they do during bright moonlight (Kaufman and Kaufman 1982), twilight and *aurora borealis* (Gummer and Bender pers. obs.). If artificially bright conditions persist indefinitely or coincide with important periods of above-ground activity, then light pollution may suppress above-ground activity, potentially affecting foraging, mate searching, breeding, dispersal, etc. Alternatively, kangaroo rats may resume these above-ground activities with heightened predation risk or disperse in search of habitats that present less predation risk. In any event, artificial light is likely to interfere with natural behaviour of Ord's Kangaroo Rats, similar to the effects of moonlight, twilight, or the *aurora borealis*. Artificial light sources and gas flares from industrial refineries in Alberta near Burstall (SK) frequently brighten the night sky enough that it appears to influence Ord's Kangaroo Rat activity as far as 10 – 20 km from the source, depending on sky conditions and the size of the flares (Gummer and Bender pers. obs.).

### Sound pollution

Some industrial refineries, compressor stations, wellsite drilling, seismic surveys, power lines, and military training exercises generate significant auditory and seismic disturbances within Ord's Kangaroo Rat habitats. For example, some industrial compressor stations generate constant, low frequency humming sound that is audible to humans for several km. Military live-fire training exercises are often conducted at night when kangaroo rats are most active, and these activities frequently generate noise and seismic vibrations that are conspicuous and detectable by humans at long distances (e.g., up to 30 km). The effects of auditory disturbances on kangaroo rats have not specifically been investigated. Kangaroo rats are particularly sensitive to low frequency sounds for predator detection (Webster and Webster 1975), and therefore some noise disturbances, including auditory signals inaudible to the human ear, may be significant enough to displace kangaroo rats, adversely affect behaviour, or interfere with their ability to detect and evade predators.

## **Invasive and Other Problematic Species**

### Invasive non-native plants

Invasive plants are widely distributed in Ord's Kangaroo Rat range in Canada, but the overall impact of these plants is unknown. Non-native seeds are commonly collected as food items in Ord's Kangaroo Rat cheek pouches, particularly in roadside habitats. Of 71 recognized seed types collected by Ord's Kangaroo Rats from 1994 to 2004 ( $n = 1444$  samples), there were 16 non-native plant species represented. The two most commonly collected species overall were both non-native, invasive plants: Russian Thistle and Common Knotweed (Gummer *et al.* 2005). The potential effects of this different diet remain to be investigated; it is possible that differences in nutritional value, handling times, spoilage, or germination rates in underground food caches may negatively affect body condition. Also, regardless of dietary implications, these invasive plants may exacerbate natural habitat loss by colonizing and stabilizing open, sandy soils.

### Predators and parasites

Native predators and parasites represent direct threats to Ord's Kangaroo Rat persistence because predation and parasitism are exacerbated by road and trail networks (see above). Fences and sign posts may further promote predation risk along roads by providing artificial perch sites for owls. Apart from development of roads and trails, other human activities may also infrequently promote significant impacts of natural predators. Kangaroo rats whose burrows are excavated or disturbed by vehicles, construction equipment, or agricultural activities, are likely to flee and be exposed to much higher risk of predation until they find or develop new burrows for shelter. While the magnitude of these impacts is relatively uncertain, predators and parasites are estimated to represent a slight-to-moderate severity impact over a large proportion of Ord's Kangaroo Rat occurrences, because of numerous anthropogenic developments and activities.

## **Natural System Modifications**

### Fire suppression

Fire is actively suppressed on the landscape in both Alberta and Saskatchewan in an effort to protect agricultural resources, infrastructure, and private residences. There is considerable public concern for fire hazard and rapid mobilization of resources to fight accidental grass fires. In some areas, extensive fireguards are cultivated in a proactive effort to help contain future fires. Apart from research experiments (see below), purposeful application of fire has not been used as a tool to manage grasslands within the Canadian range of Ord's Kangaroo Rats. Historically, frequent fire was a key component of the natural disturbance regime that would have helped maintain open, sandy habitats that Ord's Kangaroo Rats require. Within CFB Suffield, military training causes accidental fires in some parts of the Base. Although there are intensive efforts to contain and suppress fires in CFB Suffield, accidental fires occasionally reach the sand hills where Ord's Kangaroo Rats occur. Recent fires in the Middle Sand Hills of CFB Suffield appear to have temporarily

reduced vegetation stabilization and improved habitats for Ord's Kangaroo Rats in the short-term (Bender unpubl. data). A small-scale experiment in CFB Suffield demonstrated that prescribed fire, in combination with ungulate grazers, temporarily restored suitable habitat for Ord's Kangaroo Rats, but without additional disturbance the habitat quickly became stabilized with vegetation and unsuitable for Ord's Kangaroo Rats within 3 to 4 years (CFB Suffield 2011).

### Other ecosystem modifications

Free-roaming Plains Bison were extirpated from Canada in the late 1800s because of extreme over-hunting across the Great Plains (Roe 1970). Although Plains Bison have been successfully re-established in several places, wild Plains Bison remain absent from the sand hill areas of Canada where Ord's Kangaroo Rats occur (COSEWIC 2013). Historically, Plains Bison would have contributed to the maintenance and promotion of open, sandy habitats, through bison modifying vegetation structure and disturbing soils by their extensive grazing, trampling, and wallowing (Fox *et al.* 2012). Moreover, bison were likely attracted to areas that recently burned that offer high quality forage; together, frequent fire and intensive disturbance by Plains Bison may have been instrumental in perpetuating heterogeneity in grassland ecosystems (Hugenholtz *et al.* 2010).

## **Climate Change and Severe Weather**

### Habitat shifting and alteration

Vegetation encroachment and stabilization of open sand habitats are considered as natural limiting factors for Ord's Kangaroo Rats (see **Limiting Factors**) because the primary drivers are long-term (> 100 years) climatic variations in precipitation, temperature, and wind (David 1993, Wolfe *et al.* 1995, 2000, Hugenholtz *et al.* 2010) that are not necessarily anthropogenic in origin. However, the impacts of these trends on kangaroo rat habitats have likely been exacerbated by anthropogenic suppression of natural disturbance regimes (e.g., fire and bison; Hugenholtz *et al.* 2010) that would otherwise promote soil erosion and counteract vegetation encroachment. In the long term, it is possible that anthropogenic climate change may mitigate or reverse habitat loss for the species by promoting soil erosion and dune activity in this region (Wolf and Nickling 1997) as a result of frequent drought and climate extremes (Sauchyn and Kulshreshtha 2008, Sauchyn *et al.* 2009). Within the next 10 years, however, the likelihood and severity of projected anthropogenic climate change and its impacts on Ord's Kangaroo Rat habitat in Canada are entirely unknown.

### Temperature extremes

Severe winter weather, in the form of extreme cold temperatures and prolonged snow cover, is considered a natural limiting factor that contributes to low overwinter survival and drastic population fluctuations of Ord's Kangaroo Rats in Canada (see **Limiting Factors**). Although extreme or prolonged cold temperatures and snow conditions are not directly anthropogenic in origin, their impacts are likely exacerbated by the tendency of Ord's

Kangaroo Rats to opportunistically inhabit anthropogenic habitats (roads and trails) where they are subjected to even colder soil microclimates than in more natural habitats (Teucher 2007). Variations in slope, aspect, soil compaction, and depth of insulating snow likely contribute to this difference between habitat types (Teucher 2007). In years of extreme or prolonged cold temperatures or snow conditions, differences in soil temperature or frost depth likely reduce survival of Ord's Kangaroo Rats in road habitats compared to natural habitats where soil temperatures are more moderate. Projections for future climate change indicate that winter temperature and precipitation in winter and spring will increase in this region (Sauchyn and Kulshreshtha 2008, Sauchyn *et al.* 2009). Warmer and wetter winters may mitigate the anthropogenic threat of extreme cold temperatures and prolonged snow conditions on Ord's Kangaroo Rats, although this will depend greatly on the timing, distribution and magnitude of these changes in climate.

## **Residential and Commercial Development**

### Commercial and industrial areas

There are several industrial refineries and compressor stations that operate within and near Ord's Kangaroo Rat habitat in Canada. Previously built, existing facilities likely pose a continuing threat to Ord's Kangaroo Rats indirectly through: (i) access roads and related traffic and maintenance activities; and (ii) sensory disturbance as a result of continuous noise and artificial illumination of the night sky (see **Pollution**). In contrast, new facilities or significant expansions may have more serious direct impacts on kangaroo rats in the immediate vicinity if there is construction of new infrastructure, access roads, lighting, and noise pollution.

### Military training areas

CFB Suffield is a permanent military training area that encompasses approximately 13% of Ord's Kangaroo Rat range in Canada. Military training is estimated to have only negligible or neutral direct impact on the species. The majority of military training activities are concentrated near the centre of the base where they do not physically overlap with most Ord's Kangaroo Rat occurrences, and military training is prohibited within the National Wildlife Area where most Ord's Kangaroo Rat primary habitat occurs on the Base. Intensive live-fire training exercises with artillery and heavy vehicles may occasionally collapse burrows and disturb, displace, or kill kangaroo rats directly within training areas. However, very few occurrences of Ord's Kangaroo Rats occur within the areas where intensive military training occurs, and there also may be positive effects of military training (e.g., ignition of wildfires that remove vegetation in occupied areas) on Ord's Kangaroo Rat habitat.

## **Agriculture**

### Annual and perennial crops

Agricultural production of annual cereal and oilseed crops, as well as hay production from perennial grasses and forbs, occurs in some restricted areas within and near Ord's Kangaroo Rat occurrences. Direct impacts from crop and hay production are estimated as moderate in severity because cultivation and heavy equipment are likely to excavate or collapse burrows and may cause kangaroo rats to be disturbed, displaced, or killed. Tilling of sandy soiled areas for crop production in close proximity to kangaroo rat habitats may create population sinks by attracting kangaroo rats to colonize cultivated fields where they are unlikely to survive (Gummer and Robertson 2003a).

### Livestock farming and ranching

Livestock production is common and widely distributed throughout the majority of Ord's Kangaroo Rat habitats, apart from the military lands within CFB Suffield. It is only in a small subset of sites where livestock production is expected to pose a slight, negative impact. In some localized areas where livestock are concentrated at high densities for prolonged periods, such as small, heavily stocked pastures or localities where they are regularly provided hay or water, they may directly trample and collapse kangaroo rat burrows and risk disturbing or displacing kangaroo rats in their underground burrow systems. These potential effects are corroborated by anecdotal observations of Ord's Kangaroo Rats disappearing from habitats that have been heavily impacted by cattle. Other activities associated with livestock production appear to represent lesser or indirect threats to Ord's Kangaroo Rats, such as off-road vehicle travel for livestock management, handling facilities, fencing, watering systems, feed sites, and fire suppression to protect grazing resources. Fencing and other built structures serve as artificial perches for owls that prey on Ord's Kangaroo Rats. Overall, the direct impacts of livestock production are likely offset by the longer-term positive effects of grazing and disturbance of vegetation, which help to moderate vegetation encroachment on open, sandy habitats. Livestock grazing likely serves as a valuable source of vegetation disturbance that helps mitigate the absence of free-roaming Plains Bison (extirpated) and fires (suppressed) from the ecosystem.

## **Limiting Factors**

The primary limiting factor for the persistence of Ord's Kangaroo Rats in Canada is vegetation encroachment and stabilization of open sand dune habitats that the species requires (Hugenholtz *et al.* 2010; Habitat Trends). This long-term trend of habitat loss is well documented and is caused primarily by variations in natural climatic conditions: precipitation, temperature, and wind (Wolfe *et al.* 1995, Vance and Wolfe 1996, Muhs and Wolfe 1999, Bender *et al.* 2005, Hugenholtz and Wolfe 2005, Hugenholtz *et al.* 2010). However, there are many human threats (above) that contribute to this trend and exacerbate its effects. In particular, suppression of natural disturbances from frequent fire and extirpation of wide ranging Plains Bison have likely reduced the resiliency of the sand dune ecosystem to vegetation encroachment, negatively affecting habitat specialists like the Ord's Kangaroo Rat.

Additionally, the combination of a relatively small population that undergoes substantial seasonal fluctuations puts Canadian Ord's Kangaroo Rats at imminent risk of extirpation. While population fluctuations have a natural component, there are many anthropogenic factors that likely contribute to the amplitude of fluctuation (Threats). Like any small population that fluctuates in numbers, the Canadian population of Ord's Kangaroo Rats is highly susceptible to extirpation from stochastic events, including extreme weather events, unforeseen human disturbances, disease outbreaks, demographic stochasticity, genetic bottlenecks or inbreeding effects, and difficulty finding mates when populations are low. Winter severity, particularly extreme cold temperature and prolonged snow cover, appears to be a critical, limiting factor for Ord's Kangaroo Rat survival (Gummer 1997, 2005, Gummer and Robertson 2003c).

## **Number of Locations**

The largest threat to the Canadian population of Ord's Kangaroo Rat is habitat loss, which operates on a long time scale (10-100yrs). Because there are enough differences in stabilization rates and in localized threats (prevalence of roads) between the different sand hill regions, it is not possible to quantify number of locations, although they are certainly more than 10.

## **PROTECTION, STATUS AND RANKS**

### **Legal Protection and Status**

Ord's Kangaroo Rat is listed as Endangered in Canada under the federal *Species at Risk Act* (SARA). A federal recovery strategy was completed in 2012 (Environment Canada 2012), which included identification of critical habitat only on federal lands in Alberta (CFB Suffield) and immediately adjacent parcels of provincial land (115 km<sup>2</sup>), which likely represents about one-quarter of habitat for the species in Canada. Critical habitat has not been assessed or identified for the remainder of provincial lands in Alberta or for any lands within Saskatchewan. The Recovery Strategy has prompted continued efforts at population inventory and monitoring, as well as new research assessing the effectiveness of translocations as a management tool (Bender *et al.* 2010a, Brands 2016).

Ord's Kangaroo Rat has been designated as Endangered in Alberta under the *Alberta Wildlife Act* since 2002, which makes it illegal to harvest or traffic the species and prohibits disturbing its residence but offers no habitat protection. A provincial recovery plan has been in place since 2005 (Alberta Ord's Kangaroo Rat Recovery Team 2005, 2013). Implementation of the Alberta Recovery Plan has included population surveys, annual population monitoring, habitat identification, habitat improvements, and research on threats, population trends, habitat trends, function of primary vs. secondary habitats, habitat restoration, and use of translocations as a management tool (see Gummer and Robertson 2003a, Bender *et al.* 2007, Teucher 2007, Robertson 2007, Bender *et al.* 2010a,b, Heinrichs 2010, Heinrichs *et al.* 2010). Alberta has also prepared a strategy for beneficial

management practices to guide development and human disturbances within the range of the species (Kissner 2009).

Saskatchewan has not designated the Ord's Kangaroo Rat as a wild species at risk under its *Wildlife Act*, nor does it consider it a game species, so the species has no explicit legal protection or regulation for harvest under provincial law in that jurisdiction. There are no records of the species occurring in a provincial park or on federal lands within Saskatchewan that could confer additional protections (e.g., through the federal *Species at Risk Act*); most animals in Saskatchewan reside on public leased or private land used for agricultural purposes with no specific protections.

## Non-Legal Status and Ranks

The global heritage status rank for the species is G5 (demonstrably secure; NatureServe 2015) and the IUCN lists the species as Least Concern. In Canada, the species' NatureServe Conservation Status is N2 (Imperilled). The Alberta General Status and Saskatchewan Conservation Data Centre both list the provincial status rank of Ord's Kangaroo Rat as S2 (Imperilled).

## Habitat Protection and Ownership

A portion (811 km<sup>2</sup>) of the Canadian range of Ord's Kangaroo Rats occurs in CFB Suffield. There is no public access to this area and the Department of National Defence is committed to conducting military activities in an environmentally sustainable manner (DND 2015). Base Standing Orders currently do not permit activities within 250 m of kangaroo rat burrows. Slightly less than half of the distribution of Ord's Kangaroo Rats in CFB Suffield (376 km<sup>2</sup>) falls within lands designated as a National Wildlife Area (NWA) under the *Canada Wildlife Act* in 2003. Thus, a significant portion of the species in Canada has been relatively undisturbed by human activities over the last 10 years. Perhaps counterintuitively, however, this same region has also experienced the highest recorded levels of habitat decline (see **Habitat Trends**), which may be related to suppression of natural disturbance regimes (see **Natural System Modifications**). As demonstrated in Alberta, protecting habitat for this species will likely require mitigation of numerous, possibly interacting, cumulative threats and limiting factors, such as vegetation encroachment, soil erosion, disturbance suppression, and direct human impacts (e.g., from energy or agricultural development), but existing protections generally only target one or few of these effects (see **Threats and Limiting Factors**) and have not mitigated the ongoing habitat and (inferred) population decline.

In Saskatchewan, the *Wildlife Habitat Protection Act* protects Ord's Kangaroo Rat habitat by preventing the clearing and breaking of Crown lands. Further protection, preventing cultivation and new industrial developments, has been provided to 366 km<sup>2</sup> of Ord's Kangaroo Rat range in the Great Sand Hills under the *Representative Areas Ecological Reserves Act* (Saskatchewan Environment 2015). However, an unknown portion of the Canadian population is protected by this act because the distribution of the species in Saskatchewan is largely unknown.

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## INFORMATION SOURCES

- Alberta Environment and Sustainable Resource Development. 2013. Ord's Kangaroo Rat recovery plan 2013-2018. Alberta Environment and Sustainable Resource Development, Alberta Species at Risk Recovery Plan No. 31. Edmonton, Alberta. 23 pp.
- Alberta Ord's Kangaroo Rat Recovery Team. 2005. Draft recovery plan for Ord's Kangaroo Rat in Alberta. Alberta Sustainable Resource Development, Fish and Wildlife Division. Edmonton, Alberta. 29 pp.
- Alcoze, T.M., and E.G. Zimmerman. 1973. Food habits and dietary overlap of two heteromyid rodents from the mesquite plains of Texas. *Journal of Mammalogy* 54:900-908.
- Anderson, R.M. 1946. Catalogue of Canadian recent mammals. National Museum of Canada, Bulletin No. 102, Biological Series 31. Ottawa, Ontario. 238 pp.
- Armstrong, D.M. 1979. Ecological distribution of rodents in Canyonlands National Park, Utah. *Great Basin Naturalist* 39:199-205.
- Bartholomew, G.A., and H.H. Caswell. 1951. Locomotion in kangaroo rats and its adaptive significance. *Journal of Mammalogy* 32:155-169.
- Beatley, J.C. 1969. Dependence of desert rodents on winter annuals and precipitation. *Ecology* 50: 721-724.
- Beatley, J.C. 1976. Environments of kangaroo rats (*Dipodomys*) and effects of environmental change on populations in southern Nevada. *Journal of Mammalogy* 57:67-93.
- Beaudoin, A. B. 1999. What they saw: the climatic and environmental context for Euro-Canadian settlement in Alberta. *Prairie Forum* 24(1):1-40.
- Bender, D.J., D.L. Gummer, S. Robertson, A. Teucher, P. Knaga, E. Baird, and E. Jochum. 2005. Conservation management of Ord's Kangaroo Rats and sandy habitats of the Middle Sand Hills of Alberta. Report for Canadian Forces Base Suffield, Medicine Hat, Alberta. 33 pp.
- Bender, D.J. and R. Dzenkiw. 2010. Ord's Kangaroo Rat Population Monitoring August 2009 – July 2010. Report for Canadian Forces Base Suffield, Medicine Hat, Alberta. 68 pp.
- Bender, D.J., R. Dzenkiw, and D.L. Gummer. 2010b. Translocation Protocol for the Ord's Kangaroo Rat (*Dipodomys ordii*). Alberta Sustainable Resource Development, Fish and Wildlife Division. Alberta Species at Risk Report No. 131. Edmonton, AB. 18 pp.
- Bender, D.J., D.L. Gummer, R. Dzenkiw, and J.A. Heinrichs. 2010a. An Occurrence-based Habitat Model for the Ord's Kangaroo Rat (*Dipodomys ordii*) in Alberta. Alberta Sustainable Resource Development, Fish and Wildlife Division. Alberta Species at Risk Report No. 136, Edmonton, Alberta. 17 pp.

- Bender, D.J., D.L. Gummer, and R. Dzenkiw. 2007. Monitoring Protocol for the Ord's Kangaroo Rat. Alberta Sustainable Resource Development, Fish and Wildlife Division. Alberta Species at Risk Report No. 113, Edmonton, Alberta. 36 pp.
- Best, T.L. 1993. Patterns of morphologic and morphometric variation in heteromyid rodents. pp. 197-235. *in* H.H. Genoways and J.H. Brown (eds.). Biology of the Heteromyidae, American Society of Mammalogists, Special Publication No. 10. Provo, Utah.
- Best, T.L., and B. Hoditschek. 1986. Relationships between environmental variation and the reproductive biology of Ord's Kangaroo Rat (*Dipodomys ordii*). *Mammalia* 50:173-183.
- Boonstra, R., C.J. Krebs, and T.D. Beacham. 1980. Impact of botfly parasitism on *Microtus townsendii* populations. *Canadian Journal of Zoology* 58: 1683-1692.
- Brands, L. 2016. Using stepping-stones and translocations to increase population viability in the endangered Ord's Kangaroo Rat. M.Sc. thesis. University of Calgary, Calgary, Alberta, Canada. 110 pp.
- Breyen, L.J., W.G. Bradley, and M.K. Yousef. 1973. Physiological and ecological studies on the chisel-toothed kangaroo rat, *Dipodomys microps*. *Comparative Biochemistry and Physiology A* 44:543-555.
- Brock, R.E., and D.A. Kelt. 2004. Keystone effects of the endangered Stephens' kangaroo rat (*Dipodomys stephensi*). *Biological conservation* 116:131-139.
- Brown, L. 1989. Grasslands. Chanticleer Press, Inc. New York, New York. 606 pp.
- Brown, J.H., and B.A. Harney. 1993. Population and community ecology of Heteromyid rodents in temperate habitats. pp. 618-651. *in* H.H. Genoways and J.H. Brown (eds.). Biology of the Heteromyidae, American Society of Mammalogists, Special Publication No. 10. Provo, Utah.
- Brown, J.H., and E.J. Heske. 1990. Control of a desert-grassland transition by a keystone rodent guild. *Science* 250:1705-1707.
- Burns, C.E., B.J. Goodwin, and R.S. Ostfeld. 2005. A prescription for longer life? Bot fly parasitism of the white-footed mouse. *Ecology* 86:753-761.
- Capelle, K.J. 1970. Studies on life history and development of *Cuterebra-polita* (Diptera-Cuterebridae) in 4 species of rodents. *Journal of Medical Entomology* 7:320-327.
- Carleton, R.R. 1956. Kangaroo rat. *Blue Jay* 14:100.
- Carpenter, R.E. 1966. A comparison of thermoregulation and water metabolism in the kangaroo rats *Dipodomys agilis* and *Dipodomys merriami*. *University of California Publications in Zoology* 78:1-36.
- CFB Suffield. 2011. Habitat restoration and monitoring for Ord's Kangaroo Rat. Final Report for Interdepartmental Recovery Fund. CFB Suffield, Department of National Defence. Ottawa, Ontario.
- Collins, J.C., T.C. Pilkington, and K. Schmidt-Nielsen. 1971. A model of respiratory heat transfer in a small mammal. *Biophysical Journal* 11: 886-914.

- COSEWIC. 2006. COSEWIC assessment and update status report on the Ord's Kangaroo Rat *Dipodomys ordii* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 34 pp.
- COSEWIC. 2013. COSEWIC assessment and update status report on the Plains Bison *Bison bison bison* and the Wood Bison *Bison bison athabasca* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xv + 109 pp.
- Curtin, C.G., D.A. Kelt, T.C. Frey, and J.H. Brown. 2000. On the role of small mammals in mediating climatically driven vegetation change. *Ecology Letters* 3:309-317.
- Daly, M., M.I. Wilson, and P. Behrends. 1984. Breeding of captive kangaroo rats, *Dipodomys merriami* and *D. microps*. *Journal of Mammalogy* 65:338-341.
- David, P.P. 1993. Great Sand Hills of Saskatchewan: an overview. pp. 59-81 *in*: D.J. Sauchyn (ed.). Quaternary and Late Tertiary landscapes of southwestern Saskatchewan and adjacent areas. Special Publication of the Canadian Plains Research Centre, University of Regina, Regina, Saskatchewan.
- Dawson, W.R. 1955. The relation of oxygen consumption to temperature in desert rodents. *Journal of Mammalogy* 36:543-553.
- Day, B.N., H.J. Egoscue, and A.M. Woodbury. 1956. Ord kangaroo rat in captivity. *Science* 124:485-486.
- Department of National Defence. 2003. Defence Environmental Strategy. Web site: [http://www.forces.gc.ca/assets/FORCES\\_Internet/docs/en/defence-environmental-strategy\\_en\\_v7\\_small.pdf](http://www.forces.gc.ca/assets/FORCES_Internet/docs/en/defence-environmental-strategy_en_v7_small.pdf) [Accessed December 2015].
- Duke, K.L. 1944. The breeding season of two species of *Dipodomys*. *Journal of Mammalogy* 25:155-160.
- Egoscue, H.J., J.G. Bittmenn, and J.A. Petrovich. 1970. Some fecundity and longevity records for captive small mammals. *Journal of Mammalogy* 51:622-623.
- Eisenberg, J.F. 1963. The behavior of heteromyid rodents. University of California Publications in Zoology 69:1-100.
- Eisenberg, J.F. 1993. Ontogeny. pp. 479-490. *in* H.H. Genoways and J.H. Brown (eds.). Biology of the Heteromyidae, American Society of Mammalogists, Special Publication No. 10. Provo, Utah.
- Engstrom, M.D., and R.C. Dowler. 1981. Field observations of mating-behaviour in *Dipodomys-ordii*. *Journal of Mammalogy* 62:384-386.
- Environment Canada. 2012. Recovery Strategy for the Ord's Kangaroo Rat (*Dipodomys ordii*) in Canada. *Species at Risk Act* Recovery Strategy Series. Environment Canada, Ottawa. vi + 28 pp.
- Epp, H.T., and B.D. Waker. 1980. Terrestrial vertebrate fauna of the Great Sand Hills. pp. 75-89. *in* H.T. Epp and L. Townley-Smith (eds.). The Great Sand Hills of Saskatchewan. Saskatchewan Environment, Regina, Saskatchewan.

- Fairbanks, W.S., D. Greigor, L. Staudinger, and E. Bitterbaum. 1983. Water conservation of the kangaroo rat, *Dipodomys ordii*. Transactions of the Nebraska Academy of Science 11:27-30.
- Flake, L.D. 1973. Food habits of four species of rodents on a short-grass prairie in Colorado. Journal of Mammalogy 54:636-647.
- Fox, T.A., C.H. Hugenholtz, D.J. Bender, and C.C. Gates. 2012. Can bison play a role in conserving habitat for endangered sandhills species in Canada? Biodiversity and Conservation 21:1441-1455.
- Frank, C.L. 1988. The relationship of water content, seed selection, and the water requirements of a heteromyid rodent. Physiological Zoology 61:527-534.
- French, A.R. 1993. Physiological ecology of the Heteromyidae: economics of energy and water conservation. pp. 509-538. in H.H. Genoways and J.H. Brown (eds.). Biology of the Heteromyidae. American Society of Mammalogists, Special Publication No. 10. Provo, Utah.
- French, N.R., B.G. Maza, H.O. Hill, A.P. Aschwanden, and H.W. Kaaz. 1974. A population study of irradiated desert rodents. Ecological Monographs 44:45-72.
- Garner, H.W. 1974. Population dynamics, reproduction, and activities of the kangaroo rat, *Dipodomys ordii*, in western Texas. Graduate Studies, Texas Tech University. 7:1-28.
- Grinnell, J. 1921. Revised list of species of *Dipodomys*. Journal of Mammalogy 2:94-97.
- Gummer, D.L. 1997a. Effects of latitude and long-term isolation on the ecology of northern Ord's Kangaroo Rats (*Dipodomys ordii*). M.Sc. thesis, University of Calgary, Calgary, Alberta, Canada. 111 pp.
- Gummer, D.L. 1997b. Status of Ord's kangaroo rat (*Dipodomys ordii*) in Alberta. Alberta Environmental Protection, Wildlife Management Division, Wildlife Status Report No. 4. Edmonton, Alberta. 16 pp.
- Gummer, D.L. 1999. Distribution and abundance of Ord's Kangaroo Rats in Canadian Forces Base Suffield National Wildlife Area. Report for Canadian Wildlife Service, Edmonton, Alberta. 29 pp.
- Gummer, D.L. 2005. Geographic variation in torpor patterns: the northernmost prairie dogs and kangaroo rats. Ph.D. dissertation, University of Saskatchewan, Saskatoon, Saskatchewan, Canada. 210 pp.
- Gummer, D.L., and K.J. Gummer. 1997. Distribution surveys for Ord's Kangaroo Rats in Alberta. Report for Alberta Environmental Protection, Wildlife Management Division, Edmonton, Alberta. 21 pp.
- Gummer, D.L., and S.E. Robertson. 2003a. Distribution of Ord's Kangaroo Rats in southeastern Alberta. Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta Species at Risk Report No. 63. Edmonton, Alberta. 16 pp.

- Gummer, D.L., and S.E. Robertson. 2003b. Evaluation of survival and activities of Ord's Kangaroo Rats: one year after construction of the North Suffield gas pipeline. Report for Alberta Conservation Association. Edmonton, Alberta. 14 pp.
- Gummer, D.L., and S.E. Robertson. 2003c. Evaluation of activities and survival of Ord's Kangaroo Rats during and post- construction of the North Suffield pipeline. Report for EnCana Corporation, Calgary, Alberta. 43 pp.
- Gummer, D.L., M.R. Forbes, D.J. Bender, and R.M.R. Barclay. 1997. Botfly (Diptera: Oestridae) parasitism of kangaroo rats (*Dipodomys ordii*) at Suffield National Wildlife Area, Alberta, Canada. *Journal of Parasitology* 83:601-604.
- Hall, E.R. 1981. The mammals of North America. Second ed. John Wiley and Sons, New York, New York. 1:565-570.
- Hallett, J.G. 1982. Habitat selection and the community matrix of a desert small-mammal fauna. *Ecology* 63: 1400-1410.
- Hanski, I. 1989. *Metapopulation Ecology*. Oxford University Press, Oxford UK. ix + 313 pp.
- Harrison, S. 1991. Local extinction in a metapopulation context: an empirical evaluation. *Biological Journal of the Linnean Society* 42:73-88.
- Heinrichs, J.A. 2010. The Relative Influence of Habitat Quality on Population Extinction. Ph.D. dissertation, University of Calgary, Calgary, Alberta, Canada. 134 pp.
- Heinrichs, J.A., D.J. Bender, D.L. Gummer, and N.H. Schumaker. 2010. Assessing critical habitat: Evaluating the relative contribution of habitats to population persistence. *Biological Conservation* 143:2229-2237.
- Heinrichs, J.A., J.L. Lawler, N.H. Schumaker, C. Wilsey, and D.J. Bender. 2015. Divergence in sink contributions to population persistence. *Conservation Biology* 29:1674–1683.
- Heske E.J., J.H. Brown, and Q. Guo. 1993. Effects of kangaroo rat exclusion on vegetation structure and plant species diversity in the Chihuahuan Desert. *Oecologia* 95:520-524.
- Hinds, D.S. and R.E. MacMillen. 1985. Scaling of energy metabolism and evaporative water loss in Heteromyid rodents. *Physiological Zoology* 58:282-298.
- Hoditschek, B., and T.L. Best. 1983. Reproductive biology of Ord's Kangaroo Rat (*Dipodomys ordii*) in Oklahoma. *Journal of Mammalogy* 64:121-127.
- Hoffmeister, D.F. 1942. New subspecies of kangaroo rats of the *Dipodomys ordii* group from Montana and Wyoming. *Proceedings of the Biological Society of Washington* 55:165-168.
- Hugenholtz, C.H., and S.A. Wolfe. 2005. Recent stabilization of active sand dunes on the Canadian prairies and relation to recent climate variations. *Geomorphology* 68:131-147.

- Hugenholtz, C.H., D.J. Bender, and S.A. Wolfe. 2010. Declining sand dune activity in the southern Canadian prairies: Historical context, controls and ecosystem implications. *Aeolian Research* 2:71-82.
- IUCN Standards and Petitions Subcommittee. 2016. Guidelines for Using the IUCN Red List Categories and Criteria. Version 12. Prepared by the Standards and Petitions Subcommittee. Downloadable from <http://www.iucnredlist.org/documents/RedListGuidelines.pdf>.
- Jackson, D.C., and K. Schmidt-Nielsen. 1964. Countercurrent heat exchange in the respiratory passages. *Proceedings of the National Academy of Sciences of the United States of America* 51:1192-1197.
- Johnson, D.R. 1961. The food habits of rodents on rangelands of southern Idaho. *Ecology* 42:407-410.
- Jones, W.T. 1985. Body size and life-history variables in heteromyids. *Journal of Mammalogy* 66:128-132.
- Jones, W.T. 1993. The social systems of heteromyid rodents. pp. 575-595. *In* H.H. Genoways and J.H. Brown (eds.). *Biology of the Heteromyidae*. American Society of Mammalogists, Special Publication No. 10. Provo, Utah.
- Kaufman, D.W., and G.A. Kaufman. 1982. Effect of moonlight on activity and microhabitat use by Ord's Kangaroo Rat (*Dipodomys ordii*). *Journal of Mammalogy* 63:309-312.
- Kenagy, G.J. 1973. Daily and seasonal patterns of activity and energetics in a heteromyid rodent community. *Ecology*. 54: 1201-1219.
- Kenagy, G.J. 1976. The periodicity of daily activity and its seasonal changes in free-ranging and captive kangaroo rats. *Oecologia* 24:105-140.
- Kenagy, G.J., and G.A. Bartholomew. 1985. Seasonal reproductive patterns in five coexisting California desert rodent species. *Ecological Monographs* 55:371-397.
- Kennedy, M.L., and G.A. Schnell. 1978. Geographic variation and sexual dimorphism in Ord's Kangaroo Rat, *Dipodomys ordii*. *Journal of Mammalogy*. 59:45-59.
- Kenny, R.J.L. 1989. Population, distribution, habitat use, and natural history of Ord's Kangaroo Rat (*Dipodomys ordii*) in the sand hill areas of south-western Saskatchewan and south-eastern Alberta. M.Sc. thesis, University of Manitoba, Winnipeg, Manitoba, Canada. 69 pp.
- Kerley, G.I.H., W.G. Whitford, and F.R.Kay. 1997. Mechanisms for the keystone status of kangaroo rats: graminivory rather than granivory? *Oecologia* 111:422-428.
- Kissner, K.J. 2009. Beneficial management practices for Ord's Kangaroo Rat in Alberta. Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta Species at Risk Report Series No. 125. Edmonton, Alberta. 42. pp.
- Levins, R. 1969. Some demographic and genetic consequences of environmental heterogeneity for biological control. *Bulletin of the Entomological Society of America* 15:237-240.

- MacMillen, R.E. 1983. Adaptive physiology of Heteromyid rodents. Great Basin Naturalist Memoirs 7:65-76.
- MacMillen, R.E., and D.S. Hinds. 1983. Water regulatory efficiency in heteromyid rodents: a model and its application. Ecology 64:152-164.
- Marshall, I.B., and P.H. Schut. 1999. A national ecological framework for Canada. Agriculture and Agri-Food Canada. Web site:  
<http://sis.agr.gc.ca/cansis/nsdb/ecostrat/index.html> [accessed June 2005].
- Master, L., D. Faber-Langendoen, R. Bittman, G.A. Hammerson, B. Heidel, J. Nichols, L. Ramsay, and A. Tomaino. 2009. NatureServe conservation status assessments: factors for assessing extinction risk. NatureServe, Arlington, VA. Web site:  
[http://www.natureserve.org/publications/ConsStatusAssess\\_StatusFactors.pdf](http://www.natureserve.org/publications/ConsStatusAssess_StatusFactors.pdf) [accessed May, 2010]
- McCulloch, C.Y., and J.M. Inglis. 1961. Breeding periods of the Ord kangaroo rat. Journal of Mammalogy 42:337-344.
- Montana Natural Heritage Program. 2015. Montana Field Guide, Ord's Kangaroo Rat. Web site: <http://fieldguide.mt.gov/speciesDetail.aspx?elcode=AMAFD03010> [accessed December 2015].
- Muhs, D.R., and S.A. Wolfe. 1999. Sand dunes of the northern Great Plains of Canada and the United States. pp. 183-197. *In*: D.S. Lemmen and R.E. Vance (eds.). Holocene Climate and Environmental Change in the Palliser Triangle: A Geoscientific Context for Evaluating the Impacts of Climate Change on the Southern Prairies. Geological Survey of Canada Bulletin 534, Ottawa, Ontario.
- Mullen, R.K. 1971. Energy metabolism and body water turnover rates of two species of free-living kangaroo rats, *Dipodomys merriami* and *Dipodomys microps*. Comparative Biochemistry and Physiology A 39:379-390.
- Nagy, K.A., and M.J. Gruchacz. 1994. Seasonal water and energy metabolism of the desert-dwelling kangaroo rat (*Dipodomys merriami*). Physiological Zoology 67:1461-1478.
- NatureServe. 2015. NatureServe Explorer: An online encyclopedia of life [web application]. Version 7.1. NatureServe, Arlington, Virginia. Web site:  
<http://explorer.natureserve.org>. (Accessed: November 2015).
- Nielsen, S.E., and R. Bjork. 2007. Biodiversity assessments for the Great Sand Hills: Response of focal species to livestock grazing and gas development. Report for The Great Sand Hills Regional Environmental Study, Regina, Saskatchewan. 40 pp.
- Nielson, P.E. 1941. The fetal membranes of the kangaroo rat, *Dipodomys*, with a consideration of the phylogeny of the Geomyidae. Anatomical Record 77:103-121.
- Nero, R.W. 1956. The kangaroo rat in Saskatchewan. Blue Jay 14:3-4.
- Nero, R.W., and R.W. Fyfe, 1956. Kangaroo rat colonies found. Blue Jay 14:107-110.
- O'Farrell, M.J. 1974. Seasonal activity patterns of rodents in a sagebrush community. Journal of Mammalogy 55:809-823.

- Patton, J.L. 2005. Family Heteromyidae. pp. 844–858. *In* D.E. Wilson and D.M. Reeder (eds.). Mammal Species of the World: A Taxonomic and Geographic Reference, 3rd edition. Volume 2. Johns Hopkins University Press, Baltimore, MD. xx + 1398 pp.
- Patton, J.L., and D.S. Rogers. 1993. Cytogenetics. pp. 236-258. *In*: H.H. Genoways and J.H. Brown (eds.). Biology of the Heteromyidae, American Society of Mammalogists, Special Publication No. 10. Provo, Utah.
- Poulin, R., T. Wellicome, and D. Todd. pers. comm. 2005. *Email correspondence to D.L. Gummer*. March 2005. R. Poulin, Department of Biological Sciences, University of Alberta, Edmonton, Alberta.
- Randall, J.A., and C.M. Stevens. 1987. Footdrumming and other anti-predator responses in the bannertail kangaroo rat (*Dipodomys spectabilis*). Behavioral Ecology and Sociobiology 20:187-194.
- Reichman, O.J., A. Fattaey, and K. Fattaey. 1986. Management of sterile and mouldy seeds by a desert rodent. Animal Behaviour 34:221-225.
- Reynolds, H.G. 1958. The ecology of the Merriam kangaroo rat (*Dipodomys merriami* Mearns) on the grazing lands of southern Arizona. Ecological Monographs 28:111-127.
- Reynolds, H.W., S.J. Barry, and H.P.L. Kiliaan. 1999. Small mammal component report, Canadian Forces Base Suffield National Wildlife Area Wildlife Inventory. Report for Canadian Wildlife Service, Edmonton, Alberta. 140 pp.
- Robertson, S.E. 2007. Spatial patterns and effects of bot fly (*Cuterebra polita*) parasitism in Ord's Kangaroo Rat (*Dipodomys ordii*). M.Sc. thesis, Department of Biological Sciences, University of Calgary, Calgary, Alberta, Canada. 122 pp.
- Robbins, A. 2013. Range-Wide Habitat Mapping for Ord's Kangaroo Rats (*Dipodomys ordii*) in Canada. M.Sc. thesis, Department of Geography, University of Calgary, Calgary, Alberta, Canada. 84 pp.
- Roe, F.G. 1970. The North American Buffalo. A Critical Study of the Species in its Wild State. Second Edition. University of Toronto Press, Toronto, Ontario. Viii +957 pp.
- Rosenzweig, M.L. 1974. On the optimal aboveground activity of bannertail kangaroo rats. Journal of Mammalogy 55:193-199.
- Saskatchewan Environment. 2015. Great Sand Hills. Web site: <http://www.environment.gov.sk.ca/Default.aspx?DN=bc247d49-29a2-4685-98bc-ed6cc4a3c7e0> [accessed December 2015].
- Sauchyn, D., and S. Kulshreshtha. 2008. Prairies. pp. 275-328. *In* D.S. Lemmen, F.J. Warren, J. Lacroix, and E. Bush (eds.). From impacts to adaptation: Canada in a changing climate 2007. Government of Canada. Ottawa, Ontario.
- Sauchyn, D., E. Barrow, X. Fang, N. Henderson, M. Johnston, J. Pomeroy, J. Thorpe, E. Wheaton, and B. Williams. 2009. Saskatchewan's natural capital in a changing climate: an assessment of impacts and adaptation. Report to Saskatchewan Ministry of Environment from the Prairie Adaptation Research Collaborative. Regina, Saskatchewan. 162 pp.

- Schmidly, D.J., K.T. Wilkins, and J.N. Derr. 1993. Biogeography. pp. 319-356. *In* H.H. Genoways and J.H. Brown (eds.). Biology of the Heteromyidae, American Society of Mammalogists, Special Publication No. 10. Provo, Utah.
- Schmidt-Nielsen, B., and K. Schmidt-Nielsen. 1951. A complete account of the water metabolism in kangaroo rats and an experimental verification. *Journal of Cellular and Comparative Physiology* 38:165-182.
- Schmidt-Nielsen, K. 1964. Desert animals, physiological problems of heat and water. Oxford University Press, New York.
- Schmidt-Nielsen, K., F.R. Hainsworth, and D. E. Murrish. 1970. Counter-current heat exchange in the respiratory passages: effect on water and heat balance. *Respiratory Physiology* 9:263-276.
- Setzer, H.W. 1949. Subspeciation in the kangaroo rat, *Dipodomys ordii*. University of Kansas publications, Museum of Natural History 1:473-573.
- Smith, H.C. 1972. Some recent records of Alberta mammals. *Blue Jay* 30:53-54. Smith, H.C. 1993. Alberta mammals, an atlas and guide. The Provincial Museum of Alberta, Edmonton, Alberta.
- Smith, H.C. and M.J. Hampson. 1969. A kangaroo rat colony in Alberta. *Blue Jay* 27:224-225.
- Smith, H.D., and C.D. Jorgensen. 1975. Reproductive biology of North American desert rodents. *In*: Rodents in desert environments. Edited by I. Prakash and P.K. Ghosh. Dr. W. Junk b.v. Publishers, Hague, Netherlands. pp. 305-330.
- Stangl, F.B. Jr., T.S. Schafer, J.R. Goetze, and W. Pinchak. 1992. Opportunistic use of modified and disturbed habitat by the Texas kangaroo rat (*Dipodomys elator*). *Texas Journal of Science* 44:25-35.
- Stearns, S.C., and R.E. Crandall. 1981. Bet-hedging and persistence as adaptations of colonizers. pp. 371-383. *In*: G.G.E. Scudder and J.L. Reveal (eds.). Evolution today: proceedings of the 2nd International Congress of Systematic and Evolutionary Biology. Carnegie-Mellon University, Pittsburgh, Pennsylvania.
- Stock, A.D. 1974. Chromosome evolution in the genus *Dipodomys* and its taxonomic and phylogenetic implications. *Journal of Mammalogy* 55:505-526.
- Teucher, A. C. 2007. Impacts of anthropogenic habitat use on the Ord's Kangaroo Rat (*Dipodomys ordii*) in Alberta. M.Sc. thesis, Department of Biological Sciences, University of Calgary, Calgary, Alberta, Canada. 167 pp.
- Tracy, R.L. and G.E. Walsberg. Kangaroo rats revisited: re-evaluating a classic case of desert survival. *Oecologia* 133:449-457.
- Vance, R. E., A. B. Beaudoin, and B. H. Luckman 1995. The Paleoecological record of 6 ka BP climate in the Canadian prairie provinces. *Géographie physique et Quaternaire* 49:81-98.

- Vance, R.E., and S.A. Wolfe. 1996. Geological indicators of water resources in semi-arid environments: southwestern interior of Canada. pp. 251-263. *In* A.R. Berger, W.J. Iams (eds.). *Geoindicators: assessing rapid environmental changes in earth systems*. A.A. Balkema, Rotterdam.
- Ward, D.W., and J.A. Randall. 1987. Territorial defense in the bannertail kangaroo rat (*Dipodomys spectabilis*): footdrumming and visual threats. *Behavioral Ecology and Sociobiology* 20:323-328.
- Webster, D.B. and M. Webster. 1971. Adaptive value of hearing and vision in kangaroo rat predator avoidance. *Brain, Behavior, and Evolution* 4:310-322.
- Webster, D.B. and M. Webster. 1975. Auditory systems of Heteromyidae: functional morphology and evolution of the middle ear. *Journal of Morphology* 146:343-376.
- Williams, D.F., H.H. Genoways, and J.K. Braun. 1993. Taxonomy. pp. 38-196. *In* H.H. Genoways and J.H. Brown (eds.). *Biology of the Heteromyidae*, American Society of Mammalogists, Special Publication No. 10. Provo, Utah.
- Wolfe, S.A. 2001. Eolian Deposits of the Prairie Provinces of Canada. Geological Survey of Canada, Ottawa, Open File 4118, CD-ROM.
- Wolfe, S.A. 2010. An inventory of active sand dunes and blowouts in the Prairie Provinces, Canada, Geological Survey of Canada, Open File 6680, 21 pp + CD-ROM.
- Wolfe, S.A., D.J. Huntley, and J. Ollerhead. 1995. Recent and late Holocene sand dune activity in southwestern Saskatchewan. *Current Research 1995-B*, Geological Survey of Canada:131-140.
- Wolfe, S.A., and W.G. Nickling. 1997. Sensivity of eolian processes to climate change in Canada. Geological Survey of Canada, Bulletin 421. 30 pp.
- Wolfe, S.A., D.R. Muhs, P.P. David, and J.P. McGeehin. 2000. Chronology and geochemistry of late Holocene eolian deposits in the Brandon Sand Hills, Manitoba, Canada. *Quaternary International* 67:61-74.
- Wolfe, S.A., D.J. Huntley, P.P. David, J. Ollerhead, D.J. Sauchyn, and G.M. MacDonald. 2001. Late 18th century drought-induced sand dune activity. Great Sand Hills, Saskatchewan. *Canadian Journal of Earth Science* 38:1-13.
- Woodhouse S.W. 1853. Description of a new species of pouched rat, of the genus *Dipodomys*, Gray. *Proceedings of the Academy of Natural Sciences of Philadelphia* 6:235-236.
- Yousef, M.K., and D.B. Dill. 1971. Daily cycles of hibernation in the kangaroo rat, *Dipodomys merriami*. *Cryobiology* 8:441-446.
- Yousef, M.K., W.D. Robertson, D.B. Dill, and H.D. Hudson. 1970. Energy expenditure of running kangaroo rats *Dipodomys merriami*. *Comparative Biochemistry and Physiology* 36:387-393.

## **BIOGRAPHICAL SUMMARY OF REPORT WRITER(S)**

Darren Bender is an Associate Professor of Geography at the University of Calgary. He first encountered kangaroo rats in 1995 while employed as a field research assistant at the University of Calgary under David Gummer. For the last decade, a focus of his research program has been the habitat and population ecology of Ord's Kangaroo Rats in Alberta, as well as conservation research about habitat restoration in sand hills ecosystems and translocation strategies for kangaroo rats. Darren holds a PhD in Biology (ecology specialization) from Carleton University.

David Gummer began researching Ord's Kangaroo Rats in 1994 in preparation for the original COSEWIC status report and later co-wrote the 2006 status report update for COSEWIC. David studied ecology of kangaroo rats and other prairie small mammals from 1994 through 2007, over the course of his postgraduate studies and previous work as Curator of Mammalogy at the Royal Alberta Museum (2001 to 2007). David holds an MSc from the University of Calgary and PhD from the University of Saskatchewan. He is currently a wildlife ecologist with Parks Canada in Banff National Park, where he applies lessons learned from his previous work on kangaroo rats to larger mammals of concern.

## **COLLECTIONS EXAMINED**

Canadian Museum of Nature, Ottawa, Ontario, Canada [collections data]

Royal Alberta Museum, Edmonton, Alberta, Canada

Royal Ontario Museum, Toronto, Ontario, Canada [collections data]

Royal Saskatchewan Museum, Regina, Saskatchewan, Canada [collections data]

United States National Museum of Natural History (Smithsonian Institution), Washington D.C., USA [collections data]

University of Alberta Museum of Zoology, Edmonton, Alberta, Canada

## Appendix 1. Threats calculator spreadsheet for the Ord's Kangaroo Rat.

<b>Species or Ecosystem Scientific Name</b>		<i>Dipodomys ordii</i> , Ord's Kangaroo Rat																											
<b>Element ID</b>		<b>Elcode</b>																											
<b>Date (Ctrl + ";" for today's date):</b>		2016/08/17																											
<b>Assessor(s):</b>		Bender, D.; Gummer, D.; Ray, J.; Teucher, A.; Keith, J.; Timm, K.; Robertson, S.																											
<b>References:</b>																													
<b>Overall Threat Impact Calculation Help:</b>		<table border="1"> <thead> <tr> <th colspan="2" rowspan="2">Threat Impact</th> <th colspan="2">Level 1 Threat Impact Counts</th> </tr> <tr> <th>high range</th> <th>low range</th> </tr> </thead> <tbody> <tr> <td>A</td> <td>Very High</td> <td>0</td> <td>0</td> </tr> <tr> <td>B</td> <td>High</td> <td>0</td> <td>0</td> </tr> <tr> <td>C</td> <td>Medium</td> <td>6</td> <td>0</td> </tr> <tr> <td>D</td> <td>Low</td> <td>2</td> <td>8</td> </tr> <tr> <td colspan="2"><b>Calculated Overall Threat Impact:</b></td> <td>High</td> <td>Medium</td> </tr> </tbody> </table>		Threat Impact		Level 1 Threat Impact Counts		high range	low range	A	Very High	0	0	B	High	0	0	C	Medium	6	0	D	Low	2	8	<b>Calculated Overall Threat Impact:</b>		High	Medium
Threat Impact		Level 1 Threat Impact Counts																											
		high range	low range																										
A	Very High	0	0																										
B	High	0	0																										
C	Medium	6	0																										
D	Low	2	8																										
<b>Calculated Overall Threat Impact:</b>		High	Medium																										
<b>Assigned Overall Threat Impact:</b>		B = High																											
<b>Impact Adjustment Reasons:</b>		Selected higher range of uncertainty due to cumulative effects of threats in combination with severity of natural limiting factors (habitat loss, small population, severe fluctuations).																											
<b>Overall Threat Comments</b>																													

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	
1.1	Housing & urban areas						
1.2	Commercial & industrial areas	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	Primarily industrial refineries and compressor stations. This category would also include CFB Suffield military training area, which is estimated at lesser severity of Slight or Neutral. Indirect impacts from associated roads/traffic, noise and lights are estimated separately, below. New industrial developments on CFB Suffield are presumed to pose negligible threat due to SARA protection of individuals, residences and critical habitat on federal land. Note the Scope may be in the lower end of the Small category. Severity assumes that individuals will move/avoid the area if developed.
1.3	Tourism & recreation areas						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2	Agriculture & aquaculture	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	
2.1	Annual & perennial non-timber crops	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	Cultivation, rotational crops, and hay production are likely to cause destruction of burrows and direct mortality, may serve as population sinks, and may also exacerbate predation threat 8.2 (e.g., through destruction of burrows and daytime disturbance creating exposure to diurnal predators like hawks). Scope of this threat may have been larger in past but given recent declines in occurrences the scope for the next 10 years is estimated at small. Habitat is not entirely lost, so severity is Moderate and less than Threat 1.2. Scope is Small because the majority of the species' range is ranched for cattle production (Threat 2.3), and only a Small portion is cultivated for hay, tame pasture, or annual crops. Cropland that is regularly tilled/disturbed by machinery likely has more continued severity through time. In localized areas kangaroo rats colonize cultivated, sandy soils but these areas may serve as population sinks.
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	Livestock ranching is the predominant land-use. It is mainly cattle, but also some horses and possibly other domestic species in small areas. Livestock grazing and disturbance of vegetation and soil likely helps to maintain natural habitats in the absence of bison and frequent fire on the landscape. However, livestock production can have slight negative effects in localized areas where livestock are concentrated and may directly crush burrows or animals underground, or otherwise interfere with suitability of habitat through livestock feeding (hay), water developments, fencing, vehicles etc. The scope is Large because livestock ranching occurs throughout the majority of range except for much of the range within CFB Suffield. Overall severity is estimated at negligible because in some local areas the severity would be higher (Slight to Moderate) but across the majority of the range livestock production is considered neutral or positive.
2.4	Marine & freshwater aquaculture						
3	Energy production & mining	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3.1	Oil & gas drilling	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	Direct impacts of natural gas exploration (seismic), drilling, extraction, maintenance, reclamation. New exploration or well sites are presumed to pose negligible threat on CFB Suffield due to SARA protection of individuals, residences and critical habitat on CFB Suffield. It is assumed that this Threat is potentially serious across most of the range, although it is impossible to predict given current economic situation. Some of the Threat activities are short in duration and irregular or infrequent; however, still may have significant impact considering small population and demographic limitations. Specific mitigations for kangaroo rats can minimize the impacts; however, it is unknown if this level of mitigation is standard practice across the range. There is considerable uncertainty in the severity so a range of Slight to moderate was estimated.
3.2	Mining & quarrying						
3.3	Renewable energy	D	Low	Small (1-10%)	Serious - Slight (1-70%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Effects of wind turbine developments are unknown but possible in the short-term. Future solar energy developments are likely (e.g., within 10 years) on a small proportion of the range, but impacts may be large. Scope would be at the lower end of the Small category. There are no wind or solar sites on landscape currently, so these would be future installations. There is a large amount of uncertainty regarding the severity of impacts, ranging from Slight to Serious.
4	Transportation & service corridors	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.1	Roads & railroads	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	<p>Direct effects of existing and new developments, vehicle traffic and maintenance of roads and trails through direct mortality and damage to burrows, and loss of natural habitats. Indirect effects through impacts on burrow microclimate, body condition, overwinter survival, predators and parasites, are estimated separately.</p> <p>Includes secondary roads, industrial access roads, and two track trails used mainly by ranchers, oil and gas, and maintenance for pipelines or power lines. There may be a lower density of existing sandy roads and trails in Saskatchewan range than in Alberta, although the magnitude of difference is unknown. New roads and trails are relatively rare, but existing roads/trails pose continuing impacts. There is a Large scope estimated based on the proportion of occurrences that are along roads and trails. Kangaroo rats are attracted to roads and trails where they are exposed to both direct and indirect impacts. Note: the impacts of this Threat in SK may be at the lower end of both Scope and Severity categories.</p>
4.2	Utility & service lines	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	<p>Pipelines and power lines. Effects of associated roads/trails are estimated in 4.1</p> <p>Smaller scope and severity than roads. There is less human activity associated with these and the disturbed areas are reclaimed or gradually become vegetated over time. Main impacts are likely during installation.</p>
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use						
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources						
6	Human intrusions & disturbance						
6.1	Recreational activities						
6.2	War, civil unrest & military exercises						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
6.3	Work & other activities						
7	Natural system modifications	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
7.1	Fire & fire suppression	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Fire suppression to protect homes and agricultural resources is pervasive, although there is more accidental fire in some areas of CFB Suffield (but also heavily suppressed). Fire suppression on its own is estimated at only slight severity except in combination with habitat loss from other factors. Proximate effect is that fire suppression exacerbates decline of habitat quality and quantity over time.
7.2	Dams & water management/use						
7.3	Other ecosystem modifications	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	<p>Absence of Plains Bison (extirpated), which are expected to have helped maintain open habitats; also weed control, spraying and mowing may cause incidental mortalities and damage to burrows; erosion control efforts such as flax bales and snow fences contribute to stabilization; Note: interactive effect between fire suppression and loss of bison, and therefore combined severity was increased to Slight-to-moderate uncertainty range. Similar interactive effect is expected between these threats and 11.1.</p> <p>***In the meeting there was discussion about raising the Severity of #7 to Moderate category; however, this overestimates the certainty regarding the interactive effects and would have the effect of raising this threat category to the single largest for the species in Canada, which seems disproportionate in comparison with the other threats and the state of knowledge/uncertainty. Hence the severity for #7 was adjusted to the uncertainty range of Slight-to-moderate.</p>
8	Invasive & other problematic species & genes	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	
8.1	Invasive non-native/alien species/diseases		Unknown	Large (31-70%)	Unknown	High (Continuing)	Non-native, invasive plants are widespread in kangaroo rat habitat and their diet, particularly in anthropogenic habitats (exacerbated by roads and trails), but direct effects are not known. May negatively impact body condition and habitat loss through invasive colonization and stabilization of open, sandy habitats.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.2	Problematic native species/diseases	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	Effects of natural predators and parasites exacerbated by transportation and service corridors (roads, trails, pipelines) and agricultural practices. To a lesser extent may also be affected by artificial perches from fences, powerlines and poles; energy production, commercial and industrial areas, light and noise pollution. Botfly parasite is considered a native species but typically parasitizes pocket gophers elsewhere in N. America. Kangaroo rats may be a secondary host. As per the definition of this threat, the scope and severity scores reflect those areas where native predators and parasites are "out of balance" and does not include the areas where they occur at natural levels.
8.3	Introduced genetic material						
8.4	Problematic species/diseases of unknown origin						
8.5	Viral/prion-induced diseases						
8.6	Diseases of unknown cause						
9	Pollution	CD	Medium - Low	Restricted (11-30%)	Serious - Moderate (11-70%)	High (Continuing)	
9.1	Domestic & urban waste water						
9.2	Industrial & military effluents						
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste						
9.5	Air-borne pollutants						
9.6	Excess energy	CD	Medium - Low	Restricted (11-30%)	Serious - Moderate (11-70%)	High (Continuing)	Displacement/disturbance and degradation of habitat due to light and noise pollution from refineries, compressor stations, military training, construction/wellsites, seismic exploration, etc. Could be serious by compromising the foraging, mating, anti-predator abilities of kangaroo rats, as well as excluding them from habitat. Note the severity score of Moderate to Serious has high uncertainty range because the impacts of anthropogenic light and noise have not been directly studied.
10	Geological events						
10.1	Volcanoes						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	
11.1	Habitat shifting & alteration		Unknown	Unknown	Unknown	High (Continuing)	Natural vegetation encroachment/stabilization of open sand due to long-term trends in climate (temperature, moisture, growing season, wind regimes). Note: this is a limiting factor that is included in the Threats assessment for completeness due to its likely interactive effects with the other Threats. Some amount of habitat stabilization is generally considered within natural range of variation whereas human-caused threats that contribute to this trend (e.g., 7.1 and 7.3) are estimated above. Scope and severity of the natural component of the trend are unknown. In the long-term, it is possible that anthropogenic climate change may mitigate or reverse habitat loss for the species by promoting soil erosion and dune activity in this region as a result of frequent drought and climate extremes. Within the next 10 years, however, the likelihood and severity of anthropogenic climate change and its impacts on kangaroo rat habitat in Canada are entirely unknown.
11.2	Droughts						

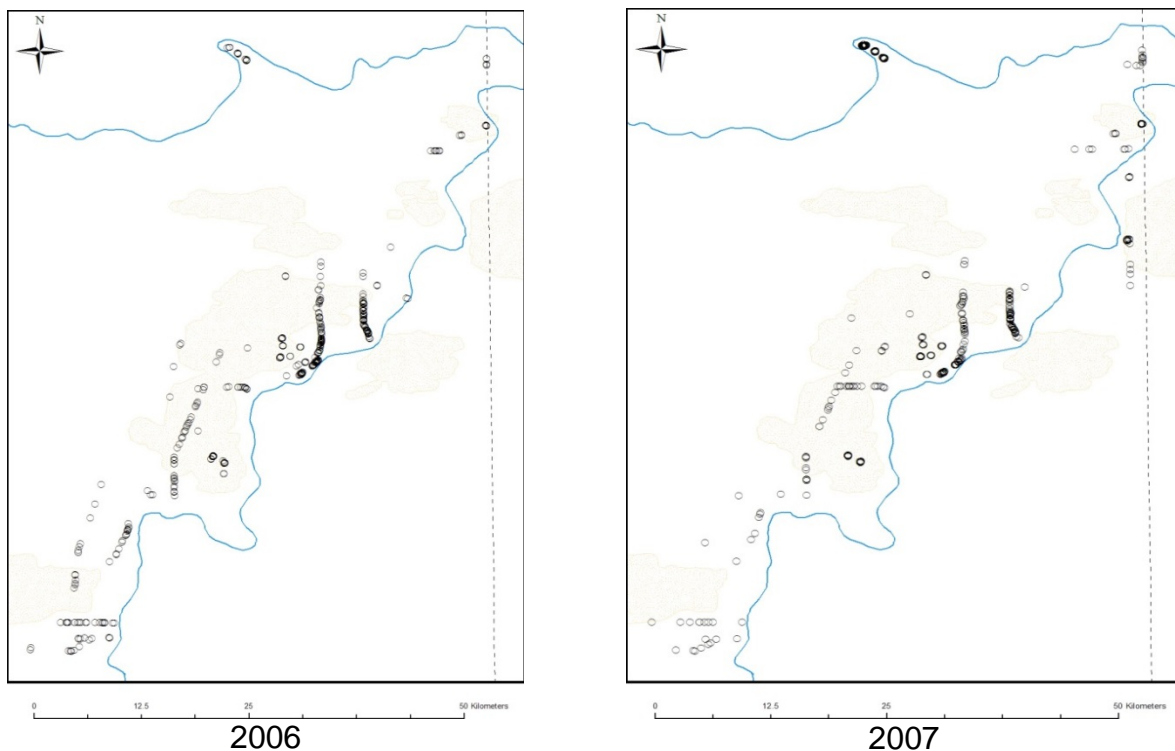
Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.3	Temperature extremes	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	<p>Severe winter weather (extreme cold and prolonged snow cover) is a natural limiting factor but its impacts on over-winter survival are likely exacerbated by kangaroo rats' tendency to colonize roads and trails where there are colder winter microclimates, lower body condition, and they are presumed to have slight or moderately lower over-winter survival than in natural habitats. Projections for future climate change indicate that winter temperature and precipitation in winter and spring will increase in this region. Warmer and wetter winters may mitigate the anthropogenic threat of extreme cold temperatures and prolonged snow conditions on kangaroo rats in anthropogenic habitats; however, this will depend greatly on the timing, distribution and magnitude of these changes in climate.</p> <p>Note: high temperature extremes and drought are not expected to negatively impact kangaroo rats, which are highly adapted for survival in arid conditions and high temperature extremes.</p>
11.4	Storms & flooding						
11.5	Other impacts						

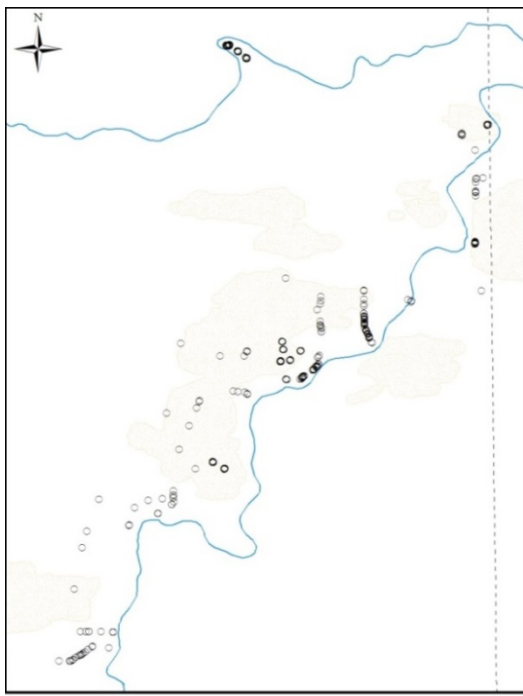
Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008).

## Appendix 2. Map series of Ord's Kangaroo Rat distribution trends for Alberta, 2006 – 2015.

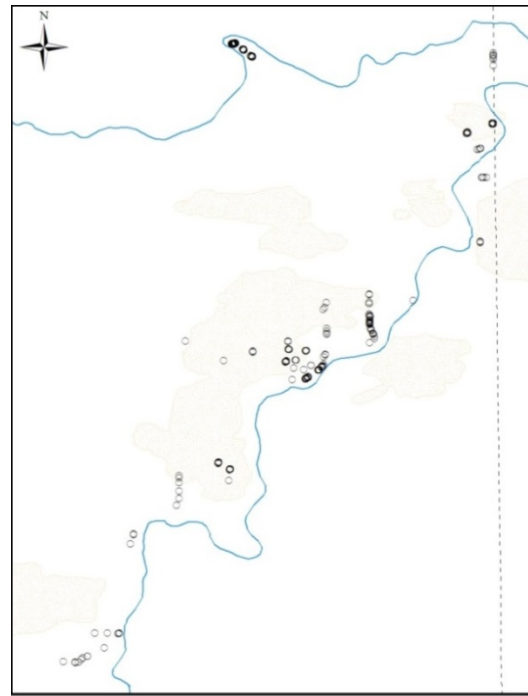
The following maps show the distribution of Ord's Kangaroo Rats in Alberta based on standardized population monitoring at the same sites annually. Circles indicate capture locations where an animal was first observed in the year (i.e., recaptures within the same year are not shown). Blue lines represent the Red Deer River (northernmost blue line) and South Saskatchewan River (south line). Light stippled polygons represent the sandy habitats. The dashed vertical line represents the position of the Alberta-Saskatchewan border.

Saskatchewan is not presented in the maps because no annual population surveys have been conducted in that province. The temporal decline in distribution in Alberta is presumed to be representative of the species in Canada.

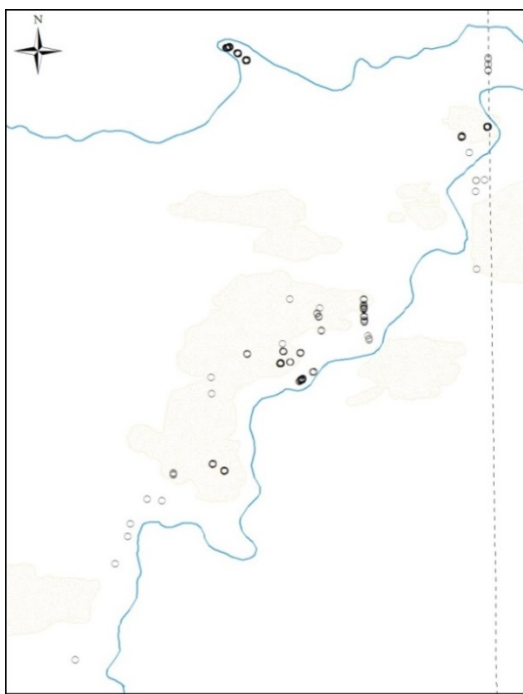




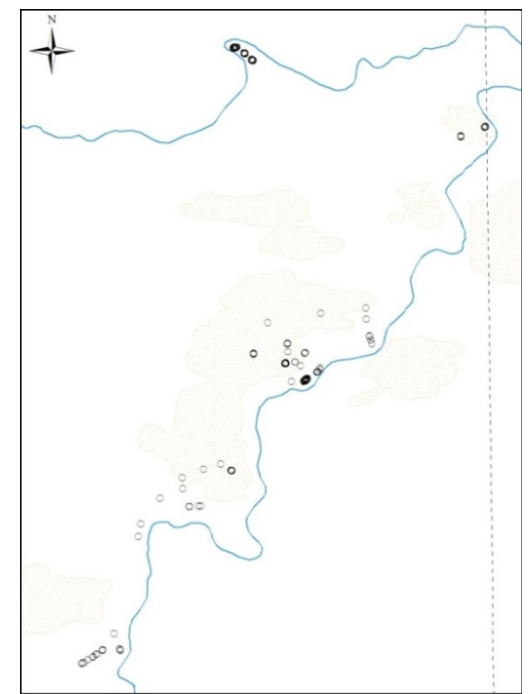
2008



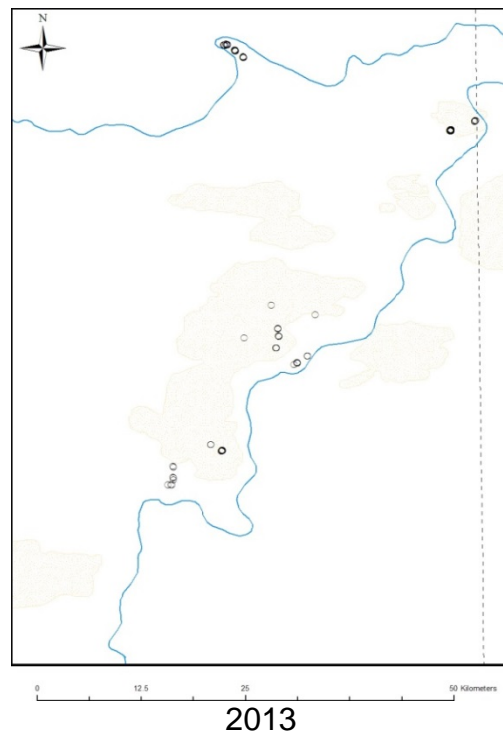
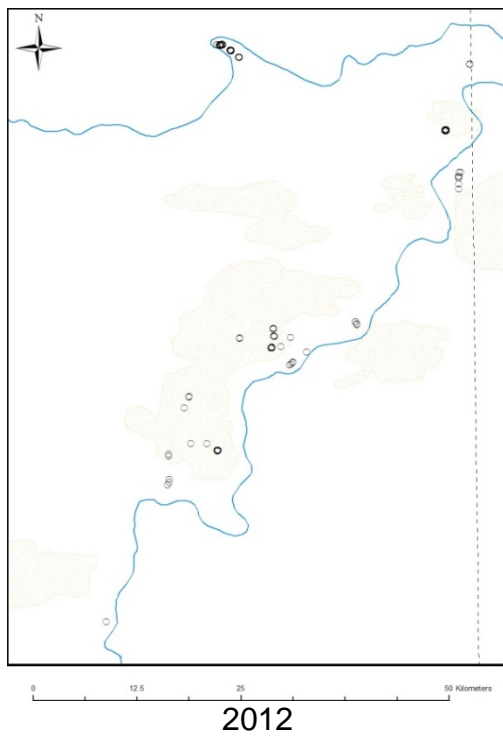
2009

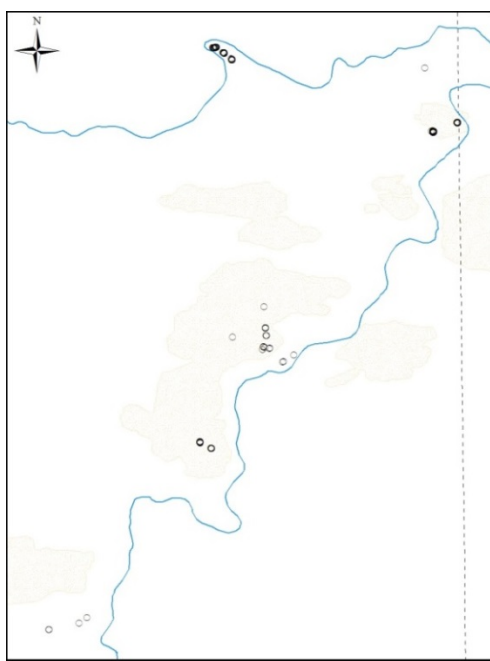


2010

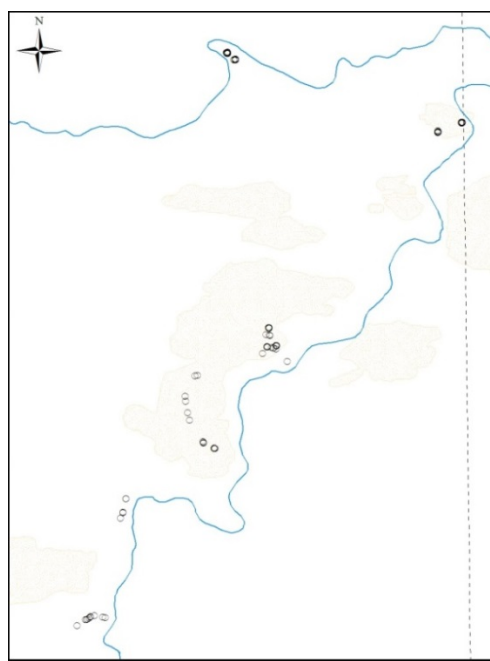


2011





2014



2015