COSEWIC
Assessment and Status Report

on the

Short-eared Owl
Asio flammeus

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:

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Previous report(s):

COSEWIC. 2008. COSEWIC assessment and update status report on the Short-eared Owl *Asio flammeus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 24 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Cadman, M.D, and Page A.M. 1994. COSEWIC status report on the Short-eared Owl *Asio flammeus* in Canada. Committee on the Status of Endangered Wildlife in Canada. i + ii - 53 pp.

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COSEWIC would like to acknowledge Marcel Gahbauer for writing the status report on Short-eared Owl, *Asio flammeus*, in Canada, prepared under contract with Environment and Climate Change Canada. This report was overseen and edited by Richard Elliot, Co-chair of the COSEWIC Birds Specialist Subcommittee.

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COSEWIC
Assessment Summary

Assessment Summary – April 2021

Common name
Short-eared Owl

Scientific name
Asio flammeus

Status
Threatened

Reason for designation
The Canadian population of this widespread nomadic owl breeds in open grassland, tundra, and wetland habitats in all provinces and territories, and winters in southern Canada and the United States. The use of new atlas-based population estimation procedures suggests that the size of the Canadian population is about 31,000 mature individuals, roughly 10% of previous estimates. Its numbers vary over space and time in response to cycles in the availability of small mammals—its main prey. This adds uncertainty to estimates of the rate of decline in the Canadian population. Data from both the Breeding Bird Survey and Christmas Bird Counts indicate a decline of more than 30% over the past three generations. The Canadian population is projected to continue to decline because of future threats, including reduced availability of nesting and wintering habitat resulting from crop conversion, agricultural intensification, urbanization, and invasive plants. In low Arctic habitats, increased growth of shrubs as a result of climate warming (shrubification) will further reduce prey availability and increase predation risk.

Occurrence
Yukon, Northwest Territories, Nunavut, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Prince Edward Island, Nova Scotia, Newfoundland and Labrador

Status history
Designated Special Concern in April 1994 and April 2008. Status re-examined and designated Threatened in May 2021.

COSEWIC
Executive Summary

Short-eared Owl
Asio flammeus

Wildlife Species Description and Significance

Short-eared Owl (*Asio flammeus*) is a medium-sized owl, approximately 34-42 cm in length. Plumage is mottled brown above and buff with heavy streaking below, varying only slightly by sex and age. Short-eared Owl is largely crepuscular and hunts through the evening and into the night, and is recognizable by its agile, moth-like flight over open areas.

Distribution

Short-eared Owl has the broadest global distribution of any owl, with a range that includes most of North America and Eurasia, parts of South America, Africa, and many oceanic islands. North American breeding range extends from the Canadian Arctic south to Nevada in the west and Massachusetts in the east, and the winter range spans from southern Canada to Mexico. It breeds across Canada, regularly in the subarctic tundra and prairies, and more sparsely elsewhere.

Habitat

Short-eared Owl favours open habitats throughout the year, including grasslands, tundra, and wetlands. Breeding typically occurs in open landscapes at least 50-100 ha in area, and nests are preferentially located on the ground near clumps of taller vegetation that provide concealment. In winter, Short-eared Owls roost in conifers adjacent to open areas used for hunting or on the ground in the shelter of tall grasses or forbs. Declines in the extent and quality of open grassland and wetland habitats have likely reduced the distribution and abundance of Short-eared Owl in southern Canada.

Biology

Age of first breeding is thought to be one year; lifespan is poorly documented but generation time is considered to be about 4 years. A single brood is raised annually, although a replacement clutch may be laid in cases of early nest failure. Diet primarily comprises voles, lemmings, and other small mammals. Short-eared Owls tend to be nomadic, often moving relatively long distances through the year to areas with high rodent abundance. This results in substantial fluctuations in abundance at local and regional scales, complicating the estimation of overall numbers and population trends.

Population Sizes and Trends

The previous COSEWIC estimate of the size of the Canadian Short-eared Owl population of about 350,000 mature individuals was based on Breeding Bird Survey (BBS) data. However, the BBS samples only a small part of the Canadian breeding range with low sample sizes. Interpretation and extrapolation of breeding bird atlas results from the past two decades likely provide a more accurate estimate of approximately 31,000 mature individuals, over half of which breed in Northwest Territories and Nunavut.

Short-eared Owl population trends estimated from BBS data indicate declines of -70% between 1970 and 2019, and -31% over the most recent three-generation period, although the BBS does not sample the core of the Canadian population breeding in the tundra. There is greater overlap between the wintering range and coverage by the Christmas Bird Count (CBC). CBC trends for Canada show similar declines of -79% between 1970 and 2019, and -27% over the past three generations, with steepest decreases in Alberta, Manitoba, Ontario, and Quebec. The winter distribution of Canadian birds is poorly known, but most individuals likely overwinter in the United States. At a continental scale, CBC trend estimates for 2007 to 2019 range from -6.5% to -33.6%, depending on the method of analysis. Declines in numbers and range have also been documented by breeding bird atlases completed in British Columbia and Quebec since the previous status report.

Threats and Limiting Factors

Natural system modifications, and climate change and severe weather, are the most important threats to Short-eared Owl, and each is expected to have a low to medium impact on populations. In low Arctic habitats, where a large percentage of the population nests, increased growth of shrubs as a result of climate warming (shrubification) will further reduce prey availability and increase predation risk. The cumulative effect of these threats and six others considered to be of low impact is anticipated to have a medium to high overall impact on the species.

Protection, Status and Ranks

Short-eared Owl is listed as a species of Special Concern under Canada's *Species at Risk Act*. It is listed under provincial endangered species legislation in Manitoba (Threatened), Ontario (Special Concern), New Brunswick (Special Concern), and Newfoundland and Labrador (Vulnerable). In Quebec, it is on the list of wildlife species likely to be designated threatened or vulnerable.

In the United States, Short-eared Owl is protected under the *Migratory Bird Treaty Act,* but is not listed under the *Endangered Species Act*. It is considered Endangered in 11 states, and Threatened or Special Concern in five others.

Globally, Short-eared Owl is classified as Least Concern by IUCN. NatureServe ranks Short-eared Owl as Secure (G5) globally, Apparently Secure as a breeder and migrant but Vulnerable as a non-breeding/wintering population in Canada (N4B-N3N-N4M in Canada), and nationally Secure (N5) in the United States. The breeding status of Short-eared Owl is ranked as Critically Imperilled to Vulnerable (S1 to S3) in all provinces and territories, with status having worsened in four provinces and one territory since the previous status report.

TECHNICAL SUMMARY

Asio flammeus

Short-eared Owl

Hibou des marais

Inuktitut: Unnuasiutik or Unnuasiutiapik (Nunavik), Ukpigjuaq

Range of occurrence in Canada: Yukon, Northwest Territories, Nunavut, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Prince Edward Island, Nova Scotia, Newfoundland and Labrador.

Demographic Information

Generation time (the average age of parents in the population)	4 years, based on Bird *et al*. (2020).
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes, inferred from Christmas Bird Count (CBC) and Breeding Bird Survey (BBS) trends.
Estimated percent of continuing decline in total number of mature individuals within 2 generations, up to a maximum of 100 years.	Inferred to be over 20%, based on CBC and BBS results.
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last 3 generations, up to a maximum of 100 years.	Reduction of at least 30% over 3 generations (2007-2019), inferred from CBC and BBS data.
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations, whichever is longer up to a maximum of 100 years].	Projected future reduction of about 30% over three generations, based on anticipated impact of threats, and continuing decline in IAO and habitat quality.
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any period [10 years, or 3 generations, whichever is longer up to a maximum of 100 years], including both the past and the future.	Projected continuing reduction of at least 30% over three generations, based on recent trends, anticipated impact of threats, and continuing decline in IAO and habitat quality.
Are the causes of the decline a. clearly reversible? b. understood and c. ceased?	a. Partly. Some threats cannot be reversed. b. Yes, partly. Impact of habitat loss is understood, but other factors are less clear. c. No. Habitat loss and other threats are ongoing.
Are there extreme fluctuations in number of mature individuals?	No. Numbers may fluctuate substantially at a local scale, but not overall.

Extent and Occupancy information

Estimated extent of occurrence (EOO)	12,196,000 km^2; calculated using a minimum convex polygon around the Canadian breeding range.

Index of area of occupancy (IAO), reported as 2x2 km grid value.	15,500-62,000 km^2; based on the median population estimate and an assumption of 1-4 pairs per 2x2 km grid square.
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. b. No.
Number of "locations"*	Unknown, but certainly >10, based on the large EOO and variety of threats.
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	No.
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	Yes. Observed continuing decline in IAO in parts of southern Canada.
Is there an [observed, inferred, or projected] continuing decline in number of subpopulations?	Not applicable, no defined subpopulations.
Is there an [observed, inferred, or projected] continuing decline in number of "locations"*?	Unknown. Cannot be evaluated without an accurate estimate of the number of locations.
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality of] habitat?	Yes, inferred continuing decline in extent and quality of breeding and wintering habitat in southern Canada.
Are there extreme fluctuations in number of subpopulations?	Not applicable, no defined subpopulations.
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.

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

Number of Mature individuals (in each subpopulation)

Provincial/Territorial Totals (no identifiable subpopulations)	N Mature Individuals (range of estimate)
British Columbia	410 (110-710)
Alberta	640 (150-1130)
Saskatchewan	680 (160-1200)
Manitoba	670 (190-1150)
Ontario	4200 (520-7880)
Quebec	3685 (880-6490)
New Brunswick	125 (40-210)
Nova Scotia	30 (10-50)
Prince Edward Island	80 (20-140)
Newfoundland and Labrador	555 (130-980)
Yukon	2010 (200-3820)
Northwest Territories	6390 (620-12,160)
Nunavut	11,720 (1120-22,320)
TOTAL	**31,195 (4150-58,240)**

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations whichever is longer up to a maximum of 100 years, or 10% within 100 years]?	Unknown; analysis not conducted.

Threats and Limiting Factors

Was a threats calculator completed for this species?

Yes, on 21 May 2019 (See Appendix 1 for participants).

The assigned overall threat impact is: Medium to High, and the following contributing threats were identified, listed in decreasing order of impact:

Key threats were identified as:

i. IUCN 7. Natural system modifications – low-medium impact threat
ii. IUCN 11. Climate change and severe weather – low-medium impact threat
iii. IUCN 1. Residential and commercial development – low impact threat
iv. IUCN 2. Agriculture and aquaculture – low impact threat
v. IUCN 4. Transportation and service corridors – low impact threat
vi. IUCN 5. Biological resource use – low impact threat
vii. IUCN 6. Human intrusions and disturbance – low impact threat
viii. IUCN 8. Invasive and other problematic species and genes – low impact threat

What additional limiting factors are relevant? The availability of rodent prey is the main factor potentially limiting Short-eared Owl numbers, although it is rarely a concern at the population level, given the tendency of individuals to move nomadically in search of prey.

Rescue Effect (natural immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Declining in most potential sources areas. Apparently Secure (S4) in Alaska and Montana, but Critically Imperilled to Vulnerable (S1 to S3) in all other states bordering Canada, and declining in all border states.
Is immigration known or possible?	Yes, immigration from adjacent US states is known to occur.
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes, although habitat availability is declining in some areas, especially southern Canada.
Are conditions deteriorating in Canada?[+]	Yes, habitat conditions are deteriorating in some areas, especially southern Canada.
Are conditions for the source (i.e., outside) population deteriorating?[+]	Yes, habitat conditions are deteriorating in some potential source areas, in the border US states.
Is the Canadian population considered to be a sink?[+]	No.
Is rescue from outside populations likely?	Unlikely. Rescue may be possible in western Canada, but unlikely in eastern Canada.

Data Sensitivity

Is this a data sensitive species?	No.

Status History

COSEWIC Status History
Designated Special Concern in April 1994 and April 2008. Status re-examined and designated Threatened in May 2021.

Status and Reasons for Designation

Status:	**Alpha-numeric codes:**
Threatened	A2bc+4bc

Reasons for designation:
The Canadian population of this widespread nomadic owl breeds in open grassland, tundra, and wetland habitats in all provinces and territories, and winters in southern Canada and the United States. The use of new atlas-based population estimation procedures suggests that the size of the Canadian population is about 31,000 mature individuals, roughly 10% of previous estimates. Its numbers vary over space and time in response to cycles in the availability of small mammals—its main prey. This adds uncertainty to estimates of the rate of decline in the Canadian population. Data from both the Breeding Bird Survey and Christmas Bird Counts indicate a decline of more than 30% over the past three generations. The Canadian population is projected to continue to decline because of future threats, including reduced availability of nesting and wintering habitat resulting from crop conversion, agricultural intensification, urbanization, and invasive plants. In low Arctic habitats, increased growth of shrubs as a result of climate warming (shrubification) will further reduce prey availability and increase predation risk.

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

PREFACE

New information on the status and ecology of Short-eared Owl in Canada has become available since the last COSEWIC status report (COSEWIC 2008), both through focused research and as part of broader studies, many of which are referenced in the federal management plan (ECCC 2018a).

Publication of new Breeding Bird Atlases for British Columbia (Davidson *et al.* 2015), Manitoba (Artuso *et al.* 2018), Quebec (Robert *et al.* 2019), and the Maritime provinces (Stewart *et al.* 2015) has yielded new insights into the distribution and relative abundance of Short-eared Owl, and in the case of Quebec and the Maritimes, allows for comparison with results from the first atlas approximately 20 years earlier. Additionally, targeted surveys for Short-eared Owl have been undertaken in three areas of Quebec (Rivard *et al.* 2011; Gagnon *et al.* 2015), and parts of Newfoundland and Labrador (Garland pers. comm. 2019). Three publications have reported breeding evidence in the Arctic beyond the previously documented range of Short-eared Owl (Therrien 2010; Reid *et al.* 2011; Smith *et al.* 2013). Analytical approaches using data from the North American Breeding Bird Survey and the Christmas Bird Count have evolved over the past decade, and the latest trend estimates derived from these sources present a more reliable interpretation of population trends than in the past. It has become apparent that population estimates largely derived from Breeding Bird Survey data tend to over-estimate Short-eared Owl abundance, and that estimates derived from breeding bird atlas data generally are lower but likely more reliable.

A review of the status of Short-eared Owl in North America by Booms *et al.* (2014) highlighted knowledge gaps considered important for effective management and conservation of the species. Larson and Holt (2016) and Swengel and Swengel (2017) recommended species-specific survey techniques, and the Western *Asio flammeus* Landscape Study established a systematic approach to monitoring population changes in eight western US states (Miller *et al.* 2018). There have been recent publications on breeding ecology in southern Canada (Keyes *et al.* 2016) and seasonal movements tracked using satellite telemetry (Johnson *et al.* 2017). Gahbauer *et al.* (2021) presented a current overview of movements and habitat selection by Short-eared Owl in North America, including irruptions in Alberta, winter habitat use in New York, and satellite telemetry tracking of individuals migrating between New York and the Quebec-Labrador peninsula.

The status of Short-eared Owl has continued to decline in the United States, with the species now considered Possibly Extirpated, Critically Imperilled, or Imperilled in 30 states (NatureServe 2020). Rosenberg *et al.* (2016) classified Short-eared Owl as a “common bird in steep decline” in Partners in Flight’s latest assessment of the status of birds in North America.

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.

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Table 2. Estimated number of Short-eared Owls (mature individuals) by province and territory, based on PIFSC (2013) and PIFSC (2019). See text in the Abundance section for important caveats about the limited reliability of these estimates.. 30

Table 3. Short-term (three-generation, 2007-2019) and long-term (1970-2019) population trends for Short-eared Owl based on regression analysis of Christmas Bird Count data; bolded trends are statistically significant (Meehan *et al.* 2020). Data are insufficient to generate estimates for other provinces and territories. 32

Table 4. Short-term (three-generation, 2007-2019) and long-term (1970-2019) population trends for Short-eared Owl in Canada, states bordering Canada, and the United States overall, based on generalized additive modelling of Breeding Bird Survey data; bolded trends have 95% credible intervals that do not cross zero and are highly likely to represent a substantial rate of change (A. Smith unpubl. data). Reliability is a qualitative assessment that takes into consideration factors such as precision and extent of coverage. Data are insufficient to generate estimates for other provinces, territories, and border states. 35

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific name: *Asio flammeus*

English name: Short-eared Owl

French name: Hibou des marais

Spanish names: Lechuzón de campo / Búho campestre

Inuktitut names: Unnuasiutik or Unnuasiutiapik (Nunavik), Ukpigjuaq

Classification: Class: Aves
Order: Strigiformes
Family: Strigidae

The genus *Asio* comprises the "eared" owl species, which have a pair of small erectable feather tufts on the forehead. Short-eared Owl is the most widespread globally of the seven species in the genus, of which Long-eared Owl (*Asio otus*) is the only other species to occur in Canada (del Hoyo and Collar 2014). One hybrid Short-eared x Long-eared Owl has been reported in Ontario (Gosselin and Keyes 2009).

Morphological Description

Short-eared Owl is a medium-sized owl, approximately 34-42 cm in length (cover photo; Wiggins *et al.* 2006). The head is large and round, with the "ear" tufts typically concealed (Wiggins *et al*. 2006). Adult Short-eared Owls are largely mottled brown above, and buff with heavy streaking below. Females tend to be slightly darker, although there is considerable overlap in colour, and sexes are generally not distinguishable by plumage (Pyle 1997). Females are on average slightly larger and heavier than males, with a mean mass of 378 g (range 206-368, n=20) versus 315 g (range 284-475, n=27; Earhart and Johnson 1970) for males. Adults of both sexes have pale grey to whitish facial disks and yellow eyes (Pyle 1997). Juveniles are similar in appearance, but have more buff on the upperparts, a less distinct facial pattern, and brownish eyes (Pyle 1997). In flight, Short-eared Owls are readily recognized by their agile, moth-like flight with deep wing beats and tendency to fly low over open habitat, hovering occasionally (Wiggins *et al*. 2006).

Population Spatial Structure and Variability

Eleven Short-eared Owl subspecies are recognized globally (del Hoyo and Collar 2014), but only *Asio flammeus flammeus* occurs in Canada (Wiggins *et al*. 2006). Although this subspecies breeds across North America, Europe, and parts of northern Africa and Asia, geographic variation is considered to be limited at a global scale (Wiggins *et al*. 2006), and none has been described in Canada.

Designatable Units

As there are no discrete subpopulations or subspecies in Canada, nor evidence of evolutionary divergence by any part of the Canadian population, Short-eared Owl is treated here as a single designatable unit, as in previous assessments (e.g., COSEWIC 2008).

Special Significance

Short-eared Owl was historically common in the Canadian prairies, and a regular and widespread resident of grasslands, marshes, and tundra elsewhere in the country. Over the past century, numbers have declined substantially in most of North America. Short-eared Owl is a member of the grassland bird community that has experienced a steady and substantial decline in Canada since the late 1970s (NABCI Canada 2019). There is considerable public interest in this species, and sites where large numbers of Short-eared Owls congregate attract many birders and photographers. No publicly available Aboriginal Traditional Knowledge was identified, although this species is part of Canadian ecosystems that are important to Indigenous people, who recognize the interconnectedness of all species.

DISTRIBUTION

Global Range

Short-eared Owl has the most extensive global distribution of any owl, extending across most of North America and Eurasia, parts of South America and northern Africa, and various oceanic islands, including the Greater Antilles, Galapagos archipelago, and Hawaii (Duncan 2003; del Hoyo and Collar 2014). However, the species has a patchy distribution within much of its range, favouring open habitat with high concentrations of small mammals, and avoiding forested areas (Wiggins *et al*. 2006).

Canadian Range

Short-eared Owl breeds in all provinces and territories, with only most Arctic islands considered to be beyond its regular summer range (Figure 1). The core breeding range is primarily in the tundra, northern Quebec and Ontario, and the prairies. Short-eared Owl is considered uncommon in most of the remaining breeding range where the availability of nesting habitat is relatively limited, especially in the boreal forest and Rocky Mountains (Figure 1).

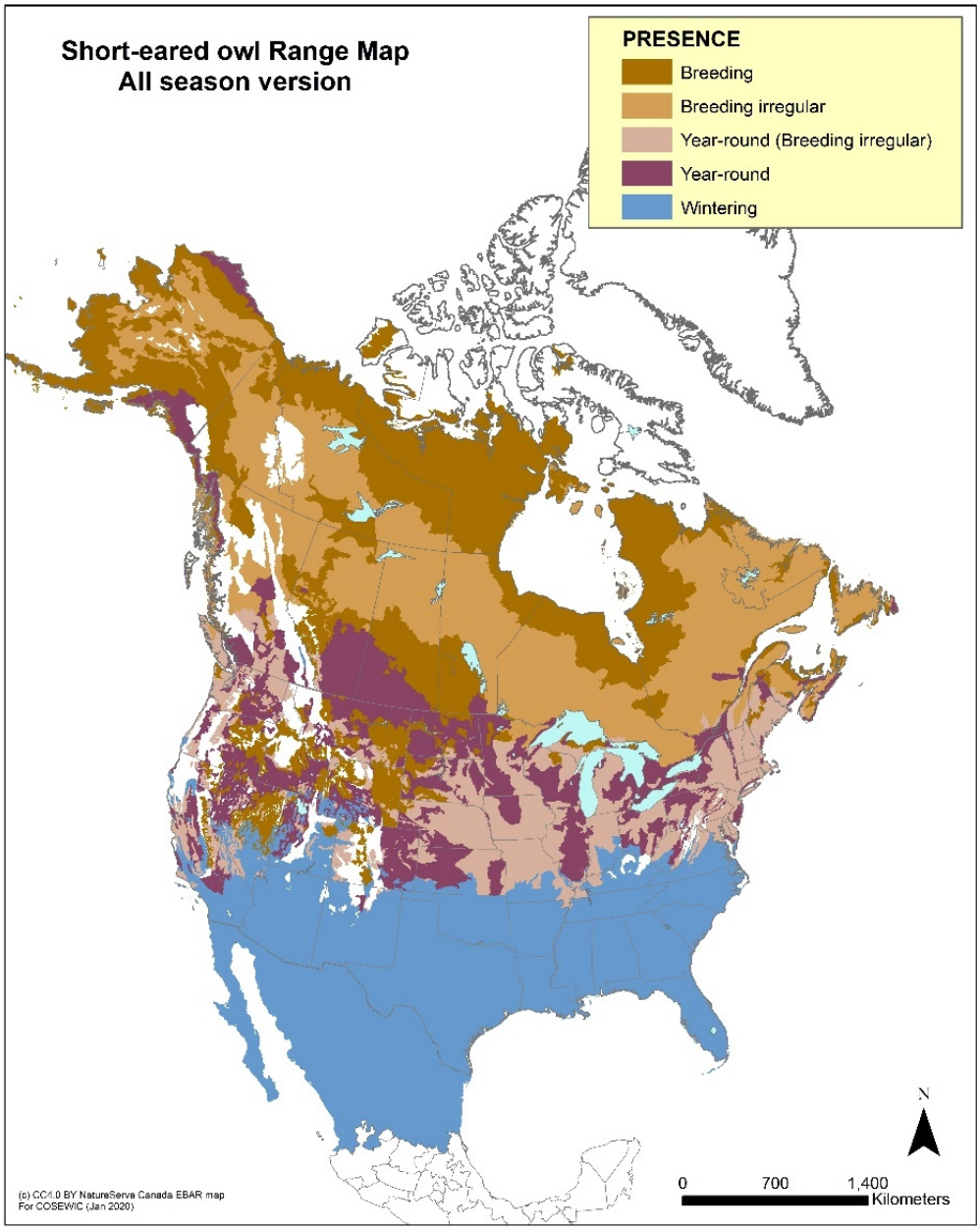

Figure 1. Breeding, wintering, and year-round distribution of Short-eared Owl in North America depicted using the Ecosystem-based Automated Range (EBAR) mapping method, where a mosaic of ecoshapes (ecological regions or districts) are categorized based on documented site data from the Global Biodiversity Information Facility (2018) modified by documented expert knowledge. Breeding ecoshapes contain at least one summer site record (June through August), but no winter ones; parts of the breeding range with infrequent use are classified as irregular, based on data from the Breeding Bird Survey and eBird. Winter ecoshapes contain at least one winter record (December through February) but no summer ones. Year-round ecoshapes contain both winter and summer records. Areas shown in white are unlikely to support Short-eared Owl in either season. © NatureServe Canada EBAR SEOW Map 2019 under CC Attribution 4.0 International License. Map created by Suzanne Carrière (NT Conservation Data Centre), modified by expert reviewers Christian Artuso and François Shaffer (Environment and Climate Change Canada), Sean Blaney (Atlantic Conservation Data Centre), Mike Burrell (Ontario Ministry of Natural Resources and Forestry), Jim Duncan (Retired Director, Manitoba Wildlife and Fisheries), Marcel Gahbauer (COSEWIC Birds Specialist Sub-committee).

The winter range of Short-eared Owl in North America extends across the lower 48 US states and northern Mexico, with some birds frequently wintering in southern parts of British Columbia, the prairie provinces, Ontario, Quebec, and Nova Scotia (Figure 1).

As Short-eared Owl is patchily distributed within its Canadian range, an overview of its occurrence in each territory and province is provided below.

Breeding records for Short-eared Owl are scattered widely throughout British Columbia, associated with old fields, grasslands, and wetland edges (Cannings 2015). Given these habitat preferences, breeding is largely restricted to areas below 1000 m elevation (Campbell *et al*. 1990) and much of the province is unsuitable for this species. The 2008-2012 breeding bird atlas shows the Peace River lowlands around Fort St. John as the only remaining area with a moderate clustering of breeding records (Davidson *et al*. 2015; Figure 2); formerly there was a dense breeding concentration in the Fraser River Delta (Campbell *et al.* 1990). Most winter records are from the Lower Mainland and southern interior valleys (eBird 2021).

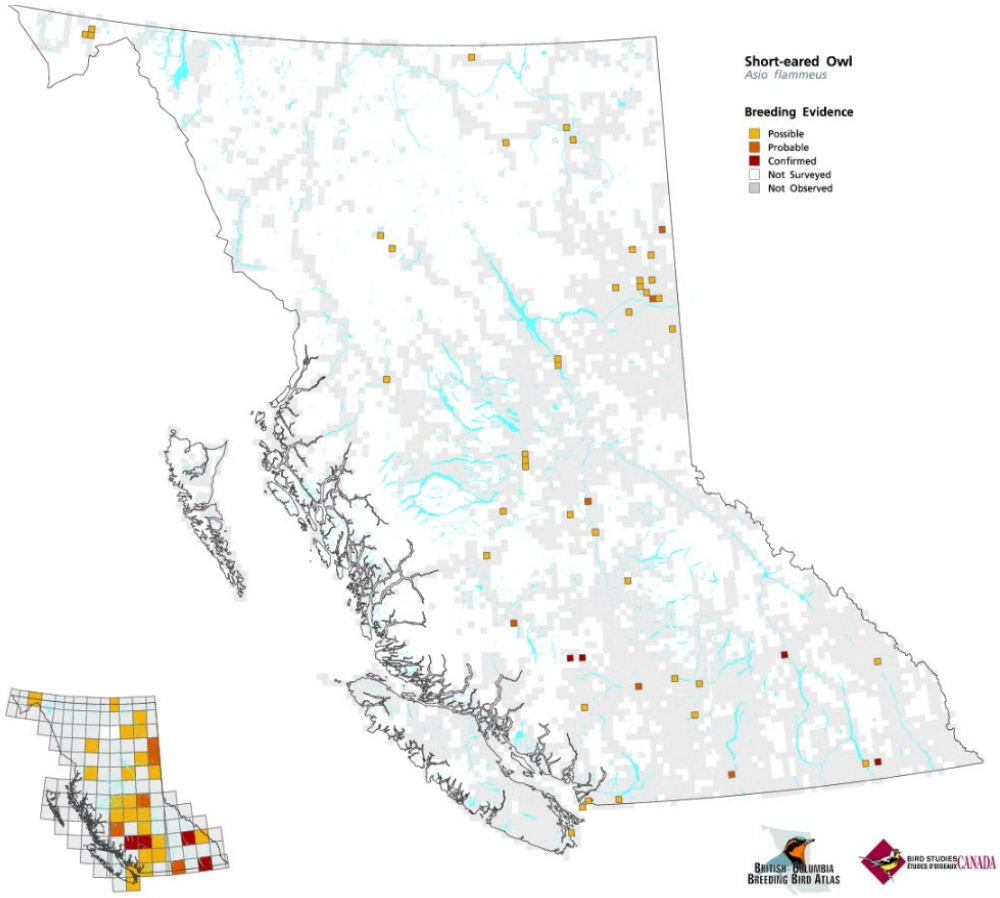

Figure 2. Short-eared Owl breeding distribution in British Columbia during 2008-2012, from the British Columbia Breeding Bird Atlas (Davidson *et al.* 2015).

Across the prairie provinces, Short-eared Owl primarily breeds throughout the grassland region, but also in the Hudson Bay Lowland in Manitoba and scattered sites in suitably large wetlands or other open habitat within the boreal forest in all three provinces (Smith 1996; Federation of Alberta Naturalists 2007; Artuso 2018; Birds Canada 2021; Figures 3-5). However, even within grassland regions, Short-eared Owl distribution tends to be highly localized and variable from year to year. It is largely absent from the prairies in some winters, with large numbers observed in other years (eBird 2021), typically associated with spikes in vole abundance (Clayton 2000). Notable concentrations were observed at Beaverhill Lake, Alberta, in winters of 2005-2006 and 2015-2016, peaking at 191 and 29 individuals, respectively (Priestley *et al.* 2008; Gahbauer *et al.* 2021).

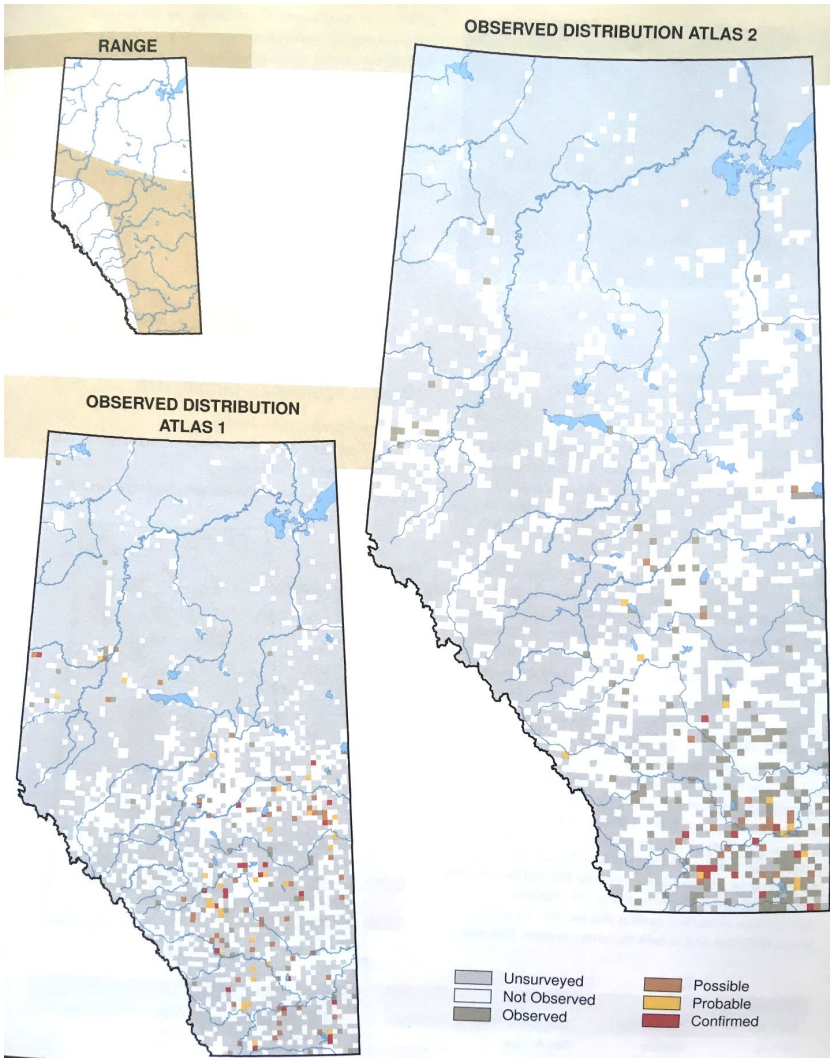

Figure 3. Short-eared Owl breeding distribution in Alberta during 2001-2005 from the second Atlas of Breeding Birds of Alberta (at right), compared to results from the first atlas (at lower left), and showing the overall range within Alberta (at upper left) (Federation of Alberta Naturalists 2007).

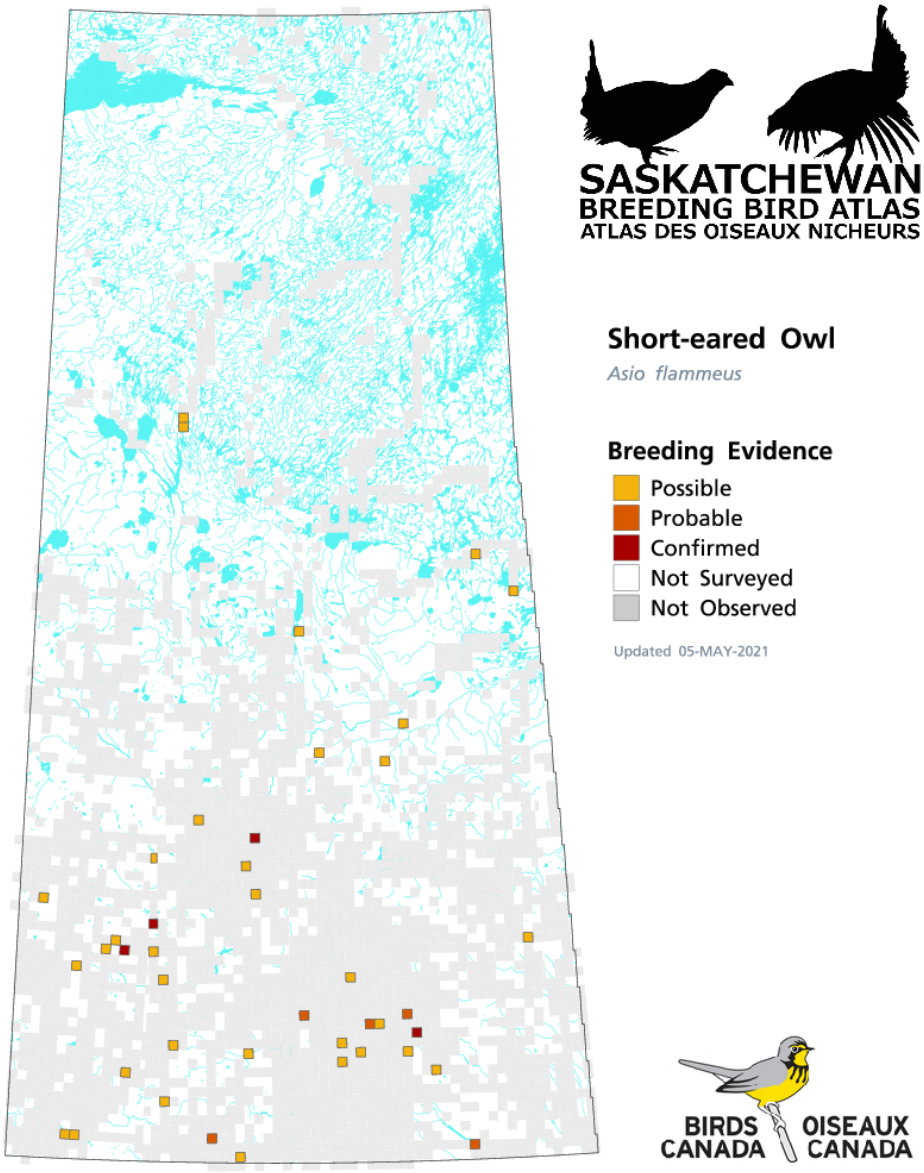

Figure 4. Distribution of Short-eared Owl in Saskatchewan during the initial years of the Saskatchewan Breeding Bird Atlas, 2017-2020 (Birds Canada 2021).

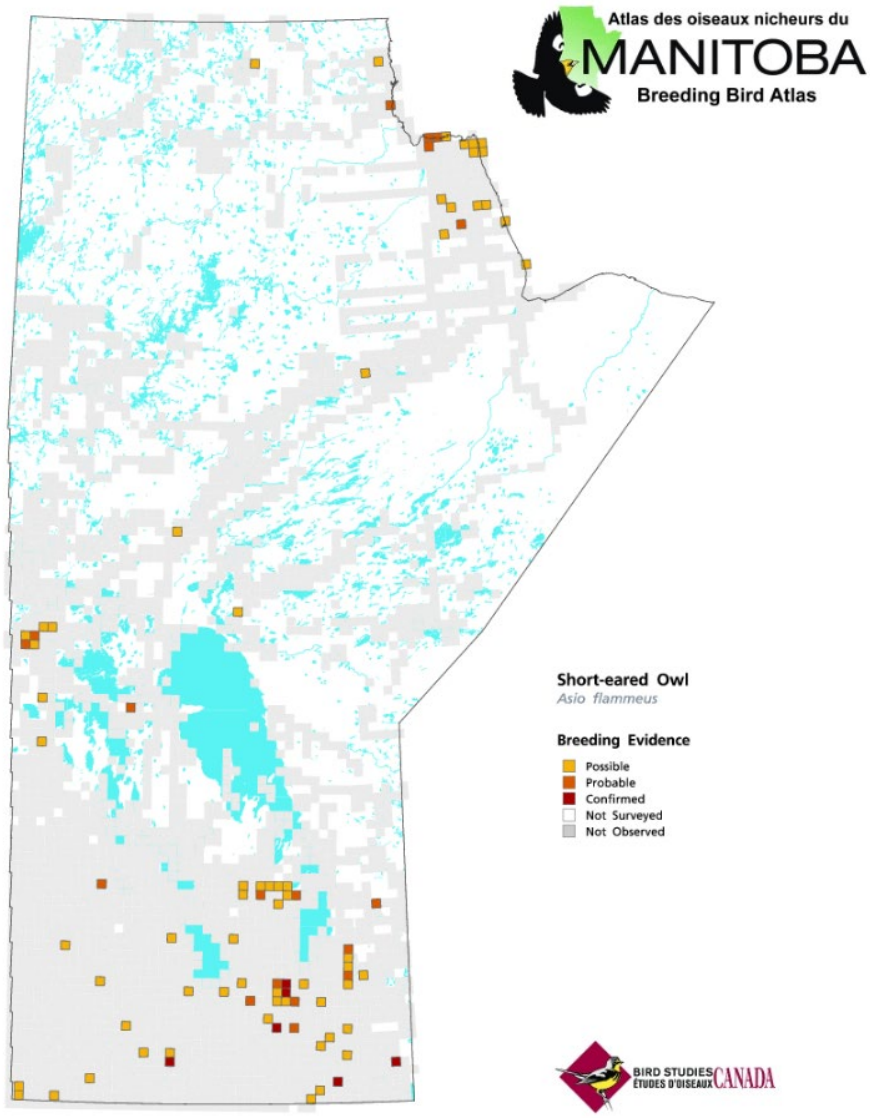

Figure 5. Short-eared Owl breeding distribution in Manitoba during 2010-2014, from the Manitoba Breeding Bird Atlas (Artuso *et al.* 2018).

Short-eared Owl has become a rare and irregular breeder in southern Ontario, primarily associated with remnant habitat near Kingston, the lower Ottawa River, the Niagara Peninsula, and Sault Ste. Marie. Breeding season observations are scarce within the boreal forest zone, except in grassland habitat near Rainy River (Gahbauer 2007; eBird 2021). The stronghold of the species in Ontario appears to be the Hudson Bay Lowland, where the probability of observation during Ontario's second breeding bird atlas (2001-2005) was over seven times higher than the average for the rest of the province (Gahbauer 2007; Figure 6). Wintering distribution and abundance vary annually in relation to weather conditions and prey abundance, and occurrence is typically limited to the Carolinian zone and the Kingston region; Long Point, Haldimand County, Amherst Island, and Wolfe Island are of particular importance (eBird 2021).

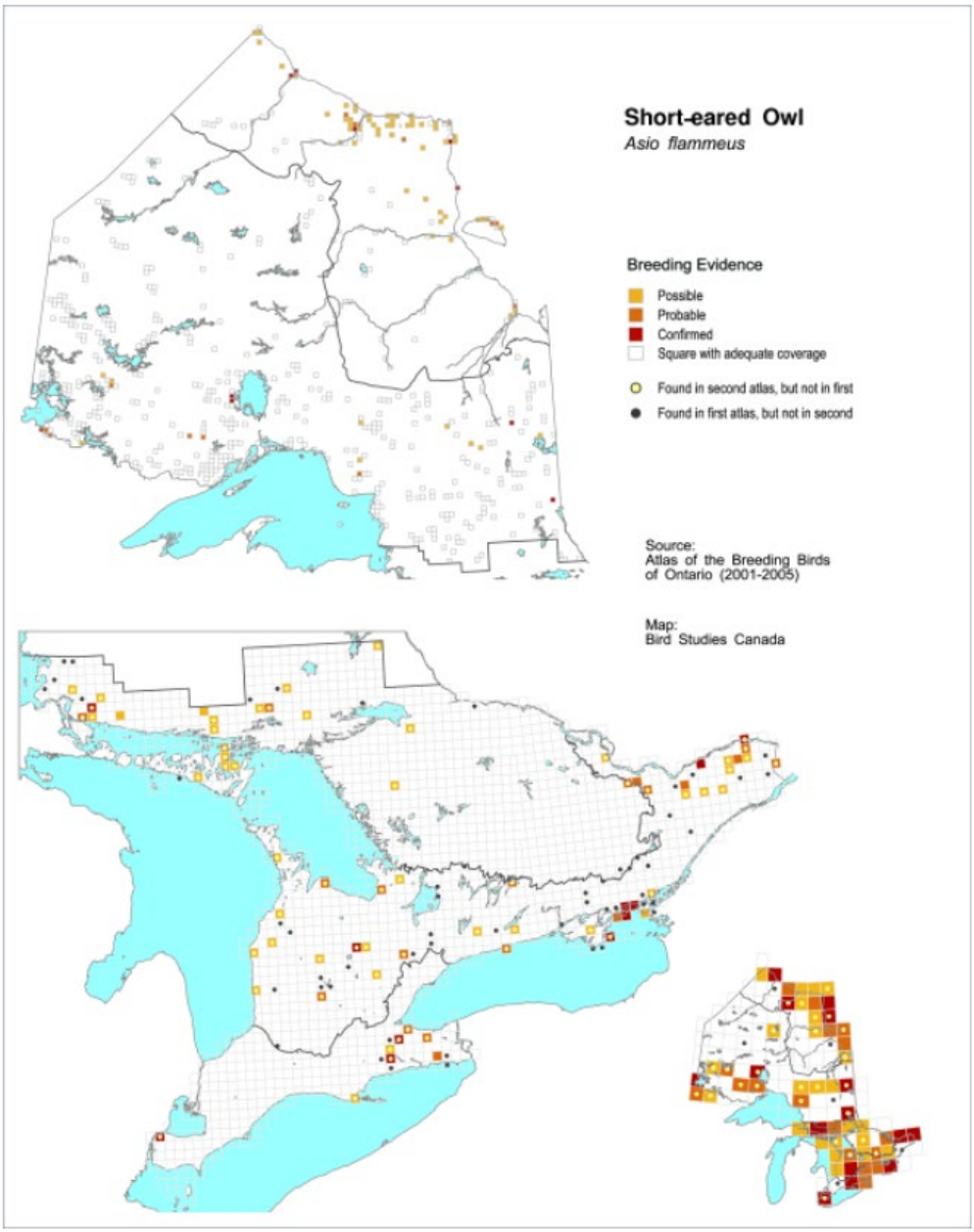

Figure 6. Short-eared Owl breeding distribution in Ontario during 2001-2005, from the second Ontario Breeding Bird Atlas (Cadman *et al.* 2007). Black dots depict 10 x 10 km squares (n=51) and 100 x 100 km blocks (n=6) where Short-eared Owl was recorded during the first atlas (1981-1985), but not the second. Yellow dots depict squares (n=59) and blocks (n=26) where it was recorded during the second atlas, but not the first.

In southern Quebec, the only notable concentrations of breeding records are in the Saguenay-Lac-Saint-Jean region and along the St. Lawrence River and Estuary, although the number of occupied squares along the St. Lawrence declined markedly between atlas periods (Shaffer 2019). There are also scattered observations from the second breeding

bird atlas (2010-2014) east of Montréal and in Abitibi-Témiscamingue (Gagnon *et al.* 2015; Shaffer 2019; Figure 7). As in Ontario, breeding records from the second atlas within boreal forest regions were scarce. However, there were numerous records on the Ungava Peninsula, especially near the Hudson Bay and Ungava Bay coasts or associated with large interior wetlands (QBBA 2019, Figure 7). Small numbers winter in southwestern Quebec and along the St. Lawrence River (eBird 2021).

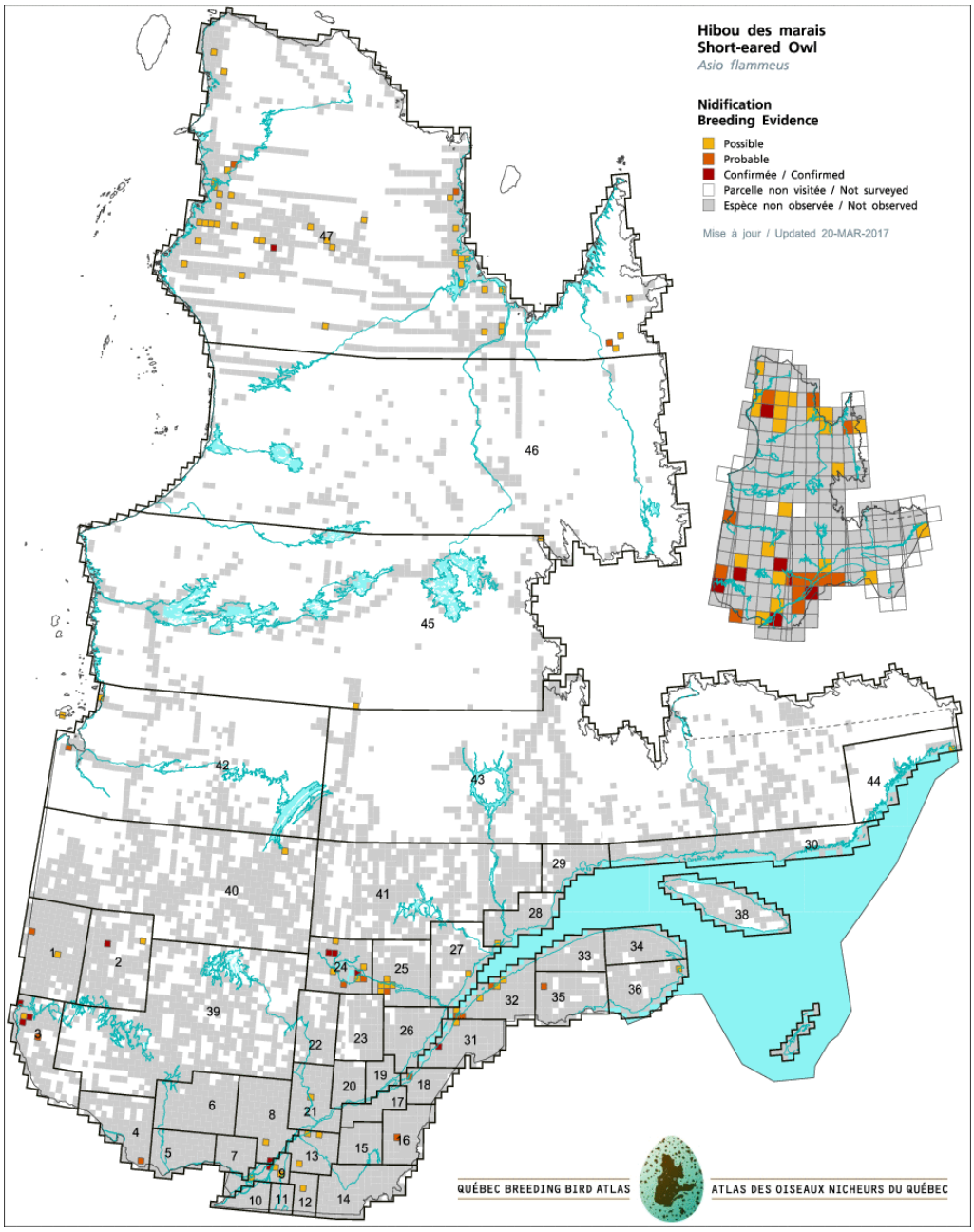

Figure 7. Short-eared Owl breeding distribution in Quebec during 2010-2014, from the second Quebec Breeding Bird Atlas (QBBA 2019).

In the Maritime provinces, Short-eared Owl is a rare and localized breeder, with only the areas around the Tantramar Marshes, CFB Gagetown, and northern valley lowlands of New Brunswick having concentrations of records during the second breeding bird atlas (2006-2010, Lauff 2015; Figure 8). Most breeding evidence in Nova Scotia and Prince Edward Island was from coastal areas (Lauff 2015; Figure 8). Wintering records are largely limited to coastal habitat in the southern half of Nova Scotia (eBird 2021).

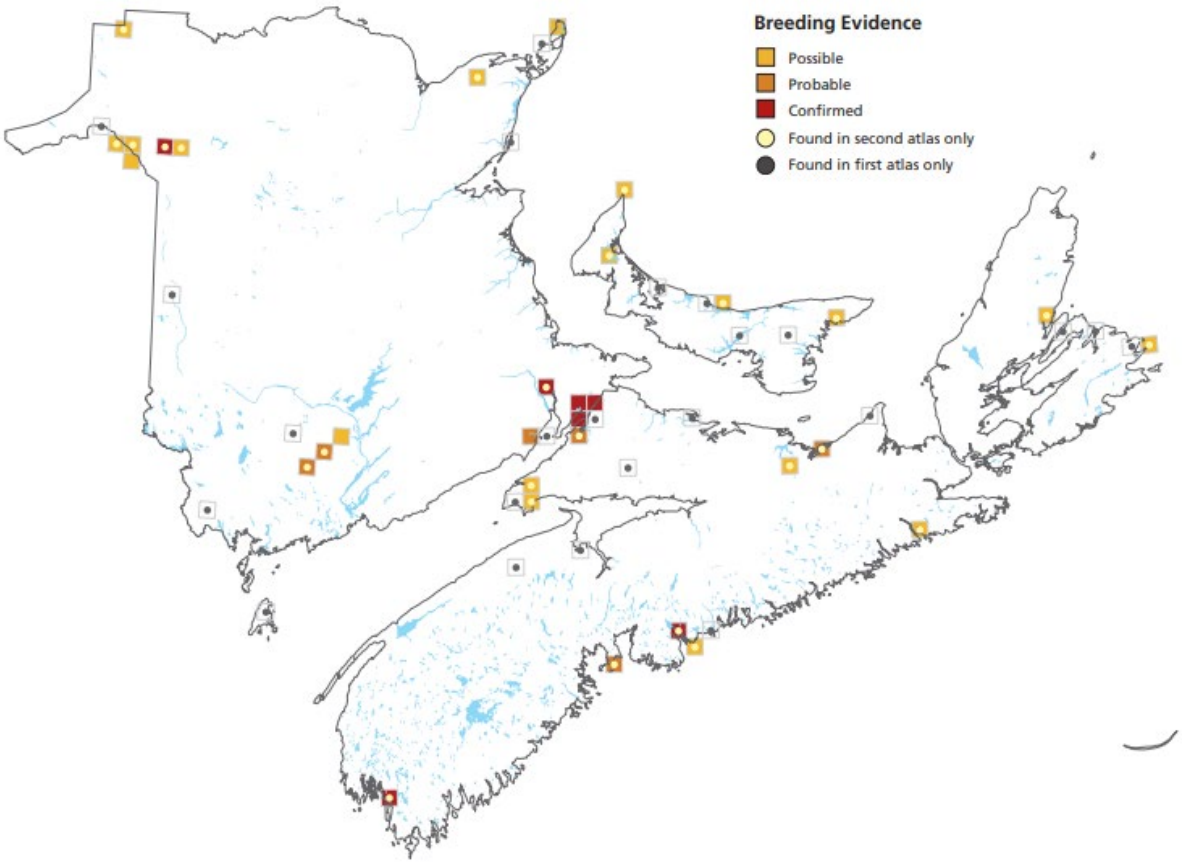

Figure 8. Short-eared Owl breeding distribution in the Maritime provinces (New Brunswick, Prince Edward Island, and Nova Scotia) during 2006-2010, from the second Atlas of Breeding Birds of the Maritime Provinces (Stewart *et al.* 2015). Black dots (n=15) depict 10 x 10 km squares where Short-eared Owl was recorded during the first atlas (1986-1990), but not the second. Yellow dots depict squares (n=25) where it was recorded during the second atlas, but not the first.

In Newfoundland and Labrador, historical breeding records are primarily associated with coastal sites (Schmelzer 2005). Satellite telemetry research on Short-eared Owls wintering in New York has shown them migrating to inland Labrador in summer (Gahbauer *et al*. 2021). Winter records are scarce (eBird 2021).

Short-eared Owl is a summer resident and migrant across much of mainland Yukon, Northwest Territories, and Nunavut, with potential to occur wherever there is suitable open habitat. Abundance in Yukon varies considerably from year to year in response to the cyclical abundance of lemmings (Sinclair *et al*. 2003), and this is likely the case across the Arctic (Pitelka *et al.* 1955). Short-eared Owl is considered uncommon in northern Yukon, and density is generally much lower south of the treeline, with breeding largely limited to extensive deltas or wetland complexes that offer sufficiently large areas for nesting and hunting (Sinclair *et al.* 2003; Reid *et al.* 2011). Breeding occurs on Herschel Island only in years of particularly high vole and lemming abundance (Reid *et al.* 2011). The distribution of Short-eared Owl in Northwest Territories and Nunavut has not been assessed in detail, but records are most frequent in coastal tundra along the mainland coast of the Beaufort Sea (ECCC 2018). The northern limits of its range have been recently extended to Banks Island (Smith *et al.* 2013) and Bylot Island (Therrien 2010), but it is unknown whether these represent occasional occurrences or a range expansion. Short-eared Owl is generally considered to be restricted to the mainland of Nunavut (Richards and Gaston 2018), although eBird (2021) also shows records from Victoria, Southampton, and Coats Islands.

Extent of Occurrence and Area of Occupancy

Extent of occurrence (EOO) of Short-eared Owl is approximately 12,196,000 km^2 within Canada, based on a minimum convex polygon drawn around the breeding, wintering, and year-round distribution in Canada (Figure 9). The previous report provided an estimate of 7,500,000 km^2, derived from the Partners in Flight (PIF) database (COSEWIC 2008). The difference between these estimates stems in part from differences in calculation methods. However, because additional high Arctic breeding sites have been documented in recent years, most notably on Bylot Island by Therrien (2010), the present EOO would regardless be larger than previously calculated.

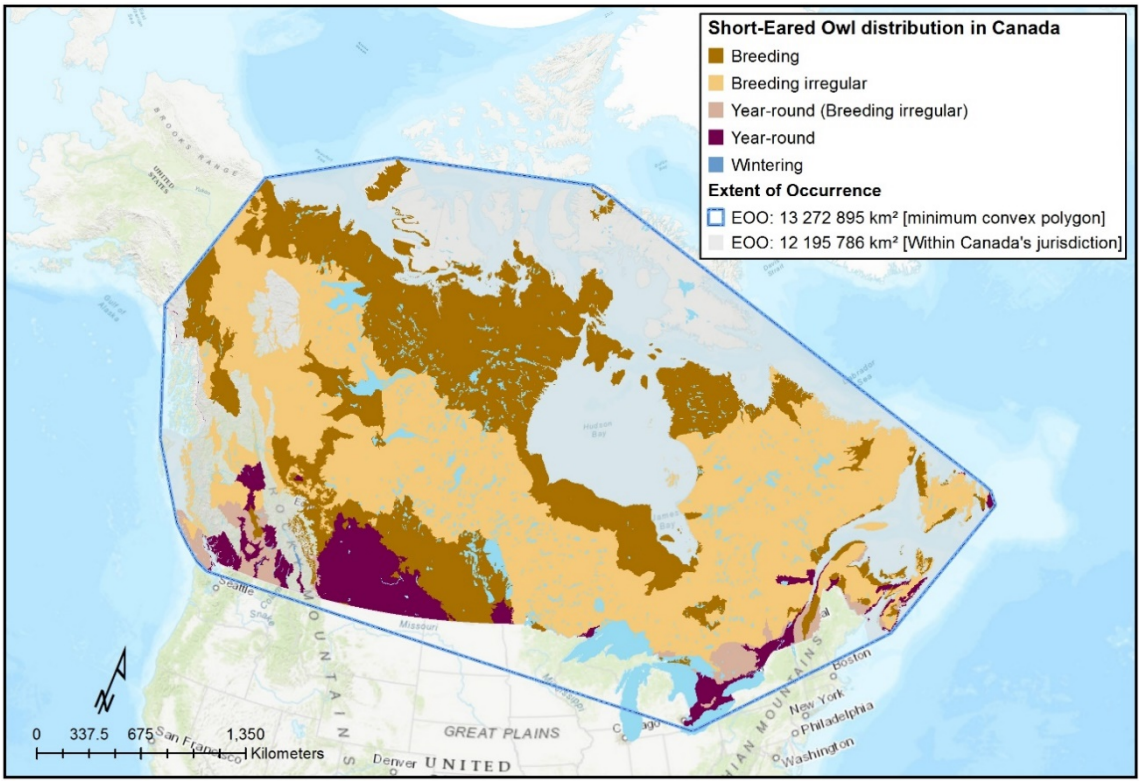

Figure 9. Extent of occurrence of Short-eared Owl in Canada (prepared by COSEWIC Secretariat).

Index of area of occupancy (IAO) of Short-eared Owl was reported at 1,500,000 km^2 in the previous status report, based on the extent of suitable habitat (COSEWIC 2008). However, IAO is now calculated based on occupancy of 2 x 2 km grid squares. Given a national population estimate of approximately 31,200 mature individuals (see **Population Sizes and Trends**), IAO would be approximately 62,000 km^2 if each pair was in a separate 2 x 2 km grid, and this can be taken as a maximum estimate. IAO is almost certainly smaller, as Short-eared Owls may often nest relatively close together when habitat and prey abundance are suitable for breeding. It is unlikely that IAO is less than 15,500 km^2, equivalent to an average breeding density of four pairs per grid square, giving a range of 15,500-62,000 km^2. Although the current IAO cannot be directly compared with the value reported in the previous report (COSEWIC 2008) due to the change in methods, it is assumed to have declined, given evidence of reduced occupancy in several provinces, such as declines noted in Quebec between breeding bird atlases (see **Population Sizes and Trends**).

Search Effort

Knowledge of the current distribution of Short-eared Owl in Canada is largely derived from provincial and regional Breeding Bird Atlases (BBAs) and eBird data, supplemented by records from the Breeding Bird Survey (BBS) and Christmas Bird Count (CBC) databases, input from provincial/territorial conservation data centres and biologists, and in the case of Quebec, targeted searches for Short-eared Owl in two regions (see **Population Sizes and Trends**).

HABITAT

Habitat Requirements

Short-eared Owl is a bird of open landscapes, including grasslands, tundra, and wetlands, but the relative importance of these habitat types and the key features within them remain poorly understood (Wiggins *et al*. 2006; Booms *et al.* 2014). Although open areas are favoured throughout the year, there are specific attributes associated with both breeding and wintering habitat (described below). In all seasons, potentially suitable habitat tends to be occupied only when there is a reliable source of small mammal prey (Korpimaki and Norrdahl 1991; Wiggins *et al.* 2006).

Breeding habitat

Nesting generally occurs in large open areas, and the species is considered to be sensitive to habitat fragmentation (Wiggins 2004). Austen *et al.* (1994) suggested a minimum area requirement of about 50-100 ha, consistent with the mean territory size of 82 ha reported in Manitoba by Clark (1975). Nest scrapes are typically located on dry spots beside vegetation sufficiently large to conceal the adult female while incubating, and the nestlings after hatching (Wiggins *et al.* 2006). In southern parts of the range, ungrazed grasslands away from trees and shrubs are favoured for nesting, with grass height generally below 60 cm (Herkert *et al.* 1999; Fondell and Ball 2004), but often adjacent to a clump of taller grasses (Evrard *et al.* 1991; Keyes *et al.* 2016). Some Short-eared Owls nest in stubble fields, hay fields and other agricultural lands, although success at these sites may be reduced by human disturbance (Campbell *et al.* 1990), mowing (Arroyo and Bretagnolle 1999), or higher rates of predation (Fondell and Ball 2004). In the Maritimes, most nests are found in well-drained grasslands or dyked areas in coastal wetlands (Erskine 1992), often strongly associated with shrublands (Lauff 2015). In the north, nests are primarily in tundra (Sinclair *et al.* 2003), and sometimes beside a small shrub that provides cover (Jehl 2004).

Winter habitat

Winter habitat also primarily includes a variety of open areas, but there may be a greater preference for areas adjacent to trees for roosting and shelter (Clark 1975; Bosakowski 1986; Wiggins *et al.* 2006). Telemetry research in New York state revealed that wintering Short-eared Owls favoured areas with a high density of vole runways, and preferentially hunted in fields with high forb cover, thatch depth and plant species diversity (Gahbauer *et al.* 2021). At several sites in that study, Short-eared Owls roosted exclusively in conifers, notably Christmas tree plantations and shelterbelt rows; elsewhere others used ground roosts, mostly among taller wetland plants including Common Reed (*Phragmites australis*), Reed Canary Grass (*Phalaris arundinacea*), Purple Loosestrife (*Lythrum salicaria*), and cattails (*Typha* sp.). Two of three conifer roosts were near buildings; similarly, a winter roost of 18 individuals was found in a single Eastern Red Cedar (*Juniperus virginianus*) 3 m from an occupied residence on Amherst Island, Ontario (Keyes *et al.* 2016). These observations suggest that availability of thermal shelter may be a key factor in winter habitat selection, especially during periods of extreme weather.

Habitat Trends

The distribution and abundance of Short-eared Owl in Canada prior to European settlement is unknown, but based on habitat preferences, this species was presumably most common in the prairies and Arctic tundra; subsequent clearing of forested land in other parts of Canada likely made new areas available for nesting. However, over the past century, the widespread conversion of both native grassland and wetland habitat for agricultural development and urban expansion has resulted in substantial loss of habitat for Short-eared Owl across much of its range in southern Canada (e.g., Campbell *et al.* 1990; Austen *et al.* 1994; Smith 1996; Clayton 2000). Telfer (1992) estimated a 39% loss of native grasslands in the prairies from 1949 to 1986; Samson and Knopf (1994) concluded that in total 61% of mixed grass prairie in Alberta, 81% of mixed grass prairie and 85% of shortgrass prairie in Saskatchewan, and 99% of tallgrass and mixed grass prairie in Manitoba had been lost since European settlement. Subsequent agricultural intensification over the past 25 years has rendered additional habitat unsuitable.

Increases in shrub biomass, cover and abundance (shrubification) have been observed in northern regions over the past century, with expansion of shrubs such as birch *Betula* spp, willow *Salix* spp, and alder *Alnus* spp. into tundra habitat across much of the western and eastern Canadian Arctic (Myers-Smith *et al.* 2011). This enhanced shrub production reflects a climate warming-driven increase in growing season length (Miller and Smith 2012). Shrubification reduces the area of open ground by infilling shrub cover between existing patches (Myers-Smith *et al.* 2011). It is anticipated to reduce the suitability of many open habitats used by Short-eared Owl, especially in low Arctic tundra, by impairing its foraging efficiency, reducing availability of nesting sites, and providing additional cover and hunting perches for predators.

In southern Ontario and Quebec, loss of wetland areas is a particular concern; for example, over 3600 ha of wetland habitat along the St. Lawrence River in Quebec was lost between 1950 and 1978 (Lands Directorate 1986). Urban expansion has long been recognized as a threat to Short-eared Owl in the United States, especially in parts of the northeast where human population density is highest (Holt and Melvin 1986). In Canada, urban growth has particularly affected the wintering range of Short-eared Owl, with a cumulatively substantial loss of formerly occupied sites around cities, including the greater Vancouver, Calgary, Toronto, Ottawa, and Montréal areas, all of which have experienced ongoing reduction in suitable habitat which has continued within the past decade (M. Gahbauer pers. obs.).

BIOLOGY

A detailed overview of the biology of Short-eared Owl is provided by the Birds of North America species account (Wiggins *et al.* 2006). Much of the basic knowledge of breeding and wintering ecology of Short-eared Owl in North America was described by Clark (1975) and Holt (1992). Key aspects of Short-eared Owl biology relevant to the assessment of its status are highlighted below.

Life Cycle and Reproduction

Age at first breeding for Short-eared Owl appears to be one year (Wiggins *et al*. 2006). Post-fledging and adult survival rates are poorly known, and only limited data exist on lifespan and generation time. The longevity record for a wild Short-eared Owl in North America is 4 years and 2 months, but this is based on only 54 banding recoveries over the past century (Laurin 2018). This is likely a substantial underestimate, as the European longevity record is 12 years and 9 months (Wiggins *et al.* 2006).

BirdLife International estimated the generation length (the average age of parents in the population) to be 4.0 years, based on modelled estimates of annual survival rate of 0.59, age at first breeding of 1 year, and maximum lifespan of 21.8 years (Bird *et al.* 2020). This estimate is longer than the period of 2 years used by COSEWIC (2008), but appreciably shorter than the 7.2 years previously estimated by Birdlife International (2016). The estimate of 4 years is used throughout this report. As this is the shortest estimate of generation length provided by Bird *et al.* (2020) for seven owl species in the genus *Asio* (range 4.0-6.6 years), it is considered to be a minimum estimate. Short-term population declines are estimated over a three-generation period of 12 years.

Pair formation may begin as early as February, with egg-laying from late March in southern Canada where the species is resident, to late June or early July in the Arctic (Wiggins *et al.* 2006). Nests are simple scrapes in the ground, lined with grasses and feathers (Mikkola 1983), and often concealed by adjacent vegetation (Wiggins *et al.* 2006). Nest failure due to predation may be high (e.g., Lockie 1955), and replacement clutches may be laid. There is no evidence of second broods in North America, although they have been reported in Europe (Mikkola 1983). Murray (1976) identified mean clutch size in North

America as 5.6 eggs, with larger clutches farther north, on average. Clutch size is also positively correlated with local prey abundance (Clark 1975). Incubation averages about four weeks, and as it begins once the first egg is laid, hatching is asynchronous.

Younger nestlings have a lower probability of survival, especially if prey are not abundant (Wiggins *et al.* 2006). Young are semi-altricial, and grow quickly, walking away from the nest at 12-18 days of age, although unable to fly, and are still fully dependent on their parents for at least another two weeks (Clark 1975; Holt 1992). Clark (1975) reported 86% hatching success and 46% fledging success in southern Manitoba; a large study in Montana found 74% hatching success and 91% fledging success (Wiggins *et al.* 2006). Other studies with smaller sample sizes have indicated hatching success as low as 21% (Lockie 1955) and fledging success as low as 10% (Fondell and Ball 2004). Overall, variation in prey availability, predator pressure, and environmental conditions may significantly influence nesting success, although there have been too few studies to determine a typical rate for this species.

Physiology and Adaptability

Most Short-eared Owls nest away from human activity and may be sensitive to disturbance during laying and incubation (Leasure and Holt 1991; Reid *et al.* 2011). However, some individuals nest in agricultural areas subject to activities such as haying, mowing and livestock grazing.

Short-eared Owl is largely crepuscular and actively hunts through the evening and into the night (Wiggins *et al.* 2006). Holt (1993) reviewed studies from across North America, and concluded that small mammals comprise about 75% of the diet. Typical mammal prey includes voles, lemmings, mice, shrews, moles, rats, and pocket gophers, and occasionally larger species such as rabbits, weasels, and muskrat (*Ondatra zibethicus*; Wiggins *et al.* 2006). Voles are particularly important, with Short-eared Owls often roaming widely and settling in areas where they detect temporary spikes in vole abundance. Communal roosts at such sites may be active for weeks to months, and may vary considerably in size from day to day (Clark 1975; Gahbauer *et al.* 2021).

Dispersal and Migration

Little is known about Short-eared Owl juvenile dispersal, as the few studies of long-distance movements have mostly focused on adults. Dispersal patterns are likely to be highly variable given that the species is often nomadic, moving in response to densities of voles or other small mammal prey (Korpimaki and Norrdahl 1991; Houston 1997; Poulin *et al.* 2001).

Short-eared Owl is considered a partial migrant (Wiggins *et al.* 2006). In Canada, those breeding in the north are highly migratory, whereas some breeding in the south may be resident. All seven Short-eared Owls wintering in New York State that were tracked on migration by satellite telemetry headed to northern Quebec and Labrador for summer (Gahbauer *et al.* 2021). However, it is unknown whether other individuals observed breeding near the wintering sites were year-round residents, or arrived there after wintering elsewhere (Gahbauer *et al.* 2021).

A large telemetry study of 26 adult Short-eared Owls from Alaskan breeding sites showed considerable variability, with wintering areas ranging from California east to Kansas, and from Montana south to Mexico (Johnson *et al.* 2017). The mean distance travelled was 4722 km, over a mean duration of 85 days. Many migrants passed through western Yukon and southeastern Alberta or southern Saskatchewan *en route* to wintering sites. All owls tracked until the following summer established breeding territories in Idaho, Montana, or Alberta, showing no fidelity to the previous year's breeding sites in Alaska. In contrast, limited satellite telemetry data from wintering sites in southern Ontario and New York state (n=6) suggest more consistent use of both winter and summer ranges, and stronger migratory connectivity to breeding sites in Quebec and Labrador (Bird Studies Canada 2011; Gahbauer *et al.* 2021), suggesting that movement patterns may differ between western and eastern North America. The satellite telemetry results are consistent with band recovery data which show that Short-eared Owl is highly nomadic, but with relatively little east-west exchange within Canada, with most individuals remaining either west or east of the Great Lakes (Gahbauer *et al.* 2021).

Interspecific Interactions

Nest and adult predation

As a ground-nesting bird, Short-eared Owl is vulnerable to predation by mammals such as foxes and skunks, as well as larger owls and hawks, gulls, jaegers, and corvids (Bluhm and Ward 1979; Maxson and Herr 1990; Wiggins *et al.* 2006). Eggs and young nestlings are at greatest risk, but juveniles remain vulnerable until capable of flight, and adults may also be depredated while incubating, or while roosting on the ground at other times of year. In Scotland (Lockie 1955) and Alaska (Pitelka *et al.* 1955), egg and nestling predation were identified as the most significant source of reproductive failure for Short-eared Owl.

Non-predatory interspecific interactions

Short-eared Owl and Northern Harrier (*Circus hudsonius*) have overlapping habitat preferences and often co-occur in suitable habitat (Swengel and Swengel 2017). Although Northern Harriers have been reported to harass Short-eared Owls and cause them to drop their prey (e.g., Clark and Ward 1974), conflict may be relatively infrequent given that harriers are primarily diurnal, whereas the owls are largely crepuscular and often hunt at night. Short-eared Owl may also compete for prey with Snowy Owl (*Bubo scandiacus*) and other raptors, on both breeding and wintering grounds, but there is no evidence that such interactions are frequent or affect Short-eared Owl occurrence or survival.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Short-eared Owl is not particularly well-detected by any of the standard North American bird monitoring programs, but collective insights gained from the Christmas Bird Count (CBC), Breeding Bird Survey (BBS), and Breeding Bird Atlases (BBAs) can be used as a basis for inference about population size and trends.

The Western *Asio flammeus* Landscape Study (WAfLS) is a standardized breeding population monitoring initiative that began in Idaho and northern Utah in 2015, and has expanded to eight western states (Miller *et al.* 2018). Although this program does not yet extend to Canada, it demonstrates a successful approach to targeted monitoring of Short-eared Owl and provides insights into short-term trends in populations adjacent to western Canada.

Christmas Bird Count

The CBC is the oldest systematic bird survey in North America, dating back to 1900 (National Audubon Society 2015). There are over 2400 CBC survey circles in North America, each with a 12 km radius around a fixed centre, and surveyed by volunteer observers on a single day each year between 14 December and 5 January (National Audubon Society 2014; LeBaron 2018).

Although the CBC was not initially designed for population monitoring (Dunn *et al.* 2005), it may be the best available source of data for understanding changes in Short-eared Owl numbers over time, as most of the species' wintering range is well-sampled by the program. Results for Canada in part reflect changes in the availability of wintering habitat in the southern part of the country, including counts in urban areas from which Short-eared Owl may have been displaced over time. Based on satellite tracking data available to date (Johnson *et al.* 2017), it appears that Alaskan birds tend not to winter in Canada, so only Canadian breeding birds are likely to be reflected in Canadian CBC results. However, continental CBC results may be even more relevant, as the majority of Short-eared Owls that breed in Canada likely winter in the United States. Trends at that scale can be difficult to interpret, as they also include owls that breed in the United States, and there is considerable variability in trends among states, with little knowledge about whether Canadian birds may be concentrated in particular regions.

The standard CBC analysis corrects for effort to account for increases in observer participation over time, using a non-linear function to generate an estimate of the number of birds per observer party-hour. This approach is appropriate for most bird species, where increase in observer effort correlates positively with the number of individuals observed. However, in the case of Short-eared Owl, most individuals are likely counted at known roost sites, with the number observed therefore having little relationship to overall time spent in

the field. Given that the effort in seeking out roost sites is likely similar from year to year, and the number of CBCs operated in North American has been fairly stable over the past decade, the absolute number of individuals counted annually across all count circles likely gives a direct indication of population trend.

Breeding Bird Survey

The BBS is a standardized program initiated in 1966 that provides a foundation for monitoring the population trends of over 400 bird species (ECCC 2018b). Each 39.2 km survey route comprises 50 three-minute point counts conducted at 800 m intervals, and is monitored once annually during the peak of the breeding season by an experienced observer (ECCC 2018b).

Although population trends have been calculated using BBS data, that survey is not optimal for tracking trends of this species because it is conducted in early morning, when Short-eared Owls are rarely active or vocal and are therefore seldom detected even if present. Additionally, most of the Canadian breeding population is believed to occur in roadless parts of the north not covered by the BBS. Compounding these factors is the nomadic nature of the species, which may result in temporary spikes in local abundance that could have an undue influence within a data set where results are otherwise typically sparse. In principle, these limitations are consistent over time, and therefore estimated trends should be representative of changes in the population. However, BBS trends are most likely to be reliable when considered over large temporal and geographic scales, and should be viewed with caution at smaller scales.

The BBS is also the primary source of data used by PIF to estimate population sizes (Will *et al.* 2019). BBS data are limited for northern Ontario, where PIF instead extrapolated results from point counts conducted during the second Ontario Breeding Bird Atlas (2001-2005). For all other provinces except British Columbia, there were regions with no relative abundance information from the BBS, and PIF extrapolated population estimates under the assumption that densities there were comparable to those elsewhere in the same Bird Conservation Region. In most cases, these extrapolations were based on data from only a few BBS routes, resulting in very broad confidence intervals around the estimates.

Breeding Bird Atlases

BBAs are intensive volunteer-based surveys spanning multiple years (usually five) that aim to summarize the distribution and relative abundance of breeding bird species at a provincial or regional scale. Records are primarily compiled at the scale of 10 x 10 km grid squares, with a focus on documenting possible, probable, or confirmed breeding evidence for each species in every square surveyed. Participants are typically asked to survey for at least 20 hours in each atlas square, a level of effort considered sufficient to detect the majority of species present. However, as the actual level of effort varies, presence/absence results are generally considered more robust than abundance data. Alberta, Ontario, Quebec, and the Maritimes have all completed a second atlas, allowing for comparison with the original effort about 20 years earlier, although the first two were completed prior to the

previous status report and no longer reflect current status in those provinces. British Columbia and Manitoba have each completed a single atlas within the past decade, while first formal atlas programs started in Saskatchewan in 2017, and Newfoundland in 2020.

Most atlases conducted since 2000 have also included point counts that allow mapping of relative abundance for common species, although this has not yet been done for Short-eared Owl anywhere due to insufficient data for abundance modelling. However, basic presence/absence results are generally informative, as experienced observers participating in each BBA make particular efforts to document uncommon and rare species. Level of effort varies by region, with southern areas of most provinces generally having good coverage, compared to more scattered surveys in less readily accessible northern areas.

In interpreting BBA data, it is important to note that maps reflect all observations across 5-6 years of the project; for a nomadic species such as Short-eared Owl, the number of squares occupied in a given single year may be considerably smaller. This may partly offset the concern that individuals can be present in some squares without being detected. On the other hand, Short-eared Owls may aggregate to some degree in loose breeding groups where habitat is suitable. However, it is unlikely that the average number of pairs per occupied square would exceed five, and most often is likely considerably less. Therefore, a range of one to five pairs (two to ten mature individuals) per occupied atlas square is used here to estimate plausible bounds on a population estimate derived from BBA data.

The first British Columbia BBA took place from 2008 to 2012, with over 56,000 hours of field effort in more than 4500 squares, and over 40,000 point counts (Davidson *et al.* 2015). Coverage was lower in remote areas and at higher elevations, but habitat in these regions is generally of limited suitability for Short-eared Owl, so coverage of the potential range of occurrence of this species was likely quite good, estimated here to be in the range of 70-90% (Figure 2).

Alberta undertook its first BBA from 1987 to 1991 (Semenchuk 1992), and its second from 2001-2005 (Federation of Alberta Naturalists 2007). The second involved over 45,000 hours of field effort in over 1900 squares, representing 29% of the province. Coverage was most extensive in the southern half of the province, where most potentially suitable habitat for Short-eared Owl occurs, and likely covered 40-60% of the regular range of the species (Figure 3).

The first Saskatchewan Breeding Bird Atlas is being undertaken from 2017 to 2021 (Birds Canada 2021). As effort is ongoing, the interim results have not been applied toward population estimation, although the distribution of records to date shows a higher concentration in southern grassland regions (Figure 4).

The first Manitoba Breeding Bird Atlas took place from 2010 to 2014, with over 42,000 hours of field effort in nearly 3000 squares, and over 38,000 point counts (Artuso *et al.* 2018). Nearly all squares in the southern third of the province received coverage; farther north there was extensive coverage along the Hudson Bay coast and major waterways (Figure 5). The sampling effort aligns well with the distribution of Short-eared Owl in the province (Artuso 2018), and likely sampled 75-90% of the numbers present.

Ontario's first BBA from 1981 to 1985 (Cadman *et al.* 1987) was followed by a second from 2001-2005 (Cadman *et al.* 2007). The second had over 152,000 hours of field effort in nearly 5000 squares, and over 68,000 point counts (Cadman *et al.* 2007). Nearly all squares in southern Ontario were atlassed in both BBAs, representing at least 90-95% coverage (Figure 6). Effort in northern Ontario was generally more extensive in the second BBA, especially in the Hudson Bay Lowland, believed to be an important breeding region for Short-eared Owl. However, coverage was likely limited to 25-40% of that region, and in many cases was limited to a single year during the atlas period, such that effective detection of occupied squares may have been as low as 10-20%. Species accounts described changes in numbers of occupied squares between atlas periods, taking into account differences in levels of effort by region (Cadman *et al.* 2007).

Quebec's two BBAs were undertaken from 1984 to 1989 (Gauthier and Aubry 1996), and 2010 to 2014 (Robert *et al.* 2019), with some atlassing in the northern part of the province in subsequent years. The second BBA had over 97,000 hours of field effort in more than 4,000 squares, and over 34,000 point counts. Atlassing coverage of squares in suitable habitat in the south was likely in the range of 70-90%, compared to only 10-15% in the north (Figure 7).

The first BBA for the Maritimes was based on field surveys from 1986 to 1990 (Erskine 1992); the second BBA covered 2006-2010 and included over 48,000 hours of field effort in nearly 1,700 squares, and almost 13,000 point counts (Stewart *et al.* 2015). Geographic coverage was generally good, except for central New Brunswick, which is largely forested with limited potential habitat for Short-eared Owl, so that lower effort there did not likely affect results for this species. Taking this into account, coverage of potentially suitable habitat is estimated to be 90% in New Brunswick and Nova Scotia, and 95% in Prince Edward Island (Figure 8).

<u>eBird</u>

eBird is an online checklist program widely used by birders for reporting field observations (eBird 2021). The program was established in 2002, and its use has increased markedly in recent years. Although some users have entered historical data, and many historical records from the previous NWT Checklist Program and Étude des populations d'oiseaux du Québec (EPOQ) have been incorporated into eBird, data remain heavily weighted to recent years, precluding reliable trend analysis at this time. However, eBird records are informative regarding recent patterns of distribution for this species and notable concentrations of individuals.

Short-eared Owl surveys

There have been relatively few surveys in Canada specifically focused on Short-eared Owl. In 2004, the Migration Research Foundation conducted breeding season searches in areas of southern and eastern Ontario previously identified as occupied during the first provincial BBA (Hunt 2004). In Quebec, Short-eared Owl was among three species at risk targeted by Canadian Wildlife Service searches of Île aux Grues and Île aux Oies in the St. Lawrence River (Rivard *et al.* 2011), and was the sole focus of transect surveys by the Zoo sauvage de Saint-Félicien and the Ministère des Ressources naturelles et de la Faune in the Saguenay-Lac-Saint-Jean area (Gagnon *et al.* 2013). Newfoundland and Labrador has undertaken annual surveys for Short-eared Owl at selected sites since 2009 (Garland pers. comm. 2019).

Western *Asio flammeus* Landscape Study (WAfLS)

WAfLS was established in 2015 in response to Booms *et al.* (2014) identifying the need to better describe important habitat types and improve population monitoring as conservation priorities for Short-eared Owl (Miller *et al.* 2016a). Volunteer observers survey roadside transects in suitable breeding habitat twice each year between early March and mid-May, conducting 8-11 five-minute point counts approximately 800 m apart, during the peak period of evening activity from 100 to 10 minutes before civil twilight (Larson and Holt 2016). Observers also classify the proportion of habitat within 400 m of each survey site that is shrubland, grassland, wetland, or agriculture (fallow, stubble, ploughed, or newly growing; Miller *et al.* 2016b). As of 2018, 368 transect sites had been established within eight US states, but none in Canada (Miller *et al.* 2018).

Summary

None of the existing data sources is considered to be particularly reliable for estimating abundance and trends of Short-eared Owl in Canada. Only PIF has published regional population estimates, but as these have high uncertainty and are based on sparse data for some regions, their reliability is uncertain. Deriving population estimates from BBA data involves many assumptions and extrapolations, but is likely to be more accurate overall. Trend data over broad temporal and spatial scales are available only from the BBS and CBC. Despite its limitations in detecting Short-eared Owl, trends detected by the BBS are still informative about population status in southern Canada. The CBC provides better geographic coverage for Short-eared Owl, but interpretation of results for the Canadian population is complicated by uncertainty over the proportion of these birds that overwinter in the United States, and whether they are concentrated in areas that show increasing or declining trends.

Abundance

BirdLife International (2016) reported a global population estimate of 350,000-2,000,000 mature Short-eared Owls, based on estimates by the Partners in Flight Science Committee (PIFSC 2013), but indicated that an alternative estimate derived by extrapolating from recent European population estimates (BirdLife International 2015) was 780,000-2,660,000.

PIFSC (2019) estimates that 26.4% of the global population occurs in North America, and that 46% of the continental population (i.e., 12% of the global total) breeds in Canada. Based on the two ranges of values presented, a rough estimate of the number of mature individuals in Canada would be 42,000 to 319,000. The PIFSC (2019) estimate of 280,000 mature individuals in Canada (95% confidence limits 230,000, 340,000), near the upper end of this range, is based on data from the BBS, Northwest Territories Checklist program, the second Ontario BBA, and range map-based extrapolation. Both estimates are much larger than that suggested by Kirk and Hyslop (1998) of 20,000-40,000, although those authors acknowledged their estimate was approximate, with little data upon which to evaluate its precision. However, their range is consistent with the atlas-derived current population estimate of 31,195 (Table 1; details below).

Table 1. Estimated number of Short-eared Owls (mature individuals) by province and territory, based on interpretation and extrapolation of provincial/regional breeding bird atlas results (Federation of Alberta Naturalists 2007; Gahbauer 2007; Cannings 2015; Lauff 2015; Artuso 2018; Robert *et al.* 2019; see Abundance section).

Province or territory	No. squares observed[1]	Atlas coverage[2]	Atlas-based estimate[3]	Density (No./100 km^2)
British Columbia	50	70-90%	410 (110 - 710)	0.071
Alberta	45	40-60%	640 (150 - 1130)	0.104
Saskatchewan	n/a	n/a	680 (160 - 1200)[4]	0.110
Manitoba	86	75-90%	670 (190 - 1150)	0.115
Ontario (south) Ontario (north)	79 70	90-95% 10-40%	525 (170 - 880) 3675 (350 - 7000)	0.257 0.544
Quebec (south) Quebec (north)	41 59	70-90% 10-15%	340 (90 - 590) 3345 (790 - 5900)	0.157 0.286
New Brunswick	17	80-90%	125 (40 - 210)	0.172
Prince Edward Island	4	85-95%	30 (10 - 50)	0.506
Nova Scotia	11	80-90%	80 (20 - 140)	0.149
Newfoundland and Labrador	n/a	n/a	555 (130 - 980)[5]	0.143
Yukon	n/a	n/a	2010 (200 - 3820)[6]	0.482
Northwest Territories	n/a	n/a	6390 (620 - 12,160) [6]	0.654

Province or territory	No. squares observed[1]	Atlas coverage[2]	Atlas-based estimate[3]	Density (No./100 km^2)
Nunavut	n/a	n/a	11,720 (1120 - 22,320)[6]	1.252
Canada total			**31,195 (4150 - 58,240)**	**0.415**

[1] – Number of 10x10 km squares in which Short-eared Owl was reported as a possible, probable, or confirmed breeder during the most recent BBA.

[2] – Approximate proportion of the provincial breeding range of Short-eared Owl which was surveyed by the most recent BBA, inferred from mapped coverage effort.

[3] – Average (and low - high) estimates of provincial breeding populations, assuming a minimum of one pair and an average maximum of five pairs of mature individuals per atlas square with breeding record observations.

[4] – In the absence of BBA data for Saskatchewan, the provincial estimate is derived by assuming the core and uncommon range densities are similar to those in Alberta.

[5] – In the absence of BBA data for Newfoundland and Labrador, the provincial estimate is derived by assuming the core and uncommon range densities are similar to those in northern Quebec.

[6] – In the absence of BBA data for the territories, estimates are derived by assuming the core breeding densities (primarily tundra) are comparable to northern Ontario (Hudson Bay Lowland), and the densities in uncommon breeding range (primarily boreal forest) are similar to Alberta.

In Canada, Short-eared Owl is thought to be most abundant in the Arctic lowlands, and to a lesser extent in the prairies (ECCC 2018a), although it is generally uncommon throughout its range. Estimating abundance is difficult, especially in remote northern areas where there is little survey effort. The nomadic nature of the species further complicates interpretation of available data, in that areas supporting large numbers in one year may have very few in subsequent years, so that survey data from a given year may be unrepresentative of typical numbers (Clayton 2000).

PIFSC (2013) provided national and provincial/territorial population estimates, which were updated using new methods in February 2019, so that differences between the two estimates are not considered reflective of population changes (PIFSC 2019; Table 2). However, as noted above, the BBS is not well-suited to detecting Short-eared Owls, and extrapolations based on its output may be imprecise, particularly for areas with few records. Where available, breeding bird atlas maps and species accounts provide better regionally focused perspectives on abundance, as discussed below.

Table 2. Estimated number of Short-eared Owls (mature individuals) by province and territory, based on PIFSC (2013) and PIFSC (2019). See text in the Abundance section for important caveats about the limited reliability of these estimates.

Province or territory	PIFSC 2013 estimate (data quality rating)	PIFSC 2019 estimate (lower - upper 95% bounds)
British Columbia	1700 (poor)	30,000 (0 - 88,000)
Alberta	11,000 (fairly good)	27,000 (11,000 - 55,000)
Saskatchewan	20,000 (poor)	7800 (730 - 23,000)
Manitoba	7300 (fairly good)	1600 (430- 3400)
Ontario	5000 (fairly good)	5200 (5100 - 5800)
Quebec (total) Quebec (south) Quebec (north)	n/a 20,000 (poor) 30,000 (very poor)	37,000 (35,000 - 43,000) n/a n/a
New Brunswick	n/a	n/a
Prince Edward Island	n/a	n/a
Nova Scotia	n/a	n/a
Newfoundland and Labrador	n/a	2900 (0 - 9,000)
Yukon	8000 (poor)	14,000 (2700 - 37,000)
Northwest Territories	52,000 (poor / very poor)	33,000 (23,000 - 53,000)
Nunavut	188,000 (poor / very poor)	120,000 (120,000 - 120,000)
Canada total	**343,000**	**280,000[1] (230,000 - 340,000)**

[1] – National level estimate, which differs from the sum of provincial / territorial estimates (278,500; 194,160 - 441,000)

In British Columbia, the provincial BBA recorded breeding evidence in just 50 10 x 10 km squares, despite most areas with potentially suitable nesting habitat receiving coverage (Cannings 2015). Taking into account the extent of coverage, the atlas-based population estimate is 410 mature individuals (range 110-710; Table 1). This reflects the limited availability of suitable breeding habitat in British Columbia, and is considerably lower than estimates from PIFSC (2013) and PIFSC (2019; Table 2).

The second Alberta BBA reported breeding evidence in 45 squares (Federation of Alberta Naturalists 2007); considering the extent of coverage, there are an estimated 640 mature individuals in the province (range 150-1130; Table 1). In Manitoba, breeding evidence was found in 86 squares (Artuso 2018), translating to approximately 670 mature individuals (range 190-1150; Table 1). Atlas data are not yet available for Saskatchewan, but overall density is likely comparable to that in Alberta, resulting in an estimate of about 680 mature individuals (range 160-1200; Table 1). All abundance estimates for the prairie provinces are appreciably lower than those from PIFSC (2013) and PIFSC (2019; Table 2).

In Ontario, the second BBA documented breeding evidence in 70 squares in southern Ontario, where coverage was nearly complete, and 79 squares in northern Ontario, where coverage was more limited (Gahbauer 2007). Taking into account extent of atlas coverage, the provincial estimate based on BBA results is approximately 4200 mature individuals (range 525-7880; Table 1). PIFSC (2013) estimated 5000 mature individuals, and PIFSC (2019) revised this only slightly to 5200 (95% CL 5100, 5800), taking Ontario BBA results into consideration (Table 2).

In Quebec, the second BBA documented breeding evidence in 41 squares in southern Quebec, where coverage was extensive, and in 59 squares in northern Quebec, mostly on the Ungava Peninsula (QBBA 2019). Accounting for the extent of atlas coverage, approximately 340 mature individuals (range 90-590) are estimated to occur in southern Quebec (Table 1), although Shaffer (2019) estimated that fewer than 100 pairs of Short-eared Owl breed annually in southern Quebec, based on atlas results. Using the former estimate, and assuming that only 10-15% of occupied squares in the north were detected by the BBA, yields a provincial estimate of approximately 3685 mature individuals (range 880-6490; Table 2). Estimates provided by PIFSC (2013) and PIFSC (2019) were again appreciably higher (Table 2).

The second Maritimes BBA documented breeding evidence in 17 squares in New Brunswick, 11 in Nova Scotia, and 4 in Prince Edward Island (Stewart *et al.* 2015). Given relatively good field coverage, estimates for the number of mature individuals based on the BBA results are 125 in New Brunswick (range 40-210), 30 in Prince Edward Island (range 10-50), and 80 in Nova Scotia (range 20-140; Table 1). Short-eared Owl density in the Maritimes was too low for PIFSC (2013) or PIFSC (2019) to generate population estimates.

For Newfoundland and Labrador, Schmelzer (2005) noted that abundance fluctuates from year to year, and data were insufficient to estimate populations or trends. As there has been no BBA in Newfoundland and Labrador, a population estimate was derived by assuming that the density of Short-eared Owls is comparable to that in adjacent northern Quebec. This results in an estimate of 555 mature individuals (range 130-980; Table 1). Only PIFSC (2019) provided an estimate for Newfoundland and Labrador, about five times the atlas-derived estimate (Table 2).

There are no BBA data or other population estimates for any of the territories. However, estimates can be derived by assuming the density in forested areas is comparable to the density in “uncommon” habitat in Alberta, and the density in tundra is similar to that in the core habitat in the Hudson Bay Lowland of northern Ontario. This generates estimates of 2010 (200-3820) for Yukon, 6390 (620-12,160) for Northwest Territories, and 11,720 (1120-22,320) for Nunavut (Table 1). These estimates are substantially lower than those provided by PIFSC (2013) and PIFSC (2019; Table 2).

In summary, although the most recent results from PIFSC (2019) estimate a Canadian population of about 280,000 mature individuals, there is considerable uncertainty in the precision of the source data. In contrast, BBA-derived estimates for provinces that have completed atlases over the past 18 years average an order of magnitude smaller. The one

exception is Ontario, where PIFSC (2019) incorporated results of the provincial BBA and generated an estimate quite similar to that extrapolated from BBA results, suggesting that the BBA-based approach may have merit for other provinces as well. This is supported by the US results from WAfLS, where targeted Short-eared Owl surveys in 2018 yielded a total estimate of about 21,000 mature individuals across eight states (Miller pers. comm. 2019), for which the corresponding PIFSC (2019) estimate is about eight-fold greater at 172,400. The atlas-derived estimates for Canada used here suggest a total abundance across all provinces of about 11,075, with another 20,120 in the territories, for a national estimate of 31,195 mature individuals (overall range of estimates: 4,150-58,240 mature individuals).

Fluctuations and Trends

Christmas Bird Count

Standard analysis of CBC data from Canada shows an estimated annual rate of change of -3.12% (95% CI -4.47%, -1.89%) from 1970 to 2019, resulting in a cumulative decline of -78.9% (95% CI -89.3%, -60.7%) over 49 years (Meehan *et al.* 2020; Table 3). The long-term trend was less pronounced at a continental scale, at -2.01% annually (95% CI -2.72%, -1.14%) with a cumulative trend of -63.0% (95% CI -74.1%, -43.0%). There are sufficient CBC records for long-term provincial-level estimates in eight provinces, with substantial declines of -2.48% to -4.41% per year in six of them, translating to cumulative long-term losses of -70.8 to -89.0%. In the United States, there are negative long-term trends in 36 of the 41 states with sufficient data for trend estimation, and in 20 cases they are statistically significant. Five states have long-term positive trends (Oklahoma, Arkansas, Missouri, Indiana, and Ohio), but only in Indiana and Arkansas are the trends statistically significant (Figure 10).

Table 3. Short-term (three-generation, 2007-2019) and long-term (1970-2019) population trends for Short-eared Owl based on regression analysis of Christmas Bird Count data; bolded trends are statistically significant (Meehan *et al.* 2020). Data are insufficient to generate estimates for other provinces and territories.

Region	Annual % Rate of Change (95% Lower/Upper CI)	Cumulative % Change (95% Lower/Upper CI)
SHORT-TERM (3-GENERATION)		
British Columbia	-1.94 (-9.40, 3.86)	-21.0 (-69.4, 57.6)
Alberta	-4.20 (-13.11, 5.04)	-40.2 (-81.5, 80.4)
Saskatchewan	-1.90 (-17.60, 14.94)	-20.5 (-90.2, 431.4)
Manitoba	-11.17 (-33.46, 2.83)	-75.9 (-99.2, 39.7)
Ontario	-4.66 (-10.46, 1.29)	-43.6 (-73.5, 16.7)
Quebec	-5.17 (-16.66, 2.29)	-47.1 (-88.8, 31.3)
New Brunswick	-2.35 (-25.26, 11.06)	-24.9 (-97.0, 252.2)
Nova Scotia	-2.87 (-8.29, 3.88)	-29.5 (-64.6, 58.0)
Canada	-2.56 (-8.07, 2.57)	-26.7 (-63.6, 35.5)
North America	-0.56 (-2.27, 2.40)	-6.5 (-24.1, 32.9)

Region	Annual % Rate of Change (95% Lower/Upper CI)	Cumulative % Change (95% Lower/Upper CI)
LONG-TERM		
British Columbia	-1.91 (-3.89, 0.19)	-61.1 (-85.7, 9.9)
Alberta	**-4.41 (-6.53, -2.26)**	**-89.0 (-96.3, -67.3)**
Saskatchewan	**-2.48 (-4.62, -0.31)**	**-70.8 (-90.1, -14.1)**
Manitoba	**-4.18 (-8.20, -0.25)**	**-87.7 (-98.5, -11.7)**
Ontario	**-2.56 (-3.44, -1.65)**	**-71.9 (-82.0, -55.7)**
Quebec	**-3.67 (-6.28, -1.00)**	**-84.0 (-95.8, -39.0)**
New Brunswick	1.19 (-2.90, 5.68)	78.5 (-76.3, 1396)
Nova Scotia	**-3.29 (-5.81, -0.78)**	**-80.6 (-94.7, -31.9)**
Canada	**-3.12 (-4.47, -1.89)**	**-78.9 (-89.3, -60.7)**
North America	**-2.01 (-2.72, -1.14)**	**-63.0 (-74.1, -43.0)**

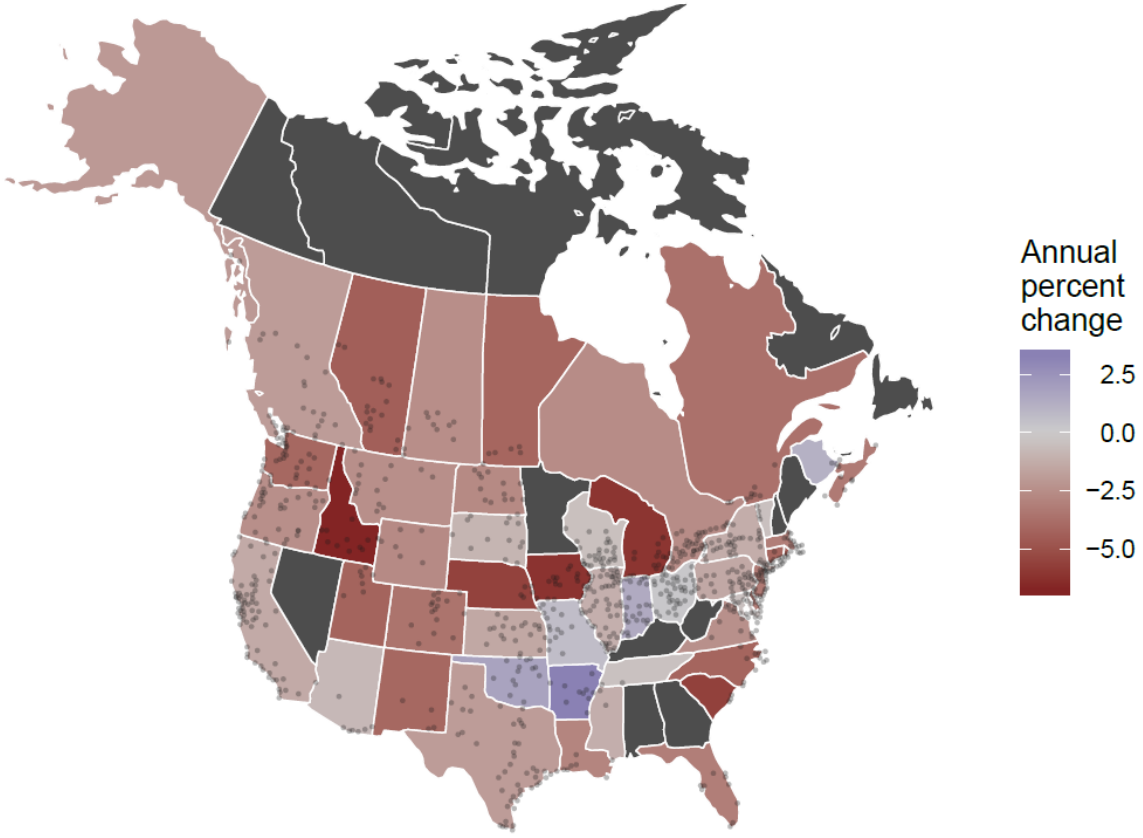

Figure 10. Geographic variation in annual rate of long-term change in the index of Short-eared Owl abundance, based on Christmas Bird Count data from 1970 to 2019 (Meehan *et al.* 2020). Grey dots indicate Christmas Bird Counts which had Short-eared Owl observations during this period. Jurisdictions shaded in dark grey have insufficient Short-eared Owl records to assess trend.

Over the most recent three-generation period (2007-2019), the annual rate of decline in Canada estimated by the CBC has been slightly less than over the long term (-2.56%), although estimates are highly uncertain (95% CI -8.07%, 2.57%), and equivalent to a three-generation trend of -26.7% (95% CI -63.6%, 35.5%; Meehan *et al.* 2020; Table 3). The overall three-generation trend for North America is -0.56% per year (95% CI -2.27, 2.40) and -6.5% cumulatively (95% CI -24.1%, 32.9%) over three generations (Meehan *et al.* 2020; Table 3). Three-generation trends are negative in 26 states versus positive in 15 states. Given limited knowledge about where Canadian individuals overwinter, it is unknown whether they may be more concentrated in states with increasing or decreasing trends.

Closer examination of raw data from CBCs over the past three generations shows that 8583 individuals were reported from 1371 count circles, although a majority (58%) were observed at just 58 "core" sites that had records of the species in 10 or more years between 2007 and 2019. Overall counts declined by an average of -3.35% (-33.6% total) across this period (Figure 11); the decrease was slightly less at the core sites, at -2.58% per year (-28.8% cumulatively). At the 212 Canadian count circles with Short-eared Owl records between 2007 and 2019, the decline is steeper, at -5.20% per year (-47.3% cumulatively).

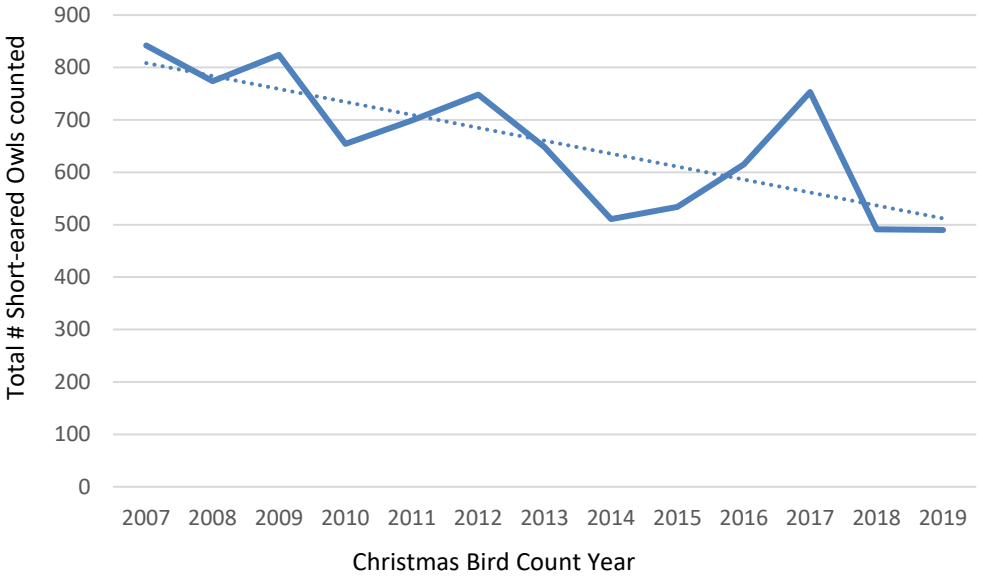

Figure 11. The total uncorrected number of Short-eared Owls counted annually at those Christmas Bird Counts circles in North America with at least one Short-eared Owl observation during the past three generations (2007-2019; n=1371). The dotted line represents the average annual trend over this period.

Breeding Bird Survey

BBS data for Canada analyzed using a hierarchical generalized additive model show a long-term (1970-2019) annual rate of decline of -2.44% (95% CI -3.82%, -1.25%), equivalent to a cumulative decline of -70.1% (95% CI -85.2%, -46.1%) over 49 years (A. Smith unpubl. data; Table 4). Four provinces and one territory have sufficient data for individual estimates over this time period, all with cumulative decline estimates of -63.5% to -74.1% (Table 4). The long-term trend estimate for the United States over the same time period is slightly more moderate, at -2.02% per year (95% CI -3.23%, -0.91%) and -63.2% cumulatively (95% CI -80.0%, -36.2%). The long-term trend is negative in all states with sufficient data for trend estimation, with 95% credible intervals entirely below zero in all except Oregon, Montana, South Dakota, and Utah.

Table 4. Short-term (three-generation, 2007-2019) and long-term (1970-2019) population trends for Short-eared Owl in Canada, states bordering Canada, and the United States overall, based on generalized additive modelling of Breeding Bird Survey data; bolded trends have 95% credible intervals that do not cross zero and are highly likely to represent a substantial rate of change (A. Smith unpubl. data). Reliability is a qualitative assessment that takes into consideration factors such as precision and extent of coverage. Data are insufficient to generate estimates for other provinces, territories, and border states.

Region	Annual % Rate of Change (95% Lower/Upper CI)	Cumulative % Change (95% Lower/Upper CI)	Probability of decline >30%	# routes	Reliability
SHORT-TERM					
Yukon	-3.05 (-8.09, 2.48)	-31.0 (-63.7, 34.2)	0.519	5	Low
Alberta	-3.34 (-7.69, 0.93)	-33.5 (-61.7, 11.8)	0.571	60	Low
Saskatchewan	-3.23 (-8.32, 2.25)	-32.6 (-64.7, 30.6)	0.549	22	Low
Manitoba	-3.65 (-8.40, 0.67)	-36.0, (-65.1, 8.3)	0.639	20	Low
Newfoundland & Labrador	-2.80 (-8.40, 2.90)	-17.2 (-53.1, 50.1)	0.481	5	Low
Canada	-3.05 (-6.37, 0.52)	-31.1 (-54.6, 6.4)	0.529	112	High
Alaska	-3.07 (-7.04, 1.08)	-31.2 (-58.3, 13.7)	0.534	25	Low
Washington	-3.99 (-8.92, 0.73)	-38.6 (-67.4, 9.1)	0.665	22	Low
Idaho	-3.15 (-7.42, 1.14)	-31.9 (-60.4, 14.5)	0.543	25	Low
Montana	-1.50 (-5.11, 3.45)	-16.6 (-47.7, 50.3)	0.229	52	Low
North Dakota	-3.29 (-7.82, 1.11)	-33.0, -62.4, 14.1)	0.565	32	Low
Minnesota	-3.46 (-8.45, 1.11)	-34.4 (-65.3, 14.2)	0.596	13	Low

Region	Annual % Rate of Change (95% Lower/Upper CI)	Cumulative % Change (95% Lower/Upper CI)	Probability of decline >30%	# routes	Reliability
United States	-2.62 (-5.60, 0.61)	-27.3 (-49.9, 7.6)	0.417	309	Medium
LONG-TERM					
Yukon	-2.05 (-4.24, 0.31)	-63.7 (-88.0, 16.4)	0.886	5	Low
Alberta	**-2.56 (-4.38, -0.98)**	**-72.0 (-88.9, -38.4)**	0.988	67	High
Saskatchewan	**-2.72 (-4.93, -0.84)**	**-74.1 (-91.6, -34.0)**	0.981	34	Medium
Manitoba	**-2.61 (-4.61, -1.00)**	**-72.6 (-90.1, -38.8)**	0.990	21	Medium
Newfoundland & Labrador	-2.04 (-4.38, 0.25)	-63.5 (-88.9, 12.9)	0.879	5	Low
Canada	**-2.44 (-3.82, -1.25)**	**-70.1 (-85.2, -46.1)**	0.997	132	High
Alaska	**-2.18 (-3.90, -0.65)**	**-66.1 (-85.7, -27.2)**	0.988	27	Low
Washington	**-2.37 (-4.33, -0.54)**	**-69.1 (-88.6, -23.1)**	0.960	25	Medium
Idaho	**-2.24 (-3.94, -0.69)**	**-67.1 (-86.1, -28.9)**	0.973	26	High
Montana	-1.50 (-2.89, 0.23)	-52.2 (-76.4, 12.0)	0.829	53	High
North Dakota	**-2.15 (-3.82, -0.45)**	**-65.5 (-85.2, -20.0)**	0.956	35	High
Minnesota	**-2.23 (-4.15, -0.54)**	**-66.9 (-87.4, -23.3)**	0.956	13	Medium
United States	**-2.02 (-3.23, -0.91)**	**-63.2 (-80.0, -36.2)**	0.916	335	High

Over the most recent three-generation period (2007-2019), the annual rate of decline in Canada measured by the BBS has accelerated slightly to -3.05% (95% CI -6.37%, 0.52%), equivalent to a cumulative decline of -31.1% (95% CI -54.6%, 6.4%; A. Smith unpubl. data; Table 4). As indicated by the broad confidence intervals, there is considerable uncertainty in this estimate. Among the four provinces and one territory with enough data to estimate trends, declines varied only slightly, from -2.80% per year in Newfoundland and Labrador to -3.65% per year in Manitoba. In the United States, the annual rate of decline also worsened, to -2.62% (95% CI -5.60%, 0.61%), equivalent to a decline of -27.3% (95% CI -49.9%, 7.6%) over the past three generations (Table 4). Three-generation trends are non-significantly negative for all 13 states with sufficient data for trend estimation (A. Smith unpubl. data; Figure 12).

Figure 12. Annual rates of population change estimated over three generations (2007-2019) from Breeding Bird Survey data for Bird Conservation Regions, within provinces and states with sufficient data to estimate trends (A. Smith unpubl. data).

Breeding Bird Atlases and other provincial sources

Campbell *et al.* (1990) suggested that loss and degradation of habitat in British Columbia had caused a dramatic decline in the number of wintering and breeding Short-eared Owls, and threatened the persistence of a formerly dense breeding concentration in the Fraser River lowlands. The provincial breeding distribution documented by the BBA is superficially similar to that given by Campbell *et al.* (1990), but Short-eared Owl is now only considered a “possible” breeder in the Fraser River lowlands (Cannings 2015).

In Alberta, Clayton (2000) suggested a statistically significant decline over the previous three decades. The number of 10 x 10 km squares with breeding evidence declined from 107 in the first Alberta BBA to 45 in the second, despite greater field effort, with decreases primarily in the boreal forest and parkland natural regions (Federation of Alberta Naturalists 2007; Figure 3).

In Saskatchewan, Houston (1997) reported that over a 50-year banding program, 63.5% of Short-eared Owls were banded in just two years, 1960 and 1969, corresponding to major outbreaks of *Microtus* voles. Smith (1996) noted that Short-eared Owl had declined in Saskatchewan, and was then a rare breeder except in the Last Mountain - Quill

Lake area. Further declines are believed to have occurred since then, attributed to habitat loss, predation, and collisions with vehicles and anthropogenic structures (Smith *et al.* 2019).

In Manitoba, Short-eared Owl was reported as abundant in some areas in the late 19th century, including the Portage la Prairie region (Thompson 1891). By the 1980s, it was encountered only rarely on BBS routes, and MARC (2003) considered it to be only an occasional breeder in the province. In contrast, the recently completed BBA documented breeding evidence in many parts of Manitoba (Artuso *et al*. 2018), although there is no previous comparable effort with which to assess change over time.

In Ontario, Short-eared Owl was presumably limited historically to natural prairies in the south, large wetlands and burns throughout the province, and the Hudson Bay Lowland (Austen *et al.* 1994). Clearing of forests for agriculture in the 19th century increased the availability of open habitat, and Nash (1913) suggested that Short-eared Owl was likely the most abundant owl in southern Ontario early in the 20th century. The first Ontario BBA showed only scattered pockets of occurrence in southern Ontario, where it was considered rare to locally uncommon by the 1990s (Cadman *et al.* 1987; Austen *et al.* 1994). In 2004, targeted searches of core areas of southern Ontario occupied during the first BBA suggested further reductions (Hunt 2004). Overall, the second Ontario BBA showed a roughly similar distribution to that from the first BBA, with an increase in the number of 10 x 10 km squares with breeding evidence when differences in effort were accounted for (Gahbauer 2007). The probability of observation increased significantly only in the Hudson Bay Lowland, where survey effort was much higher in the second BBA and coincided with a peak in small mammal abundance in 2003; the probability of observation declined slightly from the first BBA in all regions of southern Ontario (Gahbauer 2007). There has been no assessment of the provincial population since the BBA ended in 2005.

In Quebec, Short-eared Owl was considered common in the first half of the 20th century in areas including Montréal and Saguenay-Lac-St-Jean (Macoun and Macoun 1909; Godfrey and Wilk 1948), but declines were noticed by the 1970s (Ouellet 1974). Short-eared Owl was observed in 120 10 x 10 km squares in southern Quebec during the first BBA (Bélanger and Bombardier 2006), but only in 52 squares there during the second. Considering the increased effort in the second atlas, this represented a 74% decline in the percentage of surveyed squares with Short-eared Owl observations, the third-largest decrease among all species (Robert *et al*. 2019). Declines apparently occurred in all regions, but were most pronounced along the St. Lawrence River, Lac-St-Jean, Abitibi lowlands, and on the Magdalen Islands. No comparisons are available for the northern part of the province, which was not surveyed during the first BBA.

In the Maritimes, Erskine (1992) used the results of the first BBA to estimate an average population of 200 mature individuals for the region, reflecting 60 pairs in New Brunswick, 10 pairs in Prince Edward Island, and 30 pairs in Nova Scotia. Population estimates were not provided in the second Maritimes BBA, but the number of 10 x 10 km squares with breeding evidence increased 14% from 28 to 32, similar to the 13% increase in observer effort between the two BBAs (Erskine 1992; Stewart *et al.* 2015). This suggests

the population remained relatively stable in the Maritimes between the two BBA periods. Erskine (1992) noted that there is no firm evidence that Short-eared Owl was more or less common prior to the first BBA, but that regional numbers fluctuated in relation to vole abundance, and the historical dyking of salt marshes may have been beneficial in creating areas suitable for breeding in coastal wetlands.

In Newfoundland and Labrador, Schmelzer (2005) concluded there was likely little change in the distribution and abundance of Short-eared Owl in the province over the previous century, and that the species has been consistently uncommon to rare in coastal grasslands and marshes. Garland (pers. comm. 2019) reports that although provincial monitoring efforts have been limited, numbers recorded have declined recently, with a mean annual count of 10.0 from 2014-2018, compared to 16.2 observations annually from 2009-2013.

There are insufficient data on population status in Yukon, Northwest Territories, and Nunavut to estimate any territory-specific trends, although changes in this region are presumably reflected in the continental Christmas Bird Count results.

Western *Asio flammeus* Landscape Study

Although WAfLS surveys only began in 2015, the study design allows for estimation and comparison of annual occupancy rates. Results to date show declining occupancy rates in Utah and Wyoming, somewhat offset by increases in Idaho and Nevada (Miller *et al.* 2018). This appears to reflect the nomadic nature of the species, with distribution shifting from year to year in relation to availability of prey resources. Expansion of WAfLS into Canada, or development of a complementary species-specific monitoring program, would allow for greater confidence in describing future Canadian Short-eared Owl population trends.

Summary

As no single data source adequately estimates Short-eared Owl population trends on its own, a weight of evidence approach is taken here, considering the results of all available monitoring programs. Over nearly five decades (1970-2019), the BBS and CBC data respectively indicate statistically significant declines of -70% and -79% in Canada. During the most recent three-generation period (2007-2019), standard BBS and CBC trend estimates for Canada show ongoing declines of -31% and -27%, respectively. However, the majority of Canadian Short-eared Owls likely overwinter in the United States. At the continental scale, CBC trend estimates over this period are -6.5% and -33.6%, based on modelling and raw counts respectively, although not enough is known about the migratory connectivity of Canadian Short-eared Owls to understand whether they occur largely in states with increasing or decreasing wintering population trends.

Overall, there is broad agreement among data sources that the Canadian Short-eared Owl population has decreased substantially over the long term and continues to decline. Trend estimates over the past three generations are somewhat more variable, reflecting the nomadic movements of the species and the limited power of existing monitoring programs. Overall, a decline of -30% or greater over the past three-generations is inferred for the Canadian population from the weight of evidence, given the trend estimates derived from the BBS and CBC, reduced area of occupancy reported in recent breeding bird atlases, worsening conservation status in many jurisdictions (see **Non-legal Status and Ranks**), and the variety of threats potentially affecting the species (see **Threats**).

Rescue Effect

Short-eared Owl breeds in all US states bordering Canada. Satellite telemetry research has shown that some Short-eared Owls breeding in Alaska in one year spent the following summer in Alberta or Saskatchewan (Johnson *et al*. 2017). Given the nomadic nature of the species, it is probable that individuals move between Canada and the United States elsewhere as well. Alaska and Montana are two of only four states where Short-eared Owl is considered apparently secure (NatureServe 2020), and are therefore plausible sources for immigrants to western Canada, although BBS data indicate declining populations even in these states. In central and eastern Canada, the status of Short-eared Owl is considered either Critically Imperilled or Imperilled in all adjacent states except Minnesota (Vulnerable; NatureServe 2020), suggesting that immigration from these states is possible, but very unlikely. It is unclear whether any areas can be considered to be consistent population sources or sinks for this species.

THREATS AND LIMITING FACTORS

Threats

Short-eared Owl is vulnerable to the cumulative effects of various threats at breeding and wintering areas, and likely also along migration routes. These factors 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 (greatest to least), ending with those for which scope or severity is unknown. The overall threat impact is considered to be High to Medium, corresponding to an anticipated further decline of between 3 and 70% over the next ten years (Master *et al.* 2012; see **Appendix 1** for further details, including threats considered to have negligible impact).

IUCN 7. Natural system modifications (medium-low threat impact)

IUCN 7.3. Other ecosystem modifications (medium-low threat impact)

Extensive conversion of grassland to Cheat Grass (*Bromus tectorum*) is considered a leading cause of habitat loss in the Intermountain West region of the western United States. Cheat Grass supports lower prey density and appears to reduce habitat suitability for Short-eared Owl. The expansion of Crested Wheat Grass (*Agropyron cristatum*) in the Canadian prairies poses similar concerns. However, some invasive plants, such as Common Reed (*Phragmites australis*) and Purple Loosestrife (*Lythrum salicaria*), are used by Short-eared Owls for shelter at winter roosts (Gahbauer *et al.* 2021).

IUCN 11. Climate change and severe weather (medium-low threat impact)

IUCN 11.1. Habitat shifting and alteration (medium-low threat impact)

Projected increases in shrub biomass, cover, and abundance (shrubification) due to climate warming-driven increases in growing season length are anticipated to reduce the area of open ground by infilling of shrub cover, increased shrub growth, and northward colonization (Myers-Smith *et al.* 2011; Miller and Smith 2012). Shrubification is anticipated to reduce habitat suitability for Short-eared Owl, especially in low Arctic tundra, by impairing its foraging efficiency, reducing availability of nesting sites, and providing cover for ground predators and hunting perches for aerial predators.

IUCN 11.2. Droughts (unknown threat impact)

Extreme drought could limit growth of grass cover preferred by Short-eared Owl as shelter, especially for nesting. Conversely, dried-up lake beds in Alberta have been colonized by grasses, supporting large vole populations and attracting high numbers of Short-eared Owls (Priestley et al. 2008).

IUCN 11.4. Storms and flooding (low threat impact)

As a ground-nesting species, Short-eared Owl may be vulnerable to storm-induced flooding in low-lying areas during the breeding season (Rivard et al. 2011), causing nest loss and potential short-term reductions in prey availability.

IUCN 1. Residential and commercial development (low threat impact)

IUCN 1.1. Housing and urban areas (low threat impact)

Urban expansion continues to remove Short-eared Owl nesting and wintering habitat, especially in extreme southern British Columbia and Ontario (M. Gahbauer pers. obs.). Although much of the suitable habitat in these regions has already been lost, some loss of habitat to urbanization is ongoing.

IUCN 2. Agriculture and aquaculture (low threat impact)

IUCN 2.1. Annual and perennial non-timber crops (low threat impact)

Rosenberg *et al.* (2016) noted that most species classified as "common birds in steep decline", including Short-eared Owl, depend in part on agricultural landscapes, and may be affected by intensification of agriculture, which results in loss of pasturelands and fewer fields being left fallow and available for nesting. Conversion of farmland has been correlated with Short-eared Owl population declines in the Fraser River delta of British Columbia (Campbell *et al.* 1990), the prairies (Smith 1996) and southern Ontario (Hunt 2004). Further conversion of agricultural land may threaten relatively few Short-eared Owls, given the small numbers remaining in these regions. However, individuals and nests are at risk in hayfields and agricultural lands that are actively managed during early summer, where mowing and harvesting contribute to egg and nestling mortality (Arroyo and Bretagnolle 1999).

IUCN 4. Transportation and service corridors (low threat impact)

IUCN 4.1. Roads and railroads (low threat impact)

Short-eared Owl is known to perch along roads and fly relatively close to the ground, with the potential for collisions with vehicles (Fajardo *et al.* 1994). Despite being relatively uncommon, 13 Short-eared Owls were found during a study of vehicle-induced owl mortality in southwestern British Columbia (Preston and Powers 2006). In the northwestern United States, WAfLS documented 120 road mortalities over four years, mostly on lightly travelled roads (Miller *et al.* 2018). Of 161 Short-eared Owls admitted for treatment by the Owl Foundation in southern Ontario from 1970-2018, 24 (15%) were hit by cars, and another 105 (65%) had fractures suggesting a traumatic collision, likely with a vehicle (Gionet-Rollick, pers. comm. 2019). Of 18 Short-eared Owls received by the Union québécoise de réhabilitation des oiseaux de proie from 1986-2013 for which cause of injury could be determined, 16 (89%) were from collisions (Fitzgerald 2015). Fragmentation of breeding habitat by roads and other anthropogenic developments may also favour predators and increase predation risk (Johnson and Temple 1986).

IUCN 4.4. Flight paths (low threat impact)

Short-eared Owls are attracted to open habitat at airports. In most cases, there are no interactions, but some owls die from collisions with aircraft or due to wildlife control aimed at preventing such collisions, including through trapping and attacks from trained falconry birds. Together, these factors comprised 10 of 161 injured Short-eared Owls, mostly from southern Ontario, documented by the Owl Foundation since 1970 (Gionet-Rollick pers. comm. 2019). Linnell *et al.* (2018) reported 467 Short-eared Owl aircraft strikes in the United States between 1990 and 2014, with the frequency of interactions increasing significantly over time.

IUCN 5. Biological Resource Use (low threat impact)

IUCN 5.1. Hunting and collecting terrestrial animals (low threat impact)

Some Short-eared Owls breed or winter in areas of southern Canada or the United States where rodenticides may affect the availability and condition of prey, with potential for mortality of adult Short-eared Owls through bioaccumulation of these toxins. Anticoagulant rodenticides may affect predators that feed on poisoned prey, although the degree of accumulation and toxicity in species such as Short-eared Owl requires further study (Elliott *et al*. 2013). Elevated levels of DDE and heptachlor epoxide were historically found in Short-eared Owl eggs, but without evidence of effects on reproduction (Peakall and Kemp 1980; Henny *et al*. 1984). The Lower Mainland of British Columbia is a key wintering area for Short-eared Owl in Canada, where a recent study found that 29% of Barn Owls examined had symptoms of toxicosis, corresponding to elevated levels of anticoagulant rodenticide residues in the liver (Huang *et al*. 2016). Snowy Owls in the Lower Mainland showed lower levels of contamination (Hindmarch pers. comm. 2018), consistent with the expectation that raptors which are only seasonally exposed to poisoned prey are less affected (Christensen *et al.* 2012). Rodenticide poisoning of raptors has been identified as a large concern in the western United States, causing direct mortality and sub-lethal effects that may cause impairment or vulnerability to other causes of death (Miller pers. comm. 2019).

IUCN 6. Human intrusions and disturbance (low threat impact)

IUCN 6.1. Recreational activities (low threat impact)

Short-eared Owls may be disturbed at communal roosting areas in parks or other public areas by off-leash dogs, photographers, and other human passersby, particularly where large numbers of roosting owls attract many birders and photographers, although it is unknown whether repeated flushing of these owls may affect their survival.

IUCN 8. Invasive and other problematic species and genes (low threat impact)

IUCN 8.2. Problematic native species (low threat impact)

As a ground-nesting bird, Short-eared Owl is vulnerable to predation by various native mammals (e.g., Common Raccoon, *Procyon lotor*; Coyote, *Canis latrans*; Red Fox, *Vulpes vulpes*; Arctic Fox, *V. lagopus*) as well as birds (e.g., Great Horned Owl, *Bubo virginianus*; American Crow, *Corvus brachyrhynchos*). Populations of some predators near urban areas may be subsidized by access to shelter and food resources, potentially increasing the risk of predation, although few Short-eared Owls nest in these areas. The abandonment of old barns and installation of power lines and other facilities in the prairies has provided new nesting opportunities for raptors and Common Ravens (*Corvus corax*), in areas where they were formerly scarce (Schmutz *et al.* 1984; Gahbauer pers. obs.). The effects of avian predation on Short-eared Owl have not been studied, but Todd *et al.* (2003) found that 60% of known mortalities of Burrowing Owls (*Athene cunicularia*) in Saskatchewan were due to

predation, mostly by larger birds, and similar pressure may apply to Short-eared Owl to some extent. There may be increasing predation pressure from recovering Peregrine Falcon populations, and from Red Fox as it expands its range into the Canadian Arctic. There is little evidence of increasing predation pressure on Short-eared Owl in eastern North America.

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

IUCN 3.1. Oil and gas drilling (unknown threat impact)

There are no published studies on effects of oil and gas development on Short-eared Owls, but direct displacement or avoidance due to disturbance from exploration or production may occur. Oil and gas drilling continues to expand in northeastern British Columbia, and in several western US states within the wintering range of Canadian Short-eared Owls.

IUCN 9. Pollution (unknown threat impact)

IUCN 9.5 Airborne pollutants (unknown threat impact)

Most Short-eared Owls that nest in Canada are likely exposed to airborne pollutants at some point in their life-cycle; effects are unknown but considered unlikely to be severe.

Limiting Factors

Prey abundance is the primary limiting factor for Short-eared Owl. However, this is generally not a significant concern, given the tendency of individuals to move nomadically in search of suitable conditions and prey availability, and their ability to increase clutch size and productivity in years of high prey abundance (Wiggins *et al.* 2006).

Number of Locations

Short-eared Owl is highly mobile, and widely distributed across Canada. As a consequence, it is difficult to estimate the number of locations at which it occurs, based on the COSEWIC definition of geographically or ecologically distinct areas in which a single threatening event can rapidly affect all individuals present, as most threats identified above have local effects on habitat quality or quantity (Appendix 1). However, the number of locations certainly far exceeds the COSEWIC threshold of ten.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Short-eared Owl is listed as Special Concern under Schedule 1 of Canada's *Species at Risk Act* (Government of Canada 2019). The species is not protected in Canada under the *Migratory Birds Convention Act, 1994*, but receives protection under a Wildlife Act (or equivalent) in every province and territory (Government of Canada 2017). Short-eared Owl is also listed as Threatened under the Manitoba *Endangered Species and Ecosystems Act* (Manitoba Sustainable Development 2018), as Special Concern under the Ontario *Endangered Species Act, 2007* (Ontario Ministry of the Environment, Conservation and Parks 2018), as Special Concern under the New Brunswick *Species at Risk Act* (New Brunswick Natural Resources 2018), and as Vulnerable (equivalent to Special Concern) under the Newfoundland and Labrador *Endangered Species Act* (Newfoundland and Labrador Fisheries and Land Resources 2018). As Short-eared Owl is identified as a species at risk under BC's *Forest and Range Practices Act* (Government of British Columbia 2004) and *Oil and Gas Activities Act* (Government of British Columbia 2011), the species is eligible for additional protections from the impacts of activities regulated by these two statutes.

In the United States, Short-eared Owl is protected under the *Migratory Bird Treaty Act* (USFWS 2016), but is not listed under the *Endangered Species Act*. However, it is considered Endangered in 11 states (Delaware, Illinois, Indiana, Iowa, Kentucky, Maryland, Massachusetts, Michigan, New Jersey, New York, and Pennsylvania), Threatened in two states (Connecticut and Maine), and Special Concern in three states (Minnesota, Ohio, and Utah).

Non-Legal Status and Ranks

Short-eared Owl is classified by IUCN as Least Concern globally (BirdLife International 2016), consistent with a global status of G5 (Secure) by NatureServe (2020), as of 2016. In Canada, the national rank is N4B, N3N, N4M, as of 2020, indicating an Apparently Secure breeding and migratory population and a Vulnerable non-breeding (wintering) population. However, at the provincial/territorial scale, Short-eared Owl is considered Critically Imperilled to Vulnerable (S1B to S3B) in all provinces and territories (Figure 13). Compared to 2008, provincial rankings have worsened in Yukon (S4B to S3B), Saskatchewan (S4B to S2B), Manitoba (S3B to S2S3B), Ontario (S3S4B to S2B), and New Brunswick (S3B to S2B) (COSEWIC 2008; NatureServe 2020).

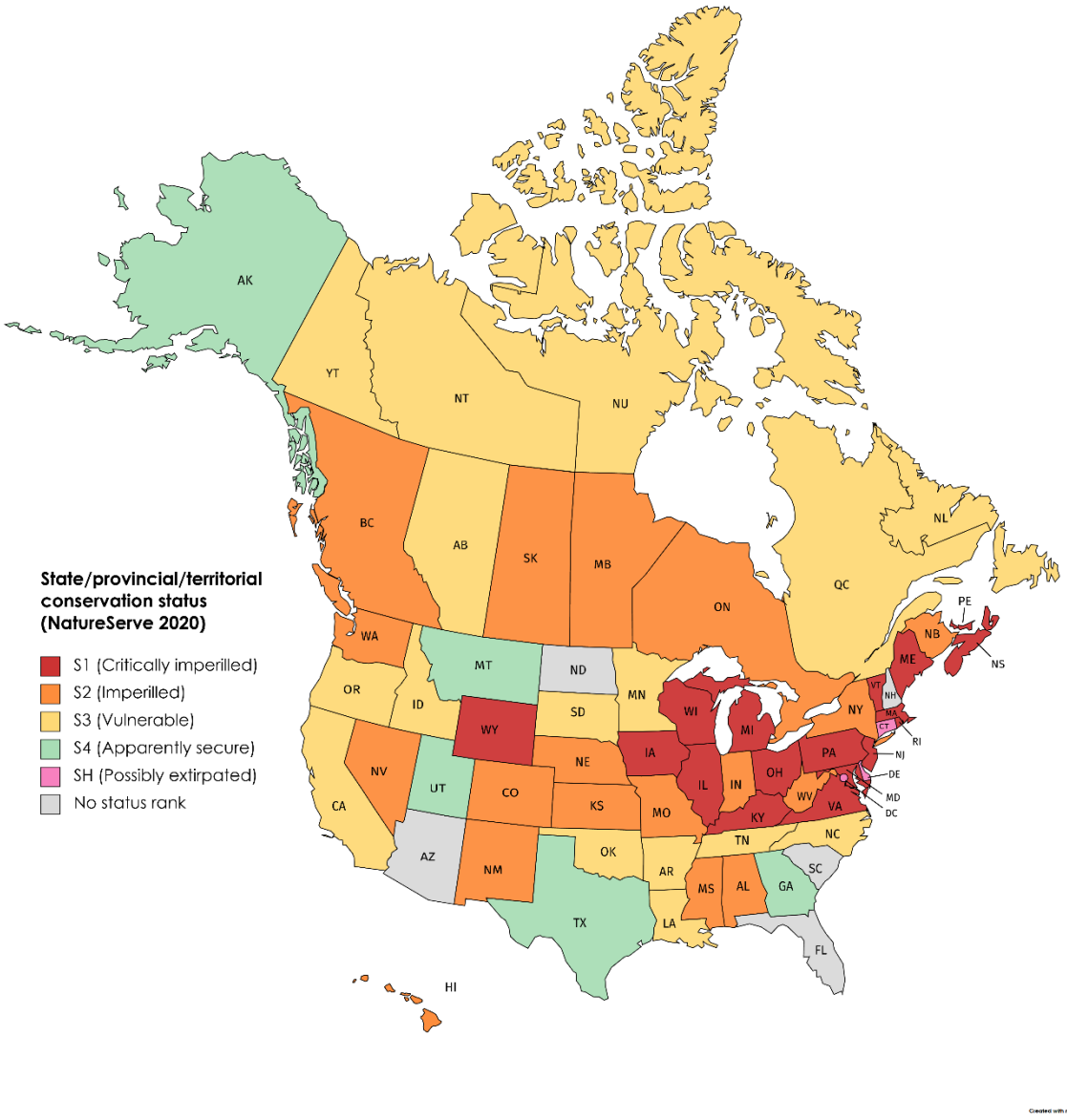

Figure 13. The conservation status of Short-eared Owl in each territory, province, and state within its range in Canada and the United States, as of 2020 (NatureServe 2020).

NatureServe (2020) also considers Short-eared Owl to be Secure (N5) in the United States, although this status was last reviewed in 1997. Despite this national ranking, Short-eared Owl is ranked Extirpated as a breeder (SHB) from two states and the District of Columbia, Critically Imperilled (S1B) in 16 states, Imperilled (S2B) in 12 states, Vulnerable (S3B) in 10 states, and Apparently Secure (S4B) in only three states within the breeding range (Alaska, Montana, and Utah) and two others that only support the species in winter (Georgia and Texas; Figure 13). Since 2016, status has worsened in three states (S4 to S3 in Idaho, S4 to S2 in Nevada, and S2 to S1 in Wyoming), and status has been assigned for the first time in ten states, including three at S2 (Alabama, Mississippi, and New Mexico), and one at S1 (Vermont). Among the 16 states where Short-eared Owl is considered

Critically Imperilled, there are five (Kentucky, New Jersey, Maryland, Rhode Island, and Virginia) without any breeding season records since 2009 (three generations) in eBird (2021), and another seven states (Illinois, Iowa, Maine, Maryland, Massachusetts, Pennsylvania, and Vermont) with five or fewer records during this period.

Although not protected under species at risk legislation in British Columbia, Alberta, and Quebec, Short-eared Owl has been flagged as being of conservation concern in these provinces. In British Columbia it is considered "blue" (comparable to Special Concern; BC CDC 2018). In Alberta, it is classified as "May Be at Risk" (Alberta Environment and Parks 2017). In Quebec, Short-eared Owl is on the list of wildlife species at risk of being designated threatened or vulnerable (*Liste des espèces susceptibles d'être désignées menacées ou vulnérables*; Gouvernement du Québec 2018).

Rosenberg *et al.* (2016) classified Short-eared Owl among its list of 24 "Common Birds in Steep Decline" in North America, defined as those which experienced a population reduction of 50-90% between 1970 and 2014 (65% in the case of Short-eared Owl) and were projected to lose a further 50% or more within the next 20-25 years, based on threats to both breeding and non-breeding habitat.

Habitat Protection and Ownership

Short-eared Owl has been recorded in many Parks Canada Agency protected heritage areas, including national parks, and at Canadian Forces bases in at least three provinces (British Columbia, Alberta, Quebec; McDonald pers. comm. 2019), but is not known to occur regularly or in large numbers at any of them.

Some habitat protection programs aimed at other species may be beneficial for Short-eared Owl. In particular, Operation Grassland Community in Alberta, and Operation Burrowing Owl in Saskatchewan, focus on preservation and enhancement of grassland habitat which would benefit Short-eared Owl. Ontario's *Forest Management Guide for Conserving Biodiversity at the Stand and Site Scales* (OMNR 2010) provides direction to assist in conservation of biodiversity by maintaining particular habitat features, including ground nests occupied by Short-eared Owl. Protection of wetlands and adjacent upland habitat by Ducks Unlimited Canada and Joint Ventures under the North American Waterfowl Management Plan also conserves Short-eared Owl breeding habitat (North American Waterfowl Management Plan 2019).

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BIOGRAPHICAL SUMMARY OF REPORT WRITER(S)

Marcel Gahbauer earned his B.Sc. in ecology at the University of Toronto in 1998, and his Ph.D. in natural resource sciences at McGill University in 2008, focusing on the nesting success and movements of urban Peregrine Falcons in eastern North America. He began studying Short-eared Owls in Ontario in 2002, and has conducted field surveys for the species in six other provinces and two territories. He established the international *Asioflammeus* research discussion group, organized a Short-eared Owl symposium at the 2016 Raptor Research Foundation conference, and coordinated a review of status and recent research on the species in the western hemisphere for the 2017 World Owl

Conference. He worked for many years as a senior biologist with Stantec Consulting, and is now a population biologist with the Canadian Wildlife Service of Environment and Climate Change Canada, and executive director of the Migration Research Foundation. As Co-chair of COSEWIC's Birds Specialist Subcommittee since 2015, he has overseen the production of more than 20 COSEWIC bird status reports.

COLLECTIONS EXAMINED

No collections were examined for the preparation of this report.

Appendix 1. Threat Calculator results for Short-eared Owl.

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	*Asio flammeus* Short-eared Owl			
Element ID			**Elcode**	
Date :	2019-05-21			
Assessor(s):	Marcel Gahbauer (report writer), Richard Elliot (co-chair), Dwayne Lepitzki (facilitator), Marie-France Noel (COSEWIC Secretariat), Louise Blight, Travis Booms, Mike Cadman, Suzanne Carrière, Kaytlin Cooper, Gord Court, Shelley Garland, Andy Horn, Jessica Humber, Frankie Jean-Gagnon, Inge-Jean Hansen, Thomas Jung, Jérôme Lemaître, Robert Miller, Mary Sabine, Jean-Pierre Savard, Krystal Rancourt, Julie Steciw, Ken Tuininga, Greg Wilson, Liana Zanette			
References:	Draft Short-eared Owl status report (April 2019)			
Overall Threat Impact Calculation Help:			**Level 1 Threat Impact Counts**	
	Threat Impact		**high range**	**low range**
	A	Very High	0	0
	B	High	0	0
	C	Medium	2	0
	D	Low	6	8
Calculated Overall Threat Impact:			High	Medium
Assigned Overall Threat Impact:	**BC = High – Medium**			
Impact Adjustment Reasons:	There was discussion on the threats assessment call about whether to reduce the overall threat impact to medium, given the potential for overlap among some categories. However, most participants felt that the assigned impact should remain as high-medium, given the large number of plausible threats and the lack of justification for downgrading the output of the threats calculator.			
Overall Threat Comments	Short-eared Owl was assessed as one designatable unit. Generation time was assumed to be approximately 4 years.			

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development	D	Low	Small (1-10%)	Slight to Serious (1-70%)	High (Continuing)	
1.1	Housing & urban areas	D	Low	Small (1-10%)	Slight to Serious (1-70%)	High (Continuing)	Habitat loss may be significant locally, especially in southern parts of British Columbia and Ontario, but is unlikely to affect >1% of the breeding population over the next decade. However, these regions support a larger proportion of the wintering population, and this issue also affects wintering sites in the United States, so the scope in winter is likely toward the lower end of the range for small. Severity is likely to be slight in most cases, as Short-eared Owls are highly mobile, but effects may vary depending on availability and quality of alternate habitat.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1.2	Commercial & industrial areas		Negligible	Negligible (<1%)	Slight to Serious (1-70%)	High (Continuing)	Commercial and industrial expansion continues to remove habitat, although at a slower rate than urban expansion, and so is likely only negligible in scope.
1.3	Tourism & recreation areas		Negligible	Negligible (<1%)	Slight to Serious (1-70%)	High (Continuing)	Development of recreation areas continues to remove habitat, although at a much slower rate than urban expansion, and so is likely only negligible in scope.
2	Agriculture & aquaculture	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	
2.1	Annual & perennial non-timber crops	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	In western US states, Short-eared Owls occur more frequently in stubble than hay fields, perhaps in response to prey abundance, although implications are unknown. Mowing of hayfields in southern Canada is likely a greater concern than conversion, as eggs and flightless nestlings are at high risk. However, as most birds breed in the north, these risks likely apply to <10% of the population. Severity may only be slight to moderate for habitat loss, depending on the availability of suitable unoccupied habitat, but is considered serious overall based on the risk of nest failure, which can occur year after year.
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching		Not a Threat	Small (1-10%)	Neutral or Potential Benefit	High (Continuing)	Likely only a very small proportion of the Canadian population is exposed to livestock ranching. Grazing at low intensity is likely beneficial overall through maintaining grassland habitat, although high intensity grazing can reduce suitability for both nesting and prey. Trampling poses a risk to nests, but likely occurs rarely. Short-eared Owl is among those bird species occasionally found drowned in livestock watering holes (Miller et al. 2018)
2.4	Marine & freshwater aquaculture						
3	Energy production & mining		Unknown	Small (1-10%)	Unknown	High (Continuing)	
3.1	Oil & gas drilling		Unknown	Small (1-10%)	Unknown	High (Continuing)	Oil and gas drilling continues to expand in northeastern British Columbia, as well as in several western US states within the wintering range of Canadian Short-eared Owls. There are no published studies demonstrating effects of oil and gas drilling on Short-eared Owls, although as areas with expanding development are often in particularly suitable habitat, some degree of displacement is anticipated. Severity is unknown, and likely varies in relation to the availability of suitable unoccupied habitat nearby.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3.2	Mining & quarrying		Negligible	Negligible (<1%)	Serious - Moderate (11-70%)	High (Continuing)	Mining and quarrying are infrequent within suitable breeding or wintering habitat for Short-eared Owl, and likely very localized in effect and negligible in scope. Severity depends on the extent of activities and the availability of alternative habitat nearby, and local displacement and avoidance of disturbance may occur.
3.3	Renewable energy		Negligible	Restricted (11-30%)	Negligible (<1%)	High (Continuing)	The footprint of wind energy (and to a much lesser extent solar energy) developments is small but increasing in southern Canada, overlapping with Short-eared Owl range in the prairies, southern Ontario, potentially in the Maritimes, and much of the US wintering range. There is potential for direct mortality, as well as avoidance of or displacement from otherwise suitable habitat (Zimmerling *et al*. 2013). No effects have been documented for Short-eared Owl, despite ongoing environmental assessments of developments. Although a restricted proportion of the population may encounter renewable energy developments at some point, population level effects are likely to be negligible.
4	Transportation & service corridors	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
4.1	Roads & railroads	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Although many Short-eared Owls breed in the far north away from roads, most winter far enough south to encounter roads. Owls often fly low and may perch along roadsides. Road mortality is believed to be having the greatest impact in western US states, based on numerous incidental records; more formal research is currently underway. Overall severity is considered to be slight, given the low probability of individual birds being involved in collisions.
4.2	Utility & service lines		Negligible	Large (31-70%)	Negligible (<1%)	High (Continuing)	A large proportion of Short-eared Owls likely encounter utility and service lines, at least during winter, and often use them safely as hunting perches. Although Short-eared Owls are too small to be at risk of electrocution on most lines, there is evidence of infrequent mortality from collisions with power lines and barbed-wire fences (Fitzner 1975; Knight and Skriletz 1980; Miller *et al*. 2018; Gionet-Rollick, pers. comm. 2019).
4.3	Shipping lanes						
4.4	Flight paths	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Short-eared Owls occur at airports, and appear to be disproportionately vulnerable to aircraft collisions, based on strike data from the United States. Airport wildlife management authorities may undertake lethal control, but this is likely to be of negligible frequency. Although some mortality likely occurs annually, it probably has only a slight effect on the population.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5	Biological resource use	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	There is potential for secondary exposure to rodenticides and other pesticides from prey consumed by Short-eared Owls in agricultural or near-urban areas. The effect is likely greatest on nestlings, with potential for adult mortality through bioaccumulation. Rodenticide poisoning of raptors is a high concern in western US states, through both direct mortality and sub-lethal levels that may cause impairment or vulnerability to other causes of death. Illegal killing of owls remains a concern in many areas, and is considered a management priority in some western US states.
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources						
6	Human intrusions & disturbance	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Wintering Short-eared Owls may occur in parks or other public areas and may be disturbed by walkers, photographers, and off-leash dogs. Although such sites are relatively few, several attract large numbers of owls and a high volume of birder/photographer activity (e.g., Boundary Bay, and the Nanaimo River and Cowichan River estuaries in British Columbia; Frank Lake in Alberta; I. Cruickshank pers. comm. 2020; M. Gahbauer pers. obs.). This threat also applies to owls wintering in the United States. It is unclear whether repeated flushing of these birds may affect survival, but as much of this disturbance occurs in winter conditions, overall severity is likely more than negligible.
6.2	War, civil unrest & military exercises		Not a Threat	Negligible (<1%)	Neutral or Potential Benefit	High (Continuing)	Short-eared Owls use suitable habitat at Canadian Forces bases with extensive grassland areas. However, the percentage of the population using these areas is likely negligible, and considering that they are often managed for wildlife conservation, net effects are likely to be negligible or positive.
6.3	Work & other activities		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	There is very little ongoing field research on Short-eared Owls, and the limited banding and telemetry work that does occur is unlikely to have more than a negligible effect on individuals involved.
7	Natural system modifications	CD	Medium - Low	Restricted (11-30%)	Moderate - Slight (1-30%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.1	Fire & fire suppression		Not a Threat	Small (1-10%)	Neutral or Potential Benefit	High (Continuing)	Fire is unlikely in most of the tundra breeding range and in many parts of the south; occasional fires in the prairies are sufficiently infrequent that few Short-eared Owls are likely to be affected. Fire may cause mortality if it coincides with eggs or flightless young in the nest. Conversely, Dechant et al. (2001) noted that in tallgrass prairie, periodic burning or mowing can benefit Short-eared Owl by promoting habitat suitable for voles. In many open habitats, fire maintains habitat structure and limits growth of taller vegetation, including shrubs, and may be an important factor in maintaining habitat quality.
7.2	Dams & water management/use		Negligible	Negligible (<1%)	Serious (31-70%)	High (Continuing)	Impoundments behind dams may flood grassland or wetland habitat used by Short-eared Owl. The area to be affected by the Site C dam in northern British Columbia is regionally important for this species, with limited unoccupied suitable nesting habitat nearby (CEAA 2014). No other dams currently proposed in Canada are known to pose a risk to Short-eared Owls.
7.3	Other ecosystem modifications	CD	Medium - Low	Restricted (11-30%)	Moderate - Slight (1-30%)	High (Continuing)	In western US states, large-scale conversion of habitat to Cheat Grass is of concern as it supports lower prey density. This is a leading cause of habitat loss in the Intermountain West region. The invasion of Crested Wheat Grass and other invasive plants is causing similar overall reduced productivity in the Canadian prairies. Ecosystem modifications are likely of lesser concern in other parts of the range.
8	Invasive & other problematic species & genes	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	
8.1	Invasive non-native/alien species		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	Predation by feral cats (*Felis catus*) is an important source of human-related mortality for birds in Canada (Calvert *et al.* 2013), especially for ground-nesting species (Blancher 2013; Loss et al. 2013). Risk is primarily to nestlings and flightless juveniles for Short-eared Owl. West Nile Virus is contracted by Short-eared Owls (Fitzgerald *et al.* 2003), although frequency of infection is little known and severity is likely low. An Ontario study of captive owls reported that only 12.5% of Short-eared Owls exposed to West Nile Virus died (n=16), compared to 92.3-100% of five other species (Gancz *et al.* 2004). Only the small proportion of Short-eared Owls breeding in the southern Canada are likely exposed to cats or West Nile Virus.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.2	Problematic native species	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	The abundance and likely impact of various predators has increased throughout much of the range of Short-eared Owl as a consequence of human activity. There is no direct evidence of increased predation having an effect on Short-eared Owl populations, but it is plausible that severity is in the range of slight.
8.3	Introduced genetic material						
9	Pollution		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
9.1	Household sewage & urban waste water						
9.2	Industrial & military effluents						
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste						
9.5	Air-borne pollutants		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Many Short-eared Owls are likely exposed to airborne pollutants at some point in their life cycle. It is unclear whether any of them may affect this species, and effects are unlikely to be severe.
9.6	Excess energy						
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	
11.1	Habitat shifting & alteration	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	As climate change models predict significant warming and drying in the Canadian Arctic and prairies, which account for most of the Short-eared Owl's breeding range, most of the population is likely to be exposed to consequent changes in habitat quality, although the scope within the next three generations may only be large. Ongoing shrubification is a key concern in the low Arctic, where it reduces the extent of open tundra and grassy areas used by Short-eared Owl for nesting and foraging, and provides additional cover for predators.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.2	Droughts		Unknown	Restricted (11-30%)	Unknown	High (Continuing)	Droughts may affect some Short-eared Owls breeding in southern Canada. Droughts are also occurring more frequently in parts of the United States wintering range, although it is unclear whether summer droughts affect winter habitat suitability. Severity is unknown, as individuals may be able to move to avoid negative consequences, while in some cases drought may be beneficial by increasing prey availability.
11.3	Temperature extremes						
11.4	Storms & flooding	D	Low	Restricted - Small (1-30%)	Slight (1-10%)	High (Continuing)	Many climate change models suggest increased storm frequency and severity. As a ground-nesting species, Short-eared Owl may be vulnerable to nest failure from flooding, and there is potential for short-term reduced prey availability as a result. The effect is primarily expected to be on nestlings, and is likely to be slight at most over the next three generations.

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