# COSEWIC
# Assessment and Status Report

on the

# Swift Fox
*Vulpes velox*

**in Canada**

**THREATENED**
**2021**

**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:

COSEWIC. 2021. COSEWIC assessment and status report on the Swift Fox *Vulpes velox* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xii + 61 pp. (https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html).

Previous report(s):

COSEWIC. 2009. COSEWIC assessment and status report on the Swift Fox *Vulpes velox* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 49 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC. 2000. COSEWIC assessment and update status report on the Swift Fox *Vulpes velox* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. v + 44 pp.

Carbyn, L.N. 1998. Update COSEWIC status report on the Swift Fox *Vulpes velox* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-44 pp.

Saskatchewan Department of Tourism and Renewable Resources. 1978. COSEWIC status report on the Swift Fox *Vulpes velox* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 7 pp.

Production note:
COSEWIC would like to acknowledge François Blouin for writing the status report on Swift Fox (*Vulpes velox*), in Canada, prepared under contract with Environment and Climate Change Canada. This report was overseen and edited by Stephen Peterson, Co-chair of the COSEWIC Terrestrial Mammals Specialist Subcommittee.

For additional copies contact:

COSEWIC Secretariat
c/o Canadian Wildlife Service
Environment and Climate Change Canada
Ottawa, ON
K1A 0H3

Tel.: 819-938-4125
Fax: 819-938-3984
E-mail: ec.cosepac-cosewic.ec@canada.ca
www.cosewic.ca

Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le Renard véloce (*Vulpes velox*) au Canada.

Cover illustration/photo:
Swift Fox — Cover photo credit: G. Court.


Catalogue No. CW69-14/108-2021E-PDF
ISBN 978-0-660-39578-4

# COSEWIC
# Assessment Summary

**Assessment Summary – April 2021**

**Common name**
Swift Fox

**Scientific name**
*Vulpes velox*

**Status**
Threatened

**Reason for designation**
This small prairie canid was extirpated from Canada in the 1930s. Following reintroduction programs initiated in 1983, it has re-established in southern Alberta and Saskatchewan as well as in Northern Montana. Regular monitoring suggests that the population reached a peak in 2005 but had subsequently declined when surveyed again in 2014/15. The reason for the decline is unknown but suspected to be related to severe winter conditions in 2010/11. Occupancy surveys in 2015 and 2018 suggest the population has remained stable since 2010/11. The species persists at very low numbers. Threats include accidental or intentional poisoning, disease, habitat loss, habitat fragmentation, and severe winters.

**Occurrence**
Alberta, Saskatchewan

**Status history**
Last seen in Saskatchewan in 1928. Designated Extirpated in April 1978. Status re-examined and designated Endangered in April 1998 after successful re-introductions. Status re-examined and confirmed in May 2000. Status re-examined and designated Threatened in November 2009. Status re-examined and confirmed in May 2021.

**COSEWIC**
**Executive Summary**

**Swift Fox**
*Vulpes velox*

## Wildlife Species Description and Significance

Swift Fox (*Vulpes velox*) is one of the smallest canids and one of the fastest mammals in North America, capable of reaching 60 km/h. It has an adult body length of 68–88 cm, a shoulder height of 30–32 cm and a body mass of 1.5–3.0 kg, with males being slightly larger than females. Pelage on the upper body is dark buffy-grey, with sides, legs, and beneath the tail orange-tan, and the undersides buff to pure white. Swift Fox is a grassland specialist and considered an important indicator of the integrity of the short-grass and mixed-grass prairies. Swift Fox have a strong spiritual and cultural significance for the Niitsitapi (Blackfoot Confederacy) and specifically for the Kainai (Blood) Tribe in Alberta, Canada.

## Distribution

The historical range of Swift Fox extended from central Alberta, south to central Texas, and from North Dakota west to central Colorado. In Canada, it originally occurred from the Pembina Hills in Manitoba, across southern Saskatchewan, and west to the foothills of the Rocky Mountains in Alberta. Swift Fox were extirpated from Canada by the 1930s and reintroductions from 1983 to 1997 led to the current distribution. Swift Fox currently occur in the southernmost portion of the prairies on both sides of the Alberta-Saskatchewan border and in and around Grasslands National Park, Saskatchewan. The Canadian and adjacent Montana population is geographically and genetically isolated from the contiguous Swift Fox range in the United States.

## Habitat

Swift Fox inhabit grasslands on level terrain or gently rolling hills, with short, sparse herbaceous vegetation. They prefer relatively dry homogeneous areas and avoid cropland and fragmented habitats. The range of Swift Fox encompasses some of the most modified landscapes in North America, and conversion of at least 70% native prairie to cropland agriculture has been implicated as a primary reason for the historical range contraction of this species. Current estimates indicate that only 19% of the Canadian Prairies ecozone remains as grassland habitat.

## Biology

Swift Fox are opportunistic foragers that eat mammals, birds, insects, plants, and carrion. Swift Fox either dig their own dens or modify those of other species such as American Badger and ground squirrels. They are one of the most burrow-dependent canids and use burrows throughout the year as refugia from predators, protection from extreme weather, shelter to prevent excess water loss, periodic resting cover, and as places to raise young. Females have litters of four and up to eight pups. Pups disperse between 9.5 and 18 months of age over distances typically less than 15 km from the natal area. Swift Fox that survive their first year usually live for 3–7 years. They are territorial, with home ranges in Canada averaging 32 $km^2$ in size. Predation by Coyote is the primary known natural mortality factor in Canada, but Golden Eagles, American Badger, and possibly Red Fox can kill Swift Fox.

## Population Sizes and Trends

The current population of Swift Fox in Canada and adjacent Montana arose from reintroductions. Four systematic winter surveys were conducted between 1996/1997 and 2014/2015 to monitor the population with estimates reaching a high of 1163 foxes (adults and juveniles combined) in 2005/2006. The most recent (2014/2015) population estimate was 523 foxes across a 14,402 $km^2$ survey area in Canada. The number of reproductively mature individuals in Canada was estimated to be 445. An inferred population decline of 45% took place between surveys conducted in 2005/2006 and 2014/2015. Camera trapping in 2015 and 2018 suggested that the population has remained stable at the lower abundance.

## Threats and Limiting Factors

Accidental poisoning from the misuse of toxicants (rodenticides, predacides), road mortality from collision with vehicles, and interspecific competition with and predation by other sympatric canids are currently among the most important threats and limiting factors to Swift Fox in Canada. Diseases are ongoing threats to small canids around the world and this could impact Swift Fox although no significant disease outbreaks have been documented in Swift Fox yet. Limiting factors include predation by Coyote and severe winters. These threats and factors may act singly or synergistically to affect Swift Fox survival, reproductive success, and distribution.

## Protection, Status and Ranks

Swift Fox is listed as Threatened within Schedule 1 of the *Species at Risk Act*, and as Endangered under the Alberta *Wildlife Act* and the Saskatchewan *Wildlife Act* (and associated *Wild Species at Risk Regulations*). The International Union for the Conservation of Nature (IUCN) lists the species as “Least Concern”. Under the General Status of Wild Species 2015, Swift Fox was listed as Imperilled in Canada, Critically Imperilled to Imperilled in Alberta, Vulnerable in Saskatchewan, and Presumed Extirpated in Manitoba. NatureServe ranks Swift Fox as Vulnerable across its global distribution and as Vulnerable to Critically Imperilled in Canada. The Alberta Conservation Information Management System also ranks Swift Fox as Critically Imperilled to Imperilled, the Saskatchewan Conservation Data Centre as Vulnerable, and the Manitoba Conservation Data Centre as Presumed Extirpated. A recovery strategy for Swift Fox is available and Critical Habitat has been identified in southwestern Saskatchewan and in Grasslands National Park under two multi-species action plans.

## TECHNICAL SUMMARY

*Vulpes velox*

Swift Fox

Renard véloce

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) | 2 yrs |
| Is there an [observed, inferred, or projected] continuing decline in number of mature individuals? | Unknown but presumed stable<br>*Catch and release-trapping indicate a decline between 2005 and 2014. Camera trapping data suggests population may have been stable between 2015 and 2018.* |
| Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations] | Unknown but *presumed stable between 2015 and 2018.* |
| [Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations]. | Unknown<br>*Reduction in the index of abundance (presence in townships) between 2005/2006 and 2014/2015 but presumed to be stable between 2015 and 2018.* |
| [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. | Unknown |
| Are the causes of the decline a. clearly reversible and b. understood and c. ceased? | a. Unknown<br>b. No<br>c. Unknown |
| Are there extreme fluctuations in number of mature individuals? | No |

**Extent and Occupancy Information**

| | |
|---|---|
| Estimated extent of occurrence (EOO) | 6,405 $km^2$<br>*14,713 $km^2$ (Canadian and contiguous Montana population).* |
| Index of area of occupancy (IAO) | 4,411 $km^2$ |

| | |
|---|---|
| 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. No<br>b. No |
| Number of "locations"* (use plausible range to reflect uncertainty if appropriate) | Unknown but likely >10 |
| Is there an [observed, inferred, or projected] decline in extent of occurrence? | Unknown |
| Is there an [observed, inferred, or projected] decline in index of area of occupancy? | No |
| Is there an [observed, inferred, or projected] decline in number of subpopulations? | Not Applicable |
| 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? | No |
| 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)** | **N Mature Individuals** |
|---|---|
| *Canada: 0.85 X 522.9±115.2 (SE)*<br><br>*(estimated proportion of reproductively active individuals) X (estimated overall abundance using spatially explicit capture-recapture estimation (SECR), which differs from method used in 2009 assessment). See "Abundance" section.* | 445 |

**Quantitative Analysis**

| | |
|---|---|
| Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]? | N/A |

* See Definitions and Abbreviations on COSEWIC web site and IUCN (Feb 2014) for more information on this term

**Threats (direct, from highest impact to least, as per IUCN Threats Calculator)**

| |
|---|
| Was a threats calculator completed for this species?<br>Yes, June 2019 (Appendix 1)<br><br>Overall threat impact: High<br><br>Key threats were identified as:<br>i. IUCN 9. Pollution: high - medium threat impact<br>Accidental direct or secondary poisoning from legal or illegal rodenticides or predacides use.<br>ii. IUCN 8. Invasive and other problematic species and genes: medium threat impact<br>transmission of disease from domestic dogs to wild canids or among wild canids in the ecosystem.<br>iii. IUCN 2. Agriculture and aquaculture: low threat impact<br>Habitat loss resulting from changes in government policies which creates uncertainty about future integrity of native prairie in former community pastures.<br>iv. IUCN 3. Energy production and mining: low threat impact<br>Loss, degradation, and fragmentation of habitat related to energy production and reduced reproductive success from disturbance.<br>v. IUCN 4. Transportation and service corridors: low threat impact<br>Potential for 24 hr border crossing to significantly increase traffic on major north-south route.<br>vi. IUCN 7. Natural system modifications: low threat impact<br>Droughts or severe winters, which can limit food availability, lower survival and/or reproductive success, and increase competition with other canids.<br>vii. IUCN 11. Climate change: low threat impact<br>Climate change mediated habitat shifting and alteration, storms and flooding, and temperature extremes.<br><br>What additional limiting factors are relevant?<br><br>Intraguild predation and competition (Red Fox, Coyote), and prey availability which may interact synergistically with some of the above threats. |

**Rescue Effect (immigration from outside Canada)**

| | |
|---|---|
| Status of outside population(s) most likely to provide immigrants to Canada.<br><br>*Expected that population trend in contiguous Montana will generally be consistent with population trends in Canada.* | Overall contiguous Montana population: 346.9 ± 79.5 foxes (~295 mature individuals) |
| Is immigration known or possible? | Yes, between Canada and Montana within the northern range segment but not between the northern and southern portions of the range |
| Would immigrants be adapted to survive in Canada? | Yes |
| Is there sufficient habitat for immigrants in Canada? | Yes |
| Are conditions deteriorating in Canada?+ | No |
| Are conditions for the source (i.e., outside) population deteriorating?+ | No |

+ See Table 3 (Guidelines for modifying status assessment based on rescue effect)

| | |
|---|---|
| Is the Canadian population considered to be a sink?[+] | No |
| Is rescue from outside populations likely? | Yes, but limited. The contiguous Canada-Montana are demographically linked and experience similar threats. |

**Data Sensitive Species**

| | |
|---|---|
| Is this a data sensitive species? | No |

**Status History**

| |
|---|
| COSEWIC: Last seen in Saskatchewan in 1928. Designated Extirpated in April 1978. Status re-examined and designated Endangered in April 1998 after successful re-introductions. Status re-examined and confirmed in May 2000. Status re-examined and designated Threatened in November 2009. Status re-examined and confirmed in May 2021. |

**Status and Reasons for Designation:**

| **Status:**<br>Threatened | **Alpha-numeric codes:**<br>D1 |
|---|---|
| Reasons for designation: This small prairie canid was extirpated from Canada in the 1930s. Following reintroduction programs initiated in 1983, it has re-established in southern Alberta and Saskatchewan as well as in Northern Montana. Regular monitoring suggests that the population reached a peak in 2005 but had subsequently declined when surveyed again in 2014/15. The reason for the decline is unknown but suspected to be related to severe winter conditions in 2010/11. Occupancy surveys in 2015 and 2018 suggest the population has remained stable since 2010/11. The species persists at very low numbers. Threats include accidental or intentional poisoning, disease, habitat loss, habitat fragmentation, and severe winters. | |

**Applicability of Criteria**

| |
|---|
| Criterion A (Decline in Total Number of Mature Individuals):<br>Not Applicable. May meet Threatened A2b but camera trapping surveys between 2015 and 2018 and data from adjacent Montana suggest that the population has not continued to decline since the suspected harsh-winter die-off in 2010/11. |
| Criterion B (Small Distribution Range and Decline or Fluctuation):<br>Not Applicable. Below the threshold for Threatened B1 with an EOO of 10,998 $km^2$ but no continuing decline and no identified threat that could rapidly affect the entire Canadian population, thus more than 10 locations. |
| Criterion C (Small and Declining Number of Mature Individuals):<br>Not Applicable. All individuals are part of a single population with fewer than 1000 mature individuals, but camera trapping surveys between 2015 and 2018 and data from adjacent Montana suggest that the population has not continued to decline since the suspected harsh winter die-off in 2010. |
| Criterion D (Very Small or Restricted Population):<br>Meets Threatened, D1, Number of mature individuals estimated to be 445. |
| Criterion E (Quantitative Analysis):<br>Not applicable. No quantitative analysis was performed. |

[+] See Table 3 ( Guidelines for modifying status assessment based on rescue effect)

## PREFACE

Since the last assessment by COSEWIC in 2009, there has been one intensive capture-mark-recapture session in the winter of 2014/15 and two camera trapping sessions in the summers of 2015 and 2018. The 2014/15 session identified a significant decline in Swift Fox abundance which was thought to be due to a severe winter in 2010/11. The camera trapping surveys suggested that the population remained low but stable between 2015 and 2018.

Road mortality, accidental poisoning from the misuse of toxicants (rodenticides and predacides), and changes in the dynamics of interspecific competitors brought about by anthropogenic factors are thought to be important threats to the Swift Fox. Changes in federal and provincial government policies regarding community pastures since 2009 have brought uncertainty about the future of large tracts of native grassland in Swift Fox range that were previously maintained as compatible pasture land. Many of these tracts of land are now part of 15-year leases. While oil and gas development has previously been extensive in the Canadian Swift Fox range, it has largely subsided during this period, due in part to low commodity prices.

As part of the Recovery Strategy for the Swift Fox, critical habitat has been identified in Grasslands National Park, Saskatchewan, and in an area known as "South-of-the-Divide", representing the Saskatchewan portion of the Milk River drainage basin. In addition, multiple species action plans have been developed for those areas to conserve the Swift Fox and other species at risk, and their supporting habitats, through collaboration with land owners and other stakeholders. Critical habitat is awaiting identification in Alberta.

The contiguous Canada-Montana Swift Fox population was found to exist as two clusters ('eastern', 'western') based on genetic differences. These clusters reflect the geographical distribution of the original reintroduction sites around Grasslands National Park and the Alberta-Saskatchewan border. They are indicative of reduced gene flow between the two areas, possibly due to habitat characteristics that limit dispersal.

## 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
## (2021)

| | |
|---|---|
| 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.

Environment and Climate Change Canada
Canadian Wildlife Service

Environnement et Changement climatique Canada
Service canadien de la faune

Canada

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

# COSEWIC Status Report

on the

# Swift Fox
*Vulpes velox*

**in Canada**

2021

## TABLE OF CONTENTS

**List of Figures**



**List of Appendices**

# WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

## Name and Classification

Scientific name: *Vulpes velox*, Say 1823

English name: Swift Fox

French name: Renard véloce

Aboriginal names: Senopah (Aamsskaapi Piikani [Blackfeet Nation]), Sinopaa (Kainai [Blood Tribe])

Classification: Class – Mammalia

Order – Carnivora

Family – Canidae

Genus – Vulpes

First described by Say (1823) as *Canis velox* (see Thwaites 1905), Swift Fox was re-assigned to the genus *Vulpes* by Audubon and Bachman (1851), and their status as a full species has been validated by genetic work (Mercure *et al.* 1993). Merriam (1902) gave subspecific designations of *V. v. hebes* (northern Swift Fox; Canada and northern United States [US]) and *V. v. velox* (southern Swift Fox; southern range in US). Despite significant geographic variation in morphology within the species, these subspecific assignments are not considered valid (Stromberg and Boyce 1986; Dragoo *et al.* 1990).

## Morphological Description

Swift Fox are one of the smallest North American canids, measuring 68–88 cm in length (including the tail), standing 30–32 cm at the shoulder, and with a body mass of 1.5–3.0 kg. On average, males are 8% larger than females. Winter pelage is long and dense, with dark buffy-grey upper parts, orange-tan sides, legs, and ventral surface of the tail, with buff to pure white fur underneath; summer pelage is shorter and more reddish. Swift Fox have black patches on either side of the muzzle and a black-tipped tail, which along with their small size and light colouration, distinguish them from all other foxes in Canada (Naughton 2012). Swift Fox in Canada are not known to exhibit distinct colour phases (Cypher 2003).

## Population Spatial Structure and Variability

Results of analyses from genotyped hair samples collected during live-trap surveys of Swift Fox in 2001/2002 and 2005/2006 showed the presence of two genetic clusters in the Alberta, Saskatchewan, and adjacent Montana area (Cullingham and Moehrenschlager

2013; 2019). The east and west genetic clusters generally match the geographic locations of original Swift Fox release sites in Canada even though efforts were made during the reintroductions to ensure both locations were founded from similar mixed sources (Carbyn 1998). Agriculture (crop production) was a factor believed to limit gene flow between some populations in the US (Schwalm *et al.* 2014). However, Cullingham and Moehrenschlager (2019) reported that the distribution of cropland did not explain the two genetic clusters, but there was a relationship between gene flow and terrain ruggedness and isolation by distance. Genetic analyses measured with 18 microsatellite loci over the two survey periods indicated that the Canada-Montana population was genetically diverse (i.e., a relatively high heterozygosity $H_o$: 0.476-0.858) and showed a growing total effective population in the absence of ongoing released animals (Cullingham and Moehrenschlager 2013; 2019).

## Designatable Units

The species is considered to be a single designatable unit in Canada. No subspecies designation is currently recognized under *V. velox* (Mercure *et al.* 1993). Temporal genetic analysis of the Canada-northern Montana population three years after the reintroduction program ended, showed high genetic diversity, a growing effective population size, and evidence of two genetic clusters (see **Population Spatial Structure and Variability** section above). The observed structure is thought to have arisen from founder effects of the reintroduction locations and/or the presence of a dispersal barrier between the two clusters and limited genetic mixing (Cullingham and Moehrenschlager 2019). Long-distance dispersal up to nearly 200 km has been observed (Ausband and Moehrenschlager 2009) but is thought to be rare for the species. Swift Fox typically disperse within about 15 km (Moehrenschlager 2000; Sovada *et al.* 2003), which would limit gene flow between groups separated by unsuitable habitat. East and west subpopulations are still highly related, and differences are thought to have arisen in part from human-related habitat fragmentation; therefore, the two clusters are not considered “discrete”.

## Special Significance

Swift Fox are one of the smallest canids and one of the fastest mammals on the North American prairies, running up to 60 km/h (Moehrenschlager and Sovada 2004). It is also one of the few canids in North America to use dens throughout the year. It is a specialist of short-stature grasslands (Egoscue 1979; Gese and Thompson 2014) and as such, it is considered an important indicator species of the former extent of short-grass and mixed-grass prairies (Sovada *et al.* 2009). As a wide-ranging meso-predator in Canada negatively impacted by habitat fragmentation (Moehrenschlager *et al.* 2007a), its continued presence attests to the intactness and the functioning of the remaining short and mixed grassland ecosystems.

Swift Fox has strong spiritual and cultural significance for the Kainai (Blood Tribe) in Alberta (Pruss *et al.* 2008) and the Aamsskaapi Piikani (Blackfeet Nation) in Montana, USA (Waters *et al.* 2007).

## DISTRIBUTION

### Global Range

Historically, Swift Fox occurred in mixed- and short-grass prairies from southern Alberta, Saskatchewan, and Manitoba, south to New Mexico and Texas, and from North Dakota west to Montana (Figure 1; Moehrenschlager and Sovada 2016) – an estimated range of approximately 1.5 million km$^2$ (Sovada *et al.* 2009).

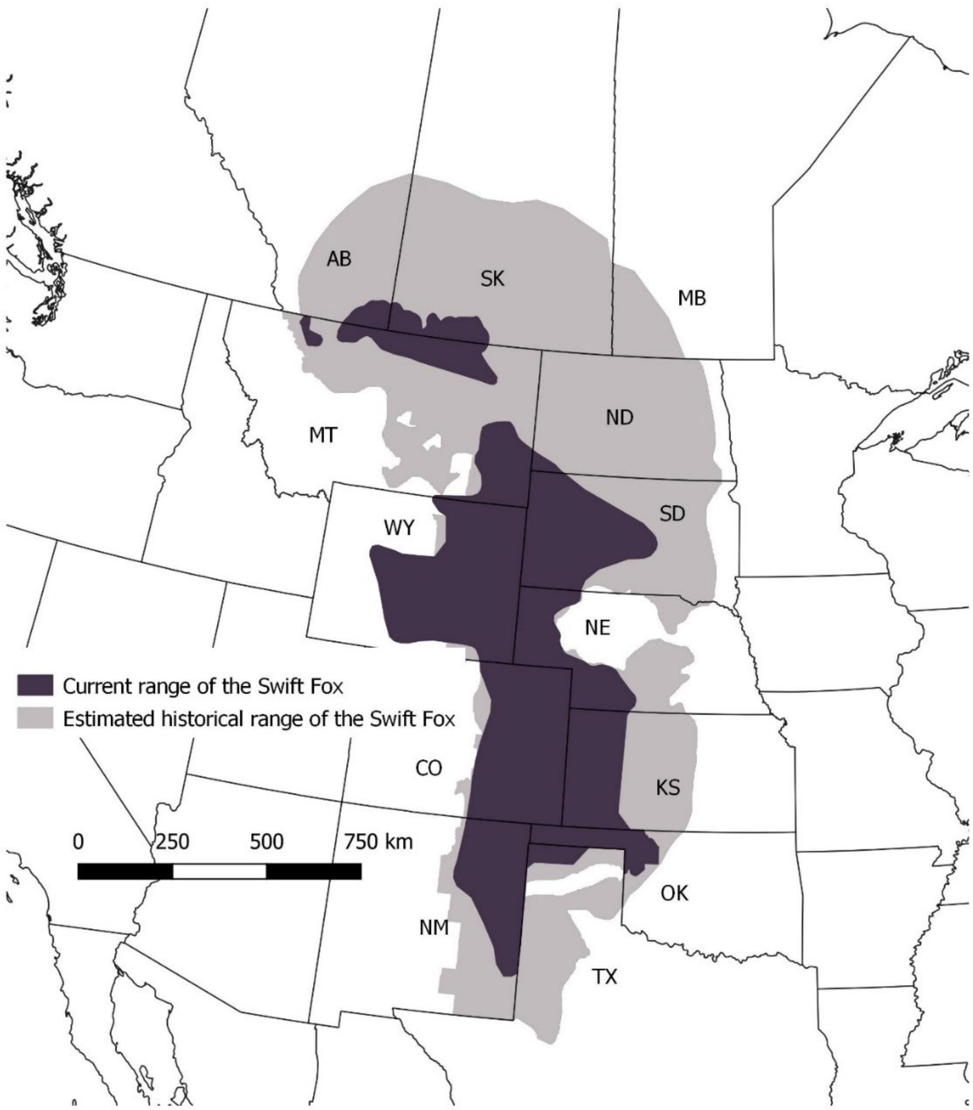


Figure 1. Estimated historical (from USGS and IUCN 2016) and current Swift Fox distribution in North America (from Figure 2, Harrison *et al*. 2004; NENHP 2011; Schwalm *et al.* 2012; USGS and IUCN 2016; Bly pers. comm. 2018; Bjornlie pers. comm. 2018; Dowd Stukel pers. comm. 2018; CONHP 2018; Schmidt *et al.* 2018; Montana Field Guide 2019; NDGFD 2019). Map prepared by F. Boulin.

The most dramatic reductions in the range of Swift Fox occurred in the mid-1800s to the early-1900s due to the activities of European settlers on the Great Plains. By the late 1950s Swift Fox started to show signs of recovery in some core areas of its historical range. By 2006, Swift Fox was estimated to occupy about 30% of its historical North American range (Sovada *et al.* 2009).

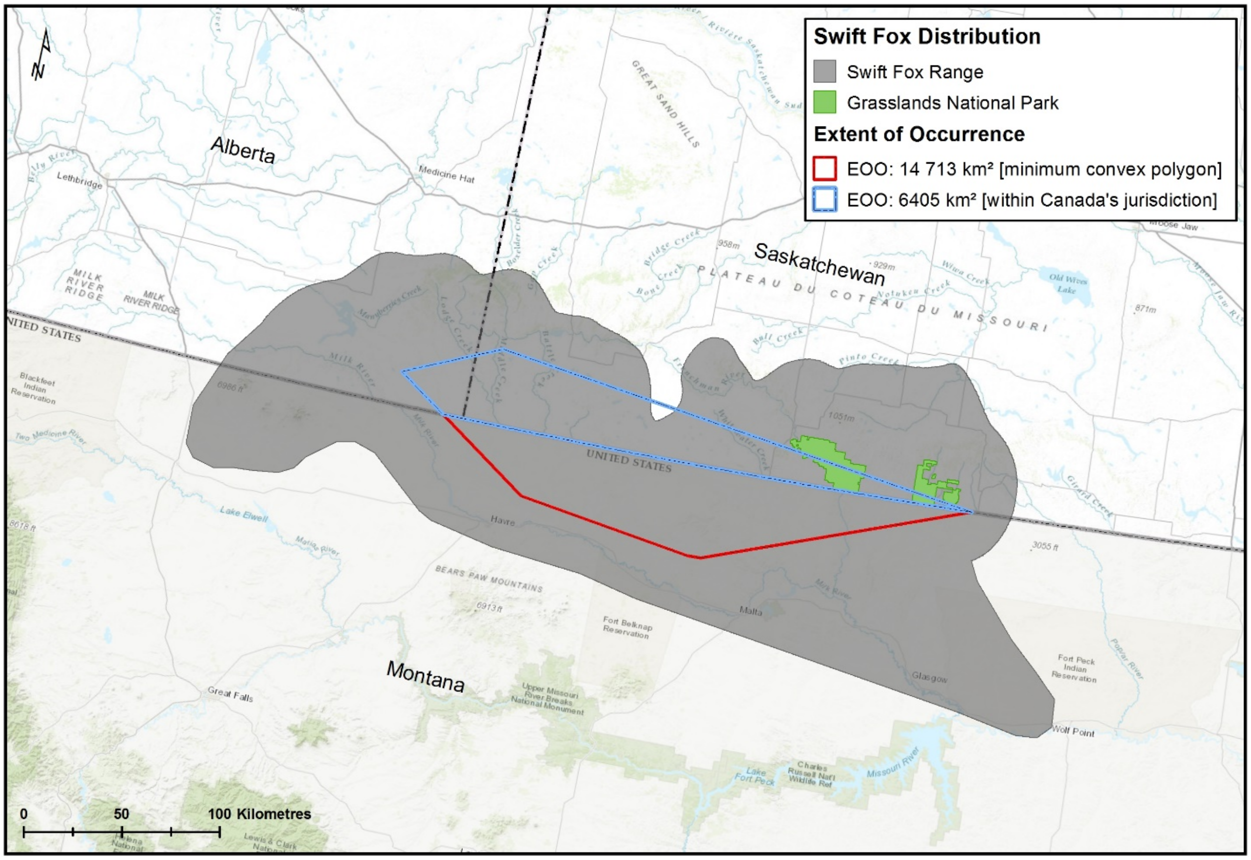


Figure 2. Map of current Swift Fox distribution and extent of occurrence (EOO) in Canada and northern Montana. EOO boundaries are based on the 2018 camera trap survey data of Swift Fox detections (Moehrenschlager *et al.* 2020). Map prepared by S. Allen.

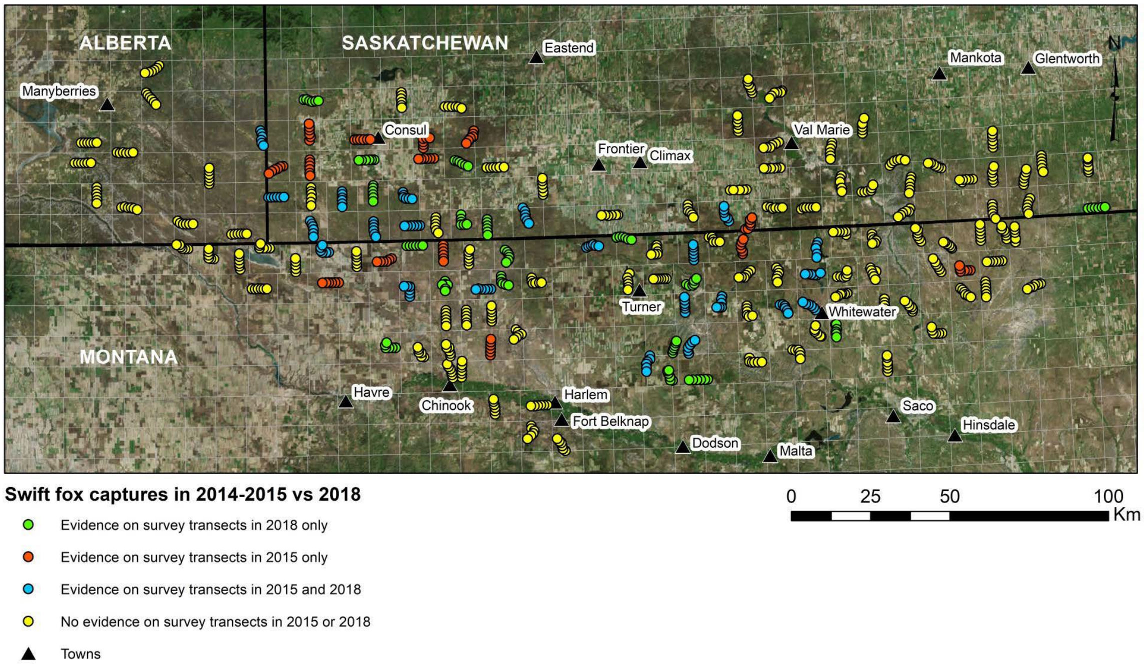


Figure 3. Evidence of Swift Fox on townships that were replicated in 2014/2015 (from release-trapping or camera trapping) and in 2018 (from camera trapping only) (from Moehrenschlager *et al.* 2020).

## Canadian Range

Prior to 1900, the Canadian distribution of Swift Fox likely approximated what is now recognized as the Mixed and Moist Mixed Grassland Ecoregions of the Prairies Ecozone (ESTR Secretariat 2014) in southern Alberta and Saskatchewan, and possibly the southwestern corner of Manitoba, an area that extends from the Pembina Hills in Manitoba west to the foothills of the Rocky Mountains in Alberta (Figure 1; Carbyn *et al.* 1994). The northern distributional limit in Canada was originally the 53$^{rd}$ parallel in Alberta. Sovada *et al.* (2009) estimated the historical Canadian range to be 362 436 km$^2$, or 25% of its North American range. Swift Fox was extirpated from Canada and the last specimen was collected in 1928 near Govenlock, Saskatchewan, 14 km east of the Alberta border and 28 km north of the US border (Carbyn 1998). A sighting near Manyberries, Alberta in 1938 was reported in a 1950 newspaper article (Pied Piper 1950).

From 1983 to 1997 reintroduction efforts through captive breeding and translocation from the US allowed a Swift Fox population to become established in two areas of southwestern Saskatchewan and southeastern Alberta. As the population grew, it expanded into adjacent north-central Montana (Moehrenschlager and Sovada 2016). Observations outside the core range in Canada have been made in the Yorkton, Hudson Bay, Saskatoon, Battlefords, and Wynyard areas in Saskatchewan and in Banff National Park, Alberta (Bilyk pers. comm. 2017; Keith pers. comm. 2017). The current Canadian and adjacent Montana population is geographically and genetically isolated from the rest of the Swift Fox range in the United States (Figure 1; Schwalm *et al.* 2014; Alexander *et al.* 2016).

## Search Effort

Data on the distribution of Swift Fox in Canada and adjacent northern Montana come from various sources. They come from targeted surveys or incidental encounters, pre-industrial development surveys, academic or other research work added to the Alberta Fish and Wildlife Management Information System, the Saskatchewan Conservation Data Centre database, and Parks Canada Agency's database for Grasslands National Park. Four standardized capture-mark-recapture (hereafter mark-recapture) and sign surveys have been conducted between 1996/1997 and 2014/2015 during winter months in Alberta, Saskatchewan, and adjacent northeastern Montana to assess population status and distribution (Moehrenschlager and Moehrenschlager 2018). The original Canadian Swift Fox population's suspected range was determined by the National Swift Fox Recovery Team in 1996 and comprised 108 townships in Canada, of which about 75% were randomly selected for subsequent sampling (Cotterill 1997). An additional 80 townships (75% were randomly sampled) were added in Montana in 2000/2001, 49 in 2005/2006, and another 19 in 2014/2015, for a combined total of 256 townships (Moehrenschlager and Moehrenschlager 2018). In 2014/2015, 189 townships were sampled in Canada and Montana (102 in Canada), including sites in 170 townships that had been surveyed in 2005/2006 and 19 new townships. Both mark-recapture and camera-trapping were used for the survey, with some townships surveyed using both techniques for comparison. Mark-recapture trapping was conducted in 94 townships (42 in Canada) and camera-trapping in 133 townships (98 in Canada) in a minimum convex polygon area of 32,608.5 km$^2$ (Moehrenschlager and Moehrenschlager 2018). An additional round of camera trapping following the methods and placement of the 2014/2015 survey was conducted in the summer of 2015 and 2018 (Moehrenschlager *et al.* 2020).

## Extent of Occurrence and Index of Area of Occupancy

<u>Canada:</u>

The extent of occurrence (EOO) of the Canadian segment of the Swift Fox population as calculated from the 2014/2015 survey data, covered 10,998 km$^2$ (Figure 2). This is a 22% decrease from 14,038 km$^2$ calculated in 2005/2006. The EOO for sample locations with Swift Fox detections in 2018 is estimated at 6,405 km$^2$ (Moehrenschlager 2021 pers. comm.). These estimates are not directly comparable, but the number of townships with Swift Fox presence detected in the 2015 and 2018 can serve as an index of change in distribution. In both surveys, 67 townships were replicated and 17 and 16 townships had detections in 2015 and 2018, respectively (Moehrenschlager *et al.* 2020).

The index of area of occupancy (IAO) for the Canada portion of the range remained relatively stable between 2005/2006 (4,655 km$^2$) and 2014/2015 (4,411 km$^2$) (Moehrenschlager and Moehrenschlager 2018). The IAO was calculated by Moehrenschlager and Moehrenschlager (2018) for 2014/2015 (and recalculated for 2005/2006) as follows: 1) initial captures from mark-recapture and camera-trapping were plotted; 2) all trap sites on transects that had captures were buffered by 3.19 km (approximate radius of 32 $km^2$ Swift Fox home range – inferred occupation) and the number of 2 x 2-km grid cells overlapped by occupied buffer zones were identified; 3) the number of inferred occupied grid cells was adjusted using a probability of detection of 0.865, which is the average of estimated mark-recapture and camera-trapping samples; 4) the proportion of occupied grid squares was determined by dividing the number of squares inferred in step #3 by those determined in step #2; 5) the total number of grid squares overlapping the sampled population was counted; 6) the proportion of occupied grid squares from step #4 was multiplied by the total number of grid squares comprising the Swift Fox study area; and 7) the number of grid squares inferred to have Swift Fox presence was multiplied by 4 $km^2$ to obtain the IAO.

Montana:

The EOO of the Montana segment of the Swift Fox population from the 2014/2015 survey data covered 6,916 $km^2$. This is a 40% decrease from 11,495 $km^2$ calculated in 2005/2006. The IAO in Montana also showed a decrease of 54% between the two survey periods, from 4,314 $km^2$ in 2005/2006 to 1,999 $km^2$ in 2014/2015, largely due to fewer occupied townships in 2014/2015 (Moehrenschlager and Moehrenschlager 2018).

Canada/Montana:

The EOO of the entire Canada-Montana population of Swift Fox as calculated from the last survey (2014/2015) covered 19,779 $km^2$. This is a decrease of 10% from the 21,954 $km^2$ calculated in 2005/2006. The EOO for the area sampled in 2018 is 14,713 $km^2$ (Moehrenschlager 2021 pers. comm.). However, the 2014/2015 and 2018 EOOs cannot be directly compared as the 2018 EOO does not include off transect effort that was previously included. The IAO for the entire Canada-Montana range decreased by 29% between 2005/2006 and 2014/2015 from 8,969 $km^2$ to 6,410 $km^2$, largely due to a reduced number of occupied areas in Montana in 2014/2015 (Moehrenschlager and Moehrenschlager 2018). The IAO from sample locations with Swift Fox detection in 2018 is 2,928 $km^2$, although this estimate cannot be directly compared to previous estimates (Moehrenschlager 2021 pers. comm.).

# HABITAT

## Habitat Requirements

Primary habitat for Swift Fox is short- or mixed-grass prairie on level or gently rolling terrain (Moehrenschlager and Sovada 2016). Individuals usually select areas where vegetation is short (30 cm or less) and sparse, and with minimal elevational changes or topographic features such as canyons, steep hills, or coulees (Whitaker 1997; Russell 2006; Moehrenschlager *et al.* 2007a) but will sometimes select slightly raised sites within those areas to den (Pruss 1999; Tannerfeldt *et al.* 2003). Those areas offer greater visibility and mobility, facilitating prey hunting and detection and evasion of predators (Sovada *et al.* 2009).

In Canada and adjacent Montana, Swift Fox prefer native grassland over cropland (Carbyn 1998). In other regions of the range, Swift Fox have adapted to atypical habitats [e.g., mixed agricultural areas (Moehrenschlager and Sovada 2016), sagebrush steppe and short-grass prairie transition (Olson and Lindzey 2002), and piñon-juniper habitat (Covell 1992)]. In Kansas, for example, Swift Fox use fallow wheat or milo fields, winter wheat fields, and dryland crop fields (most fields fallowed every other year) and exhibited similar survival rates and home range sizes to those living in native prairie habitat (Sovada *et al.* 2003). Farmlands within the range of Swift Fox in Canada do not appear to be similarly usable. Annual crop production and associated tillage, or other potential ecological factors, such as the abundance of competing Red Fox (Moehrenschlager *et al.* 2004) may preclude their use by Swift Fox (Moehrenschlager *et al.* 2007a). Availability of mixed-grass prairie in Alberta and Saskatchewan therefore appears critical to sustain this reintroduced population (Carbyn 1998).

Dens are a fundamental element of habitat for this canid, and several are used throughout the year (Allardyce and Sovada 2003). Den distribution and density is important in terms of providing shelter for rearing young, providing protection against extreme climate conditions and for avoiding Coyote (*Canis latrans*) or Golden Eagle (*Aquila chrysaetos*) predation (Tannerfeldt *et al.* 2003; Moehrenschlager *et al.* 2007b). Two types of dens are recognized: natal dens, where young are born and raised and shelter dens that provide protection from weather extremes and escape refugia from predators (Tannerfeldt *et al.* 2003). Natal dens typically have a more complex structure with several entrance holes (four in top 75% quartile in Canada; Pruss 1999), while shelter dens may have only one opening (Tannerfeldt *et al.* 2003). Use of up to 14 dens in a season has been recorded (Kitchen *et al.* 1999). The highest number of dens is used during the pup-rearing season (Schauster *et al.* 2002). Pairs in Canada have been documented to use up to eight different den sites during the pup whelping/rearing period (Pruss 1994; Tannerfeldt *et al.* 2003). Den shifts, typically less than 500 m in Canada, are frequent (Pruss 1994; Tannerfeldt *et al.* 2003). However, a pair in the Alberta-Saskatchewan border area was observed moving a litter of seven pups across a highway to a new den 1.9 km from their original one (Tannerfeldt *et al.* 2003).

The presence of fossorial species, like American Badger (*Taxidea taxus*), ground squirrels (*Urocitellus* spp.), and prairie dogs (*Cynomys* spp.) in Swift Fox habitat is therefore desirable, providing burrows, which they may readily modify (Tannerfeldt *et al.* 2003). However, they may use unmodified badger or similar sized holes as shelter dens (Moehrenschlager *et al.* 2007b) or excavate their own dens (Hillman and Sharps 1978). Anthropogenic habitats have also been used for denning such as roadsides, culvert pipes, cemeteries, and farm buildings (Kilgore 1969; Hillman and Sharps 1978; Tannerfeldt *et al.* 2003). In Canada, badger excavations appear to be their main source of burrows (Pruss 1999; Moehrenschlager *et al.* 2007b) with badger burrow density being directly related to the density of ground-squirrel openings (Proulx *et al.* 2011).

Moehrenschlager *et al.* (2007a) analyzed population survey data to assess critical habitat characteristics that predict Swift Fox occurrence. They developed model parameters from winter live-trap survey data collected in Alberta, Saskatchewan, and Montana between 15 October 2005 and 15 February 2006. They also used satellite image data from August 1999 and September/October 2000 to assess 15 environmental variables in the trapping area that might be useful in predicting Swift Fox distribution. Four habitat parameters successfully explained variation in Swift Fox presence: moisture, topography, cropland, and habitat fragmentation. Swift Fox primarily occurred in relatively dry areas and tended to avoid areas with large elevation changes, preferring habitats with gently sloping terrain. Cropland and the presence of Swift Fox were negatively associated. Swift Fox also avoided fragmented landscapes, edge habitats, and roads. Habitat parameters affected the occurrence of Swift Fox more than 5 km from their capture site, likely owing to home range size (Moehrenschlager *et al.* 2007a). From October 2008 to April 2009, A. Moehrenschlager conducted surveys with scent-post camera-traps in 32 previously sampled and 28 unsampled townships in the western half of the Canadian Swift Fox range. Results from this effort suggest that the model is not only predictive of fox presence/absence among surveys, but also highly predictive of Swift Fox presence in previously unsurveyed regions (A. Moehrenschlager in COSEWIC 2009).

Home ranges of Canadian and Montana Swift Fox are among the largest in the species' range. Average home range size of 36 Swift Fox in the Alberta-Saskatchewan border region was 40.8 ± 6.1 $km^2$, based on the adaptive kernel (ADK) method (Worton 1989) (31.9 ± 4.8 $km^2$ based on the fixed kernel method [FK; Seaman and Powell 1996]; Moehrenschlager *et al.* 2007b). In north-central Montana, Zimmerman *et al.* (2003) estimated ADK home ranges between 8.7 $km^2$ and 20.3 $km^2$ for five individuals. In north-eastern Montana, Swift Fox home ranges were similar to those in Canada at 42.0 ± 4.7 $km^2$ (FK; Butler *et al.* 2020). In western Kansas, Sovada *et al.* (2003) estimated an average home range of 15.9 ±1.6 $km^2$ (ADK) for 21 adult Swift Fox, with similar estimates in both cropland and rangeland.

## Habitat Trends

The substantial conversion of native prairie habitats to farmland was one of the main contributors to the decline in Swift Fox across the Great Plains of North America (Egoscue 1979). Sovada *et al.* (2009) estimated the historical range of Swift Fox largely based on the extent of shortgrass and mixed-grass prairie ecosystems but also based on published accounts and historical records of Swift Fox and expert opinion. They determined that about 39% of high-quality (short to medium height perennial grass without shrubs) and 10% of less suitable (medium height perennial grass with sparse shrubs or tall grass) grassland habitats were still available from the estimated historical range of 1.5 million $km^2$. They considered an additional 25% of agricultural lands predominantly under dryland cropping practices as potentially suitable habitats. They estimated that in the remaining 39% of high-quality grassland habitat, 41% (sampling units: counties in the United States, townships in Canada) of those were occupied by Swift Fox. In Canada alone, they estimated that 39% of the former 362,436 $km^2$ Swift Fox range still contained high-quality grassland habitats and about 5% was occupied by the species (Sovada *et al.* 2009).

The Ecosystem Status and Trends Report (ESTR) Secretariat (2014) reported that an estimated 70% of the native prairie vegetation in the 465,094 $km^2$ Prairies Ecozone was lost prior to the 1990s (most of it prior to the 1930s, due to conversion to cropland) and that less than 25% of the ecozone remained as native grassland. Using agriculture census data from Statistics Canada, the ESTR Secretariat (2014) considered that the percentage of "natural land for pasture" decreased from 27% in 1971 to 24% in 1986 and remained around that level until at least 2006. However, grassland loss continues; an overall 10% loss of native grasslands was recorded on transects in some parts of the Prairies Ecozone between 1985 to 2001 (ESTR Secretariat 2014).

A recent predictive model of Swift Fox occurrence was developed by Parks Canada and A. Moehrenschlager using the preliminary approach of Moehrenschlager *et al.* (2007a) to identify critical habitat for the species. Fourteen summer landscape-scale habitat variables were analysed within 3 km of Swift Fox captures using data from the 2005/2006 winter mark-recapture survey. Results tested using previous and subsequent winter survey data (1996/1997, 2000/2001, 2008/2009) indicated that 53% (approx. 8765 $km^2$) of the total area of the species' range provided habitat attributes that were suitable to contain 89% of Swift Fox occurrences (Parks Canada Agency 2016), which is about 2.4% of the former Swift Fox range, as estimated in Sovada *et al.* (2009).

# BIOLOGY

## Life Cycle and Reproduction

The life cycle of Swift Fox varies with latitude. In the southern portion of their range, they breed from December to early January (Kilgore 1969) and as late as mid-February to March in Canada (Asa and Valdespino 2003). Females are monoestrous (Allardyce and Sovada 2003) and gestation is about 51 days (Schroeder 1985). Litter size is usually about four pups (Olson and Lindzey 2002) but can be as high as eight (Carbyn *et al.* 1994; Moehrenschlager 2000). In Canada, litter size was correlated to female's body weight prior to the mating season (Moehrenschlager 2000). Pups emerge from the natal den at about 3-4 weeks of age and are weaned at 6–7 weeks (Kilgore 1969; Hines 1980). In Canada, emergence dates were May 25 - June 9 and timing appeared related to weather conditions during the months leading up to, and including, the breeding season (Pruss 1994; Moehrenschlager 2000). Both males and females are sexually mature and can breed in their first year, but not all actually do. In Colorado, New Mexico, Texas, and northern Montana, 50% of juvenile females with known fate that survived to breeding age reproduced as yearlings (Kamler *et al.* 2004; Ausband and Foresman 2007). In Canada, 85% of females (including 1 year olds and likely males; Moehrenschlager pers. comm. 2018) are reproductively active (Moehrenschlager *et al.* 2004). Using inferred (to account for pup [0-6 months-old] mortality) juvenile survival rate to 12 months and actual average adult survival rate of 0.45 for Swift Fox in Canada (Moehrenschlager *et al.* 2007a,b), average fertility of 3.8 pups per reproductive pairs (Moehrenschlager *et al.* 2007a), and assuming post-first year fertility and survival rates to remain constant over an assumed 9 years (maximum age of reproduction for females; Moehrenschlager *et al.* 2007a), the generation length in Canada was calculated to be 2 years using the formula in option 1 of the IUCN Standards and Petitions Subcommittee (2017).

Swift Fox appear to be highly plastic in their social grouping strategies. A typical social group consists of a mated pair with pups but breeding groups of various composition exist. They generally maintain stable pair bonds (Kilgore 1969) but do not necessarily mate for life (Kitchen *et al.* 2006). Extra-pair mating occurs frequently (Kitchen *et al.* 2006). In Alberta, a male was observed with the litters of two different females on the same day (Moehrenschlager 2000). Trios (two females and one male or two males and one female) and even quartets (one male and three females and two males and two females) occasionally form, with some individuals of the social unit sometimes being related (Covell 1992; Schauster *et al.* 2002; Kitchen *et al.* 2006; Poessel and Gese 2013). Kamler *et al.* (2004) assessed the relationship between Swift Fox density, mating systems and group structure in northwestern Texas. Polygynous groups, communal denning, and non-breeding females occurred in the high Swift Fox density area with lower mortality rate from Coyote predation, whereas only monogamous pairs occurred at the low-density area where mortality from Coyote predation was significantly higher ($Z = 2.55$, $P = 0.01$). Non-breeding individuals may act as helpers to raise pups (Tannerfeldt *et al.* 2003).

Swift Fox generally live 3 - 7 years in the wild (Mamo 1994; Reid 2006). In the Alberta-Saskatchewan border region, annual adult Kaplan-Meier survival rates ranged from 0.38 (95% CI = 0.15-0.60) to 0.52 (95% CI = 0.29-0.72) in 1995-1998 (Moehrenschlager *et al.* 2007b), similar to estimates from the core range in the US (Schauster *et al.* 2002; Zimmerman *et al.* 2003). Juvenile (collared at 6 months of age) survival rates for the same period were 0 – 0.63 (95% CI =0.23-0.86) (Moehrenschlager *et al.* 2007b) and was similar to the US (i.e., 0.13 – 0.69, Covell 1992; Sovada *et al.* 1998; Kitchen *et al.* 1999; Schauster *et al.* 2002).

## Diet and Predation

Swift Fox are opportunistic omnivorous meso-predators with diets that vary geographically and seasonally, depending on the diversity and abundance of local prey species (Moehrenschlager *et al.* 2004). In the Alberta-Saskatchewan border region, scat analysis revealed that mammals are the most frequent prey (68.3%; composed of 59.5% rodents, 7.1% lagomorphs, and 1.7% large mammals [presumably carrion]), followed by insects (23.8%), and birds (8.0%) (Moehrenschlager *et al.* 2007b). Reynolds *et al.* (1991) found that small rodents and carrion from ungulates were most important with a small portion from lagomorphs and ground squirrels. In northwestern Texas, mammals and insects dominated the diet of Swift Fox. Mammals (rodents) were most important in all seasons, except autumn when insects became more important (Kamler *et al.* 2007). Murid rodents were the most frequent prey of Swift Fox in Kansas and Nebraska (Hines and Case 1991; Sovada *et al.* 2001), although hare (*Lepus* spp.) were also common (Cutter 1958; Cameron 1984; Zumbaugh *et al.* 1985). Black-tailed Prairie Dogs (*Cynomys ludovicianus*) are most important in South Dakota (Uresk and Sharps 1986), but unlikely to be important in Canada because of their rarity and limited distribution to only Grasslands National Park and neighbouring Masefield and Dixon community pastures (Tuckwell and Everest 2009). In general, prey items are not larger than White-tailed Jackrabbits (*Lepus townsendii*; 3 – 4 kg). In winter, Swift Fox in Canada rely heavily on voles (Moehrenschlager *et al.* 2007b). During 9360 trap-nights from November 1995 to March 1996 in the same study area as Moehrenschlager *et al.* (2007b), Klausz (1997) only caught 163 small mammals. This small abundance, along with low species diversity (96% were Deermouse [*Peromyscus maniculatus*] and 4% were shrews [*Sorex spp.*]), led to the hypothesis that low hunting success in the late winter period could lead to high mortalities of Swift Fox, as they would presumably have exhausted their fat reserve (Moehrenschlager *et al.* 2007b).

Mortality is primarily attributable to natural predation or human causes. There is no evidence that disease is currently an important source of mortality (Moehrenschlager *et al.* 2004). Direct human-caused mortality is caused by poison, shooting, collisions with vehicles, and trapping (Allardyce and Sovada 2003). Predation by Coyotes is the principal cause of natural mortality across the species' range but Golden Eagle predation may also be important in some years in Canada (Allardyce and Sovada 2003, Moehrenschlager *et al.* 2007b).

## Physiology and Adaptability

Swift Fox are well adapted morphologically and behaviourally for life in an open semi-arid environment where water may be scarce, climate can be extreme, and shelters are limited. Morphologically, their slender skeleton and long legs are adapted for running (Egoscue 1979), which helps them evade predators and hunt fast prey such as lagomorphs. Swift Fox grow a longer and denser pelage for winter and the foot pads are almost completely covered with fur, thus improving body insulation (Egoscue 1979; Geffen and Girard 2003). In summer, a thin coat and a small body with a large surface to volume ratio dissipates heat effectively (Geffen and Girard 2003). Swift Fox can maintain water balance with food alone (Geffen and Girard 2003). When freestanding water is available, a Swift Fox requires about 210 g of food per day; in the absence of freestanding water, moisture requirements can be satisfied by eating about 330 g per day (Flaherty and Plaake 1986).

## Dispersal and Migration

Swift Fox dispersal takes place primarily as juveniles but can take place as adults as well. Pups break close associations with their parents at 4 – 6 months (Covell 1992) and, in Canada, begin dispersal in August with all pups dispersed by 18 months of age (Pruss 1994; Moehrenschlager 2000). Juvenile dispersal in northeastern Colorado involved three strategies: some juveniles remained in their natal territory helping the mated pair to raise their litter, while others dispersed to neighbouring or to distant territories (Schauster *et al.* 2002). Juvenile dispersal distances average 10 - 15 km and are generally similar for males and females in northern populations (Moehrenschlager 2000; Schauster *et al.* 2002; Sovada *et al.* 2003; Ausband and Foresman 2007), but distances > 50 km and up to 191 km have been reported from a reintroduced northern population in Montana (Ausband and Moehrenschlager 2009). In northeastern Colorado, monitored adult foxes dispersed 12 km (on average), largely during the breeding/gestation season (7 - 12%) but also during the pup-rearing and dispersal seasons (3% each; Schauster *et al.* 2002).

### Interspecific Interactions

Coyotes are important predators of Swift Fox in Canada (Moehrenschlager *et al.* 2007b) and, along with Red Fox, compete with Swift Fox (Moehrenschlager and Sovada 2016; see the **Threats and Limiting Factors** section).

## POPULATION SIZES AND TRENDS

### Reintroductions

<u>Canada:</u>

The current population of Swift Fox in Canada is derived from reintroductions into Canada and adjacent Montana. From 1983 to 1996, 479 Swift Fox were released in the Alberta-Saskatchewan border area, and from 1990 to 1997, 420 individuals were released into the Grasslands National Park and Wood Mountain areas (Carbyn 1998). About 90% of the Swift Fox released in Alberta and Saskatchewan came from captivity (Carbyn 1998). These were supplied by Cochrane Ecological Institute (formerly the Wildlife Reserve of Western Canada) of west-central Alberta which began a Swift Fox breeding program in 1971 using animals sourced from Colorado (Moehrenschlager and Moehrenschlager 2001; Smeeton and Weagle 2000). Other facilities that contributed include: Calgary Zoo (Alberta; 1983–1994), Moose Jaw Wild Animal Park (Saskatchewan; 1984–1995), and Edmonton Valley Zoo (Alberta; 1989–1997) (Carbyn 1998). From 1973 to 1986, 151 Swift Fox were translocated from the US to support either the release or captive-breeding programs, with 99 from Wyoming, 40 from Colorado, and 12 from South Dakota (Carbyn 1998). Breeding records were kept by the breeding facilities and pairing was done to ensure maximum genetic heterozygosity with an inbreeding coefficient of <0.05 (Smeeton *et al.* 2003). Animals carrying the same bloodlines were released into different reintroduction areas. The last releases occurred in 1996 and 1997 into the border and Grasslands National Park areas, respectively. By 2001, the Swift Fox population had significantly increased in abundance and distribution and nearly all captures during Swift Fox surveys were of wild-born individuals that included juvenile and older animals (Moehrenschlager and Moehrenschlager 2001). Details about the reintroduction program are found in Carbyn (1998).

In 1989, a reintroduction was also attempted in the Milk River Ridge area of south-central Alberta with the release of 61 individuals (Brechtel *et al.* 1993). This program was discontinued after only one year due to high predator abundance and intensive predator and rabies control programs (Brechtel *et al.* 1993). Since that time, there has not been any compelling evidence of Swift Fox presence in the region (COSEWIC 2009).

In 2004, 15 Swift Fox were released onto Kainai (Blood Tribe) lands in southwestern Alberta in a 1,424-$km^2$ area of fescue prairie and foothills (Smeeton 2006). This area, to the west of current Swift Fox range, was within dispersal distance of the Aamsskaapi Piikani (Blackfeet Nation) in Montana where reintroductions during 1998−2002 had established a small population of foxes (Ausband and Foresman 2007). A verbal report to the Swift Fox Recovery Team from Blood Tribe land management staff in 2005 (J. Nicholson in COSEWIC 2009) indicated that the five radio-collared individuals from this effort either went missing (3), shed their collar (1) or were found dead (1), and there has been no additional documented follow-up.

In the US:

Swift Fox were reintroduced into the Blackfeet Nation (1998-2002) and Fort Peck Tribal Lands (2006) in Montana, and Bad River Ranches (2007), Lower Brule Tribal Lands (2006), and Badlands National Park (2007) in South Dakota (Sovada *et al.* 2009). One female captured as juvenile in 2003 on the Aamsskaapi Piikani lands east of Glacier National Park in north-central Montana, dispersed a straight-line distance of 191 km across a highly fragmented landscape to southeastern Alberta. She was re-captured within 3 km of Swift Fox males in February 2006 and potentially represents gene flow to the Canadian Swift Fox population (Ausband and Moehrenschlager 2009). This is the only record of a Swift Fox from another reintroduced population having dispersed into the Canadian population. In the autumn of 2020, 27 Swift Fox were introduced on to Tribal lands in northern Montana (Fox 2020). If they establish, they will represent the first new genetics introduced into the linked Canada-US population in a decade (A. Moehrenschlager pers. comm. 2021).

## Sampling Effort and Methods

Population surveys have been conducted four times since reintroductions stopped; from 31 October until mid-February in 1996/1997, 2000/2001, 2005/2006, and 2014/2015 in Alberta, Saskatchewan, and adjacent northeastern Montana (see **Search Effort**). The four surveys have used standardized field methodology using catch and release of live animals using baited box traps, combined with incidental sightings. These surveys were conducted at the scale of townships in Alberta, Saskatchewan, and Montana. However, number and distribution of the townships that were sampled in each survey varied over time. Several townships remained constant between each survey and were termed “replicated townships” throughout this document. The 2014/2015 survey also tested camera-trapping as an alternative method to catch-and-release for occupancy objectives and this was followed up in the summer of 2015 and 2018 with surveys using only camera-trapping (Moehrenschlager and Moehrenschlager 2018; Moehrenschlager *et al.* 2020). Although camera trapping alone can not provide abundance information, as individual foxes are not recognizable, it can be used to infer trend.

During the 2014/2015 survey, Moehrenschlager and Moehrenschlager (2018) sampled 189 townships in Canada and Montana. Sampling was conducted in 102 townships in Canada and 87 in Montana. Of these, replicated sites were surveyed in 170 of 191 townships that had been sampled in 2005/2006 plus an additional 19 townships. In 2018, 147 townships in Canada (n = 67) and Montana (n = 80), which had been sampled in 2014/2015, were sampled using camera traps alone (Moehrenschlager *et al.* 2020).

Individual release or camera-traps were placed at 1-km intervals along 5 km continuous sections of trail that were closest to the centre of respective townships. Distance adjustments, by up to 100 m, were made to allow trap placement along fences or on top of hills. Each township was surveyed with six camera or release traps for three nights. Release-trapping was conducted on consecutive nights when possible, but this was dependent on weather conditions. Both mark-recapture and camera-trapping were tested at 38 townships in Canada to compare the relative efficiency of each method with similar detection efficiencies (Moehrenschlager and Moehrenschlager 2018).

## Abundance

Using the same methods and effort as in 2005/2006, Moehrenschlager and Moehrenschlager (2018) conducted mark-recapture trapping and captured a total of 63 individual Swift Fox distributed across the Canada-Montana survey range. Another 15 foxes were inferred to occur from the photographs taken with the camera-trapping method. Using Spatially Explicit Capture-Recapture (SECR) methods (Efford 2017; R Core Team 2015), they estimated Swift Fox abundance for the 2,148.96 $km^2$ SECR-generated effective sampling area (ESA). By dividing the estimated abundance by the ESA, they obtained a Swift Fox density of 0.0036 ± SE 0.008 foxes / $km^2$. By extrapolating across the entire Canada-Montana survey range, they estimated that 522.9 ± SE 115.2 foxes occurred across the 14,402 $km^2$ of survey range in Canada, 346.9 ± SE 79.5 foxes across the 9,562 $km^2$ in Montana, and 870.1 ± SE 191.7 foxes across the entire 23,964 $km^2$ Canada-Montana sample range (Moehrenschlager and Moehrenschlager 2018).

Male and female Swift Fox are reproductively mature at one year of age (Moehrenschlager 2000) and 85% of females (likely similar for males; Moehrenschlager pers. comm. 2018) are reproductively active in the population (Moehrenschlager *et al.* 2004), therefore the number of mature individuals in the Canadian Swift Fox population was estimated as 0.85 X 522.9 = 445 individuals at the end of the 2014/2015 survey.

## Fluctuations and Trends

The 2014/2015 Swift Fox survey is the first one to indicate a decline in the post-reintroduction Swift Fox population since surveys began in 1996/1997. Abundance estimates were derived from slightly different methods and thus cannot be directly compared with previous ones. However, Swift Fox abundance is thought to have decreased between 2005/2006 and 2014/2015 (Moehrenschlager and Moehrenschlager 2018). Alternatively, percent change in replicated townships with evidence of Swift Fox (from release-trap or camera-traps) between survey years can be used as an index of population change. Replicated townships with evidence of Swift Fox went from 39.7% in 2000/2001 and climbed to 52.1% in 2005/2006, for an increase of 31% between the two survey years (Moehrenschlager and Moehrenschlager 2006). Between the 2005/2006 and 2014/2015 surveys, replicated townships with evidence of Swift Fox declined from 44.7% to 24.7%, respectively, indicating a decrease of about 45% (Moehrenschlager and Moehrenschlager 2018). Camera trapping in 147 townships across Canada and Montana that were replicated in 2015 and 2018 detected Swift Fox in 36 and 40 townships, respectively, suggesting the population has remained stable (Moehrenschlager *et al.* 2020). Within Canada, foxes were detected in 17 and 16 townships in 2015 and 2018, respectively (Moehrenschlager *et al.* 2020).

Accounting for respective capture and recapture probabilities, mark-recapture abundance estimates at the 94 sampling sites where release-trapping was replicated were 68.9 ± SE 15.4 (95% C.I. 59.3 - 90.0) for 2014/2015 compared to 243.4 ± SE 15.4 (95% C.I. 218.8 - 280.1) for 2005/2006. This represents a decrease of 75.4% between those two most recent survey years using the IUCN Criterion A model for exponential decline calculated with two data points. However, 12 replicated townships that had evidence of foxes in 2014/2015 did not have evidence in 2005/2006, which slightly offset the decrease in replicated townships with captures and/or fox abundance at sampling sites (Moehrenschlager and Moehrenschlager 2018).

Incidental evidence from camera trap surveys conducted in 2009 in a sample of previously surveyed townships did not indicate any drastic declines, suggesting that the population decline happened after 2009 but before 2014/2015 (Moehrenschlager and Moehrenschlager 2018). Because of the sampling interval, it is difficult to pinpoint what might have caused the decline. The 2005/2006 Canadian Swift Fox population reached a high during the time of a sustained high abundance of Richardson's Ground Squirrel in the prairies between 2000 and 2009 (Proulx 2010). Winter severity is thought to have been a contributing factor to the decline and likely affected the Swift Fox population uniformly. The winter of 2010/2011 was particularly severe and energetic constraints could have acted synergistically with increased mortality from predation and competition to drive down the population (Moehrenschlager and Moehrenschlager 2018).

## Rescue Effect

Repopulation of the Canadian segment of the Swift Fox population in the event of a decline or extirpation may be possible with foxes dispersing from adjacent Montana. With the reintroduction efforts that took place in Canada between 1983 and 1997 (Carbyn 1998), the growing Canadian Swift Fox population has expanded into adjacent land in Montana (Moehrenschlager and Moehrenschlager 2006). Although the range has expanded southward since the reintroductions it has not reconnected with the Swift Fox range in the south which creates northern (contiguous Canada-Montana population) and southern (core) segments to the global Swift Fox range (Figure 1). With the northern segment occupying parts of Alberta and Saskatchewan in Canada and parts of Montana in the United States. Results of genetic analyses from hair samples taken during two survey years (2000/2001 and 2005/2006) across the contiguous Canada-Montana population confirmed genetic exchange across the US border (Cullingham and Moehrenschlager 2013). The north-central Montana Swift Fox would therefore represent an important rescue source providing that 1) surplus individuals were available in Montana to disperse into Canada, 2) the factor(s) that have caused the demise of the Canadian segment of the population were not affecting the Montana segment, and 3) suitable habitat was still available in Canada. As the Canadian and Montana populations are contiguous and responding to threats and limiting factors in a similar way, rescue is likely to be possible but limited.

On a broader scale, evidence from field surveys and genetic analyses indicate that the Canada-Montana population is geographically and genetically isolated from the core Swift Fox range to the south in the US (Schwalm *et al.* 2014; Alexander *et al.* 2016, Butler *et al.* 2020). Despite the nearly 200 km dispersal of a juvenile Swift Fox between the Blackfeet Reservation in northern Montana and the contiguous Canada-Montana population, long-distance dispersals across fragmented habitat are uncommon (Ausband and Moehrenschlager 2009), limiting the rescue potential from the core Swift Fox range in the US.

## THREATS AND LIMITING FACTORS

Canadian Swift Fox faces multiple threats and limiting factors in its changing habitat, which may act singly or cumulatively to affect the population. Important threats include accidental poisoning from the misuse of rodenticides or predacides and disease. Important limiting factors include predation and interspecific competition by and with other canids and food availability, particularly during severe winters.

Threats that have been identified are categorized below, following the IUCN-CMP (International Union for the Conservation of Nature – Conservation Measures Partnership) unified threats classification system (based on Salafsky *et al.* 2008). They are listed in order of decreasing severity of impact, ending with those for which scope or severity is unknown. The overall threat impact is considered to be High (see **Appendix 1** for details).

### Threats

IUCN 9. Pollution (high-medium threat impact)

*Agricultural & forestry effluents - accidental poisoning:*

Historically, poisoning for predator control had serious impacts on Swift Fox populations, likely contributing to their decline in the early 20th century (Scott-Brown *et al.* 1987). Direct poisoning of Swift Fox is now illegal in Canada and therefore has declined as a threat. However, as a carnivore, Swift Fox is at risk of secondary poisoning from consuming prey items poisoned by rodenticide or anticoagulants or from poisoned baits (toxicants) used for control of other predators (Proulx 2011).

Following a Richardson's Ground Squirrel population outbreak on the prairies, the Pest Management Regulatory Agency (PMRA) of Canada approved an Emergency Registration program which allowed the restricted use of 2% liquid strychnine concentrate (LSC) for severe Richardson's Ground Squirrel infestations starting in 2007 in Saskatchewan and in 2008 in Alberta. The label provides a precautionary warning to the user to "not apply the product if these (Swift Fox or Burrowing Owl) or other species at risk that may feed on strychnine bait or ground squirrels are present in your area" (PMRA 2012).

Zinc phosphide is another acute poison registered for control of ground squirrels, Northern Pocket Gopher (*Thomomys talpoides*), and other rodents in Canada. Because it rapidly converts to phosphine gas and is not retained in toxicologically significant amounts in body tissue of the primary consumer, zinc phosphide is considered of low secondary hazard, except to raptors or other scavengers that may consume the gastrointestinal tract which may still contain undigested bait (Erickson and Urban 2004). As per the label, users must ensure that the bait is applied only to active burrows and ensure that there is no evidence of species at risk activity or presence in burrows (PMRA 2007).

It is municipal staff (Saskatchewan) or their appointed Agriculture Service Board (Alberta) that are responsible for the sale of rodenticides or anticoagulants to landowners. Staff must approve the sales and landowners must sign a form at the time of purchase acknowledging that they do not have Swift Fox on their property (Matz pers. comm. 2017; Storch pers. comm. 2017; Merrill pers. comm. 2017; Wilkins pers. comm. 2017a). Merrill (pers. comm. 2017) and Storch (pers. comm. 2017) mentioned that producers and landowners in the range of Swift Fox are very conscientious of Swift Fox re-establishment and are not interested in compromising these efforts or the ability of landowners in Alberta to obtain 2% LSC to control ground squirrel populations.

Toxicants (or predacides) used to control Coyotes or wolves that are depredating livestock or potentially carrying rabies may be lethal for the Swift Fox if used within the Swift Fox range and if not used according to the label. Sodium cyanide is a restricted toxicant registered to the Government of Alberta for Coyote control (PMRA 2011) and sodium monofluoroacetate (known as Compound 1080) is another restricted toxicant registered to the Governments of Alberta and Saskatchewan for the control of wolves and Coyotes (PMRA 2014). The Alberta Ministry of Agriculture and Forestry no longer issues toxicants for Coyote control in Swift Fox areas (Merrill pers. comm. 2017). Similarly, in Saskatchewan, the only registered toxicant, Compound 1080, is no longer used within the primary Swift Fox range (defined as Townships 1-7 and Ranges 1-30 west of the 3$^{rd}$ meridian) and is used only after three days of scent-post tests have revealed no sign of Swift Fox in a restricted buffer area south of the South Saskatchewan River and west from Tugaske, Moose Jaw, Milestone, and Minton (Saskatchewan Fur Program 2012).

In Alberta, there have been no Swift Fox carcasses handed over to the provincial Fish and Wildlife Laboratory (Pybus pers. comm. 2017) nor reports of Swift Fox poisoning (Nicholson pers. comm. 2017) since the emergency registration of 2% LSC was approved in 2008. Similarly, in Saskatchewan, there has been no incidence of Swift Fox poisoning reported to Saskatchewan Agriculture (Wilkins pers. comm. 2017a) nor to the Saskatchewan Fish and Wildlife authorities since the emergency registration in 2007 (Prieto pers. comm. 2017).

Restrictions for use, labeling, laws, regulations, and policies that have been put in place by government ministries and agencies in Canada, Alberta, and Saskatchewan to minimize the risk of primary or secondary poisoning of Swift Fox may in part be effective. However, it is often difficult to find carnivore carcasses in this landscape and establish a cause of death (Proulx 2011). The potential for direct or secondary poisoning still exists if regulatory measures are not observed, instructions on toxicants are not followed, or if Swift Fox venture onto farmland outside their core area (Proulx 2011). In addition, limited to no follow-up is done on application sites, especially in cropland bordering Swift Fox areas or at the interface between cropland and native grass. As part of Health Canada's National Pesticide Compliance Program in Fiscal Year 2014-2015, 107 on-farm inspections of liquid strychnine concentrate users in Saskatchewan and Alberta resulted in five violations related to not following label use directions (Health Canada 2016). Secondary poisoning may affect Swift Fox the same way as Red Fox (73% fewer adult Red Foxes per km of road in area with high (90%) poisoning than in area with low (20%) poisoning; Proulx and MacKenzie 2012). This threat is ongoing as toxicants continue to be used on the prairies for the control of rodents and Coyote populations.

<u>IUCN 8. Invasive and other problematic species and genes (medium threat impact)</u>

*Invasive non-native/alien species:*

Canine diseases are growing threats to species of conservation concern around the world (Marino *et al.* 2017). Most pathogens are either foreign in origin or variants that have been introduced to North America with European immigration. Domestic Dogs (*C. familiaris*) are known to pose a significant risk as reservoirs for infectious diseases, especially for wild canids (Aguirre 2009). The most important diseases that may affect the Swift Fox include those caused by viruses such as 1) Rabies (type *Rabies lyssavirus*; endemic to North America but canine variants brought through European immigration; Velasco-Villa *et al.* 2017), 2) Canine distemper (Canine Distemper Virus; became distributed worldwide along with domestic dogs as human populations expanded; CABI 2018), 3) Canine parvovirus (CPV; originating from Europe or Eurasia and identified in dogs in the late 1970s; Knobel *et al.* 2014), and those caused by bacteria, such as the sylvatic plague: a flea-transmitted disease caused by the bacterium *Yersinia pestis* (Olsen 1981) and introduced to western North America from Asia through non-native rats within the last 125 years (Touchman *et al.* 2007).

Swift Fox are not known to be reservoirs for rabies. Antibodies to rabies virus were found in a Swift Fox in Wyoming with no evidence of infection (Miller *et al.* 2000). However, a sudden outbreak of rabies transmitted by skunks was the suspected cause of a dramatic five-fold reduction in the closely related San Joaquin Kit Fox (*V. macrotis mutica*) over a three-year period in California (White *et al.* 2000). Skunks are one of the most important rabies vector species in Canada and the US (Brown *et al.* 2014) and their range overlaps that of Swift Fox (Helgen and Reid 2016). Distemper has been responsible for population declines in Black-footed Ferrets (*Mustela nigripes*), Catalina Island foxes (*Urocyon littoralis catalinae*), Gray Wolves, Coyotes, and many other wild carnivores worldwide (Kapil and Yeary 2011). Two Swift Fox have died of canine distemper virus in Wyoming (Olson and Lindzey 2002). In wild canids, CPV has been confirmed only in Coyotes and Gray Wolves with the virus associated with mortality and poor pup survival (Knobel *et al.* 2014). However, high prevalence of antibodies has been detected in many other canid species, including the Swift Fox (Miller *et al.* 2000). A limited serological survey of 21 Swift Fox in Canada found 52% to have antibodies to distemper, with high titres indicative of previous natural exposure to the pathogen, and 100% to have antibodies to CPV, with 71% having high titres (Miller *et al.* 2000; COSEWIC 2009). Exposure to infectious pathogens in Swift Fox is likely common but infection and illness may be rare (Pybus and Williams 2003).

Sylvatic plague entered the native rodent population in 1908 to spread rapidly to its current distribution by 1950. It results in large scale epizootics among its most susceptible rodent host groups: prairie dogs (*Cynomys* spp.) and ground squirrels (*Spermophilus* spp., now *Ictidomys* spp., *Poliocitellus* spp., *Callospermophilus* spp., and *Urocitellus* spp. for genera occurring in Canada; Helgen *et al.* 2009) (Touchman *et al.* 2007). Canids are infected by flea bites or by consuming infected rodents (Thomas *et al.* 1989) and could serve to transmit plague. Sylvatic plague is endemic (Leighton *et al.* 2001) to areas coincident with Swift Fox range. Antibody prevalence in Swift Fox was 100% in northwestern Texas (n=12; McGee *et al.* 2006), 51% in southeastern Colorado (Gese *et al.* 2004), and 6% in New Mexico (n=16; Harrison 2003). In a study in Colorado, 24% of the 61 captured foxes were seropositive for plague antibodies in an area with epizootic plague activity in prairie dog colonies. However, none of the fleas found on the foxes were positive for *Y. pestis* and Swift Fox were not confirmed as reservoirs for plague (Salkeld *et al.* 2007). Nevison (2017) came to a similar conclusion for a small, reintroduced population of Swift Fox in South Dakota where 69.6% of Swift Fox were seropositive for plague. In Canada, sylvatic plague was detected in Grasslands National Park in one Black-tailed Prairie Dog in 2010 and in one prairie dog and two Richardson's Ground-squirrels in 2017 (Antonation *et al.* 2014; Shury pers. comm. 2017), substantiating its presence in Canadian Swift Fox range. Pybus and Williams (2003) indicated that, with a few exceptions, most predators are resistant to sylvatic plague and Swift Fox are also likely resistant to developing clinical or infectious plague.

Swift Fox exposure to canine diseases has not been well studied in Canada and the United States and the sources and effects of known diseases in Swift Fox populations are not fully understood (Moehrenschlager *et al.* 2004; Moehrenschlager and Sovada 2016). Regardless, diseases are well-documented in other endangered wild canids (Laurenson *et al.* 2004), including the closely related San Joaquin Kit Fox (White *et al.* 2000), and Swift

Fox coexist with Domestic Dogs, Coyotes, Red Foxes, and Striped Skunks (*Mephitis mephitis*) in Canada. Although the two population clusters in Canada suggest some barrier to dispersal (Cullingham and Moehrenschlager 2013; 2019), disease could still threaten all Swift Fox if other canids that move freely through their range act as vectors. The western cluster during the 2005/2006 peak abundance year represented about 79% of the estimated Swift Fox population (Moehrenschlager and Moehrenschlager 2006). The severity of the threat may be slight as no significant disease outbreaks have been documented in Swift Fox to date (Moehrenschlager *et al.* 2004).

<u>IUCN 2. Agriculture and Aquaculture (low threat impact)</u>

*Annual and perennial non-timber crops:*

Native grassland conversion into farmland (row crops and hay) is thought to have been the main factor contributing to the Swift Fox range constriction through habitat loss and fragmentation (Moehrenschlager and Sovada 2016). Although nearly 70% of native vegetation conversion in the Prairies Ecozone took place prior to the 1990s (ESTR 2014) the rate of conversion has recently decreased as less native prairie land with adequate soil and moisture is available to grow crops or tame forage. However, a substantial increase in prices of commodity crops or the development of crop varieties better adapted to marginal land varieties could stimulate further native prairie conversion to cropland (ECCC 2017). In addition, the threat of conversion of large blocks of native prairie to agriculture and other land uses in Swift Fox range has re-emerged because of changes in government policies.

Changes in government policies have added uncertainty to the conservation of some remaining native grasslands. In 2012, the Government of Canada announced that it would cease operating the Prairie Farm Rehabilitation Administration (PFRA) Community Pastures Program and would turn over management and administration of the reversionary pasture lands to the respective provincial governments over the five-year period of 2014-2018 (Phillips 2015). In Saskatchewan, there are 62 former PFRA Community Pastures totaling 714,918 ha that have been or will be transitioned. Of those, eight are within newly identified Swift Fox critical habitat in Saskatchewan (AAFC 2009; and see ECCC 2017). They include Lone Tree (transitioned in 2013), Masefield (transitioned in 2017), Val Marie, Reno 1 and Reno 2 (transitioned in 2018), Battle Creek, Nashlyn, and Govenlock (McInnis pers. comm. 2017), for a total area of 166,428 ha, of which 85% (140,741 ha) was in native cover as of 2005 (Phillips 2015). Various scenarios have been proposed for ownership (sale of land with native prairie with “no-break no-drain” easements) or management of those pastures, but at the time of this report, leasing (15 years) from the Government of Saskatchewan by organized groups of former pasture patrons was the approach taken for all the pastures that had been transferred to the province (McInnis pers. comm. 2017, 2018). However, other options were also being explored for Battle Creek, Nashlyn, and Govenlock, which were still under control of the Government of Canada up until 2019 (McInnis pers. comm. 2018).

In Alberta, a single 41,000 ha PFRA-administered complex of three community pastures was located within the Canadian Forces Base (CFB) Suffield. It was found within the historical Swift Fox range, but outside of the current range. The pasture's land control reverted to the Department of National Defence (DND) in 2014 and a memorandum of understanding was developed between DND and the former pasture patrons for continued grazing. In addition, the federally managed Onefour Agricultural Research Substation, which totaled 17,300 ha within the Swift Fox range, was also administered by PFRA. Most of the land (16,098 ha) that was originally deeded to Alberta, was returned under provincial administration and management in 2013. In December 2016, a memorandum of understanding was signed between the Government of Alberta and the University of Alberta to allow the university long-term and stable access to conduct academic agricultural research on the property. Under its new status, the Onefour University Research Ranch continues to be grazed by a local grazing association through a grazing management plan that includes provisions for the management and protection of species at risk habitats and is protected from development through Disposition Reservation (DRS) with a Protective Notation (PNT) (Ehlert pers. comm. 2017). The ranch also includes 3,885 ha designated as "Heritage Rangeland Natural Area" and protected under the Alberta *Wilderness Areas, Ecological Reserves, Natural Areas and Heritage Rangelands Act* and some areas falling under the federal Emergency Order for the Protection of the Greater Sage Grouse (*Centrocercus urophasianus urophasianus*), which provide additional protection to the grasslands.

In March 2017, the Government of Saskatchewan officially announced that its Saskatchewan Pastures Program was to be phased out over a 3-year period. The program includes 50 pastures operating on 315,655 ha (780,000 acres) of land, with 1,300 current patrons in Saskatchewan (Government of Saskatchewan 2016). Three of these pastures, Arena, Dixon, and Mankota, are within recently identified Swift Fox Critical Habitat in Saskatchewan (Saskatchewan Ministry of Agriculture 2016; and see ECCC 2017). They cover a total of 57,314 ha, of which 92% (52,923 ha) is native pasture (Parsons pers. comm. 2017). The last grazing season for these three pastures as part of the program will be 2019, after which they will switch over organized pasture-patrons control under a 15-year lease with the Government of Saskatchewan to ensure continued grazing and environmental stewardship of the land. Current and potential non-agricultural uses (e.g., oil and gas activity, sand and gravel reserves, etc.) will be allowed to continue on these lands with setback distances and restrictions on timing where species at risk occur (McInnis pers. comm. 2018).

With regard to the transfer of PFRA community pastures, there are two aspects to this threat: 1) the potential outright loss of habitat from a possible sale of the lands by the Government of Saskatchewan, and 2) the loss and fragmentation of habitat from a change in policies and regulations with change in jurisdictions, leading to a potential increase in industrial activities in those areas. From a habitat loss perspective, this threat is large in scope because 38 of 84 (40.4 %) foxes caught in the Alberta-Saskatchewan border region were on townships that contained PFRA lands in the 2005/2006 peak Swift Fox abundance year (Moehrenschlager and Moehrenschlager 2006). This area includes the three PFRA community pastures (totalling 83,694 ha) that remain to be transferred to Saskatchewan as of the end of 2018. It is unknown what the fate of the remaining PFRA community pastures will be after being transferred, but so far, all former pastures' patron groups have entered into a 15-year lease with the Government of Saskatchewan and there was no interest by any of these groups to purchase the land (McInnis pers. comm. 2018). With PFRA pastures transitioning from federal to provincial Crown land, the immediate prohibitions associated with designated species at risk under SARA no longer apply and species, residence, and critical habitat protection fall under provincial responsibility. In Saskatchewan, the *Wild Species at Risk Regulations* of the *Wildlife Act* and the Activity Restriction Guidelines for Sensitive Species (Government of Saskatchewan 2017a) provide for protection of the Swift Fox and its residence, while the environmental assessment process accounts for species residence, critical habitat, and native grasslands (Government of Saskatchewan 2018). It is unknown how the Saskatchewan acts, policies, and regulations, and the enforcement associated with them compare to those associated with SARA with respect to effectively protecting Swift Fox, its residence, and its critical habitat, but these were the tools in place for the protection of species at risk on all provincial Crown land prior to this transfer.

IUCN 3. Energy Production and Mining (low threat impact)

Renewable and non-renewable energy production may affect Swift Fox directly through increased mortality related to increased road network and/or increased traffic, or indirectly through habitat loss, fragmentation or degradation, increased anthropogenic disturbance, change in density of predators or competitors and/or decrease in food availability (Cypher *et al.* 2003; Moehrenschlager and Moehrenschlager 2006; Moehrenschlager *et al.* 2007a). Mortality associated with roads and increased traffic is dealt with in the *Transportation and Service Corridors* section below.

*Oil & Gas Production:*

In Wyoming, the probability of Swift Fox extirpation was positively correlated with the number of years energy development was observed within 31 $km^2$ grids (Van Fleet *et al.* 2015). Conversely, in southwestern Saskatchewan, oil and gas sites with baited scent posts were visited regularly by Swift Fox regardless of the time since initial development (Hockaday 2011). Swift Fox den use and survival were not adversely affected by pipeline construction activities, as long as dens were not destroyed, although there was some evidence of negative effects on reproduction due to disturbance during a pipeline construction (Moehrenschlager 2000). At the Naval Petroleum Reserves in California, there was no evidence that oil fields affected survival, reproduction, dispersal space use, den use, food habits, or food availability of Kit Foxes (*V. macrotis*) and population trends were similar between the developed and the undeveloped areas but abundance in the developed area was half that in the undeveloped area (Cypher *et al.* 2003). A reduction in carrying capacity associated with 70% habitat disturbance is believed to have caused the decline. In the Milk River watershed, which encompasses much of the current Swift Fox range, the Milk River Watershed Council Canada (MRWCC) reported a total of 2,856 wells associated with oil and gas activity in Alberta, of which 35% (992) were still active in 2012 (MRWCC 2013). In the Montana portion of the watershed, the number of wells reported for 2012 was 9,586, of which 9,465 were active) (MRWCC 2013). In the South of the Divide (SoD) area, which represents the Saskatchewan portion of the Milk River watershed, ECCC (2017) reported 1,350 oil and gas wells capable of production, and 750 wells actively producing as of 2013. They indicated that oil wells and oil reserves were concentrated in a relatively small area, east of the town of Eastend while natural gas wells and estimated remaining gas reserves were concentrated in the western third of the SoD area. The latter area would have the greatest impact on Swift Fox habitat. While oil and gas activity has been relatively important in the Swift Fox range between 1997 and 2008, with peak numbers of new wells in 2005 for Saskatchewan and in 2007 for Alberta (Moehrenschlager and Moehrenschlager 2006), the recession of 2008, which saw the price of oil plummeting (Depersio 2018), has since nearly stalled new well drilling on the Alberta side and greatly reduced it in Saskatchewan.

A large segment of the Swift Fox population (especially the western cluster on the Saskatchewan side and adjacent Montana where much oil and gas activity is taking place) could be affected by energy development. There are still large reserves of oil and especially natural gas that remain undeveloped in the South of the Divide region of Saskatchewan (ECCC 2017). While traffic associated with producing oil and gas wells is still present, pressure from new oil and gas infrastructure development is currently much reduced in the Swift Fox range with low oil and gas prices and is likely to shift only with increasing prices.

IUCN 4. Transportation and Service Corridors (low threat impact)

*Roads and Railroads:*

Roads may cause direct Swift Fox mortality through collisions with vehicles, cause habitat loss and degradation, fragment the landscape, lead to avoidance (loss of functional habitat), and may impede gene flow (Moehrenschlager *et al.* 2007a). Increasing energy development activities on the Canadian prairies is associated with increasing road development and traffic, increasing the risk of collisions, especially with juveniles (Allardyce and Sovada 2003; Pruss *et al.* 2008). However, roadways may also be attractive to Swift Fox through avoidance of core area of Coyote ranges, by providing additional food sources from carrion and increased abundance of small mammals in taller disturbed roadside grass, and as travel corridors (Pruss 1999; Harrison and Whitaker-Hoagland 2003). It is unknown whether roads act as ecological traps for Swift Fox; however, they can be an important source of mortality in some areas. In a fragmented landscape of northwestern Texas, vehicle collisions were the primary (42%) cause of Swift Fox mortality due to the presence of a two-lane highway (Kamler *et al.* 2003b). In a predominantly ranching area of Canada, Moehrenschlager *et al.* (2007b) found that 7.7% of 39 Swift Fox with known cause of mortality between 1995 and 1998 were road kills. Through logistic regression modeling using three years of winter survey data from 1996/1997 to 2005/2006, Moehrenschlager *et al.* (2007a) showed that habitat fragmentation from linear landscape disturbance such as roads had a negative effect on Swift Fox presence that extended up to at least 5 km and suggested a loss of functional habitat. In addition, Red Foxes are known to benefit from the presence of roads and associated infrastructure on the landscape, which provide them with food sources and corridors into remote areas where they could compete with other smaller foxes (Cypher *et al.* 2003; Selås *et al.* 2010).

Overall, Swift Fox range is in an area of low road density in southwestern Saskatchewan and southeastern Alberta where the development of new roads is largely associated with energy development activity, which is currently low. The majority of roads tend to have low traffic volume but there are ongoing talks about extending the border crossing hours at Wild Horse, AB to 24, which would lead to an increased volume of traffic on Highway #41 during the hours of high Swift Fox activity (Nicholson, pers. comm. 2019).

IUCN 11. Climate Change and Severe Weather (low threat impact)

*Droughts:*

Based on recent climate change predictions, droughts are likely to increase in prevalence and severity in the Canadian Prairie Ecozone (Thorpe 2011). Swift Fox may not be directly impacted by drought as they can meet their water requirements from food alone (Flaherty and Plaake 1986). However, severe, or prolonged droughts may impact their body condition and survival (Herrero *et al.* 1991) and, as with San Joaquin Kit Fox, decrease their reproductive success because of prey scarcity (White and Ralls 1993; Moehrenschlager *et al.* 2007a). Interspecific competition can exacerbate the problem. It is unknown to what extent reduced food availability may impact the Swift Fox population but in the San Joaquin Kit Fox, the numerical response was dramatic and rapid, leading to a >50% decrease in Kit Fox captures over two consecutive years, with lower reproduction believed to be the main driver (Cypher *et al.* 2003). Multiple drought years may occur over a 10-year period in the Canadian Swift Fox range, potentially affecting the entire population. A recent study on the Black-tailed Prairie Dogs near Val Marie, Saskatchewan recognized three drought years during an eight-year span between 2007 and 2014 (Stephens *et al.* 2018).

*Temperature extremes:*

Swift Fox are behaviourly and morphologically adapted to cope with seasonal environmental changes within their range (Carbyn 1998; Geffen and Girard 2003). However, at the northern extent of their range, increased energetic demand coupled with decreased prey availability during severe winters may lead to mortality from starvation and/or increased vulnerability to killing by predators or intraguild competitors (Moehrenschlager *et al.* 2007b; Moehrenschlager and Moehrenschlager 2018). Moehrenschlager and Moehrenschlager (2018) speculated that the severe winter of 2010-2011 might have been a possible cause for a 45% decline in population between the 2005/2006 and 2014/2015 survey years.

## Limiting Factors

Predation:

Coyote on the prairies have expanded in distribution and abundance with the extripation of the Gray Wolf (*Canis lupus*) and the collapse of the prairie ecosystem as it existed prior to European settlement (Herrero *et al.* 1991). Predation by Coyote is the principal natural cause of Swift Fox mortality across the range (Allardyce and Sovada 2003) and this has hindered Swift Fox reintroduction efforts in Canada (Carbyn *et al.* 1994). Of the 89 Alberta and Saskatchewan Swift Fox carcasses examined by Carbyn *et al.* (1994) between 1983 and 1992, 38% were thought to be killed by Coyotes, 8% were likely killed by avian predators (of which 71% were Golden Eagles), and 7% were known or suspected American Badger kills. Moehrenschlager *et al.* (2007b) found that 31% of radio-collared Swift Fox were killed by Coyotes and 33% by Golden Eagles (n = 39, value for one of the three years of the study), while all closely related Kit Foxes in Mexico survived the duration of the study. Swift Fox home ranges were about three times as large as the Kit Fox's and had significantly (Kruskal–Wallis $X^2 = 35.8$, d.f. = 1, $P < 0.001$) fewer escape holes within them, which made Swift Fox more susceptible to density-dependent encounters with sympatric Coyotes and depredation by Coyotes and Golden Eagles. In Texas, increases in Swift Fox survival rates and recruitment occurred following Coyote control, although the long term effect was unknown (Kamler *et al.* 2003a). In southern Colorado, Coyote population reduction temporarily increased survival rates of both juvenile and adult Swift Fox, although effects on adults were highly dependent on the timing of Coyote control (Karki *et al.* 2007). Robinson (1961) and Linhart and Robinson (1972) found no increase in Swift Fox following Coyote control in New Mexico, Colorado, and Wyoming and Swift Fox survival was not enhanced in Canada after Coyote harvesting, owing to increases in kills by Golden Eagle and Red Fox expansion into core Swift Fox habitat (Moehrenschlager 2000). Coyote populations were decimated in southwest Saskatchewan in 2010 due to a bounty control program (Proulx and MacKenzie 2012) but it is unknown what impact this had on the Swift Fox population.

There are no reports of direct Swift Fox predation by the larger Red Fox, which lives normally in more peripheral farmland and other fragmented anthropogenic areas (Larivière and Pasitschniak-Arts 1996). However, Red Fox have been observed depredating the closely related Arctic Fox (*Vulpes lagopus*; Elmhagen *et al.* 2017) and the San Joaquin Kit Fox (Ralls and White 1995). San Joaquin Kit Fox carcasses were partially eaten and completely buried (Ralls and White 1995); a behaviour typical to Red Fox that would result in undetected Swift Fox carcasses where the two coexisted without Coyote.

Interspecific competition:

Interspecific competition, particularly with other canids may limit Swift Fox. Competitive interaction strength is likely related to prey abundance (Creel *et al.* 2001). Given that Coyotes seldom consume Swift Fox after killing them is evidence for interference competition (Moehrenschlager *et al.* 2007b). Kitchen *et al.* (1999) suggested that den use and some dietary partitioning allowed Coyote and Swift Fox to cohabit.

However, Moehrenschlager *et al.* (2007b) found that Swift Fox in Canada and Kit Fox in Mexico did not and likely could not partition their habitat relative to Coyotes and that killing of Swift or Kit Foxes was likely from density-dependent chance encounters with Coyotes. However, Mitchell (2018) found that Swift Fox in the Dakotas avoided areas of high probability of occupancy by sympatric Coyote and Red Fox. Similarly, Red Fox avoided areas of high probability of occupancy by Coyote. Red Fox have recently expanded their range on the Canadian prairies, stimulated at least in part by habitat fragmentation, human presence and intervention, and access to anthropogenic food sources and shelters (Kamler and Ballard 2002; Mueller *et al.* 2018). This relatively novel competitor with Swift Fox may be even more significant than Coyote because sympatric Red Fox can exclude Swift Fox from their range through a combination of interference and exploitative competition. In disturbed agricultural landscapes, Coyotes typically select areas of natural cover and avoid denning in proximity to high human activity (farmsteads and residential areas), whereas Red Fox avoid habitats used by sympatric Coyote and use peripheral human-modified habitats for denning and as refugia where anthropogenic food sources and shelters exist (Gosselink *et al.* 2003; Tannerfeldt *et al.* 2003; Mueller *et al.* 2018). Red Fox are known to take over Swift Fox dens and could use these refugia to invade Swift Fox areas in the absence of Coyote (Moehrenschlager *et al.* 2004). While there is considerable dietary overlap between Swift Fox and Coyote that coexist in Canadian native prairies, the overlap is even greater between sympatric foxes creating greater potential for exploitative competition (Moehrenschlager *et al.* 2004). Red Fox tend to occur at higher densities than Coyote, which means that the likelihood of Red Fox encounters in Swift Fox home ranges would be greater than that of Coyote encounters (Moehrenschlager *et al.* 2004). The interaction between Coyote and Red Fox may affect the strength of competition between Red Fox and Swift Fox (Tannerfeldt *et al.* 2003). Moehrenschlager *et al.* (2004), indicated that Swift Fox persistence, in areas of sympatry, would require a sufficiently large population of Coyote to keep Red Fox numbers low, yet a sufficiently small population to minimize Swift Fox mortalities. The dynamic of ecological interactions between these three sympatric canids in a changing human-altered environment is poorly understood and may have important ramifications for the sustainability of a Swift Fox population in Canada (Pruss *et al.* 2008).

Food availability:

Food availability has likely been reduced for the Swift Fox since European settlement of the Canadian prairies and the extirpation of Bison (*Bison bison*). Previously, Bison carrion, either killed by a larger predator, or dying of natural causes, would likely have periodically supplemented their diet, especially during severe winters (Herrero *et al.* 1991; Sovada *et al.* 2009). Coyote abundance would have been kept in check by wolves (Berger and Gese 2007), which probably would have had more tolerance for and less dietary overlap (Kitchen *et al.* 1999) with Swift Fox (Herrero *et al.* 1991). In addition, the loss of mixed-grass prairie to crop production and changes in grazing patterns and intensity brought about by the replacement of native grazers with domestic cattle, have significantly transformed the prairie ecosystem and likely contributed to a decrease in prey populations for the Swift Fox (Sovada *et al.* 2009). This maybe be particularly important in the winter when insects and hibernating Richardson's Ground Squirrels (*Urocitellus richardsonii*) are unavailable (Michener 1983). They must consequently rely on other small mammals (Moehrenshchlager *et al.* 2007b), which may be rare in some years and decline over winter (Klausz 1997). As a result, late winter is likely the most critical period for generalist Swift Fox and lack of prey availability may lead to starvation (Klausz 1997). Moehrenschlager *et al.* (2007b) observed one case of late winter starvation in their study area and noted that foxes were more food-stressed in Canada than closely related Kit Fox in Mexico, which likely led to home-range sizes three times the size of those in Mexico, with associated increase in vulnerability to predators such as Golden Eagle and Coyote (Moehrenschlager *et al.* 2007b).

Intraguild competition for prey may also add pressure on Swift Fox during times of low prey abundance. Swift Fox diet overlaps considerably with that of Coyote (Kitchen *et al.* 1999) and the two may compete for food. However, in Canada, Swift Fox diet overlaps even more with that of Red Fox (Moehrenschlager *et al.* 2004). As a result, the larger Red Fox may exclude Swift Fox from some areas or prevent them from establishing in unoccupied suitable areas (Allardyce and Sovada 2003; Moehrenschlager *et al.* 2004).

The predator-prey dynamic is complex for the Swift Fox as it is confounded by interspecific and intraguild competition, which in turn is further linked to additional factors related to habitat loss, degradation, and fragmentation, and weather extremes that may act singly or cumulatively. Moreover, prey availability may not only affect Swift Fox survival, but it may also impact productivity, as Swift Fox litter sizes in Canada are correlated to body weights prior to and during the breeding season (late February to March; Moehrenschlager 2000).

### Number of Locations

Currently, the most serious plausible threat to the Swift Fox in Canada is the use of toxicants and the potential for secondary poisoning. However, it is unlikely that toxicant poisoning would act as a single event that would rapidly affect the majority of individuals in the Canadian population. Thus, the number of locations was considered as > 10.

## PROTECTION, STATUS AND RANKS

### Legal Protection and Status

Swift Fox is protected nationally under Schedule 1 (Threatened Species) of the Canadian *Species at Risk Act* - SARA (Government of Canada 2018a). SARA contains immediate prohibitions on federal lands against the killing, harming, harassing, capturing, taking, possessing, collecting, buying, selling, or trading of individuals of endangered, threatened, and extirpated species listed in Schedule 1 of the Act. The Act also contains a prohibition against the damage or destruction of their residences (e.g., nest or den) (Government of Canada 2018b). A recovery strategy has been developed for the species (Pruss *et al.* 2008).

In Alberta, Swift Fox is listed as Endangered under the *Alberta Wildlife Act*, which confers protection of individuals through prohibitions on hunting and trapping, as well as protecting den sites. The legislation does not protect habitat apart from the den. This is accomplished through Standards and Conditions that apply to formal disposition applications approved under the *Public Lands Act* (primarily relating to oil and gas development on Crown land; Government of Alberta 2017c), as well as Directives for wind energy and solar energy development (Government of Alberta 2017a,b). On private lands, guidelines for dates of activity restrictions and setback distances have been developed to "*help land users minimize, or avoid, potential adverse effects on selected wildlife and wildlife resources when conducting activities*." The guidelines for Swift Fox suggest that all levels of land use activity should be prohibited within 500 m of a den during breeding and pup-rearing season (16 February to 31 July). Outside this period, setbacks of 50 m, 100 m, and 500 m are recommended for low, medium, and high impact disturbances, respectively (Government of Alberta 2011).

Swift Fox is listed as Endangered under the *Wild Species at Risk Regulations* of the Saskatchewan *Wildlife Act*. This designation confers enhanced protection of individuals and their dens. Provincial guidelines for sensitive species provide additional habitat protection around den sites. During the breeding and pup-rearing period (15 February to 31 August), low-level (e.g., foot traffic, small vehicles) and medium-level (e.g., large vehicles, small pipeline construction, operation of compressor stations) disturbances are prohibited within 500 m, whereas high levels of disturbance activity (e.g., construction, seismic exploration, forest harvest) are not permitted within 2 km (MEFWLB 2017). During the rest of the year, the setback distances from Swift Fox dens are 100 m, 500 m, and 2 km for low, medium, and high levels of disturbance activity, respectively (MEFWLB 2017).

In the United States, Swift Fox was petitioned in 1992 for listing under the *Endangered Species Act*. Following an initial review, the US Fish and Wildlife Service (USFWS) concluded that listing of the Swift Fox was "*warranted but precluded by higher listing priorities*" (USFWS 1995). In 2001, because of new information, the USFWS concluded that "*originally identified threats were no longer applicable*" and the Swift Fox was removed from the candidate list (USFWS 2001). In response to the initial petition, state and federal agencies, tribal and non-governmental organizations, and representatives from Canada formed the Swift Fox Conservation Team in 1994 and developed the Conservation Assessment and Conservation Strategy of Swift Fox (*Vulpes velox*) in the United States to "*assemble existing information, collect new biological data, implement swift fox monitoring and management programs, and advance Swift Fox conservation and restoration and avoid future listing under the Endangered Species Act*" (Dowd Stukel 2017).

The Swift Fox is not currently listed under CITES (CITES 2017).

## Non-Legal Status and Ranks

Swift Fox was assessed as Extirpated by COSEWIC in 1978. They were re-assessed as Endangered in May 2000 after initial reintroduction success. The status was re-examined and assessed as Threatened in November 2009 (COSEWIC 2009).

The *IUCN Red List of Threatened Species* ranking for Swift Fox is Least Concern (Moehrenschlager and Sovada 2016). Under the General Status of Wild Species 2015, Swift Fox was listed as N2 (Imperilled) in Canada, S1S2 (Critically Imperilled to Imperilled) in Alberta, S3 (Vulnerable) in Saskatchewan and SX (Presumed Extirpated) in Manitoba (CESCC 2016). NatureServe (2021) ranks Swift Fox globally as G3 (Vulnerable; last reviewed April 2016) and nationally (Canada) as N3 (Vulnerable; last reviewed January 2018). The Alberta Conservation Information Management System (ACIMS 2017) ranks Swift Fox as S1S2 (Critically Imperilled to Imperilled; updated July 2017), the Saskatchewan Conservation Data Centre (SKCDC 2018) ranks it as S3 (Vulnerable; updated February 2018), and the Manitoba Conservation Data Centre ranks it as SX (Presumed Extirpated; MBCDC 2016).

## Habitat Protection and Ownership

Section 49 (1)(a) of SARA requires that Action Plans include an identification of the species' critical habitat (to the extent possible) unless such critical habitat was fully identified in a recovery strategy (Pruss *et al.* 2008). New critical habitat was partially identified as part of action plans for multiple species at risk in the South of the Divide region of southwest Saskatchewan and in Grasslands National Park (ECCC 2017; Parks Canada Agency 2016). Critical habitat was identified using modifications and refinements of the habitat suitability model developed by Moehrenschlager *et al.* (2007a) as well as other scientific information about habitat requirements of the species, and field records from provinces, universities, non-profit organizations, and federal departments (Parks Canada Agency 2016). Critical habitat was identified as "those areas within the current range of the species in which the combination of habitat attributes is at least as favourable for Swift Fox as the majority of locations where Swift Fox occurrences were documented" (Parks Canada Agency 2016). The biophysical attributes that went into the development of the refined model were assessed within a 3-km radius of Swift Fox captures from the 2005/2006 winter mark-recapture survey and included:

- Large tracts of intact (i.e., native) prairie.
- Short (< 25 cm high), sparse, and relatively homogeneous vegetation.
- Level or low variation in terrain roughness (gently sloping terrain or few. topographic features such as canyons, steep hills, or coulees).
- Dry, well-drained soils.
- High density of burrows created by fossorial mammals.
- Limited cropland.
- Limited invasive species.
- Adequate availability of prey items (small mammals and insects).

Critical habitat identified on federal lands in these action plans was protected from destruction under section 58(1) of SARA or through Orders made under subsections 58(4) and 58(5) (Parks Canada Agency 2016). Notices were published in the *Canada Gazette* on September 24th, 2016, for Grasslands National Park (Queen's Printer for Canada 2016), and on February 17th, 2018, for Prairie National Wildlife Area (unit number 11) (Queen's Printer for Canada 2018), advising of the coming into force of these Swift Fox critical habitat areas 90 days ensuing the respective notice publication dates.

The portions of critical habitat identified in the above action plans that are on non-federal lands will be assessed by Environment and Climate Change Canada for the protection they currently offer. Provincial laws and legal instruments in Saskatchewan will be reviewed in collaboration with the Government of Saskatchewan to determine if they prevent destruction of critical habitat. If there are gaps, other federal provisions under SARA, legislation or conservation measures will be reviewed to determine whether they prevent destruction of critical habitat (ECCC 2017).

Critical habitat has not been identified yet but will be identified for Alberta (ECCC 2017). Currently, Swift Fox habitat in Alberta benefits from protection conferred by the Greater Sage-grouse Emergency Order (Government of Canada 2013) as well as other regulatory requirements within the Greater Sage Grouse Range on provincial Crown lands (Downey pers. comm. 2017).

About one-sixth of the Canadian Swift Fox population resides within the boundaries of Grasslands National Park (Moehrenschlager and Sovada 2016), making their habitat federally protected.

## ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED

The writer of this updated report would like to thank the writers of the previous two reports, Jay Gedir and Lu Carbyn, whose earlier work is the foundation of this report. Axel Moehrenschlager provided recent survey data and valuable insight on the status of the Swift Fox population in Canada and adjacent Montana, and access to published and unpublished documents. Lonnie Bilyk, Andrea Benville, and Shelley Pruss provided Swift Fox occurrence data from the Alberta Fish and Wildlife Management System, the Saskatchewan Conservation Data Centre and Parks Canada, respectively. Andre Breault, Andrea Benville, Daniel Buell, Lu Carbyn, Nishanthy Chitravelu, Sue Cotterill, Brandy Downey, Pat Fargey, Chris Friesen, Mike Gollop, Susan Goods, Jeff Keith, Kamal Khidas, Dave Matz, Rachel McDonald, Brent McInnis, Phil Merrill, Amanda J Miller, Gerry Ehlert, Joel Nicholson, Sara Olimb, Rod Parsons, Beatriz Prieto, Gilbert Proulx, Shelley Pruss, Margo Pybus, Doni Schwalm, Todd Shury, Jason Storch, Bill Watkins, Richard Wilkins, and Greg Wilson contributed or facilitated access to valuable information for the report. Graphic images for figures were provided by Axel Moehrenschlager, the Milk River Watershed Council Canada, the Canadian Museum of Nature, Kristy Bly, Eileen Dowd Stukel, and Nichole Bjornlie. Dana Blouin assisted with editing the report and locating some information. Graham Forbes and Stephen Petersen (Co-chairs, COSEWIC Terrestrial

Mammals Specialist Subcommittee), Sydney Allen, Angèle Cyr, Karen Timm, and Jenny Wu (Scientific Project Officers, COSEWIC Secretariat) and Neil Jones and Gloria Goulet (ATK Subcommittee, COSEWIC Secretariat) facilitated this status report update. We acknowledge Gordon Court who generously provided his Swift Fox photo. The many contributors of Swift Fox records in the Alberta Fish and Wildlife Management Information System are acknowledged in Appendix 2 as required by Alberta Environment and Parks (Bilyk pers. comm. 2017).

## INFORMATION SOURCES

AAFC (Agriculture and Agri-Food Canada). 2017. ISO 19131 Annual Crop Inventory – Data Product Specifications, revision A. Website: http://www.agr.gc.ca/atlas/supportdocument_documentdesupport/annualCropInventory/en/ISO%2019131_AAFC_Annual_Crop_Inventory_Data_Product_Specifications.pdf. [accessed January 2018].

AAFC (Agriculture and Agri-Food Canada). 2009. AESB Community Pastures with Land Management Districts (map). Website: http://www5.agr.gc.ca/resources/prod/doc/cpp/docs/AESBCommunityPastures_w_LM_Districts_eng.pdf [accessed October 2017].

ACIMS (Alberta Conservation Information Management System). 2017. Tracking and Watch Lists. Website: https://www.albertaparks.ca/albertaparksca/management-land-use/alberta-conservation-information-management-system-acims/tracking-watch-lists/ [accessed February 2018].

ABMI (Alberta Biodiversity Monitoring Institute). 2015. The Status of Biodiversity in the Prairie and Parkland Regions of Alberta: Preliminary Assessment. Alberta Biodiversity Monitoring Institute, Alberta, Canada. 49 pp. Website: http://www.abmi.ca/home.html [accessed January 2018].

AEDT (Alberta Economic Development and Trade). 2017. Well Count by Municipality. Website: https://open.alberta.ca/dataset/well-count-by-municipality/resource/9af3462f-73e6-44d3-972a-4d95b59cca69 [accessed September 2018].

Aguirre, A.A. 2009. Wild canids as sentinels of ecological health: a conservation medicine perspective. Parasites & Vectors 2 (Suppl 1): S7.

Alexander, J.L., S.K. Olimb, K.L.S. Bly, and M. Restani. 2016. Use of least-cost path analysis to identify potential movement corridors of Swift Foxes in Montana. Journal of Mammalogy. 97:891–898.

Allardyce, D., and M.A. Sovada. 2003. A review of the ecology, distribution, and status of Swift Foxes in the United States. Pp. 3–18 in M.A. Sovada and L.N. Carbyn (eds.). The Swift Fox: Ecology and Conservation of Swift Foxes in a Changing World. Canadian Plains Research Centre, University of Regina, Regina, Saskatchewan.

Antonation, K.S., T.K. Shury, T.K. Bollinger, A. Olson, P. Mabon, G. Van Domselaar, and C.R. Corbett. 2014. Sylvatic Plague in a Canadian Black-Tailed Prairie Dog (*Cynomys ludovicianus*). Journal of Wildlife Diseases 50: 699–702.

Asa, C.S., and C. Valdespino. 2003. A review of small canid reproduction. Pp. 117-123 in M.A. Sovada and L.N. Carbyn (eds.). The Swift Fox: Ecology and Conservation of Swift Foxes in a Changing World. Canadian Plains Research Centre, University of Regina, Regina, Saskatchewan.

Audubon, J.J., and J. Bachman. 1851. The Quadrupeds of North America. V.G. Audubon, New York, New York. 334 pp.

Ausband, D.E., and K.R. Foresman. 2007. Swift fox reintroductions on the Blackfeet Indian Reservation, Montana, USA. Biological Conservation 136:423–430.

Ausband, D., and A. Moehrenschlager. 2009. Long-range juvenile dispersal and its implication for conservation of reintroduced Swift Fox *Vulpes velox* populations in the USA and Canada. Oryx 43:73-77.

Berger, K.M., and E.M. Gese. 2007. Does interference competition with wolves limit the distribution and abundance of coyotes? Journal of Animal Ecology 76:1075–1085.

Bilyk, L., pers. comm. 2017. *Email correspondence to F. Blouin*. June 2017. Resource Data Biologist, Alberta Environment and Parks, Edmonton, Alberta.

Bjornlie, N., pers. comm. 2018. *Email correspondence to F. Blouin*. November 2018. Nongame Mammal Biologist, Wyoming Game and Fish Department, Lander, Wyoming.

Bly, K., pers. comm. 2018. *Email correspondence to F. Blouin*. November 2018. Senior Wildlife Conservation Biologist, World Wildlife Fund – Northern Great Plains Program, Hamilton, Montana.

Brechtel, S.H., L.N. Carbyn, D. Hjertaas, and C. Mamo. 1993. Canadian Swift Fox Reintroduction Feasibility Study: 1989–1992. Alberta Fish and Wildlife Services, Edmonton, Alberta. 95 pp.

BP. 2018. BP Statistical Review of World Energy June 2018. BP energy charting tool and app - Oil: Spot Crude Prices. Website: https://www.bp.com/en/global/corporate/energy-economics/energy-charting-tool-desktop.html. [accessed September 2018].

Bradley, C., and M. Neville. 2010. Minimizing Surface Disturbance of Alberta's Native Prairie - Background to Development of Guidelines for the Wind Energy Industry. Foothills Restoration Forum and the Prairie Conservation Forum. Unpublished document. Website: http://www.albertapcf.org/rsu_docs/wind-energy-background-final-december-2010.pdf [accessed September 2018].

Brown, L., R.C. Rosatte, C. Fehlner-Gardiner, J.A. Ellison, F.R. Jackson, P. Bachmann, J.S. Taylor, R. Franka, and D. Donovan. 2014. Oral vaccination and protection of striped skunks (*Mephitis mephitis*) against rabies using ONRAB®. Vaccine 32: 3675–3679.

Butler, A.R., K.LS. Bly, H. Harris, R.M. Inman, A. Moehrenschlager, D. Schwalm, and D.S. Jachowski. 2020. Home range size and resource use by Swift Foxes in northeastern Montana. Journal of Mammalogy, 101(3):684-696.

CABI. 2018. Canine Distemper Virus [original text by C.A. Whitehouse]. In: Invasive Species Compendium. Wallingford, UK: CAB International. Website: www.cabi.org/isc [accessed September 2018].

Cameron, M.W. 1984. The Swift Fox (*Vulpes velox*) on the Pawnee National Grassland: its food habits, population dynamics and ecology. M.Sc. Thesis, University of Northern Colorado, Greeley, Colorado. 117 pp.

Carbyn, L.N. 1998. Updated COSEWIC status report: Swift Fox (*Vulpes velox*). Committee on the Status of Endangered Wildlife in Canada, Ottawa, Ontario. 62 pp.

Carbyn, L.N., pers. comm. 2018. *Email correspondence to F. Blouin*. June 2018. Adjunct Professor - Ecology, Renewable Resources, University of Alberta, Edmonton, Alberta.

Carbyn, L.N., H.J. Armbruster, and C. Mamo. 1994. The Swift Fox reintroduction program in Canada from 1983 to 1992. pp. 247–270 in M.L. Bowles and C.J. Whelan (eds.). Restoration of Endangered Species: Conceptual Issues, Planning and Implementation. Cambridge University Press, New York, New York. 408 pp.

CESCC (Canadian Endangered Species Conservation Council). 2016. Wild Species 2015: The General Status of Species in Canada. National General Status Working Group. Website: http://www.registrelep-sararegistry.gc.ca/document/default_e.cfm?documentID=3174 [accessed February 2018].

CITES. 2017. Appendices I, II and III. Website: https://www.cites.org/eng/app/appendices.php [accessed February 2018].

CONHP (Colorado Natural Heritage Program). 2018. Elements by 7.5 Minute USGS Quadrangle. Biodiversity Tracking and Conservation System. Colorado State University, Fort Collins, Colorado, U.S.A. Data exported 03/02/2018. Web site: https://cnhp.colostate.edu/maps/cnhp-spatial-layers/# [accessed January 2019].

COSEWIC. 2009. COSEWIC assessment and status report on the Swift Fox *Vulpes velox* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 49 pp.

Cotterill, S.E. 1997. Population Census of Swift Fox *(Vulpes velox)* in Canada: Winter 1996–1997. Alberta Environmental Protection, Natural Resources Service, Wildlife Management Division, Edmonton, Alberta. 50 pp.

Covell, D.F. 1992. Ecology of the Swift Fox *(Vulpes velox)* in southeastern Colorado. M.S. Thesis, University of Wisconsin, Madison, Wisconsin. 111 pp.

Creel, S.R., G. Spong, and N. Creel. 2001. Interspecific competition and the population biology of extinction-prone carnivores. Pp. 35–60 in J.L. Gittleman, S.M. Funk, D.W. Macdonald, and R.K. Wayne (eds.). Carnivore Conservation. Cambridge University Press, Cambridge, UK.

Cullingham, C.I., and A. Moehrenschlager. 2013. Temporal analysis of genetic structure to assess population dynamics of reintroduced Swift Foxes. Conservation Biology 27:1389–1398.

Cullingham, C.I., and A. Moehrenschlager. 2019. Genetics of a reintroduced Swift Fox population highlights the need for integrated conservation between neighbouring countries. Animal Conservation 22(6):611-621.

Cutter, W.L. 1958. Food habits of the Swift Fox in northern Texas. Journal of Mammalogy 39:527–532.

Cypher, B.L. 2003. Foxes (*Vulpes* species, *Urocyon* species, and *Alopex lagopus*). Pp. 511–546 in G.A. Feldhamer, B.C. Thompson, and J.A. Chapman (eds.). Wild Mammals of North America: Biology, Management, and Conservation, 2$^{nd}$ Edition. John Hopkins University Press, Baltimore, Maryland.

Cypher, B.L., P.A. Kelly, and D.F. Williams. 2003. Factors influencing populations of endangered San Joaquin kit foxes. Pp. 125–137 in M.A. Sovada and L.N. Carbyn (eds.). The Swift Fox: Ecology and Conservation of Swift Foxes in a Changing World. Canadian Plains Research Centre, University of Regina, Regina, Saskatchewan.

Depersio. G. 2018. Why did oil prices drop so much in 2014? Investopedia. Website: https://www.investopedia.com/ask/answers/030315/why-did-oil-prices-drop-so-much-2014.asp. [accessed December 2018].

Dowd Stukel, E. (ed). 2017 Swift Fox conservation team: Report for 2015–2016. Wildlife Division Report No. 2017-04, South Dakota Department of Game, Fish and Parks, Pierre, South Dakota, USA. 86 pp.

Dowd Stukel, E., pers. comm. 2018. *Email correspondence to F. Blouin*. November 2018. Wildlife Diversity Coordinator South Dakota Department of Game, Fish and Parks, Pierre, South Dakota.

Downey, B.L., pers. comm. 2017. *Email correspondence to F. Blouin*. September 2017. Senior Species at Risk Biologist, Ministry of Environment and Parks, Government of Alberta, Lethbridge, Alberta.

Dragoo, J.W., J.R. Choate, T.L. Yates, and T.P. O'Farrell. 1990. Evolutionary and taxonomic relationships among North American arid-land foxes. Journal of Mammalogy 71:318-332.

ECCC (Environment and Climate Change Canada). 2017. Action Plan for Multiple Species at Risk in Southwestern Saskatchewan: South of the Divide. Species at Risk Act Action Plan Series. Environment and Climate Change Canada, Ottawa. xi + 127 pp.

Efford, M. G. 2017. SECR: Spatially explicit capture-recapture models. R package version 3.1.0. Website: https://cran.r-project.org/web/packages/secr/index.html [accessed February 2018].

Egoscue, H.J. 1979. Mammalian Species: *Vulpes velox*. Lawrence, Kansas, American Society of Mammalogists 122:1–5.

Ehlert, G., pers. comm. 2017. *Email correspondence to F. Blouin*. October 2017. Rangeland Agrologist, Alberta Environment and Parks, Government of Alberta, Medicine Hat, Alberta

Elmhagen B., D. Berteaux, R.M. Burgess, D. Ehrich, D. Gallant, H. Henttonen, R.A. Ims, S.T. Killengreen, J. Niemimaa, K. Norén, and T. Ollila. 2017. Homage to Hersteinsson and Macdonald: climate warming and resource subsidies cause red fox range expansion and Arctic fox decline. Polar Research 36: sup1, 3, DOI: 10.1080/17518369.2017.1319109.

Erickson, W., and D. Urban. 2004. Potential risks of nine rodenticides to birds and nontarget mammals: A Comparative Approach. United States Environmental Protection Agency, Washington, D.C. v + 225 pp.

ESTR Secretariat. 2014. Prairies Ecozone$^+$ evidence for key findings summary. Canadian Biodiversity: Ecosystem Status and Trends 2010, Evidence for Key Findings Summary Report No. 4. Canadian Councils of Resource Ministers. Ottawa, ON. ix + 115 p. Website: http://www.biodivcanada.ca/7B68A0C4-6185-44E6-8950-39F444631A04/EN_Prairies_EKFS_FINAL_2014-05-07.pdf [accessed September 2017].

Flaherty, M., and R. Plaake. 1986. Response of Swift Fox (*Vulpes velox*) to water stress. The Journal of Colorado-Wyoming Academy of Sciences 18:51.

Fox, A. 2020. Tribes Reintroduce Swift Fox to Northern Montana's Fort Belknap Reservation. In: smithsonianmag.com, October 13, 2020

Geffen, E., and I. Girard. 2003. Behavioral and physiological adaptations of foxes to hot arid environments: comparing Saharo-Arabian and North American species. Pp. 223 - 229 in M.A. Sovada and L.N. Carbyn (eds.). The Swift Fox: Ecology and Conservation of Swift Foxes in a Changing World. Canadian Prairie Research Centre, University of Regina, Regina, Saskatchewan

Gese, E.M., S.M. Karki, M.L. Klavetter, E.R. Schauster, and A.M. Kitchen. 2004. Serologic survey of canine infectious diseases among sympatric Swift Foxes (*Vulpes velox*) and coyotes (*Canis latrans*) in southeastern Colorado. Journal of Wildlife Diseases 40:741–748.

Gese, E.M., and C.M. Thompson. 2014. Does habitat heterogeneity in a multi-use landscape influence survival rates and density of a native mesocarnivore? Plos One 9(6):e100500.

Gosselink,T.E., T.R. Van Deelen, R.E. Warner, and M.G. Joselyn. 2003. Temporal habitat partitioning and spatial use of Coyotes and Red Foxes in east-central Illinois. The Journal of Wildlife Management 67:90-103.

Government of Alberta. 2011. Recommended Land Use Guidelines for Protection of Selected Wildlife Species and Habitat within Grassland and Parkland Natural Regions of Alberta. Website: http://aep.alberta.ca/fish-wildlife/wildlife-land-use-guidelines/default.aspx [accessed March 2018].

Government of Alberta. 2017a. Wildlife Directive for Alberta Wind Energy Projects. AEP Fish and Wildlife 2016 No 6. Website: http://aep.alberta.ca/fish-wildlife/wildlife-land-use-guidelines/documents/WildlifeWindEnergyDirective-Apr07-2017.pdf [accessed November 2017].

Government of Alberta. 2017b. Wildlife Directive for Alberta Solar Energy Projects. AEP Fish and Wildlife 2016 No 5. Website: http://aep.alberta.ca/fish-wildlife/wildlife-land-use-guidelines/documents/Directive-SolarEnergyProjects-Oct04-2017.pdf [accessed November 2017].

Government of Alberta. 2017c. Master Schedule of Standards and Conditions. Website: http://aep.alberta.ca/forms-maps-services/industry-online-services/public-lands-dispositions/step-one-pre-application/documents/MasterSchedStandardsConditions-Jun28-2017.pdf [accessed November 2017].

Government of Canada. 2013. Species at Risk Public Registry - Top Questions and Answers Greater Sage-Grouse Emergency Order. Website: http://www.registrelep-sararegistry.gc.ca/virtual_sara/files/gen_info/fs_qr_qa_dec_ord_tetarm_sgrouse_1213_e.pdf [accessed February 2018].

Government of Canada. 2018a. Species at Risk Public Registry- Species Profile: Swift Fox. Website: https://www.registrelep-sararegistry.gc.ca/species/speciesDetails_e.cfm?sid=140 [accessed February 2018].

Government of Canada. 2018b. Species at Risk Public Registry - SARA and You Guide. Website: https://www.sararegistry.gc.ca/default.asp?lang=En&n=71BBC38E-1 [accessed February 2018].

Government of Saskatchewan. 2016. Saskatchewan Provincial Pastures Land - Pastures Land Education Document. Website: http://publications.gov.sk.ca/documents/20/108587-Pastures%20Education%20Document.pdf [accessed October 2017].

Government of Saskatchewan. 2017a. Saskatchewan Activity Restriction Guidelines for Sensitive Species. Website: http://publications.gov.sk.ca/documents/66/89554-Saskatchewan%20Activity%20Restriction%20Guidelines%20for%20Sensitive%20Species%20-%20April%202017.pdf [accessed November 2017].

Government of Saskatchewan. 2017b. Vertical_Wells – Shapefile. Website: https://gisappl.saskatchewan.ca/WebDocs/Geo_Atlas/MetaData/Vertical_wells.html [accessed October 2017].

Government of Saskatchewan. 2017c. NonVertical_Wells – Shapefile. Website: https://gisappl.saskatchewan.ca/WebDocs/Geo_Atlas/MetaData/NonVertical_well.html [accessed October 2017].

Government of Saskatchewan. 2018. Environmental review guidelines for oil and gas activities. Website: http://www.publications.gov.sk.ca/details.cfm?p=78871 [accessed December 10, 2018].

Harrison, R.L. 2003. Swift fox demography, movements, denning, and diet in New Mexico. The Southwestern Naturalist 48:261–273.

Harrison, R.L., and J.W. Hoagland. 2003. A literature review of Swift Fox habitat and den-site selection. Pp. 79–92 in M.A. Sovada and L.N. Carbyn (eds.). The Swift Fox: Ecology and Conservation of Swift Foxes in a Changing World. Canadian Plains Research Centre, University of Regina, Regina, Saskatchewan.

Harrison, R.L., P-G.S. Clarke, and C.M. Clarke. 2004. Indexing Swift Fox populations in New Mexico using scats. The American Midland Naturalist 151:42-49.

Health Canada. 2016. Health Canada's Pest Management Regulatory Agency / Regions and Programs Bureau Compliance and Enforcement Report 2014-2015. Website: https://www.canada.ca/content/dam/hc-sc/migration/hc-sc/cps-spc/alt_formats/pdf/pubs/pest/corp-plan/compliance-enforcement-2014-2015-conformite-application/compliance-enforcement-2014-2015-conformite-application-eng.pdf [accessed November 2017].

Helgen, K., and F. Reid. 2016. *Mephitis mephitis*. The IUCN Red List of Threatened Species 2016: e.T41635A45211301. Website: http://dx.doi.org/10.2305/IUCN.UK.2016-1.RLTS.T41635A45211301.en [accessed November 2018].

Helgen, K.M., F.R. Cole, L.E. Helgen, and D.E. Wilson. 2009. Generic revision in the holarctic ground squirrel genus *Spermophilus*. Journal of Mammalogy, 90:270–305.

Herrero, S., C. Mamo, L.N. Carbyn, and J.M. Scott-Brown. 1991. Swift fox reintroduction into Canada. Pp. 246–252 in G.L. Holroyd, G. Burns, and H.C. Smith (eds.). Proceedings of the Second Endangered Species and Prairie Conservation Workshop. Occasional Paper No. 15, Provincial Museum of Alberta, Natural History Section, Edmonton, Alberta.

Hillman, C.N., and J.C. Sharps. 1978. Return of the Swift Fox to the northern Great Plains. Proceedings of the South Dakota Academy of Sciences 57:154–162.

Hines, T.D. 1980. An ecological study of *Vulpes velox* in Nebraska. M.Sc. Thesis, University of Nebraska, Lincoln, Nebraska. 103 pp.

Hines, T.D., and R.M. Case. 1991. Diet, home range, movements, and activity periods of Swift Fox in Nebraska. Prairie Naturalist 23:131–138.

Hockaday, J. 2011. Coming to our senses of Swift Fox recovery. Wildlands Advocate 19: 11-13. Website: https://albertawilderness.ca/wordpress/wp-content/uploads/2015/08/201104_V19N2_WLA1.pdf [accessed November 2017].

IUCN Standards and Petitions Subcommittee. 2017. Guidelines for Using the IUCN Red List Categories and Criteria. Version 13. Prepared by the Standards and Petitions Subcommittee. Website: http://www.iucnredlist.org/documents/RedListGuidelines.pdf. [accessed February 2018].

Kamler, J.F., and W.B. Ballard. 2002. A review of native and non-native red foxes in North America. Wildlife Society Bulletin 30:370–379.

Kamler, J.F., W.B. Ballard, R.L. Gilliland, P.R. Lemons, and K. Mote. 2003a. Impacts of coyotes on Swift Foxes in northwestern Texas. Journal of Wildlife Management 67:317–323.

Kamler, J. F., W.B. Ballard, E.B. Fish, P.R. Lemons, K.Mote, and C.C. Perchellet. 2003b. Habitat use, home ranges, and survival of Swift Foxes in a fragmented landscape: conservation implications. Journal of Mammalogy 84:989–995.

Kamler, J.F., W.B. Ballard, P.R. Lemons, and K. Mote. 2004. Variation in mating system and group structure in two populations of Swift Foxes, *Vulpes velox*. Animal Behaviour 68:83–88.

Kamler, J.F., W.B. Ballard, M.C. Wallace, R.L. Gilliland, and P.S. Gipson. 2007. Dietary overlap of Swift Foxes and Coyotes in Northwestern Texas. The American Midland Naturalist 158:139–146.

Karki, S.M., E.M. Gese, and M.L. Klavetter. 2007. Effects of coyote population reduction on Swift Fox demographics in southeastern Colorado. Journal of Wildlife Management 71:2707–2718.

Kapil, S., and T.J. Yeary. 2011. Canine Distemper Spillover in Domestic Dogs from Urban Wildlife. Veterinary Clinics: Small Animal Practice 41:1069–1086.

Keith, J., pers. comm. 2017. *Phone correspondence to F. Blouin*. October 2017. Biodiversity Biologist, Saskatchewan Ministry of Environment, Regina, SK.

Kilgore, D.L., Jr. 1969. An ecological study of the Swift Fox (*Vulpes velox*) in the Oklahoma panhandle. American Midland Naturalist 81:512–534.

Kitchen, A.M., E.M. Gese, L.P. Waits, S.M. Karki, and E.R. Schauster. 2006. Multiple breeding strategies in the Swift Fox, *Vulpes velox*. Animal Behaviour 71:1029–1038

Kitchen, A.M., E.M. Gese, and E.R. Schauster. 1999. Resource partitioning between coyotes and Swift Foxes: space, time, and diet. Canadian Journal of Zoology 77:1645–1656.

Klausz, E.E. 1997. Small mammal winter abundance and distribution in the Canadian mixed grass prairies and implications for the Swift Fox. M.S. thesis, University of Alberta, Edmonton, Canada.

Knobel, D.L., J.R. Butler, T. Lembo, R. Critchlow, and M.E. Gompper. 2014. Dogs, disease, and wildlife. Pp.144-169 in M.E. Gompper (ed.). Free-ranging dogs and wildlife conservation. Oxford University Press, Oxford, United Kingdom.

Larivière, S., and M. Pasitschniak-Arts. 1996. *Vulpes vulpes*. American Society of Mammalogists. Mammalian species No. 537. 11 pp.

Laurenson, M.K., S. Cleaveland, M. Artois and R. Woodroffe. 2004. Assessing and Managing Infectious Disease - Threats to Canids. Pp. 246-256 in C. Sillero-Zubiri, M. Hoffmann, and D.W. Macdonald (eds.). Canids: Foxes, Wolves, Jackals and Dogs. Status Survey and Conservation Action Plan. IUCN/SSC Canid Specialist Group. Gland, Switzerland and Cambridge, UK.

Leighton, F.A., H.A. Artsob, M.C. Chu, and J.G. Olson. 2001. A serological survey of rural dogs and cats on the southwestern Canadian prairie for zoonotic pathogens. Canadian Journal of Public Health 92:67–71.

Linhart, S.B., and W.B. Robinson. 1972. Some relative carnivore densities in areas under sustained coyote control. Journal of Mammalogy 53:880–884.

Mamo, C. 1994. Swift fox Population Survey 1994. Prepared for Alberta Fish and Wildlife and The Swift Fox Conservation Society, Edmonton, Alberta. 30 pp.

Marino, J., C. Sillero-Zubiri, A. Deressa, E. Bedin, A. Bitewa, F. Lema, G. Rskay, G. Banyard, and A. Fooks. 2017. Rabies and distemper outbreaks in the smallest Ethiopian Wolf population. Emerging Infectious Diseases 23:2102-2104.

Matz, D., pers. comm. 2017. *Phone correspondence to* F. Blouin. September 2017. Agricultural Fieldman, County of Forty Mile, Foremost, Alberta.

MBCDC (Manitoba Conservation Data Centre). 2016. Vertebrate Conservation Status Ranks. Version 01-Dec-2016. Website: https://www.gov.mb.ca/sd/cdc/pdf/animal_ranks.pdf [accessed February 2018].

McGee, B.K., J.J. Butler, D.B. Pence, J.L. Alexander, J.B. Nissen, W.B. Ballard, and K.L. Nicholson. 2006. Possible vector dissemination by Swift Foxes following a plague epizootic in black-tailed prairie dogs in northwestern Texas. Journal of Wildlife Diseases 42:415–420.

McInnis, B., pers. comm. 2017. *Phone correspondence with F. Blouin*. November 2017. Assistant Manager of PFRA Transition, Saskatchewan Ministry of Agriculture, Swift Current, Saskatchewan.

McInnis, B., pers. comm. 2018. *Phone correspondence with F. Blouin*. December 2018. Assistant Manager of PFRA Transition, Saskatchewan Ministry of Agriculture, Swift Current, Saskatchewan.

MEFWLB (Ministry of Environment, Fish, Wildlife and Lands Branch). 2017. Activity Restriction Guidelines for Sensitive Species. Regina, Saskatchewan. 4 pp. Website: http://publications.gov.sk.ca/documents/66/89554-Saskatchewan%20Activity%20Restriction%20Guidelines%20for%20Sensitive%20Species%20-%20April%202017.pdf [accessed February 2018].

Mercure, A., K. Ralls, K.P. Koepfli, and R.K. Wayne. 1993. Genetic subdivisions among small canids: mitochondrial DNA differentiation of swift, kit, and Arctic foxes. Evolution 47:1313–1328.

Merriam, C.H. 1902. Three new foxes of the kit and desert fox. Proceedings of the Biological Society, Washington 15:73–74.

Merrill, P., pers. comm. 2017. *Email correspondence to* F. Blouin. November 2017. Rat and Pest Specialist, Inspection/Investigation Section, Alberta Agriculture and Forestry, Lethbridge, Alberta.

Michener, G.R. 1983. Spring emergence schedules and vernal behavior of Richardson's ground squirrels: why do males emerge from hibernation before females? Behavioral Ecology and Sociobiology 14:29-38.

Miller, D.S., D.F. Covell, R.G. McLean, W.J. Adrian, M. Niezgoda, J.M. Gustafson, O.J. Rongstad, R.D. Schultz, L.J. Kirk, and T.J. Quan. 2000. Serologic survey for selected infectious disease agents in swift and kit foxes from the western United States. Journal of Wildlife Diseases 36:798–805.

Mitchell, E.L. 2018. Distribution, Ecology, Disease Risk, and Genetic Diversity of Swift Fox (*Vulpes velox*) in the Dakotas. Electronic Theses and Dissertations. 2692. Website: https://openprairie.sdstate.edu/etd/2692 [accessed January 2019].

Moehrenschlager, A. 2000. Effects of ecological and human factors on the behaviour and population dynamics of reintroduced Canadian Swift Foxes (*Vulpes velox*). D.Phil. Dissertation, Wildlife Conservation Research Unit, University of Oxford, Oxford, UK. 301 pp.

Moehrenschlager, A., pers. comm. 2018. *Email correspondence to F. Blouin*. June 2018. Director, Conservation and Science, Calgary Zoo, Calgary, Alberta.

Moehrenschlager, A., pers. comm. 2021. *Email correspondence to S. Petersen*. April 2021. Director, Conservation and Science, Calgary Zoo, Calgary, Alberta.

Moehrenschlager, A., and D.W. Macdonald. 2003. Movement and survival parameters of translocated and resident Swift Foxes. Animal Conservation 6:199–206.

Moehrenschlager, A., and C. Moehrenschlager. 2001. Census of Swift Fox (*Vulpes velox*) in Canada and Northern Montana: 2000–2001. Alberta Sustainable Resource Development, Fish and Wildlife Division, Alberta Species at Risk Report No. 24, Edmonton, Alberta.

Moehrenschlager, A., and C. Moehrenschlager. 2006. Population Census of Reintroduced Swift Foxes, *Vulpes velox*, in Canada and Northern Montana 2005/2006. Centre for Conservation Research Report No. 1, Calgary Zoo, Calgary, Alberta.

Moehrenschlager, A. and C. Moehrenschlager. 2018. Population survey of reintroduced Swift Foxes (*Vulpes velox*) in Canada and northern Montana 2014/2015. Centre for Conservation Research, Calgary Zoological Society, Calgary, Alberta, Canada. 20 pp.

Moehrenschlager, A., Moehrenschlager, C., and H. Harris. 2020. Changes in Distribution and Occupancy of Reintroduced Canadian/Northern Montana Swift Foxes (*Vulpes velox*) between 2015 and 2018. Centre for Conservation Research, Calgary Zoological Society, Calgary, Alberta, Canada. 13 pp.

Moehrenschlager, A., and M.A. Sovada. 2004. Swift Fox – *Vulpes velox*. Pp. 109–116 in C. Sillero-Zubiri, M. Hoffman, and D.W. Macdonald (eds.). Canids: Foxes, Wolves, Jackals, and Dogs. Status Survey and Conservation Action Plan. IUCN/SSC Canid Specialist Group, Gland, Switzerland and Cambridge, UK. 430 pp.

Moehrenschlager, A., and M.A. Sovada. 2016. *Vulpes velox*. The IUCN Red List of Threatened Species 2016: e.T23059A57629306. Website: http://dx.doi.org/10.2305/IUCN.UK.2016-3.RLTS.T23059A57629306.en [accessed May 2017].

Moehrenschlager, A., S.M. Alexander, and T. Brichieri-Colombi. 2007a. Habitat suitability and population viability analysis for reintroduced Swift Foxes in Canada and Northern Montana. Centre for Conservation Research, Calgary Zoo, Calgary, Alberta. 30 pp.

Moehrenschlager, A., R. List, and D.W. Macdonald. 2007b. Escaping intraguild predation: Mexican Kit Foxes survive while Coyotes and Golden Eagles kill Canadian Swift Foxes. Journal of Mammalogy 88:1029–1039.

Moehrenschlager, A., B.L. Cypher, K. Ralls, R. List, and M.A. Sovada. 2004. Swift and Kit Foxes: comparative ecology and conservation priorities of Swift and Kit foxes. Pp. 185–198 in D.W. Macdonald and C. Sillero-Zubiri (eds.). Biology and Conservation of Wild Canids. Oxford University Press, Oxford, UK.

Moehrenschlager, A., D.W. Macdonald, and C. Moehrenschlager, C. 2003. Reducing capture-related injuries and radio-collaring effects on Swift Foxes. Pp. 107-113 in M.A. Sovada and L.N. Carbyn (eds.). The Swift Fox: Ecology and Conservation of Swift Foxes in a Changing World. Canadian Plains Research Centre, University of Regina, Regina, Saskatchewan.

Montana Field Guide. 2019. Swift Fox — *Vulpes velox*. Montana Natural Heritage Program and Montana Fish, Wildlife and Parks. Web site: http://FieldGuide.mt.gov/speciesDetail.aspx?elcode=AMAJA03030 [accessed January 2019].

MRWCC (Milk River Watershed Council Canada). 2013. Milk River Transboundary State of the Watershed Report, 2nd Edition. Compiled by Palliser Environmental Services Ltd. and prepared for Milk River Watershed Council Canada (Alberta) in collaboration with the Milk River Watershed Alliance (Montana). Milk River, Alberta. 238 pp.

Mueller M.A., D. Drake, and M.L. Allen. 2018. Coexistence of coyotes (*Canis latrans*) and red foxes (*Vulpes vulpes*) in an urban landscape. PLoS ONE 13(1): e0190971. https://doi.org/10.1371/journal.pone.0190971.

Naughton, D. 2012. The Natural History of Canadian Mammals. University of Toronto Press, Toronto, Ontario. 784 pp.

NatureServe. 2021. NatureServe Explorer: An online encyclopedia of life [web application]. NatureServe, Arlington, Virginia. Website: http://explorer.natureserve.org [accessed: May 2021].

NDGFD (North Dakota Game and Fish Department). 2019. North Dakota Carnivores – Swift Fox. Website: https://gf.nd.gov/wildlife/id/carnivores/swift-fox [accessed January 2019].

NENHP (Nebraska Natural Heritage Program). 2011. Estimated current range of Swift Fox (*Vulpes velox*). Nebraska Game and Park Commission. Website: https://outdoornebraska.gov/wp-content/uploads/2015/07/Swift-Fox.pdf [accessed January 2019].

Nevison, S.A. 2017. Swift Foxes in Southwestern South Dakota: Assessing the current status of a reintroduced population. M.Sc. Thesis, South Dakota State University, Brookings, South Dakota. 121 pp.

Nicholson, J., pers. comm. 2017. *Email correspondence to* F. Blouin. September 2017. Senior Species at Risk Biologist, Alberta Environment and Parks, Medicine Hat, Alberta.

Nicholson, J., pers. comm. 2019. *Verbal correspondence to* F. Blouin. June 2019. Senior Species at Risk Biologist, Alberta Environment and Parks, Medicine Hat, Alberta.Olsen, P.F. 1981. Sylvatic plague. Pp. 232–243 in J.W. Davis, L.H. Karstad, and D.O. Trainer (eds.). Infectious Diseases of Wild Animals, 2nd Edition. Iowa State Press, Ames, Iowa.

Olson, T.L., and F.G. Lindzey. 2002. Swift fox survival and production in southeastern Wyoming. Journal of Mammalogy 83:199–206.

Parks Canada Agency. 2016. Multi-species Action Plan for Grasslands National Park of Canada. Species at Risk Act Action Plan Series. Parks Canada Agency, Ottawa. iv + 57 pp.

Parsons, R., pers. comm. 2017. *Email correspondence to F. Blouin*. November 2017. South Regional Manager, Saskatchewan Pastures Program, Ministry of Agriculture, Regina, Saskatchewan.

Petrinex. 2018. Well Infrastructures. Website: https://www.petrinex.ca/PD/Pages/APD.aspx. [accessed September 2018].

Phillips. D. 2015. PFRA Pastures Transition Study. Frogworks Consultants. Website: http://www.naturesask.ca/rsu_docs/pfra-final-report.pdf [accessed October 2017].

Pied Piper. 1950. The third column: Passing of the kit fox. Page 4 In: The Edmonton Journal. April 26, 1950.

PMRA (Pest Management Regulatory Agency). 2007. Re-evaluation Decision document RVD2007-01: Zinc Phosphide. Health Canada, Pest Management Regulatory Agency, Ottawa, Ontario. 9 pp. Website: https://www.canada.ca/en/health-canada/services/consumer-product-safety/reports-publications/pesticides-pest-management/decisions-updates.html [accessed November 2017].

PMRA. 2011. Label transcript No. 2011-2140. Sodium Cyanide – predacide (restricted), coyote control. Website: http://pr-rp.hc-sc.gc.ca/ls-re/index-eng.php [accessed November 2017].

PMRA. 2012. Label transcript No. 2011-5377. 2% liquid strychnine concentrate (to be mixed with farm available grain to formulate 0.4% strychnine bait). Website: http://pr-rp.hc-sc.gc.ca/ls-re/index-eng.php [accessed November 2017].

PMRA. 2014. Re-evaluation Decision document RVD2014-03: Special Review Decision for Compound 1080. Health Canada, Pest Management Regulatory Agency, Ottawa, Ontario. 8 pp. Website: https://www.canada.ca/en/health-canada/services/consumer-product-safety/reports-publications/pesticides-pest-management/decisions-updates.html [accessed November 2017].

Poessel, S.A., and E.M. Gese. 2013. Den attendance patterns in Swift Foxes during pup rearing: varying degrees of parental investment within the breeding pair. Journal of Ethology (31):193–201.

Prieto, B., pers. comm. 2017. *Email correspondence to F. Blouin*. October 2017. Terrestrial Ecologist, Saskatchewan Ministry of Environment, Regina, Saskatchewan.

Proulx, G. 2010. Factors contributing to the outbreak of Richardson's ground squirrel populations in the Canadian Prairies. Pp. 213-217 in R.M. Timm and K.A. Fagerstone, (eds.). Proceedings of the 24th Vertebrate Pest Conference. University of California, Davis. California.

Proulx, G. 2011. Field evidence of non-target and secondary poisoning by strychnine and chlorophacinone used to control Richardson's Ground Squirrels in southwest Saskatchewan. Pp. 128-134 in D. Danyluk (ed.). Proceedings of the $9^{th}$ Prairie Conservation and Endangered Species Conference, February 25-27, 2010, Critical Wildlife Habitat Program, Winnipeg, Manitoba.

Proulx, G. 2012. High spring mortality of adult Richardson's Ground Squirrels, *Urocitellus richardsonii*, associated with a severe rainstorm in southwestern Saskatchewan. Canadian Field-Naturalist 126:148-151.

Proulx, G., and N. MacKenzie. 2012. Relative abundance of American Badger (*Taxidea taxus*) and Red Fox (*Vulpes vulpes*) in landscapes with high and low rodenticide poisoning levels. Integrative Zoology 7:41–47.

Proulx, G., N. MacKenzie, B. Proulx, and K. MacKenzie. 2011. Relationships among predators, prey and habitat use in southern Saskatchewan, spring and summer 2010. Alpha Research and Management Ltd. report submitted to Saskatchewan Association of Rural Communities (SARM) and Saskatchewan Ministry of Agriculture & Rural Development – ADF, Regina, Saskatchewan. 144 pp.

Provost, K. 2018. Sask. sees largest coyote fur harvest on record. Website: https://www.cbc.ca/news/canada/saskatoon/saskatchewan-coyotes-harvest-pelt-prices-1.4889413 [accessed December 2018].

Pruss, S.D. 1994. An observational natal den study of wild Swift Fox *(Vulpes velox)* on the Canadian Prairie. M.Sc. Thesis, University of Calgary, Calgary, Alberta. 214 pp.

Pruss, S.D. 1999. Selection of natal dens by Swift Fox (*Vulpes velox*) on the Canadian prairies. Canadian Journal of Zoology 77:646–652.

Pruss, S.D., P. Fargey, and A. Moehrenschlager. 2008. Recovery Strategy for the Swift Fox (*Vulpes velox*) in Canada. Prepared in consultation with the Canadian Swift Fox Recovery Team. Species at Risk Act Recovery Strategy Series, Parks Canada Agency, Ottawa, Ontario. 35 pp.

Pybus, M.J., pers. comm. 2017. *Email correspondence to F. Blouin*. October 2017. Provincial Wildlife Disease Specialist, Alberta Environment and Parks, Edmonton, Alberta.

Pybus, M.J., and E.S. Williams. 2003. A review of parasites and diseases of wild Swift Fox. Pp. 231–236 in M.A. Sovada and L.N. Carbyn (eds.). The Swift Fox: Ecology and Conservation of the Swift Fox in a Changing World. Canadian Plains Research Centre, University of Regina, Regina, Saskatchewan.

Queen's Printer for Canada. 2016. *Canada Gazette* – Part I. Ottawa, Saturday September 24, 2016, Vol. 150, No. 39. Website: http://sararegistry.gc.ca/document/default_e.cfm?documentID=3012 [accessed September 2018].

Queen's Printer for Canada. 2018. *Canada Gazette* – Part I. Ottawa, Saturday September 17, 2018, Vol. 152, No. 7. Website: http://sararegistry.gc.ca/document/default_e.cfm?documentID=3296 [accessed September 2018].

R Core Team. 2015. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing. Vienna, Austria, https://www.R-project.org.

Ralls, K., and P.J. White. 1995. Predation on San Joaquin Kit Foxes by some larger canids. Journal of Mammalogy 76:723-729.

Reid, R. 2006. Peterson Field Guide to Mammals of North America, Fourth Edition. Houghton Mifflin Company, New York, New York. 608 pp.

Reynolds, J.L., L.N. Carbyn, M. Nietfeld, H. Armbruster, S. Herrero, and C. Mamo. 1991. Food habits of Swift Foxes (*Vulpes velox*) in release programs in Alberta and Saskatchewan. Unpublished report. 26 pp.

Robinson, W.B. 1961. Population changes of carnivores in some coyote-control areas. Journal of Mammalogy 42:510–515.

Russell, T.A. 2006. Habitat selection by Swift Foxes in Badlands National Park and the surrounding area in South Dakota. M.Sc. thesis, South Dakota State University, Brookings. 119 pp.

Salafsky, N., D. Salzer, A.J. Stattersfield, C. Hilton-Taylor, R. Neugarten, S.H.M. Butchart, B. Collen, N. Cox, L.L. Master, S. O'Connor, and D. Wilkie. 2008. A standard lexicon for biodiversity conservation: unified classifications of threats and actions. Conservation Biology 22:897-911.

Salkeld, D.J., R.J. Eisen, P. Stapp, A.P. Wilder, J. Lowell, D.W. Tripp, D. Albertson, and M.F. Antolin. 2007. The potential role of Swift Foxes (*Vulpes velox*) and their fleas in plague outbreaks in prairie dogs. Journal of Wildlife Diseases 43:425–431.

Saskatchewan Fur Program. 2012. Summary of Regulations, Policy and Associated Programs - Revised June 18, 2012. 14 pp. Website: http://publications.gov.sk.ca/documents/66/76577-Saskatchewan%20Fur%20Program.pdf [accessed November 2017].

Saskatchewan Ministry of Agriculture. 2016. Saskatchewan Pasture Program – South Region (map). Website: http://publications.gov.sk.ca/documents/20/84832-SPP_South.pdf [accessed September 2017].

Say, T., 1823. Account of an expedition from Pittsburgh to the Rocky Mountains : performed in the years 1819 and 1820, by order of the Hon. J.C. Calhoun, sec'y of war, under the command of Major Stephen H. Long : from the notes of Major Long, Mr. T. Say, and other gentlemen of the exploring party compiled by Edwin James, botanist and geologist for the expedition; in two vols.

Schauster, E.R., E.M. Gese, and A.M. Kitchen. 2002. Population ecology of Swift Foxes (*Vulpes velox*) in southeastern Colorado. Canadian Journal of Zoology 80:307–319.

Schmidt, C.J., T.W. Taggart, G.A. Kaufman, D.W. Kaufman, E.J. Finck, A. Hope, M. Peek, and R. Timm 2018. Kansas Mammal Atlas: An On-line Reference. Web site: http://webapps.fhsu.edu/ksmammal [accessed January 2019].

Schroeder, C.A. 1985. A preliminary management plan for securing Swift Fox reintroductions into Canada. M.Sc. Thesis, Faculty of Environmental Design, University of Calgary, Calgary, Alberta. 211 pp.

Schwalm D.L., W.B. Ballard, E.B. Fish, and H.A. Whitlaw. 2012. Distribution of the Swift Fox (*Vulpes velox*) in Texas. The Southwestern Naturalist 57:393–398.

Schwalm, D, L.P. Waits, and W.B. Ballard. 2014. Little fox on the prairie: an assessment of genetic structure and diversity throughout the distribution of a grassland species in the United States. Conservation Genetics 15:1503-1514

Scott-Brown, J.M., S. Herrero, and J. Reynolds. 1987. Swift fox. Pp. 433–441 in M. Novak, J.A. Baker, M.E. Obbard, and B. Malloch (eds.). Wild Furbearer Management and Conservation in North America. Ontario Ministry of Natural Resources, Toronto, Ontario.

Seaman, D.E., and R.A. Powell. 1996. An evaluation of the accuracy of kernel density estimators for home range analysis. Ecology 77:2075–2085.

Selås, V., B.S. Johnsen, and N.E. Eide. 2010. Arctic fox *Vulpes lagopus* den use in relation to altitude and human infrastructure. Wildlife Biology 16:107-112.

Seton, E.T. 1909. Life Histories of the Northern Mammals: Account of the Mammals of Manitoba, Volume II – Flesh Eaters. Charles Scribner's Sons, New York, New York. 1267 pp.

Shury, T., pers. comm. 2017. *Email correspondence to F. Blouin*. October 2017. Wildlife Health Specialist, Parks Canada, Saskatoon, Saskatchewan.

SKCDC (Saskatchewan Conservation Data Centre). 2018. February 2018. Saskatchewan Vertebrate Tracked Taxa List. Regina, Saskatchewan. Website: www.biodiversity.sk.ca/SppList.htm [accessed February 2018].

Smeeton, C. 2006. Re-introduction of Swift Fox to the Blackfeet Confederacy Tribal Lands of western North America: three programs, three realities. Re-introduction News 25:33–35.

Smeeton, C., K. Weagle, and S.S. Waters. 2003. Captive breeding of the Swift Fox at the Cochrane Ecological Institute, Alberta. Pp. 199–206 in M.A. Sovada and L.N. Carbyn (eds.). Swift Fox: Ecology and Conservation of Swift Foxes in a Changing World. Canadian Plains Research Centre, University of Regina, Regina, Saskatchewan.

Sovada, M.A., C.C. Roy, J.B. Bright, and J.R. Gillis. 1998. Causes and rates of mortality of Swift Foxes in western Kansas. Journal of Wildlife Management 62:1300–1306.

Sovada, M.A., C.C. Roy, and D.J. Telesco. 2001. Seasonal food habits of Swift Fox (*Vulpes velox*) in cropland and rangeland landscapes in western Kansas. American Midland Naturalist 145:101–111.

Sovada, M.A., C.C. Slivinski, and R.O. Woodward. 2003. Home range, habitat use, pup dispersal and litter sizes of Swift Foxes in western Kansas. Pp. 149–159 in M.A Sovada and L.N. Carbyn (eds.). Swift Fox: Ecology and Conservation of Swift Foxes in a Changing World. Canadian Plains Research Centre, University of Regina, Regina, Saskatchewan.

Sovada, M.A., R.O. Woodward, and L.D. Igl. 2009. Historical range, current distribution, and conservation status of the Swift Fox, *Vulpes velox*, in North America. Canadian Field-Naturalist 123:346–367.

Stephens, T., S.C. Wilson, F. Cassidy, D. Bender, D. Gummer, D.H.V. Smith, N. Lloyd, J.M. McPherson, and A. Moehrenschlager. 2018. Climate change impacts on the conservation outlook of populations on the poleward periphery of species ranges: A case study of Canadian black-tailed prairie dogs (*Cynomys ludovicianus*). Global Change Biology. 24:836–847. DOI: 10.1111/gcb.13922.

Stromberg, M.R., and M.S. Boyce. 1986. Systematics and Conservation of the Swift fox, *Vulpes velox*, in North America. Biological Conservation 35:97–110.

Storch, J., pers. comm. 2017. *Phone correspondence to F. Blouin*. September 2017. Agricultural Fieldman, Cypress County, Dunmore, Alberta.

Tannerfeldt, M., A. Moehrenschlager, and A. Angerbjörn. 2003. Den ecology of swift, kit, and Arctic foxes: a review. Pp. 167–181 in M.A. Sovada and L.N. Carbyn (eds.). The Swift Fox: Ecology and Conservation of Swift Foxes in a Changing World. Canadian Prairie Research Centre, University of Regina, Regina, Saskatchewan.

Thomas, R.E., M.L. Beard, T.J. Quan, L.G. Carter, A.M. Barnes, and C.E. Hopla. 1989. Experimentally induced plague infection in the northern grasshopper mouse (*Onychomys leucogaster*) acquired by consumption of infected prey. Journal of Wildlife Diseases 25:477–480.

Thorpe, J. 2011. Vulnerability of Prairie Grasslands to Climate Change. Limited report prepared for the Prairies Regional Adaptation Collaborative. Saskatchewan Research Council, Saskatoon, Saskatchewan.

Thwaites, R.G. 1905. Early Western Travels, 1748–1846. Microcard Editions, Washington, DC [Originally published in 30 volumes from 1904-07 by A.H. Clark Company, Cleveland, Ohio]

Touchman J.W., D.M. Wagner, J. Hao, S.D. Mastrian, M.K. Shah, *et al.* 2007. A North American *Yersinia pestis* Draft Genome Sequence: SNPs and Phylogenetic Analysis. PLoS ONE 2(2): e220. doi:10.1371/journal.pone.0000220.

Tuckwell, J. and T. Everest. 2009. Management Plan for the Black-tailed Prairie Dog (*Cynomys ludovicianus*) in Canada. Species at Risk Act Management Plan Series. Parks Canada Agency, Ottawa. vi + 31 pp

Uresk, D.W., and J.C. Sharps. 1986. Denning habitat and diet of the Swift Fox in western South Dakota. The Great Basin Naturalist 46:249–253.

USFWS (United States Fish and Wildlife Service). 1995. Endangered and threatened wildlife and plants: 12-month finding for a petition to list the Swift Fox as endangered. Federal Register 60:31663-31666.

USFWS (United States Fish and Wildlife Service). 2001. Annual notice of findings on recycled petitions. Federal Register 66:1295–1300.

USGS and IUCN. 2016. *Vulpes velox*. The IUCN Red List of Threatened Species. Version 2016-3. Website: http://www.iucnredlist.org [accessed July 2017].

Van Fleet, L, N. Cudworth, and M. Grenier. 2015. Trends in occupancy of Swift Fox (*Vulpes velox*) in Wyoming. Pp. 36-43 in M.R. Stratman (ed.). Swift Fox Conservation Team: report for 2013–2014. Colorado Division of Parks and Wildlife, Brush, Colorado.

Velasco-Villa, A., R. Mauldin, R. Matthew, M. Shi, L.E. Escobar, N.F. GallardoRomero, I. Damon, V.A. Olson, D.G. Streicker, and G. Emerson. 2017. The History of Rabies in the Western Hemisphere. Antiviral Research 146:221-232.

Waters, S.S., C. Smeeton, K.V. Weagle, and D.E. Ausband. 2007. Re-introducing the swift fox to Blackfeet Tribal Lands, Montana, USA. Pp. 34-35 in: P.S. Soorae (ed.). Re-introduction News. Newsletter of the IUCN/SSC Re-Introduction Specialist Group, Abu Dhabi, UAE. No. 26. Website: https://iucn-ctsg.org/wp-content/uploads/2018/01/Apr_07.pdf [accessed October 2019]

Whitaker, J.W. 1997. A review of literature related to Swift Fox habitat use. Pp. 113–125 in B. Gidding (ed.). Swift Fox Conservation Team: 1997 Annual Report. Colorado Division of Wildlife, Denver, Colorado.

White, P.J., and K. Ralls. 1993. Reproduction and spacing patterns of Kit Foxes relative to changing prey availability. Journal of Wildlife Management 57:861-867.

White, P.J., W.H. Berry, J.J. Eliason, and M.T. Hanson. 2000. Catastrophic decrease in an isolated population of Kit Foxes. Southwestern Naturalist 45:204-211.

Wilkins, R., pers. comm. 2017a. *Email correspondence to F. Blouin*. November 2017. Provincial Specialist, Pesticide Regulatory, Saskatchewan Ministry of Agriculture, Regina, Saskatchewan.

Worton, B.J. 1989. Kernel methods for estimating the utilization distribution in home-range studies. Ecology 70:164–168.

Zimmerman, A.L., L. Irby, and B. Giddings. 2003. The status and ecology of Swift Foxes in north central Montana. Pp. 49–59 in M.A. Sovada and L.N. Carbyn (eds.). The Swift Fox: Ecology and Conservation of Swift Foxes in a Changing World. Canadian Plains Research Centre, University of Regina, Regina, Saskatchewan.

Zumbaugh, D.M., J.R. Choate, and L.B. Fox. 1985. Winter food habits of the Swift Fox on the central high plains. Prairie Naturalist 17:41–47.

## BIOGRAPHICAL SUMMARY OF REPORT WRITER(S)

François Blouin is a wildlife biology consultant with over 22 years of experience on species at risk management and conservation. He obtained his B.Sc. in Biology from Bishop's University in Sherbrooke, Quebec, a graduate diploma in Wildlife Management from Université du Québec à Rimouski, and his M.Sc. in Biology from Université du Québec à Montréal. He has since worked for the Manitoba Conservation Data Centre, Operation Grassland Community (Alberta), the MULTISAR program with Alberta Sustainable Resource Development (now Alberta Environment and Parks), and with the Alberta Prairie Conservation Program. He has completed multiple wildlife field surveys, habitat conservation plans, species assessment reports as well as developed species at risk Beneficial Management Practices for agricultural producers.

## Appendix 1. Threat Calculator for the Swift Fox.

| | | | | |
|---|---|---|---|---|
| **Species or Ecosystem Scientific Name** | Swift Fox, *Vulpes velox* | | | |
| **Element ID** | | | **Elcode** | |
| **Date:** | 10/06/2019 | | | |
| **Assessor(s):** | Stephen Petersen (Terrestrial Mammals Co-chair), Karen Timm (COSEWIC Secretariat), Rosie Nobre-Soares (COSEWIC Secretariat), Jennifer Heron (facilitator), Francois Blouin, Gord Court, Lu Carbyn. | | | |
| **References:** | | | | |
| **Overall Threat Impact Calculation Help:** | | | **Level 1 Threat Impact Counts** | |
| | **Threat Impact** | | **high range** | **low range** |
| | A | Very High | 0 | 0 |
| | B | High | 1 | 0 |
| | C | Medium | 1 | 2 |
| | D | Low | 4 | 4 |
| **Calculated Overall Threat Impact:** | | | High | High |
| **Assigned Overall Threat Impact:** | | | **B = High** | |
| **Impact Adjustment Reasons:** | | | | |
| **Overall Threat Comments** | | | Overall calculated and assigned threat impact of Very High - High from draft calculator decreased to High based on COSEWIC discussion at the April 2021 COSEWIC species assessment meeting. These changes are shown in red font. | |

| **Threat** | | **Impact (calculated)** | **Scope (next 10 Yrs)** | **Severity (10 Yrs or 3 Gen.)** | **Timing** | **Comments** |
|---|---|---|---|---|---|---|
| 1 | Residential & commercial development | Negligible | Negligible (<1%) | Slight (1-10%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | Overall severity changed from Negligible to Slight and timing changed from insignificant to moderate based on rolling up of level 2 threats |
| 1.1 | Housing & urban areas | Negligible | Negligible (<1%) | Slight (1-10%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | Population exists primarily in areas with limited or restricted access. Tourism pressure likely low and diurnal in nature. Grasslands National Park (GNP) is the most likely hub for tourism and recreation within the Canadian range of the Swift Fox. Grasslands National Park Swift Fox population is very small (Pruss pers. comm. 2017) and the Park has identified critical habitat within its boundaries which should prevent disturbance (Parks Canada Agency 2016). |
| 1.2 | Commercial & industrial areas | Negligible | Negligible (<1%) | Unknown | Moderate (Possibly in the short term, < 10 yrs/3 gen) | Current distribution is in largely undeveloped areas of SW Saskatchewan and SE Alberta (see comment above). |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|---|---|---|---|---|---|---|---|
| 1.3 | Tourism & recreation areas | | Negligible | Negligible (<1%) | Unknown | Moderate (Possibly in the short term, < 10 yrs/3 gen) | Population exists primarily in areas with limited or restricted access. Tourism pressure likely low and diurnal in nature. Grasslands National Park (GNP) is the most likely hub for tourism and recreation within the Canadian range of the Swift Fox. Grasslands National Park Swift Fox population is very small (Pruss pers. comm. 2017) and the Park has identified critical habitat within its boundaries which should prevent disturbance (Parks Canada Agency 2016). |
| 2 | Agriculture & aquaculture | D | Low | Small (1-10%) | Extreme - Moderate (11-100%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | |
| 2.1 | Annual & perennial non-timber crops | D | Low | Small (1-10%) | Extreme - Moderate (11-100%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | 38 of 84 (40.4 %) foxes caught in the Alberta-Saskatchewan border region were on townships that contained PFRA lands in the 2005/2006 peak abundance year (Moehrenschlager and Moehrenschlager 2006), thus small scope. With transfer of PFRA Pasture lands to provinces there is some uncertainty but currently these lands can be leased (15-year) by patron groups or purchased with a "no-break, no-drain" easement. To date most/all former patron groups have entered in to a 15-year grazing lease with Government of Saskatchewan but there is uncertainty in the future. Three PFRA pastures totaling 83,694 ha remain to be transferred (and leased or sold) within the Swift Fox range as of 2019. Loss of SARA application on provincial Crown land in Saskatchewan (former PFRA) is compensated by provincial Species at Risk law and regulations and by environmental assessment policies and laws. Some perennial crops may be beneficial. |
| 2.2 | Wood & pulp plantations | | | | | | |
| 2.3 | Livestock farming & ranching | | Not a Threat | Pervasive (71-100%) | Neutral or Potential Benefit | High (Continuing) | Swift Fox occurs largely on rangeland in Canada and grazing beneficial to limit woody vegetation, reduces grass height and is compatible with retaining native grassland. There is potential that over grazing could impact negatively but this threat section deals with current grazing practices and is focused on ranching not intensive farming (ie. feedlots). |
| 2.4 | Marine & freshwater aquaculture | | | | | | |
| 3 | Energy production & mining | D | Low | Restricted (11-30%) | Slight (1-10%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|---|---|---|---|---|---|---|---|
| 3.1 | Oil & gas drilling | D | Low | Restricted (11-30%) | Slight (1-10%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | Habitat loss, degradation and fragmentation of habitat and disturbance during drilling and pipeline construction. Pipeline construction may reduce Swift Fox reproductive success (Moehrenschlager 2000). Nine of 104 (8.7 %) foxes capture-released during the 2005-2006 survey year were in protected Parks Canada Land townships (Moehrenschlager and Moehrenschlager 2006) thus 91.3% were on unprotected land. However, in Alberta, no industrial activities allowed for disposition holders (on public Land) within Greater Sage-grouse range (which includes a large portion of Swift Fox distribution range in AB) and in Greater Sage-grouse Emergency Order areas on provincial or federal Crown land in Saskatchewan and Alberta. Unknown what percentage of the population this would account for but possibly restricted scope. Currently oil and gas development is low (thus slight severity) but activity largely tied to market prices and may return. |
| 3.2 | Mining & quarrying | | | | | | Not applicable. There are near surface deposits of industrial minerals such as clay and kaolin, near to surface deposits of coal, and subsurface potential for minerals contained within brines such as bromines in Saskatchewan but mineral and other resource extraction is absent in South of the Divide (SOD) area, which includes much of the Swift Fox range in Saskatchewan (ECCC 2017). |
| 3.3 | Renewable energy | | | | | | Not applicable. Much of Swift Fox range in Alberta falls in no development zone for wind and solar energy projects associated with Greater Sage-grouse Range (inclusive of area described in Federal Emergency Order), but large portions in periphery or range are not covered. Large portion of core Swift Fox range in Saskatchewan in "Wind energy project avoidance zones" (Saskatchewan Environment 2017) within which SaskPower does not accept wind development applications (Keith pers. comm. 2017). Some Swift Fox habitat also protected from development on provincial and federal crown lands that fall within the Greater Sage-grouse Emergency Order areas. Thus, likely a small segment of the population might be affected by renewable energy development. Habitat loss is of concern at sites where renewable energy infrastructures would be located. Bradley and Neville (2010) estimated that 5-10% of a wind project area's native vegetation was directly disturbed by all activities related to the project. This could translate in a reduction in carrying capacity of the same proportion. Renewable energy projects are likely to take place in the next 10 years to meet Alberta and Saskatchewan target date of 2030. |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|---|---|---|---|---|---|---|---|
| 4 | Transportation & service corridors | D | Low | Small (1-10%) | Serious - Moderate (11-70%) | High (Continuing) | Habitat loss, fragmentation, and degradation from road construction and direct road mortality from traffic. |
| 4.1 | Roads & railroads | D | Low | Small (1-10%) | Serious - Moderate (11-70%) | High (Continuing) | Primary and secondary roads may cause direct road mortality through vehicle traffic, especially to juveniles (Allardyce and Sovada 2003) (7.9 % in Moehrenschlager 2000 but may be underestimated). Collision risk may also be higher in the winter when foxes are ranging more widely. Proposal to create a 24hr border crossing at Wildwood on Highway 41 will significantly increase traffic. Previous scores were restricted, serious-moderate, and high. Will most fox encounter a road in the next 10 years? If so, scope should be pervasive. Yes, some will be killed but will their death result in an overall population decline in the next 3 gens/10 years, whichever is larger? i.e., If a juvenile is killed, would it have died from some other cause. Or are so many adults being killed on roads that there is indeed a population decline? A scope of pervasive and a severity of slight still results in a low threat impact. |
| 4.2 | Utility & service lines | | | | | | Largely associated with energy production but of lesser impact. Likely to impact the same portion of the population at a negligible intensity within the same time frame as energy production and therefore not scored here (and removed post WSAM). |
| 4.3 | Shipping lanes | | | | | | |
| 4.4 | Flight paths | | | | | | |
| 5 | Biological resource use | | Negligible | Negligible (<1%) | Negligible (<1%) | Insignificant/Negligible (Past or no direct effect) | |
| 5.1 | Hunting & collecting terrestrial animals | | Negligible | Negligible (<1%) | Negligible (<1%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | Unintentional trapping or hunting of Swift Fox may occur. Some limited trapping allowed in adjacent Montana, USA (Swift Fox quota: 10 in portion of trapping District #6; Montana Fish, Wildlife and Parks 2018). Swift fox may be accidentally mistaken for Red Fox and hunted. Not likely to affect a large portion of the Canadian population; not likely to significantly reduce the Canadian Swift Fox population. Given the first statement, the timing was changed to moderate. |
| 5.2 | Gathering terrestrial plants | | | | | | |
| 5.3 | Logging & wood harvesting | | | | | | |
| 5.4 | Fishing & harvesting aquatic resources | | | | | | |
| 6 | Human intrusions & disturbance | | | | | | |
| 6.1 | Recreational activities | | | | | | Not applicable/ captured in tourism (1.3) |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|---|---|---|---|---|---|---|---|
| 6.2 | War, civil unrest & military exercises | | | | | | Not applicable. CFB Suffield is in the historical range of Swift Fox but scent post camera surveys in 2013 and scat surveys in 2014 by ECCC did not reveal any evidence of the species. |
| 6.3 | Work & other activities | | | | | | Not applicable. Potential threat from pre-development surveys (industry) or other research work (e.g., winter catch-and-release trapping for population monitoring). Improvements to traps, trapping techniques and protocols, and increase use of camera-trapping to monitor populations were brought about to minimize handling of animals and the likelihood of injuries (Moehrenschlager and Moehrenschlager 2018). |
| 7 | Natural system modifications | | | | | | |
| 7.1 | Fire & fire suppression | | | | | | Not applicable. Fire suppression may contribute to tall grass and increased woody vegetation in Swift Fox habitat leading to a decreasing its suitability for the species as they increase the risk of predation by Coyotes (Thompson and Gese 2007). Fire suppression occurs across the range but tall grass and shrub encroachment is not homogeneous, as it is also affected by edaphic factors, herbivory, climate and weather as various temporal and spatial scales. |
| 7.2 | Dams & water management/use | | | | | | Not applicable. Water availability doesn't appear to strongly influence the selection of denning sites in Canada (Pruss 1999). The Swift Fox may have low physiological need for water and behavioural adaptions for water conservation. Does not occur within geographic areas with planned reservoirs. |
| 7.3 | Other ecosystem modifications | | | | | | Scores and comments transferred to threat 11.2; scope of pervasive-large changed to pervasive when transferred. |
| 8 | Invasive & other problematic species & genes | C | Medium | Pervasive (71-100%) | Moderate (11-30%) | High (Continuing) | |
| 8.1 | Invasive non-native/alien species/diseases | | | | | | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|---|---|---|---|---|---|---|---|
| 8.2 | Problematic native species/diseases | C | Medium | Pervasive (71-100%) | Moderate (11-30%) | High (Continuing) | Disease is the primary stochastic factor influencing small canid populations around the world (Moehrenschlager and Sovada 2016). In many cases these pathogens are either foreign in origin or variants have been introduced to North America with European immigration and their domestic dogs (Aguirre 2009). The most important diseases that may affect the Swift Fox include 1) rabies, 2) canine distemper, 3) canine parvovirus, and 4) sylvatic plague. Although these diseases are introduced into North America, they have been part of the disease landscape for long enough that we will treat them in the native disease section (here). Swift Fox exposure to canid diseases has not been well studied in Canada and the United States and the sources and effects of known diseases in Swift Fox populations are not fully understood (Moehrenschlager *et al.* 2004, Moehrenschlager and Sovada 2016). Regardless, diseases are well-documented in other endangered wild canids (Laurenson *et al.* 2004), including the closely related San Joaquin Kit Fox (White *et al.* 2000).<br><br>The equilibrium between competing sympatric canids may be upset by human presence and activities. In Alberta and Saskatchewan, Coyote and Swift Fox are sympatric while Red Fox occur in more peripheral to the core range (Tannerfeldt *et al.* 2003). The interplay among the three species of canids is such that human caused landscape changes that shift the abundance of particular species or that control other populations have the potential to impact Swift Fox abundance (Gosselink *et al.* 2003, Tannerfeldt *et al.* 2003, Moehrenschlager *et al.* 2004, Moehrenschlager *et al.* 2007b, Mitchell 2018). An equilibrium exists where too many or too few Coyote or Red Fox could lead to Swift Fox exclusion (Moehrenschlager *et al.* 2004) although impact of habitat fragmentation and human activities on this equilibrium is unknown. |
| 8.3 | Introduced genetic material | | | | | | Not applicable. However, past Swift Fox reintroductions have been successful and there could be potential for reintroductions in the future but this would not be a threat. |
| 8.4 | Problematic species/diseases of unknown origin | D | Low | Pervasive (71-100%) | Slight (1-10%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | This is non-native diseases only. Threats from novel diseases introduced through other canids acting as vectors or reservoirs in particular disease could be transferred between Swift Fox population clusters through movement of coyotes. |
| 8.5 | Viral/prion-induced diseases | | | | | | |
| 8.6 | Diseases of unknown cause | | | | | | |
| 9 | Pollution | BC | High - Medium | Large - Restricted (11-70%) | Extreme (71-100%) | High (Continuing) | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|---|---|---|---|---|---|---|---|
| 9.1 | Domestic & urban waste water | | | | | | |
| 9.2 | Industrial & military effluents | | | | | | |
| 9.3 | Agricultural & forestry effluents | BC | High - Medium | Large - Restricted (11-70%) | Extreme (71-100%) | High (Continuing) | Accidental poisoning. May affect Swift Fox on land in closer proximity to farmland: 1) PMRA approved the restricted use of 2% liquid strychnine concentrate for severe Richardson’s Ground Squirrel infestations starting in 2007 in Saskatchewan and in 2008 in Alberta. 81% fewer adult Red Foxes noted per km of road in high (90%) strychnine treatment area compared to low (~20%) treatment area where toxicants (largely strychnine or chlorophacinone-treated oat baits) were used to control Richardson's Ground Squirrels in SW Saskatchewan in 2010 (Proulx and MacKenzie 2012). Red and Swift Fox have large dietary overlap (Moehrenschlager *et al.* 2004). However, this study was in farmland area, which is largely avoided by Swift Fox in Canada (Moehrenschlager *et al.* 2007b). 2) Other toxicants also exist for control of Coyote and may be taken opportunistically by Swift Fox but are not issued to agricultural producers in Swift Fox areas. No Swift Fox poisoning has been reported in Saskatchewan or Alberta (Wilkins, Nicholson, Pybus pers. comms. 2017). |
| 9.4 | Garbage & solid waste | | | | | | |
| 9.5 | Air-borne pollutants | | | | | | |
| 9.6 | Excess energy | | | | | | |
| 10 | Geological events | | | | | | |
| 10.1 | Volcanoes | | | | | | |
| 10.2 | Earthquakes/tsunamis | | | | | | |
| 10.3 | Avalanches/landslides | | | | | | |
| 11 | Climate change & severe weather | D | Low | Pervasive (71-100%) | Slight (1-10%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | Has the range of Swift Fox in Canada currently experienced changes in the frequency and intensity of droughts, temperature extremes, and storms and flooding that would warrant changing the timing from moderate (only expected in the future 10 years/3 gens) to high (is happening now). Changing timing to high will not change the overall threat impact of threat 11. |
| 11.1 | Habitat shifting & alteration | | Not Calculated (outside assessment timeframe) | Pervasive (71-100%) | Unknown | Low (Possibly in the long term, >10 yrs/3 gen) | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|---|---|---|---|---|---|---|---|
| 11.2 | Droughts | D | Low | Pervasive (71-100%) | Slight (1-10%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | Droughts are expected to increase in prevalence and severity in the Canadian Prairie Ecozone (Thorpe 2011). Although Swift Fox are adapted to dry prairie conditions, severe or prolonged droughts may impact their body condition and survival (Herrero *et al.* 1991) and decrease their reproductive success because of prey scarcity (White and Rall 1993, Moehrenschlager *et al.* 2007a). |
| 11.3 | Temperature extremes | D | Low | Pervasive (71-100%) | Slight (1-10%) | Moderate (Possibly in the short term, < 10 yrs/3 gen) | Severe winters are linked to reduced survival and large population decline observes circa. 2011. It is not know if the frequency of severe winters is predicted to increase. |
| 11.4 | Storms & flooding | | Unknown | Unknown | Unknown | Moderate (Possibly in the short term, < 10 yrs/3 gen) | Potential for severe weather to flood burrows. |
| 11.5 | Other impacts | | | | | | |
| Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008). | | | | | | | |

## Appendix 2. Contributors of Swift Fox records to the Alberta Fish and Wildlife Management System as of June 2017.

| | | |
|---|---|---|
| ANGELA CHEN, ERIC BROWNRIGG, JENNIFER CARPENTER, KRISSY BUSH, LEAH DARLING, MARIA OLSEN, MELISSA MCINTOSH, MIKE SWYSTUN | CWS - EDMONTON | JON GROVES, STEVE SWARTZ |
| AXEL MOEHRENSCHLAGER | DALE KASTELEN | JULIE LANDRY-DEBOER, MEGAN JENSEN |
| AXYS ENVIRONMENTAL CONSULTING LTD. | DANIELLE CROSS | KARSTEN HEUER |
| BRANDY DOWNEY | DANIELLE CROSS, LEN LUPYCZUK | KELLY STURGESS |
| BRENT COWAN | DARRYL JARINA | KEN PITCHER, TANNER BROADBENT |
| BRIAN VANDERLINDEN | DAVE SCOBIE | KRISTEN RUMBOLT-MILLER |
| BRIAN WANNER | DEANNA WHITE, LEE MOLTZAHN | KRISTI ANDERSON |
| BRUCE CAIRNS | DENNIS MILNER | LEAH DAOUST, MARIA DIDKOWSKY |
| CALGARY ZOOLOGICAL SOCIETY | FRANCOIS BLOUIN | LEE FINSTAD |
| CAMERON ALDRIDGE | GEOFF HOLROYD, HELEN TREFRY | MIKE SWYSTUN |
| CAMERON JACKSON | GERRY EHLERT | ORRIN DELL |
| CAMERON LOCKERBIE | GHOSTPINE ENVIRONMENTAL SERVICES LTD. | PETER BALAGUS |
| CANADIAN WILDLIFE SERVICE - EDMONTON | HELEN TREFRY | ROB MORRISON |
| CHAD LYTTLE | JASON ALLISON | ROBERT WAPPLE |
| CHARLES MAMO | JASON LEWIS | RON FODE |
| CHRISTINA DEVLIN | JENNIFER HEMSING | SANDY BARRETT |
| CHRISTY SIKINA | JOE HARTY | SUSAN COTTERILL |
| CLEVE WERSHLER | JOEL NICHOLSON | SYL POMPU |
| CLIFF THESEN | JOEL NICHOLSON, KIM MORTON, MIKE GRUE | TERRY HOOD |
| COLIN STARKEVICH | JOEL NICHOLSON, MIKE GRUE, MIKE VERHAGE | TROY WELLICOME |
| COREY SCOBIE | JOHN TAGGART | VALERIE TOFT |
| COREY SKIFTUN | JOHNATHAN CUMMING, MEGAN WRIGHT | WILDLIFE MANAGEMENT |