COSEWIC
Assessment and Status Report

on the

Barn Swallow
Hirundo rustica

in Canada

SPECIAL CONCERN
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. 2011. COSEWIC assessment and status report on the Barn Swallow *Hirundo rustica* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 37 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

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Barn Swallow — Photo credit: Joshua D. Vandermeulen (used with permission).

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COSEWIC
Assessment Summary

Assessment Summary – April 2021

Common name
Barn Swallow

Scientific name
Hirundo rustica

Status
Special Concern

Reason for designation
This aerial insectivore is among the world's most widespread birds, with about 6.4 million mature individuals in Canada. It experienced a substantial population decline in North America over more than two decades, beginning in the mid- to late 1980s. However, the Canadian population has remained largely stable over the past ten years (2009-2019), with a substantial increase in Saskatchewan largely offsetting ongoing declines in several other provinces. Key threats include declining populations of insect prey, increasing frequency of severe temperature fluctuations during spring migration and the breeding season, and in some regions, loss of suitable nesting sites. Although the Canadian population remains large and overall declines have abated, the species may once again become Threatened if threats continue or worsen.

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

Status history
Designated Threatened in May 2011. Status re-examined and designated Special Concern in May 2021.

COSEWIC
Executive Summary

Barn Swallow
Hirundo rustica

Wildlife Species Description and Significance

Barn Swallow is a medium-sized passerine with metallic blue upperparts, cinnamon underparts, and a chestnut throat and forehead. Its most recognizable feature is a deeply forked tail with long outer feathers. Males have a longer tail, somewhat glossier upperparts and a darker breast.

Barn Swallow is a member of the ecological guild known as aerial insectivores, of which many members are in decline globally.

Distribution

Barn Swallow is the most globally widespread species of swallow, occurring on every continent except Antarctica. In the western hemisphere, it breeds in Canada primarily south of the treeline, the United States and Mexico; Argentina also has a small breeding population. Barn Swallow has been documented breeding in every province and territory. Barn Swallow is a long-distance migrant, overwintering in the southern United States, parts of Mexico, and Central and South America.

Habitat

Before European colonization of North America, Barn Swallows largely nested on fissures in cliffs, rock overhangs, and caves. Thereafter, their preferred nest sites became human-made structures, including barns, stables, houses, sheds, and bridges. Barn Swallows prefer to forage over open spaces such as grasslands, agricultural fields, shorelines, woodland clearings, wetlands, sand dunes, tundra, and roads.

Biology

Barn Swallows nest in colonies or independently. They construct a small cup-shaped nest and affix it to a vertical, or occasionally a horizontal surface. The breeding season in Canada is typically from May through July. Most clutches contain 4-5 eggs; a second brood is often reared, particularly in southern Canada. Some Barn Swallows of both sexes breed in their first year. Barn Swallows forage mostly on the wing, actively pursuing and catching flying insects; however, they may forage on the ground opportunistically. Generation length is estimated to be approximately 3 years.

Population Sizes and Trends

In Canada, the Barn Swallow population is currently estimated to be at least 6.4 million mature individuals. This represents approximately 3.4% of the global Barn Swallow population and 13.6% of the population in the United States and Canada. Over 60% of the Canadian population currently breeds in the Prairie provinces.

Population trend estimates for Barn Swallow are based on Breeding Bird Survey data. For the period 1970-2019, there was a statistically significant annual trend of -2.34% (95% CI = -2.66% to -2.05%) per year in Canada, corresponding to an overall decline of 68.6% over 49 years. During the most recent 10-year period (2009-2019) the Canadian population has been close to stable, changing at -0.12% (95% CI = -1.07% to 0.89%) per year, amounting to a decrease of -1.2% over the decade. However, at a regional scale there has been a large increase in Saskatchewan, offsetting substantial ongoing declines in Ontario and Quebec. Comparisons of first and second generation breeding bird atlases in Alberta, Ontario, Quebec, and the Maritimes show results consistent with long-term declines of populations across Canada, with the largest reductions in eastern provinces (Ontario, Quebec, and the Maritimes).

Threats and Limiting Factors

Substantial research is still required to better understand threats affecting Barn Swallow. Currently the most pertinent concerns are thought to be modifications to the natural system (indirect threats such as pesticides and habitat loss reducing prey quality and quantity), climate change, housing and commercial development, changes in agriculture (annual and perennial non-timber crops, and livestock farming and ranching), roads and railroads, and pollution. These threats are thought to be reducing the quantity and quality of insect prey, causing lowered reproductive success and direct mortality. Threats on the wintering grounds are not currently well understood, but are likely related to changes in land-use, resulting in the destruction of suitable foraging habitat, as well as the intensification of agricultural practices that reduce insect populations. The overall impact of threats on Barn Swallow over the next decade is considered to be medium. Limiting factors for Barn Swallow include a dietary dependence on insect prey and low post-fledging survival rates.

Protection, Status and Ranks

In Canada, the *Migratory Birds Convention Act,* 1994 protects Barn Swallow, its nests, and eggs. The species is also listed as Threatened under Schedule 1 of the *Species at Risk Act, 2002*. In Canada, Barn Swallow is listed as N3N4 (Vulnerable to Apparently Secure) nationally, and S2 (Imperilled) in the Yukon Territory, New Brunswick, Prince Edward Island and Newfoundland, S2? (Imperilled?) in the Northwest Territories, S2S3 (Imperilled to Vulnerable) in Nova Scotia, S3 (Vulnerable) in Alberta and Quebec, S3S4 (Vulnerable to Apparently Secure) in British Columbia, S4 (Apparently Secure) in Manitoba, and S5 (Secure) in Saskatchewan and Ontario. In the United States, Barn Swallow is protected under the *Migratory Bird Treaty Act*, and ranked nationally as N5 (Secure). Globally, Barn Swallow is considered G5 (Secure).

TECHNICAL SUMMARY

Hirundo rustica

Barn Swallow

Hirondelle rustique

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

Demographic Information

Generation time (average age of parents in the population)	3.13 years (Bird *et al.* 2020)
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes, but likely very slight overall, and varying somewhat among regions.
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown, but likely <10% based on recent trends and anticipated threats.
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Inferred 1.2% reduction over the last 10 years (2009-2019), based on Breeding Bird Survey data for Canada.
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown, but likely <30% reduction based on an overall threat impact of medium.
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown, but likely <30% reduction based on recent trends and anticipated threats.
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. Unknown. b. Partly. c. Unknown overall.
Are there extreme fluctuations in number of mature individuals?	No.

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	Approximately 8,749,000 km^2, calculated based on a minimum convex polygon around known occurrences in the breeding range.
Index of area of occupancy (IAO) (always report 2x2 grid value).	IAO based on a 2x2 km grid cannot be calculated, but is more than 2000 km^2, given the extensive range of the species and its large population size

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"* (use plausible range to reflect uncertainty if appropriate)	Unknown, but certainly much greater than 10.
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No.
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes; observed decline in occupancy of 10x10 km squares based on results from the second Maritimes, Ontario, and Quebec breeding bird atlases, likely not entirely offset by the increasing population in Saskatchewan and Manitoba
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Not applicable; no subpopulations recognized in Canada.
Is there an [observed, inferred, or projected] decline in number of "locations"*?	Unknown.
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes; inferred decline in anthropogenic nest site quality and foraging habitat quality.
Are there extreme fluctuations in number of subpopulations?	No, only one subpopulation recognized in Canada.
Are there extreme fluctuations in number of "locations"*?	No.
Are there extreme fluctuations in extent of occurrence?	No.
Are there extreme fluctuations in index of area of occupancy?	No.

Number of Mature Individuals (in each subpopulation)

Subpopulations	**N Mature Individuals**
Total	At least 6.4 million

Quantitative Analysis

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

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

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

Was a threats calculator completed for this species? Yes (see Appendix A); overall threat impact: medium Key threats were identified as: • IUCN 7, Natural system modifications (low to medium threat impact) • IUCN 11, Climate change (low to medium threat impact) Additional threats anticipated to pose a low threat impact are: • IUCN 1, Residential and commercial development • IUCN 2, Agriculture and aquaculture • IUCN 4, Transportation and service corridors What other limiting factors are relevant? • Dependence on insect prey • Low post-fledging survival rates

Rescue Effect (from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Stable to declining slightly in US states bordering Canada based on BBS trends (Smith unpubl. data); ranked as Secure (S5) in eight of those states, Apparently Secure (S4) in two states, and not ranked (SNR) in two states.
Is immigration known or possible?	Yes.
Would immigrants be adapted to survive in Canada?	Yes.
Is there sufficient habitat for immigrants in Canada?	Yes; however, availability of nesting and foraging habitat is declining.
Are conditions deteriorating in Canada?[+]	Yes.
Are conditions for the source population deteriorating?[+]	Yes.
Is the Canadian population considered to be a sink?[+]	No.
Is rescue from outside populations likely?	No, although immigration occurs, it is unlikely to be sufficient to rescue the population if conditions continue to decline both within Canada and in adjacent states.

Data Sensitive Species

Is this a data sensitive species? No.

Status History

COSEWIC Status History: Designated Threatened in May 2011. Status re-examined and designated Special Concern in May 2021.

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

Status and Reasons for Designation:

Status: Special Concern	**Alpha-numeric codes:** Not applicable
Reasons for designation: This aerial insectivore is among the world's most widespread birds, with about 6.4 million mature individuals in Canada. It experienced a substantial population decline in North America over more than two decades, beginning in the mid- to late 1980s. However, the Canadian population has remained largely stable over the past ten years (2009-2019), with a substantial increase in Saskatchewan largely offsetting ongoing declines in several other provinces. Key threats include declining populations of insect prey, increasing frequency of severe temperature fluctuations during spring migration and the breeding season, and in some regions, loss of suitable nesting sites. Although the Canadian population remains large and overall declines have abated, the species may once again become Threatened if threats continue or worsen.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Population has declined by about only 1% over the past ten years.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. EOO of 8,749,000 km^2 and IAO of >2000 km^2 both exceed thresholds.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Number of mature individuals is estimated to be 6.4 million, greatly exceeding thresholds.
Criterion D (Very Small or Restricted Population): Not applicable. Estimate of 6.4 million mature individuals greatly exceeds thresholds for D1, and population is not prone to rapid and substantial decline.
Criterion E (Quantitative Analysis): Not applicable. Analysis not conducted.

PREFACE

Barn Swallow was first assessed by COSEWIC in May 2011, and designated Threatened due to the continued decline of the species' population since the mid- to late 1980s (COSEWIC 2011). Since preparation of the previous status assessment report, new information has become available on Barn Swallow in Canada. This includes completion of the second Quebec, first Manitoba, and first British Columbia Breeding Bird Atlases, and the first few years of data collection for the first Saskatchewan Breeding Bird Atlas. Updated global, national, and provincial population estimates for Barn Swallow have been prepared by Partners in Flight (PIF) using data from the Breeding Bird Survey, the second Ontario Breeding Bird Atlas, the Northwest Territories and Nunavut Checklist survey data (1995-2001), eBird relative frequency data (June and July, 1970-2017) and range map extrapolation (PIF 2019). These estimates now take into account measures of uncertainty around population estimates, which include variance in Breeding Bird Survey routes, time-of-day adjustment, pair adjustment, and detection distance adjustment (Stanton *et al.* 2019). Updated population trends estimated using Breeding Bird Survey data continue to show long-term population declines for Barn Swallow in Canada, but short-term trends indicate a relatively stable population with a slight decrease overall, although they vary regionally (Smith unpubl. data). A number of new studies have been undertaken on Barn Swallow in Canada and around the globe. Many of these studies focus on the poorly understood threats impacting Barn Swallow, including pollutants and pesticides, climate change, and agricultural intensification. Many studies also provide new information on Barn Swallow survival rates (adults and fledglings), migration patterns, and limiting factors for the species. The threats leading to the observed long-term decline of the Barn Swallow population in Canada remain poorly understood; however, continued research is providing new information on how a combination of factors may be threatening this species and other aerial insectivores.

COSEWIC HISTORY

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

COSEWIC MANDATE

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

COSEWIC MEMBERSHIP

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

DEFINITIONS
(2021)

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

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

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

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

Environment and Climate Change Canada
Canadian Wildlife Service

Environnement et Changement climatique Canada
Service canadien de la faune

Canada

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

COSEWIC Status Report

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific name:	*Hirundo rustica*
English name:	Barn Swallow
French name:	Hirondelle rustique
Classification:	Class: Aves Order: Passeriformes Family: Hirundinidae

Classification follows the American Ornithological Society (AOU 1998; Chesser *et al.* 2019). Barn Swallow is the only member of the genus *Hirundo* found in North America. Only one subspecies has been documented breeding in North America, *Hirundo rustica erythrogaster*, although since 2010 there have been three records of the Eurasian subspecies *H. r. rustica* along the Yukon Territory's Arctic coast (Eckert and Gordon 2020).

Morphological Description

Barn Swallow is a medium-sized swallow (total length: 15-18 cm; body mass: 17-20 g) with a deeply forked tail, which distinguishes it from all other North American swallows (Brown and Brown 2020). Adults in the North American population have a blue-black back and wings, cinnamon to buff underparts, and a chestnut forehead and throat with a broken blue chest band. The tail is blue on top and deeply forked with elongated outer rectrices. White spots form a band across the inner web of the tail. Males and females are similar in plumage, but males have longer outer rectrices than females (79-106 mm in males versus 68-84 mm in females) and tend to have somewhat glossier upperparts and a darker breast (Pyle 1997).

Population Spatial Structure and Variability

Barn Swallow comprises seven globally recognized subspecies, based on throat and ventral plumage colouration, breast band width, morphological characteristics, and molecular phylogenetic analyses (Cramp 1988; Dor *et al.* 2010; Brown and Brown 2020).

Preliminary research on the genetic diversity and structure of Barn Swallow in North America have not found evidence of population spatial structure or variability within Canada or North America (Zink *et al.* 2006; Safran *et al.* 2016). It should be noted that there are limitations in both studies conducted, including selection of genetic markers and sample size.

Designatable Units

Barn Swallow breeds across most of southern Canada. As no distinct separations in the species' range exist and no genetic differences are known, only one designable unit is considered for this report, as in COSEWIC (2011).

Special Significance

Barn Swallow is a globally common species that has likely been living in close association with humans for thousands of years (Turner 2006). As a result of its abundance and familiarity, Barn Swallow is one of the most well-studied bird species in the world, particularly the subspecies that occur in Europe and Asia (Turner 2006). Barn Swallow is a member of the guild known as aerial insectivores, which has experienced poorly understood population declines across North America and beyond (Spiller and Dettmers 2019).

Barn Swallow is generally well-liked because of its propensity for consuming large numbers of flying insects, and is often associated with good luck and the coming of spring (Brown and Brown 2020). Some legends emphasize that misfortune may come to farmers and their farms when nesting Barn Swallows are interfered with (Brown and Brown 2020). Barn Swallows have historically even influenced the architectural design of barns in parts of their range, with holes intentionally left in gables to allow swallows access into barns (Beal 1918). However, conflict can sometimes arise between nesting Barn Swallows and homeowners or farmers, and nests are sometimes removed from structures or destroyed over concerns that defecation in buildings and on grain stockpiles will reduce quality and potentially transmit disease (Kardynal pers. comm. 2020). There is no species-specific Aboriginal Traditional Knowledge in this report. However, Barn Swallow, like all species, is important to Indigenous peoples who recognize the interrelationships of all species within the ecosystem.

DISTRIBUTION

Global Range

Barn Swallow is the most widely distributed swallow species in the world. It occurs on every continent except Antarctica, and is a widespread breeding species in North America and Eurasia (Brown and Brown 2020). In the western hemisphere, the primary breeding range extends from Alaska and the territories of northern Canada south to central Mexico; a small number also breed in Argentina (Brown and Brown 2020; Figure 1). In North America, Barn Swallow is largely absent only in the Arctic tundra, alpine zones, and expansive forests and deserts where suitable nest sites are scarce (Brown and Brown 2020).

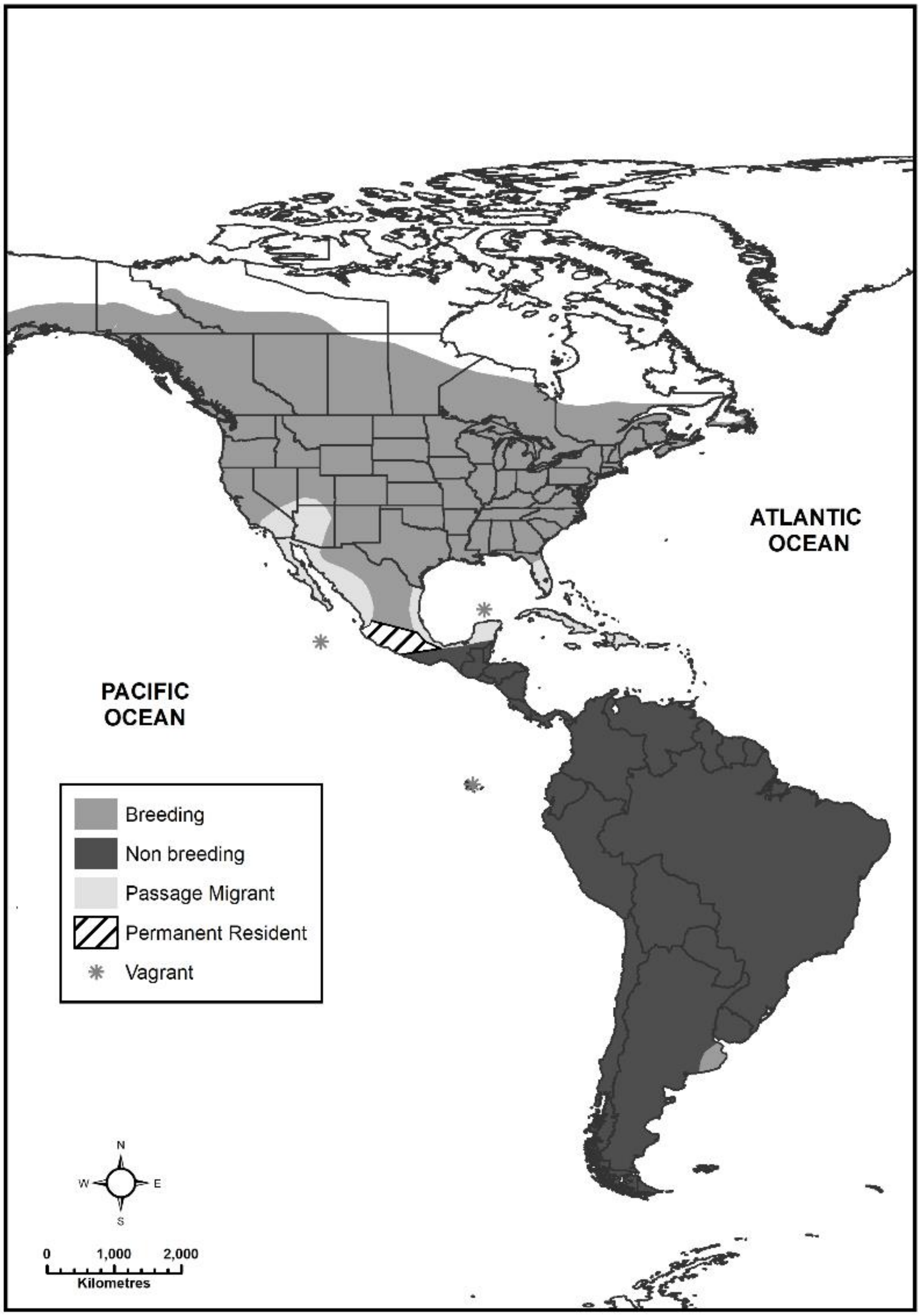

Figure 1. Breeding, migrating and wintering range of Barn Swallow in the Western Hemisphere (adapted from NatureServe 2020; eBird 2019).

As a long-distance migrant, Barn Swallow has an extremely wide distribution in North and South America and has been recorded in every country within the two continents (eBird 2019). There is little overlap between the breeding and wintering range of Barn Swallow, except for parts of Central Mexico and a small part of Argentina where a breeding population was first observed in 1980 (Martinez 1983; Winkler *et al.* 2017; Brown and Brown 2020: Figure 1). Barn Swallow is an uncommon wintering species in portions of Central Mexico south to Central America. The vast majority of the North American population spends the boreal winter in the lowlands of South America (Brown and Brown 2020). Individuals breeding in western and eastern North America (including in Canada) have been found to winter in geographically distinct areas, with eastern populations wintering farther south in eastern and southeastern Brazil, eastern Bolivia, Paraguay, Uruguay, and northeastern Argentina, whereas birds originating from the western portion of the breeding range wintered from Mexico through Central America and into Colombia (Garcia-Perez and Hobson 2014; Hobson *et al.* 2015; Hobson and Kardynal 2016; Imlay *et al.* 2018a). Barn Swallow is present in the West Indies, primarily during migration, although individuals have been recorded year-round (Raffaele *et al.* 1998). A small but increasing number of Barn Swallows overwinter in the southern United States, primarily California, Arizona and Texas (Meehan *et al.* 2018), and a small number now overwinter in southwestern British Columbia in most years (eBird 2021).

Canadian Range

The regular breeding range of Barn Swallow includes every Canadian province and territory except Nunavut (Figure 2), although it is generally rare within large portions of the heavily forested Boreal Shield Ecozone (Brown and Brown 2020; eBird 2021). Its distribution in northern Canada expanded during the mid-1900s, with the construction of settlements, roads and associated suitable nesting structures north into areas previously unoccupied by the species (Turner 2006). Barn Swallow distribution in Canada has overall remained relatively consistent since the 1980s; however, some local changes have been noted in provincial breeding bird atlases.

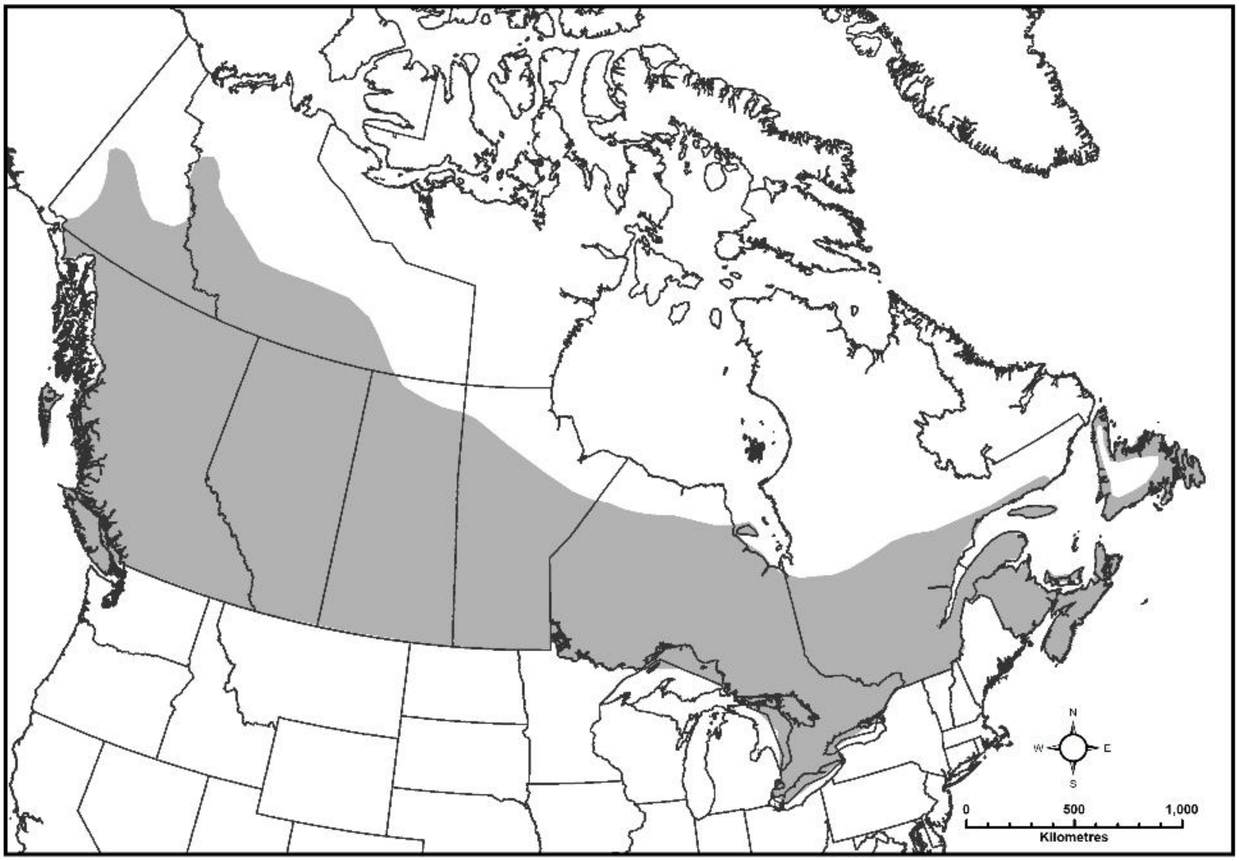

Figure 2. Canadian breeding range of Barn Swallow (based on Cadman *et al.* 2007; Federation of Alberta Naturalists 2007; Davidson *et al.* 2015; Stewart *et al.* 2015; Artuso *et al.* 2018; Government of NWT 2018; eBird 2019; Robert *et al.* 2019; Birds Canada 2021). Differences in Barn Swallow distribution from COSEWIC (2011) do not represent range extensions, but reflect increased search effort and data availability. Occupancy near the northern limits of mapped range is less continuous than depicted, and there are also scattered, un-mapped, extra-limital occurrences.

In the territories, Barn Swallow occurs from Dawson City east to Ross River and south of the Mackenzie Mountains in southern Yukon (Sinclair *et al.* 2003), and has been confirmed breeding as far north as Clarence Lagoon at the edge of the Beaufort Sea in Yukon (Yukon Conservation Data Centre 2020). In the Northwest Territories, it breeds primarily west of Great Slave Lake, and sporadically as far north as Inuvik (Government of the NWT 2018). It breeds irregularly in Nunavut, although it has been observed in nearly every region of the territory as far north as Nasaruvaalik Island, and has been documented nesting on Akimiski Island and nest building in Arviat (Richards and Gaston 2018).

Barn Swallow ranges across British Columbia, where it is most commonly associated with coastal regions and lowland valleys (Davidson *et al.* 2015; Figure 3). It can be found throughout the Prairie provinces. Data from the first and second Alberta breeding bird atlas (1987-1992 and 2001-2005) show that Barn Swallow is found throughout the province, although it is most heavily concentrated in the southern half of Alberta (Federation of Alberta Naturalists 1992, 2007). Similarly, preliminary data from the Saskatchewan breeding bird atlas (2017-2021) indicate the population is heavily concentrated in the southern half of the province (Figure 4), and Manitoba's first breeding bird atlas (2010-2014) showed abundance was highest in the southern third of the province (Artuso *et al.* 2018), especially the agricultural region in the southwest (Figure 5). In Ontario, Barn Swallow breeding records span most of the province, including the Hudson Bay Lowland; however, it is common only in southern Ontario, and rare to absent in parts of central and northern Ontario (Cadman *et al.* 2007; Figure 6). In Quebec, Barn Swallow is largely restricted to the southern third of the province, near agricultural regions, with sporadic records farther north (Robert *et al.* 2019; Figure 7). Barn Swallow is found throughout most of New Brunswick, Nova Scotia and Prince Edward Island, primarily in agricultural areas near wetlands (Stewart *et al.* 2015; Figure 8). There is only a small population in the southern portion of Newfoundland (eBird 2021), and the species occurs only occasionally in Labrador, mostly along the southeast coast. Many records from Labrador are likely of migrating individuals, although there are records from the breeding season (Imlay and Taylor 2020; eBird 2021).

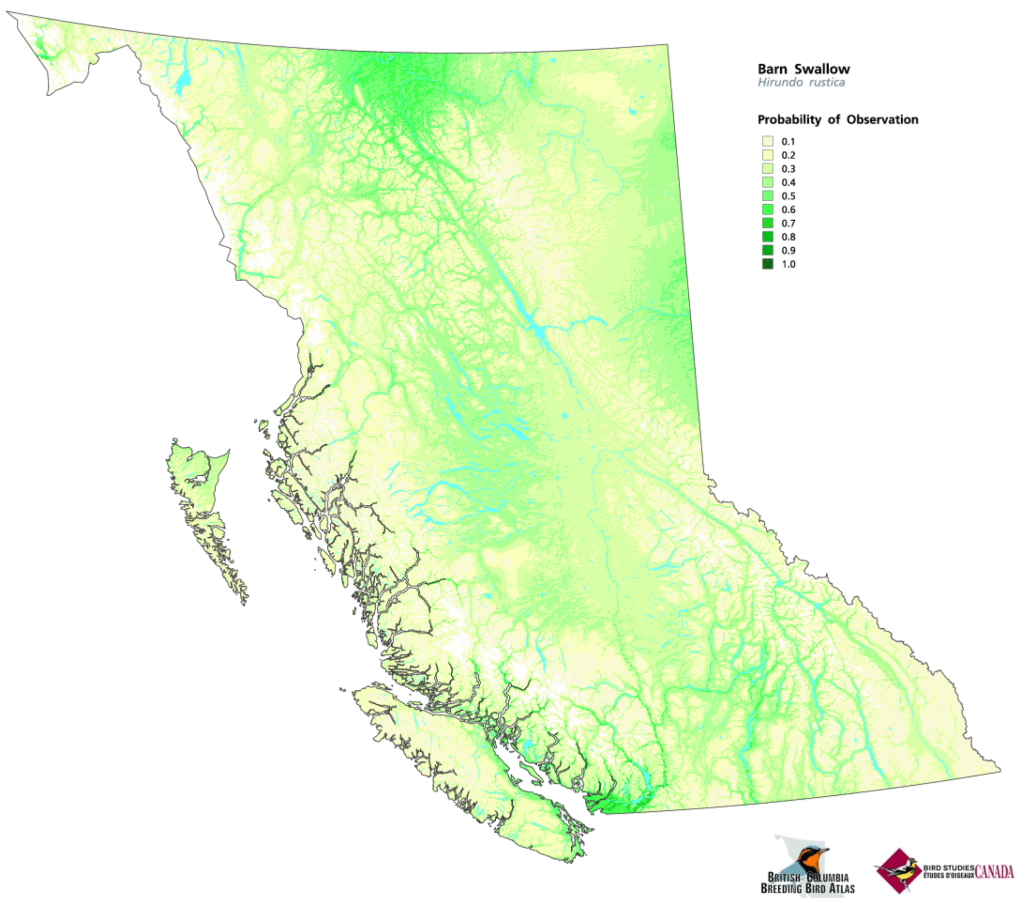

Figure 3. Probability of observation of Barn Swallow during the British Columbia breeding bird atlas, 2008-2012 (Davidson *et al.* 2015).

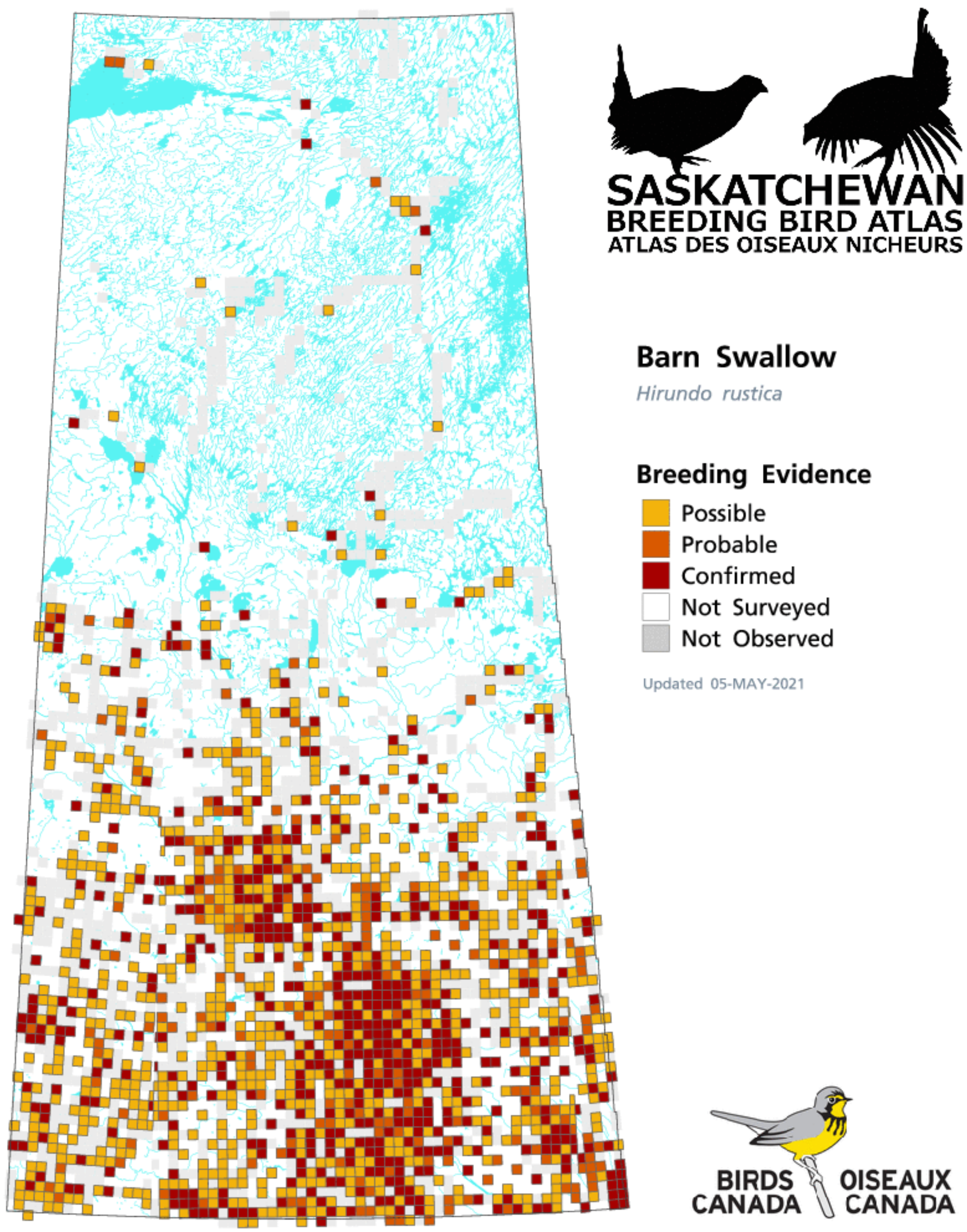

Figure 4. Distribution of Barn Swallow in Saskatchewan during the initial years of the Saskatchewan breeding bird atlas, 2017-2020 (Birds Canada 2021).

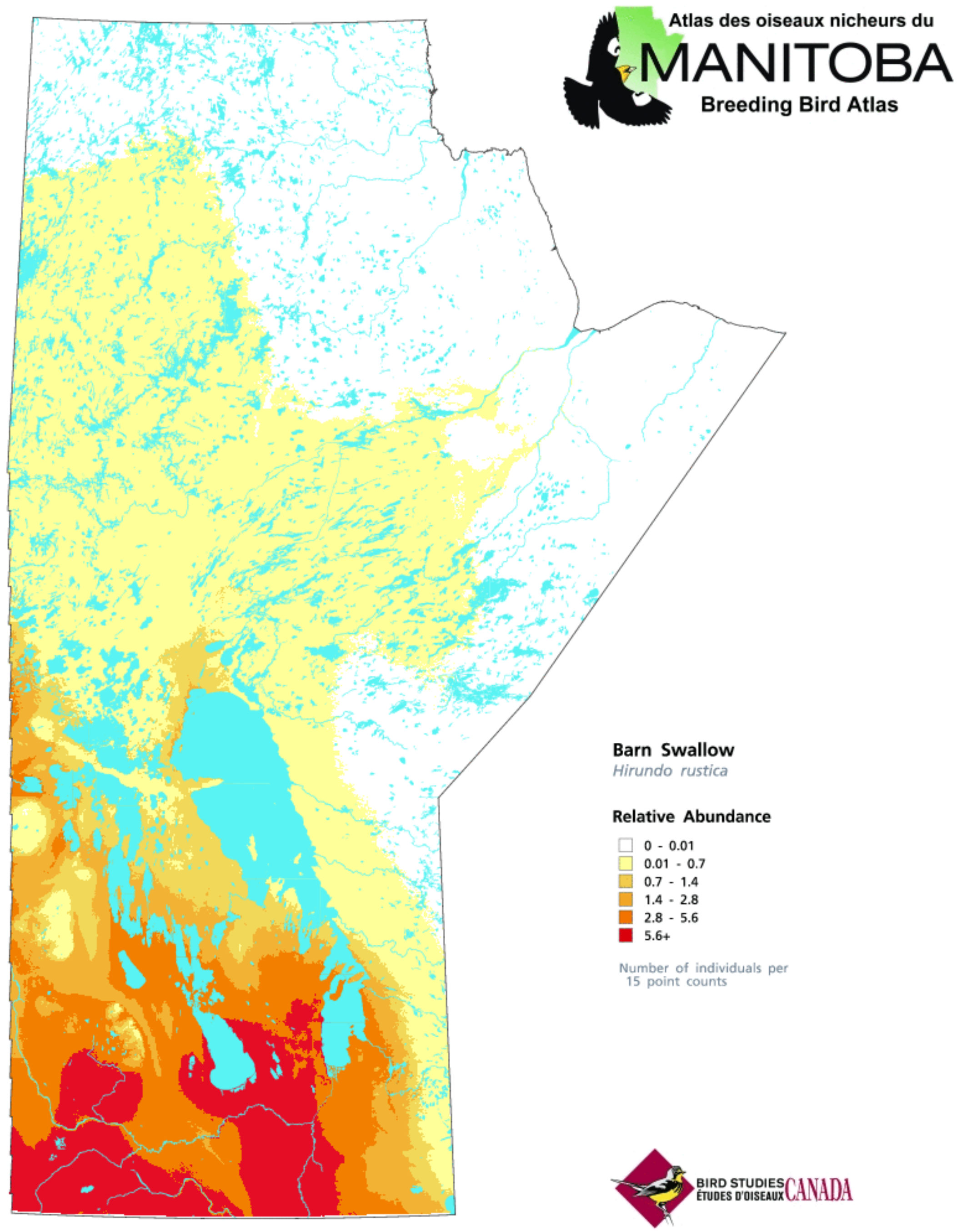

Figure 5. Relative abundance of Barn Swallow in Manitoba during the Manitoba breeding bird atlas, 2010-2014 (Artuso *et al.* 2018).

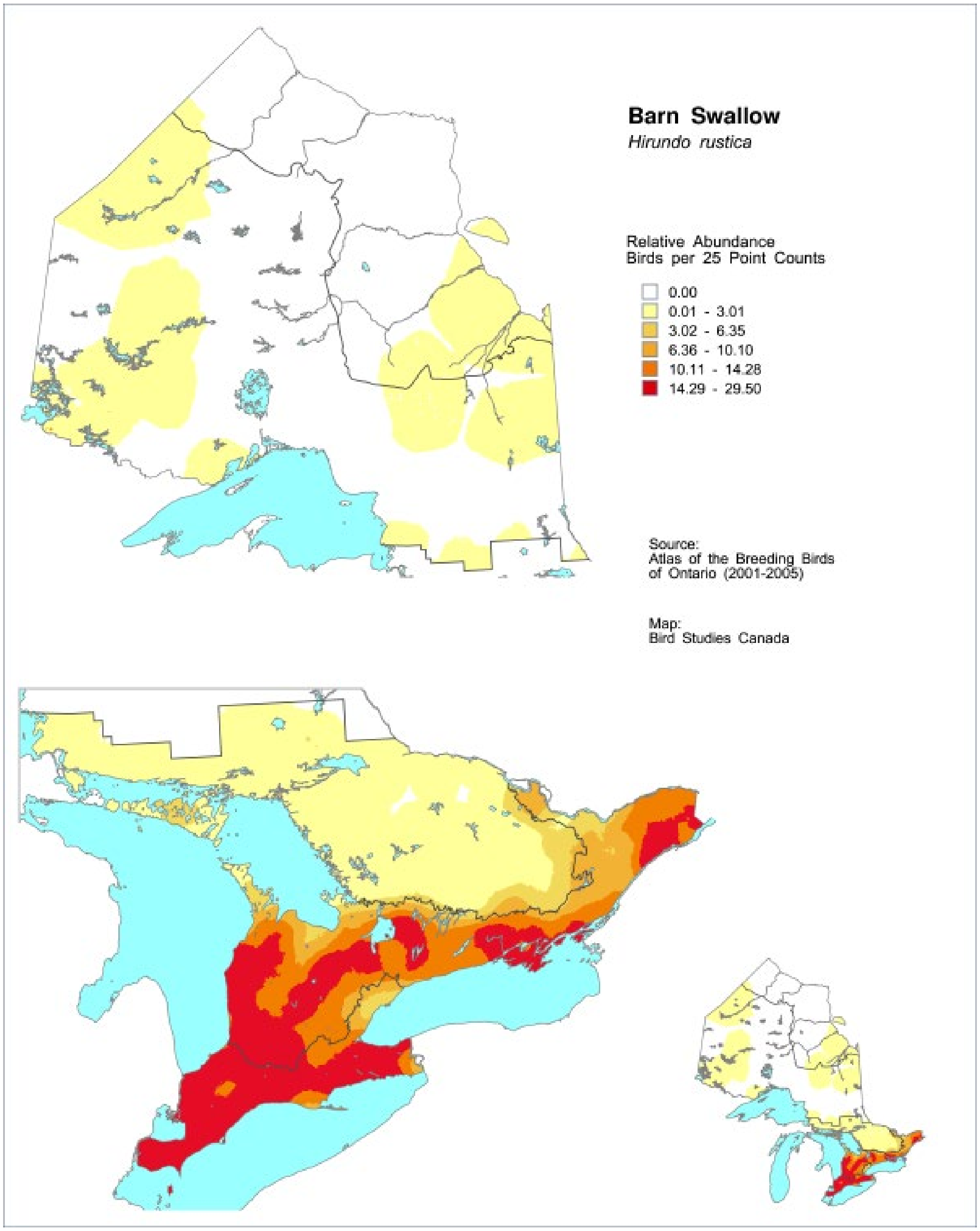

Figure 6. Relative abundance of Barn Swallow in Ontario during the second Ontario breeding bird atlas, 2001-2005 (Cadman *et al.* 2007).

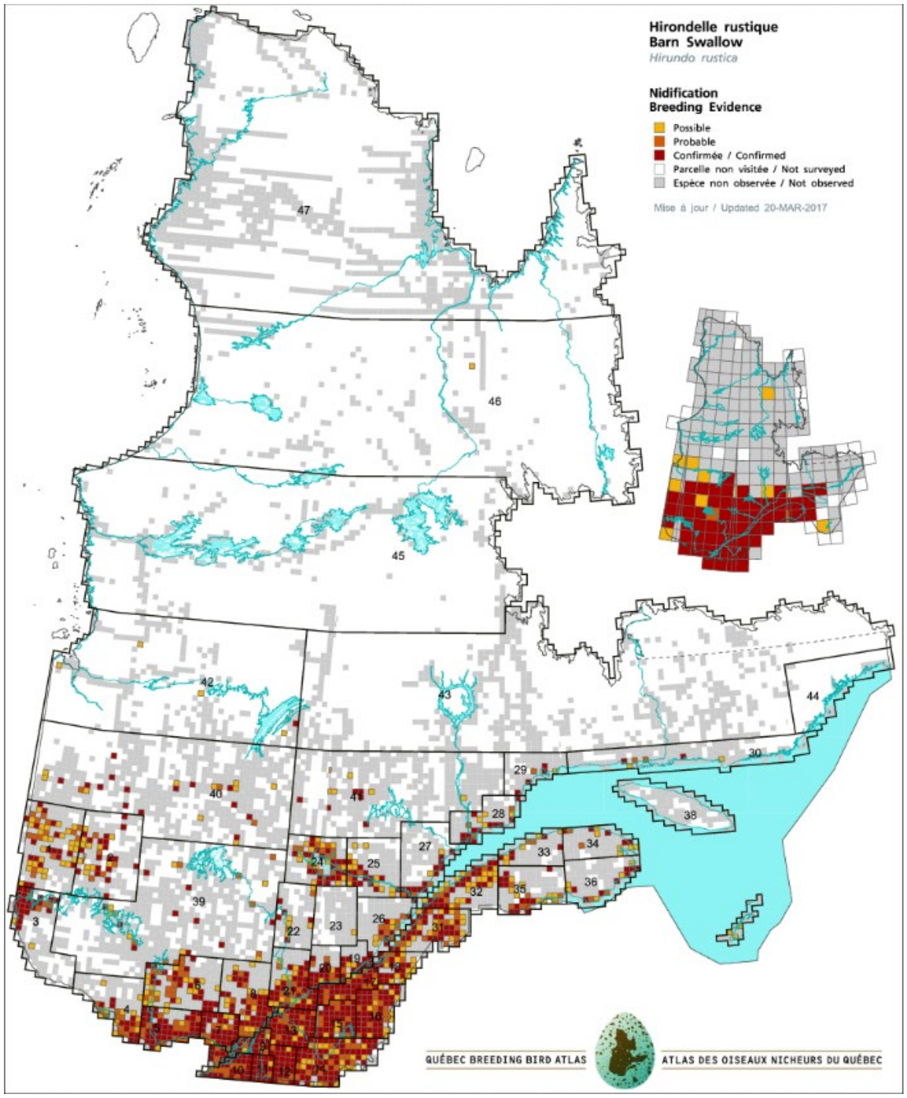

Figure 7. Distribution of Barn Swallow in Quebec during the second breeding bird atlas, 2010-2014 (Robert *et al.* 2019).

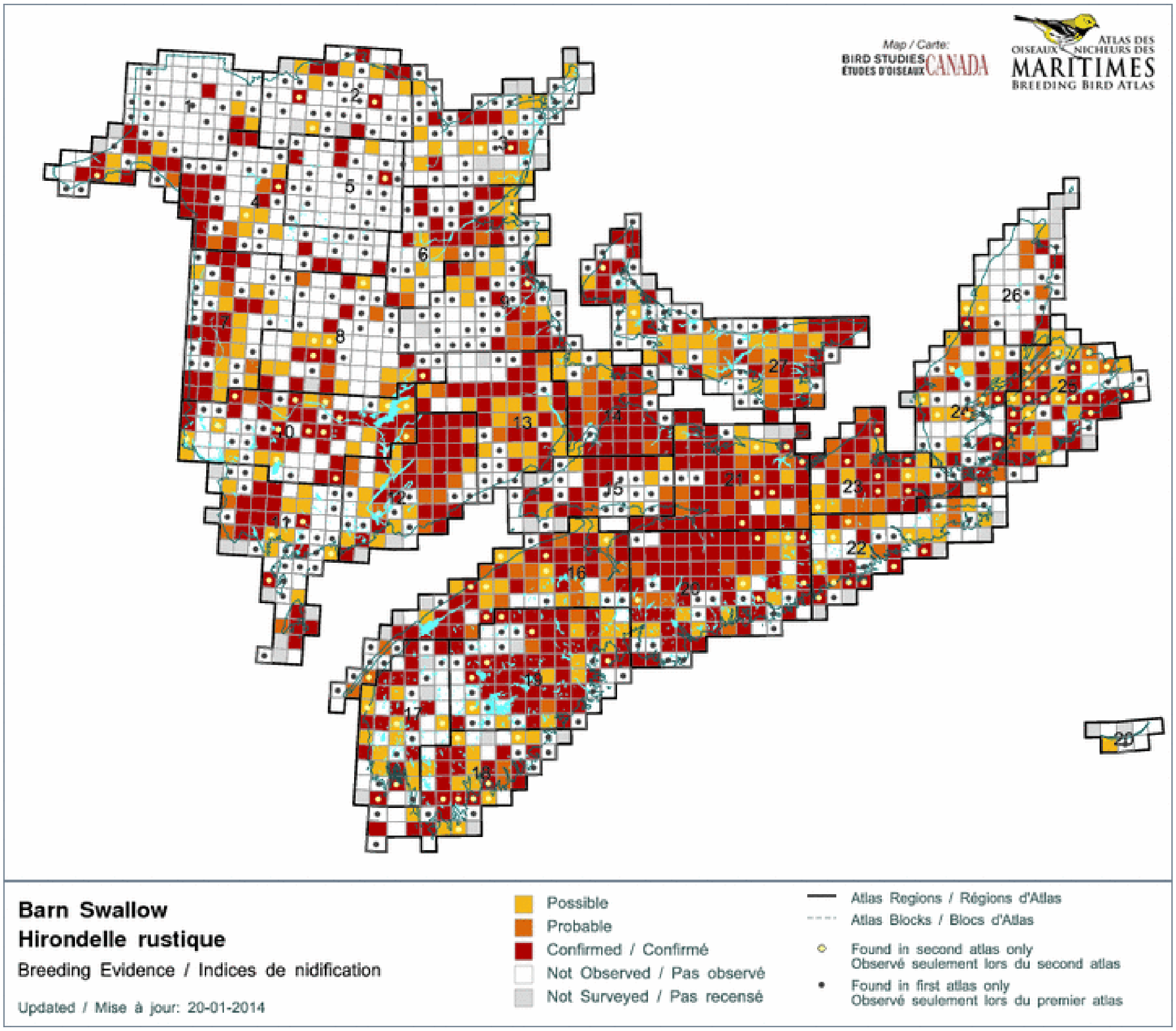

Figure 8. Distribution of Barn Swallow in the Maritime Provinces during the second breeding bird atlas, 2006-2010 (Stewart *et al.* 2015).

Extent of Occurrence and Area of Occupancy

Extent of occurrence (EOO) is estimated to be 8,749,000 km^2 within Canada, based on a minimum convex polygon around the accepted breeding range (Figure 2). Distribution within the breeding range is not mapped in enough detail to calculate area of occupancy, but given population size and EOO, it is certainly much greater than 2,000 km^2. There has been a decline in occupancy of 10x10 km squares based on results from the second Maritimes, Ontario, and Quebec breeding bird atlases.

Search Effort

Distributional data on Barn Swallow have primarily been sourced from breeding bird atlas work completed within a number of provinces since the 1980s. Additional distribution information was collected from published sources, including The Birds of Nunavut (Richards and Gaston 2018), the Birds of British Columbia (Campbell *et al.* 1997), Birds of the Yukon Territory (Sinclair *et al.* 2003), and Species at Risk in the Northwest Territories (Government of NWT 2018).

Distribution maps provided by NatureServe (2020) and the Birds of the World (Brown and Brown 2020) are considered the most reliable for the species and have been corroborated with data from eBird (2021) over the core of the breeding season (June-July) from 2010 to 2019.

BIOLOGY AND HABITAT USE

The species account for Barn Swallow in the Birds of the World (Brown and Brown 2020) provides a comprehensive overview of the biology of the species, and is a primary reference for this section; only key elements relevant to status assessment are discussed below. Where possible, Canadian sources have been consulted for the most current and relevant information. Barn Swallow has been extensively studied in Europe for over four decades, as summarized by Turner (2006); research from North America is more limited.

Life Cycle and Reproduction

The average life span for Barn Swallow is approximately four years (Langlois 2015). The oldest recorded Barn Swallow in North America was eight years and 10 months, while outside of North America birds have been recorded reaching 15 years and 11 months (Maute 2003; Turner 2004). Generation length for Barn Swallow has been estimated as 3.13 years, using modelled values of age-of-first-breeding, maximum longevity and annual adult survival (Bird *et al.* 2020).

Barn Swallow is socially monogamous, but frequent polygamy and extra-pair copulations render it genetically polygamous (Wolinski 1985; Brown and Brown 2020). Male and female Barn Swallows are able to breed as yearlings; however, many unmated birds in many populations are often first-year males (Brown and Brown 2020; NatureServe 2020). Pair formation occurs within two weeks of arriving at the breeding grounds (Wolinski 1985). Bonded pairs sometimes remain together in consecutive breeding seasons if they successfully fledge young in the first year, but often separate following nesting failure (Shields 1984). Barn Swallow pairs nest both solitarily and in colonies or groups (Turner 2006). Colony size varies substantially and is often dependent on the size of the structure being used for nesting; colonies as large as 90 nests occur, but more than 35 is unusual (Ball 1983; Campbell *et al.* 1997). Individuals regularly return to the same breeding site in consecutive years, especially if nesting was successful the previous year (Turner 2004). Rates of return at Barn Swallow colonies in New York were approximately 40% in adult

Barn Swallows, with 36% of these returning to the same nest site used in the previous year; males have higher site fidelity than females (Shields 1984).

Barn Swallows nest on horizontal and vertical structures that include natural sites, such as cliffs and caves, as well as human-made structures, such as barns, bridges, and culverts (Brown and Brown 2020). The nesting substrate must be rough, or have a ledge or projecting objects, such as bolts or light fixtures, to provide additional structural support to the nest (Turner 2006; Brown and Brown 2020). Barn Swallow nests are constructed from mud pellets, sometimes with small pieces of grass, vegetation, and other debris interspersed, then lined with soft feathers (Brown and Brown 2020). Construction of new nests has been reported to take between 6 and 26 days to complete, depending on weather conditions and other factors (Anthony and Ely 1976; Lohoefener 1980, Campbell *et al.* 1997). Barn Swallows that reuse old nests save time in construction, using less energy, reducing the risk of predation, and increasing opportunities for a second brood (Shields *et al.* 1988, Safran 2006, Turner 2006). In Manitoba, about half of clutches were laid in old nests (Barclay 1988), and in New York, pairs that reused old nests fledged, on average, 44% more young than pairs using new nests (Safran 2006).

Nest construction typically begins 5-14 days after arrival at nest sites, with solitary pairs often nesting earlier than those in colonies (Smith 1933; Shields and Crook 1987; Barclay 1988). Barn Swallows regularly rear two broods per nesting season in most of Canada, except the far north, where only one is typically produced (NatureServe 2020). Average clutch size is 4-5 eggs (Anthony and Ely 1976; Peck and James 1987; Campbell *et al.* 1997). Average first clutch initiation dates in Canada are early to mid-May (Pettinghill 1946; Peck and James 1987; Campbell *et al.* 1997; Brown and Brown 2020), and in the Maritimes they averaged 8-10 days earlier in 2006-2016 than in 1962-1972 (Imlay *et al.* 2018b). Incubation lasts 12-17 days (Smith 1933; Thompson 1961; Peck and James 1987; Campbell *et al.* 1997). Nestlings are brooded for about 15 days (Samuel 1971), and fledge after 18-23 days (NatureServe 2020). Fledging success ranges between 3.1 and 4.2 fledglings annually per pair (Brown and Brown 2020).

Survival rates for juvenile Barn Swallows are difficult to assess, as most juveniles do not return to natal sites, making recapture unlikely (Turner 2006). Post-fledging survival in Barn Swallows was found to be 42% over eight weeks in Ontario (Evans *et al.* 2019) and 44% over three weeks in British Columbia (Boynton *et al.* 2020). Mean annual survival rate estimates for adult Barn Swallows include 0.350 ± 0.054 SE (n=300) in Nebraska (Brown and Brown 2020) and 0.38 ± 0.13 SE in New York (Safran 2004). Estimates of mean model-averaged adult apparent survival of Barn Swallow based on temporal and spatial analyses of MAPS (Monitoring Avian Productivity and Survivorship) data, are 0.497 and 0.488 for temporal and spatial analyses respectively (DeSante and Kaschube 2015). These results suggest that low adult apparent survival for Barn Swallow may be linked to population declines in the species (DeSante and Kaschube 2015). Barn Swallow productivity and survival are affected by a range of factors including age of parent birds, colony size, presence of ectoparasites in the nest, inclement weather during nesting, immunocompetency of young, predation, adverse weather conditions in migration and on the wintering grounds, and human interference (Turner 2006; Brown and Brown 2020).

Factors impacting Barn Swallow survival in relation to predation and parasitism are discussed further in **Interspecific Interactions**; these factors as well as those relating to inclement weather and human caused threats are discussed in **Threats.**

Habitat Requirements

Breeding habitat

Barn Swallow has been documented breeding in a wide range of landscapes, including lake and river shorelines, wetlands, parkland, woodland clearings, sand dunes, tundra, towns, and along highways (Peck and James 1987; Brown and Brown 2020), although densely built-up cities and forested areas are generally avoided (Turner 2006). Fledging success has been shown to be lower in urban areas than rural areas, likely due to smaller aerial insect populations and greater air pollution (Teglhøj 2017). Nesting sites must provide access to open areas with an abundant supply of aerial insects to feed on; features such as wetlands, waterbodies, watercourses, meadows, grazed grassland, and farmland are preferred (Peck and James 1987; Turner 2006; Brown and Brown 2020). Proximity to a waterbody or moist area with a supply of wet mud is needed to facilitate nest construction (Brown and Brown 2020). Barn Swallow is typically associated with lowland habitats throughout much of its range, rarely nesting above 1000 m above sea level (Turner 2006); although in Colorado, Barn Swallows have been documented nesting at elevations up to 3000 m (Cramp 1988; Kingery 1998). The British Columbia Breeding Bird Atlas documented a Barn Swallow nest as high as 1750 m, but noted that abundance increased greatly at elevations below 250 m (n=267; Hearne 2015).

As its vernacular name suggests, Barn Swallow is commonly associated with anthropogenic structures. There are early accounts of Barn Swallows affixing their nests to structures in Indigenous settlements in the early 1800s (Zink *et al.* 2006). Given the relative abundance of Indigenous settlements in pre-colonial North America, it seems likely that this behaviour was exhibited by Barn Swallows before the arrival of European settlers to North America. Before anthropogenic structures were widely available for nesting, Barn Swallows relied on natural nest sites, primarily in mountainous regions, lakeshores and sea coasts where natural shelters such as caves, cliff faces, rock ledges, and outcrops are present (Speich *et al.* 1986; Brown and Brown 2020). Less frequently, Barn Swallow uses tree branches and hollow trees as nest sites (Turner 2006; Brown and Brown 2020). Nests in natural sites have become rare, estimated at only 1% in Canada (Erskine 1979), although this has not been systematically studied, and may be underestimated due to limited accessibility (Turner 2006).

The expansion of European settlement throughout North America resulted in extensive land clearing and construction of buildings, bridges, and other structures. This allowed Barn Swallow to inhabit previously unsuitable inland regions. Where humans have settled, Barn Swallow has followed; in Alberta, the northern expansion of farming and oil-prospecting is thought to have allowed the species to expand its range in the 1960s (Turner 2006). Today, Barn Swallow nests are commonly constructed on a variety of built structures, including barns, stables, sheds, garages, eaves, mine shafts, wells, bridges, jetties, and culverts (Turner 2006).

Migration habitat

In migration, Barn Swallow uses a wide variety of habitats for resting and foraging, including open water, freshwater marshes, savannah, farmland, and cities and towns (Brown and Brown 2020). Individuals commonly gather in large communal roosts in marshes, wetlands, and agricultural areas, often with other swallow species (Brown and Brown 2020; eBird 2021). During periods of cold and rainy weather, migrant Barn Swallows and other swallows forage in large flocks over bodies of water where aerial insects are still present (Brown and Brown 2020).

Winter habitat

Over-wintering Barn Swallows are typically found in flocks associated with open habitats, such as sugar cane and other agricultural fields, reed beds, and marshes (Brown and Brown 2020). Habitats used on the wintering grounds are similar to those habitats frequented during the breeding season, with open areas that have an abundance of aerial insects being favoured (Turner 2006).

Habitat Trends

Historically, availability of nest sites for Barn Swallow expanded with the increase in agricultural land and associated buildings during the 1800s and 1900s (Turner 2006; Winkler *et al.* 2015). The clearing of forests for agricultural land and the construction of houses, barns, stables, and outbuildings, provided nesting and foraging habitat in areas where it was not previously present (Turner 2006; ABMI 2019; Brown and Brown 2020). In the past 50 years, an increase in the development of road systems, including the construction of bridges and culverts, has provided Barn Swallow with additional nesting options. In Ontario, bridges and culverts accounted for 15% of nest sites by the mid-1980s (Peck and James 1987); in Jasper National Park, Barn Swallows selected concrete bridges over wooden buildings (St-Amand 2019). The availability of natural nesting sites, such as cliffs and caves, is not thought to have decreased to a degree that would influence population size (Brown and Brown 2020).

In recent decades the materials used in building construction have changed significantly; the use of metal and vinyl siding has become prevalent in the construction of rural structures and barns (Erskine 1992). These materials do not provide a suitable substrate for Barn Swallow to affix nests to, so conversion of wooden structures to their modern equivalents has resulted in a decline in available nesting sites (Nicholson 1997; Brown and Brown 2020). Changing farming practices have resulted in a net loss of the preferred nest sites and foraging habitat for Barn Swallow (Turner 2004; Grüebler *et al.* 2010; Stanton 2019). The transition from mixed farming (crops and livestock) to large farms specializing in a single row crop reduced ideal Barn Swallow habitat in Europe and North America (Turner 2006). Low-intensity livestock farms, preferably with pastures grazed by cattle, provide excellent breeding habitat for Barn Swallow, because of the increased foraging opportunities as a result of livestock flushing insects (Turner 2006). Studies in Europe have shown a positive correlation between old-style dairy farming practices and the presence of Barn Swallows; however, modernized dairy farms are generally large, intensive operations, and provide less suitable nest sites and foraging habitats for Barn Swallow (Møller 2001; Ambrosini *et al.* 2002a,b), a change which has been occurring in Canada as well.

In the past decade, artificial nesting structures for Barn Swallow have been installed in Canada, primarily in Ontario, to mitigate the temporary or permanent loss of nesting sites resulting from construction activities (BSC 2019). Monitoring of 114 such structures in 2019 found that 44% of them supported at least one Barn Swallow pair (BSC 2019), but that only 7% of available nest spots were used. Although designed to support an average of 12 nests per structure, the mean count was 2.4, compared to 5.9 in barns in the same region (BSC 2019). These findings suggest that either design of these structures is not optimal for attracting Barn Swallow, or that availability of nesting sites is not limiting population size.

Little information is available on changes to Barn Swallow habitat in migration and on the wintering grounds. However, draining of wetlands and waterbodies to create agricultural lands may have destroyed historical roosting areas and foraging grounds, potentially forcing Barn Swallows to roost in less suitable areas where they are more vulnerable to terrestrial predators (van den Brink *et al.* 2000, 2003).

Movement, Dispersal, and Migration

Barn Swallow is a diurnal, long-distance migrant, in some cases travelling >11,000 km between nesting sites in North America and wintering grounds in Central and South America (Heagy *et al.* 2014; Hobson *et al.* 2015). Individuals forage on the wing and roost nocturnally in large flocks, often with other swallow species (Brown and Brown 2020). Barn Swallows in the western part of their North American range travel shorter distances to reach their nesting sites than those in the east (Hobson *et al.* 2015). Most Barn Swallows migrate overland and follow the Isthmus of Panama, although some individuals have been documented migrating over the Gulf of Mexico and the Caribbean (Hailman 1962; Yunick 1977; Fink *et al.* 2020).

Spring migration for most North American Barn Swallows occurs between March and May (Fink *et al.* 2020). In Canada, birds start to arrive in late March in British Columbia (Campbell *et al.* 1997), late April in Ontario (Heagy *et al.* 2014; Fink *et al.* 2020), and May in the northern part of their range (Fink *et al.* 2020). Fall migration is more protracted (Fink *et al.* 2020). Large counts of Barn Swallow have been recorded passing Cape May, New

Jersey as early as late July (Sibley 1997). In British Columbia, migration takes place between early August and late September (Campbell *et al.* 1997); in Ontario, primarily in late September and October (Heagy *et al.* 2014).

Juvenile Barn Swallows rarely return to their natal nest sites during subsequent breeding seasons; however, studies have shown that they often disperse to within a few kilometres of the natal site, although this may be biased by study area size (Brown and Brown 2020). In New York, returning first year Barn Swallows were found to disperse on average 6.3 km (range: 0-8.1; n=7) from their natal site (Shields 1984). Adult Barn Swallows show greater fidelity to nest sites, in particular those at which they were successful in prior years (Brown and Brown 2020). In New York, 41.6% (n=216; Shields 1984) of birds banded as adults returned to the study area the following year, in Pennsylvania 13% (n=185; Bell 1962) returned, and in Massachusetts 34% (n=381; Iverson 1988) returned.

Physiology, Diet, and Adaptability

Barn Swallow feeds almost exclusively while in flight but also opportunistically forages on the ground, with insects comprising approximately 99.8% of their diet (Beal 1918; Hobson and Sealy 1987). It is considered a generalist aerial insectivore and has been found to consume insects from 130 different families across 13 orders (McClenaghan *et al.* 2019b). Dipteran species comprise the majority of the diet fed to young, with a disproportionate amount of larger fly species being selected (Kusack 2018; McClenaghan *et al.* 2019b). Other prey includes Hymenoptera (ants, bees, wasps, etc.), Hemiptera (true bugs), Coleoptera (beetles), Lepidoptera (butterflies and moths), Orthoptera (grasshoppers and crickets), Odonata (dragonflies and damselflies), Psocoptera (barkflies), Thysanoptera (thrips), and Neuroptera (lacewings), among others (Beal 1918; McClenaghan *et al.* 2019). Diet varies significantly by season in accordance with prey availability; in North America it was found that Diptera make up 82% of the diet in March, but only 18% in September (Beal 1918). Similarly, the diet of Barn Swallow may also vary significantly by area; for example, Hymenoptera (Formicidae) were strongly preferred in a study at the Vancouver International Airport (Law *et al.* 2017). When feeding on insects, Barn Swallows generally take larger prey that provide more energy for the amount of effort expended (Turner 1980; McClenaghan *et al.* 2019). Aside from insects, Barn Swallows have also been documented feeding on berries, primarily as an alternative early in the year when insects are in short supply (Beal 1918; von Vietinghoff-Riesch 1955).

Barn Swallows forage diurnally, catching insects in flight over open areas, waterbodies, and watercourses (Brown and Brown 2020). During the breeding season Barn Swallows generally forage within 400 m of their nest site (Snapp 1976). Barn Swallows nesting near agriculture prefer to forage over hayfields, grazed land, and near hedgerows, compared to fields with cereal crops, as the former tend to support greater insect abundance (Evans 2001; Ambrosini *et al.* 2002a, Evans *et al.* 2003).

Barn Swallows are generally adaptable and tolerant of human disturbance (Turner 2006). The ability to adapt to new nesting sites has allowed Barn Swallow to expand its range into northern Canada and Alaska (Turner 2006).

Interspecific Interactions

Predators

Barn Swallow is taken regularly by a wide range of predators (Brown and Brown 2020). Avian predators include accipiters (*Accipiter* spp.) and other raptors including hawks (Accipitridae), falcons (Falconidae) and owls (Strigiformes); gulls (Laridae); corvids (Corvidae); and grackles (*Quiscalus spp.*). These species hunt adult Barn Swallows in flight or catch roosting individuals. Barred Owl (*Strix varia*), corvids and grackles have been observed raiding nests and consuming young (Suzuki 1998; Mahony 2017). Other common nest predators include rats (*Rattus spp.*), squirrels (*Sciuridae spp.*), weasels (*Mustela spp.*), Common Raccoon (*Procyon lotor*), Bobcat (*Lynx rufus*), and domestic cat (*Felis catus*) (Brown and Brown 2020). In more unusual cases, American Bullfrog (*Lithobates catesbeianus*), fish, and even fire ants (*Solenopsis geminata* and *S. invicta*) have been observed preying on Barn Swallows or their young (Kroll *et al.* 1973; Kopachena *et al.* 2000; Brown and Brown 2020).

Non-predatory interspecific interactions

Non-predatory interactions between Barn Swallow and other species most commonly occur at nest sites (Brown and Brown 2020). In North America, Eastern Phoebe (*Sayornis phoebe*), Say's Phoebe (*S. saya*), Cliff Swallow (*Petrochelidon pyrrhonota*), Cave Swallow (*P. fulva*), House Wren (*Troglodytes aedon*), Winter Wren (*T. hiemalis*), and House Sparrow (*Passer domesticus*) have all been documented to use Barn Swallow nests (Samuel 1971; Brown and Brown 2020). In most of these cases old, unoccupied nests are taken over, or used as the base for a new nest; however, some species occasionally wrest control of an occupied Barn Swallow nest for their own use (Turner 2006). Brood parasites like Brown-headed Cowbird rarely target Barn Swallow nests (Wolfe 1994).

House Sparrow has been noted to be a particularly problematic species for Barn Swallow, as individuals destroy eggs and kill nestlings (Brown and Brown 2020). A study in Maryland found that 25% of Barn Swallow eggs laid did not produce fledged young as a result of House Sparrow interference (Weisheit and Creighton 1989). Barn Swallows sometimes nest near Cliff and Cave Swallows, as they use similar artificial substrates and materials for nest building (Brown and Brown 1996; Brown and Brown 2020). In these mixed colonies, Cliff and Cave Swallow appear to be dominant and prevent Barn Swallow from using optimal nest sites (Brown and Brown 1996). Culvert and bridge nest sites in Texas formerly occupied by Cave Swallow and Barn Swallow are now inhabited almost exclusively by Cave Swallow (Ormston 2001).

POPULATION SIZES AND TRENDS

Data Sources, Methods, and Uncertainties

North American Breeding Bird Survey (BBS)

The BBS is aimed at detecting breeding bird species through standardized roadside surveys conducted primarily by volunteers, and is coordinated in Canada by the Canadian Wildlife Service (Government of Canada 2018). The program has been run since 1966 and is the primary source for assessing long-term, large-scale population change for over 400 breeding bird species in Canada and the United States (Government of Canada 2018). Surveys are run along permanent 39.2 km routes that comprise 50 stops, spaced 0.8 km apart. Each route is surveyed once annually, during the height of the breeding season for most songbirds, and beginning one half-hour before sunrise. At each of the 50 stops, observers document the total number of individuals of each bird species heard from any distance or visually observed within 0.4 km of each stop during a 3-minute observation period (Government of Canada 2018). Trends over time in Canada are analyzed using a hierarchical generalized additive model.

In Canada, the BBS provides the most comprehensive and reliable data for Barn Swallow population and trend estimates. However, BBS data do have some limitations, primarily relating to detectability and roadside bias. Observer experience, weather conditions and the detectability of the species are all factors that can introduce bias into the dataset. However, these factors are unlikely to have changed much over time, and may therefore have more bearing on population estimation than trend estimation.

A key strength of the BBS is that data are gathered from across North America, following a standardized survey protocol. BBS routes are located throughout all major habitat types that Barn Swallow occupies. However, there are some regions, specifically at the northern edge of the species' range in Canada, which are not well surveyed by the BBS and where reliability of results is considered lower.

Breeding Bird Atlas Projects

Provincial and state breeding bird atlas projects are normally carried out over a period of about five years. They provide snapshots of breeding distribution and abundance, and when repeated, allow for analysis of change in both the extent and area of occupancy. Data are commonly recorded at the scale of a 10 x 10 km grid, with results rolled up to 100 x 100 km blocks for northern regions with less coverage. Many atlases include point counts that are used to derive an index of abundance. A general limitation of atlases is that they are typically only repeated at 20-year intervals, so for species with short generation times and rapidly changing abundance or distribution, results can be somewhat outdated by the end of the cycle.

In Canada, atlas projects have been completed (or have begun) in all provinces, but only Alberta, Ontario, Quebec, and the Maritimes have completed a second atlas. Collectively, the atlases cover the majority of Barn Swallow's Canadian breeding range. Atlas projects have been completed since 2000 in British Columbia (Davidson *et al.* 2015), Alberta (Federation of Alberta Naturalists 2007), Manitoba (Artuso *et al.* 2018), Ontario (Cadman *et al.* 2007), Quebec (Robert *et al.* 2019), and the Maritimes (New Brunswick, Prince Edward Island, and Nova Scotia; Stewart *et al.* 2015). Interim results are available from the Saskatchewan atlas currently underway (Birds Canada 2021).

Abundance

Partners in Flight (PIF) estimated the global population of Barn Swallow as of 2019 to be 190 million adults, with 47 million in Canada and the United States, including 6.4 million (13.6%) in Canada (PIF 2019; Table 1). The North American population estimates are primarily based on BBS data from 2006 to 2015. The Boreal Avian Modelling (BAM) Project estimated a Canadian population of 40 million using the BAM avian dataset (v.4), which includes BBS and breeding bird atlas data as well as automated recording unit data from the Wildtrax acoustic database (BAM 2020). The PIF and BAM estimates are quite different, and it is difficult to know which one is more accurate. The actual Canadian population size is likely somewhere in between, but conservatively estimated to be at least 6.4 million mature individuals.

Table 1. Population estimates of Barn Swallow in Canada based primarily on 2006-2015 Breeding Bird Survey data (PIF 2019).

Province / Territory	Population estimate*	% of Canadian population	Lower 95% Bound	Upper 95% Bound
Saskatchewan	1,900,000	29.5	1,200,000	2,900,000
Manitoba	1,100,000	17.1	700,000	1,500,000
Alberta	910,000	14.2	600,000	1,300,000
Ontario	860,000	13.4	550,000	1,300,000
British Columbia	800,000	12.4	410,000	1,400,000
Quebec	510,000	7.9	350,000	720,000
Northwest Territories + Nunavut	180,000	2.8	53,000	400,000
New Brunswick	78,000	1.2	36,000	140,000
Nova Scotia	76,000	1.2	41,000	130,000
Yukon	14,000	0.2	3,400	32,000
Prince Edward Island	3,700	0.06	1,400	7,000
Newfoundland and Labrador	270	0.004	0	1,200
Canada Total	**6,431,970**	**100**	**3,944,800**	**9,830,200**

*Details of the methods are presented in Will *et al.* 2019 and Stanton *et al.* 2019.

Population estimates at the provincial/territorial scale have broad ranges of uncertainty, but Saskatchewan is estimated to host about 30% of the Canadian population, with the three Prairie provinces together accounting for about 61% of the total (PIF 2019; Table 1). The second Ontario breeding bird atlas estimated 400,000 Barn Swallows in the province (Cadman *et al.* 2007), about half the PIF (2019) estimate of 860,000 individuals, but other atlases have not provided population estimates.

Fluctuations and Trends

Breeding Bird Survey

Long-term BBS results for Canada estimate an average annual trend of -2.34% (95% Credible Interval [CI] = -2.66, -2.05) per year between 1970 and 2019, corresponding to a cumulative decline of 68.6% (95% CI = -73.3, -63.8) over 49 years (Smith unpubl. data; Figure 9; Table 2). All provinces and territories with sufficient data for trend estimation have long-term declines, all of which have 95% credible intervals entirely below zero, except Northwest Territories (Table 2).

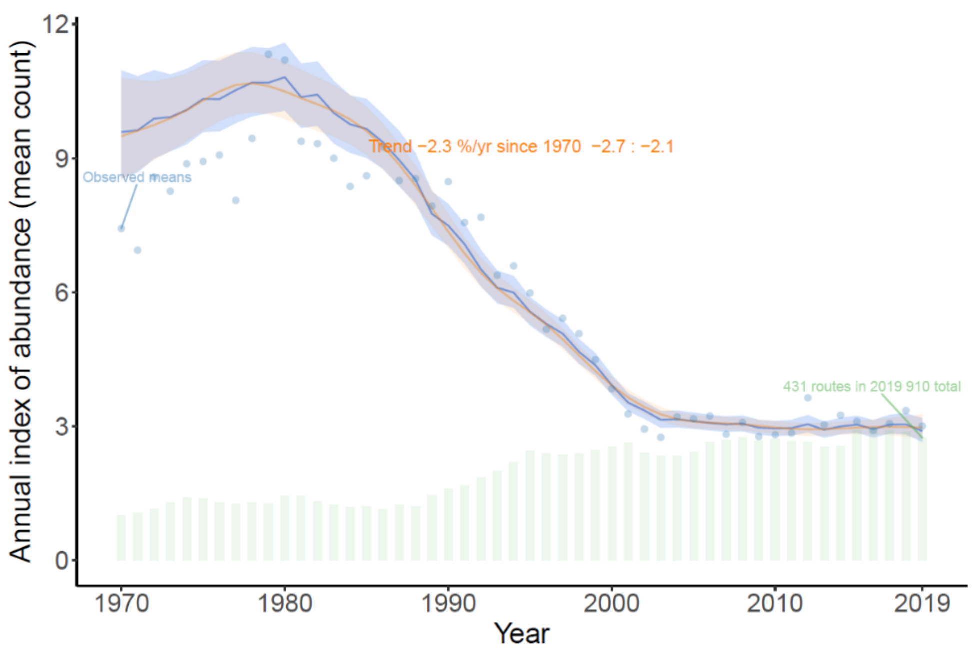

Figure 9. Annual index of population abundance for Barn Swallow in Canada, based on Breeding Bird Survey data from 1970 to 2019 (n=910 routes), with observed means shown with blue dots. The GAM (generalized additive model) trend in orange represents the best curvilinear fit of data, whereas the slope trend in blue incorporates effects of annual variation. Orange (appearing gray in areas of overlap) and blue shading, respectively, show 95% credible intervals for the GAM and slope trends. Green bars indicate the number of survey routes in Canada with Barn Swallow detections (A. Smith unpubl. data).

Table 2. Short-term (2009-2019) and long-term (1970-2019) population trends for Barn Swallow in Canada, based on 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).

Region	Annual % Rate of Change (95% lower/upper credible intervals)	Cumulative % Change (95% lower/upper credible intervals)	Probability of decline >30%	Number of routes	Reliability
Short-term					
Canada	-0.12 (-1.07, 0.89)	-1.2 (-10.3, 9.2)	0	720	High
British Columbia	-1.63 (-4.30, 1.03)	-15.2 (-35.5, 10.7)	0.10	100	Medium
Alberta	-1.93 (-4.06, 0.30)	-17.7 (-33.9, 3.0)	0.07	147	Medium
Saskatchewan	**2.71 (0.50, 5.00)**	**30.7 (5.1, 62.9)**	0	67	Medium
Manitoba	0.25 (-1.34, 1.88)	2.6 (-12.6, 20.4)	0	73	High
Ontario	**-2.95 (-4.35, -1.57)**	**-25.9 (-35.9, -14.6)**	0.22	134	High
Quebec	**-3.16 (-5.61, -0.40)**	**-27.5 (-43.9, -3.9)**	0.39	107	Medium
New Brunswick	0.19 (-2.88, 3.44)	1.9 (-25.4, 40.2)	0.01	34	Medium
Nova Scotia & Prince Edward Island	-2.85 (-6.68, 0.74)	-25.1 (-49.9, 7.7)	0.36	35	Low
Yukon	-3.58 (-13.18, 7.04)	-30.5 (-75.7, 97.4)	0.50	10	Low
Northwest Territories	4.05 (-6.16, 14.76)	48.8 (-47.1, 296.2)	0.08	7	Low
Long-term					
Canada	**-2.34 (-2.66, -2.05)**	**-68.6 (-73.3, -63.8)**	1.0	910	High
British Columbia	**-3.21 (-3.98, -2.45)**	**-79.8 (-86.3, -70.3)**	1.0	127	High
Alberta	**-1.81 (-2.49, -1.16)**	**-59.2 (-70.9, -43.6)**	1.0	181	High
Saskatchewan	**-0.81 (-1.62, -0.07)**	**-33.0 (-55.1, -3.5)**	0.60	110	High
Manitoba	**-1.67 (-2.33, -1.03)**	**-56.1 (-68.5, -39.9)**	1.0	74	High
Ontario	**-2.10 (-2.49, -1.72)**	**-64.7 (-70.9, -57.3)**	1.0	166	High
Quebec	**-4.89 (-5.61, -4.17)**	**-91.4 (-94.1, -87.6)**	1.0	142	High
New Brunswick	**-4.78 (-5.42, -4.11)**	**-90.9 (-93.5, -87.2)**	1.0	43	High
Nova Scotia & Prince Edward Island	**-4.51 (-5.29, -3.72)**	**-89.6 (-93.0, -84.4)**	1.0	39	High
Yukon	**-5.53 (-8.57, -2.29)**	**-93.8 (-98.8, -67.8)**	1.0	15	Medium
Northwest Territories	0.15 (-4.95, 5.49)	7.4 (-91.7, 1270.3)	0.38	7	Low

In contrast, the Canadian BBS trend over the most recent 10-year period (2009-2019) is close to stable, at -0.12% per year, or an estimated change of -1.2% over the decade (95% CI = -10.3% to 9.2%; Table 2). There has been a steady improvement in the national 10-year trends since 2004 (Figure 10). However, there is considerable regional variation in the latest 10-year trends across the country, and precision in some provinces and territories is quite poor (Figure 11; Table 2). Substantial rates of decline have persisted in Yukon, Ontario, Quebec, Prince Edward Island, and Nova Scotia, with lesser decreases in British Columbia and Alberta. Of the four provinces and territories showing increases, only Saskatchewan had a trend with 95% credible intervals entirely above zero, but as it has nearly 30% of the Canadian population, it strongly influenced the national trend. It is not apparent why the population increase in Saskatchewan is so much greater than elsewhere, and therefore it is unclear whether it is sustainable.

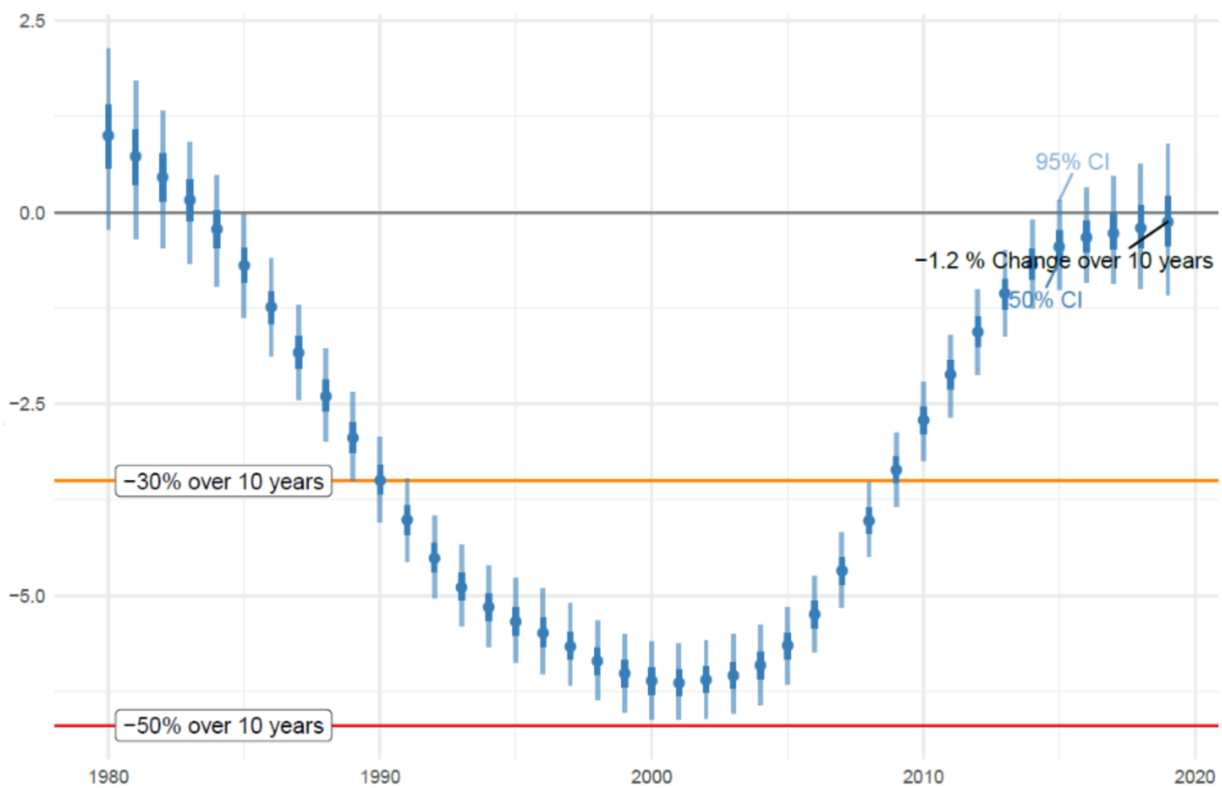

Figure 10. Rolling 10-year trends of Barn Swallow population change in Canada based on Breeding Bird Survey data for 1970-2019 (Smith unpubl. data). The vertical axis represents the average annual percent change in population size over a three-generation period. The horizontal axis represents the last year of the 10-year rolling trend (e.g., 2019 is the trend for 2009-2019). Orange and red horizontal lines depict 30% and 50% cumulative 10-year decline rates, which represent COSEWIC thresholds for assessing a species as Threatened and Endangered, respectively. Vertical bars represent the 50% (broad, dark blue) and 95% (narrow, light blue) credible intervals.

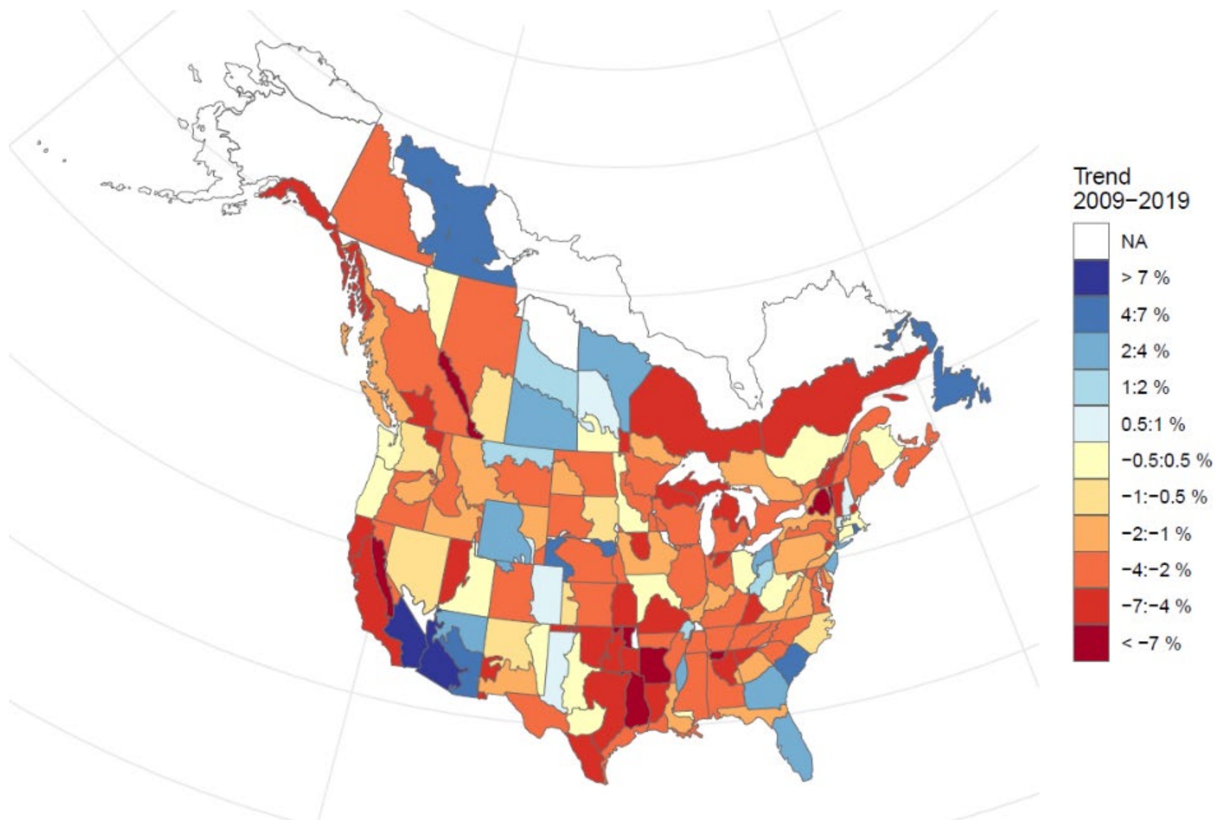

Figure 11. Regional variation in short-term (2009-2019) annual Breeding Bird Survey trends for North America, at the scale of Bird Conservation regions within provinces, territories, and states (A. Smith unpubl. data 2020).

Breeding Bird Atlas Projects

In British Columbia, the distribution of Barn Swallow during the province's first Breeding Bird Atlas (2008-2012; Hearne 2015) appears not to have undergone significant changes compared to what was previously summarized in The Birds of British Columbia in 1997 (Campbell *et al.* 1997). In Alberta, relative abundance of Barn Swallow declined in all Natural Regions between the first atlas (1987-1991) and the second (2000-2005; Federation of Alberta Naturalists 2007; COSEWIC 2011), but the period over which this decline was recorded is over 15 years ago.

In Ontario, comparisons of probability of observation between the first (1981-1985) and second (2001-2005) atlas documented an overall significant decline of 35% (Cadman *et al.* 2007; COSEWIC 2011). Breeding records of Barn Swallow became more sporadic in the Algonquin Highlands as well as the Southern Shield region of Ontario (Cadman *et al.* 2007). Again, the period over which this decline was recorded is over 15 years ago.

In Quebec, the distribution of Barn Swallow during the second breeding bird atlas (2010-2014) did not substantially differ in comparison to the first atlas (1985-1989; Robert *et al.* 2019). However, there was a reduction in the relative abundance of breeding Barn Swallow within the Boreal Shield ecozone (Robert *et al.* 2019).

In the Maritimes, Barn Swallow declined substantially between the first (1986-1990) and second (2006-2010) atlases, notably within central New Brunswick (Stewart *et al.* 2015), but the period over which this decline was recorded is over 10 years ago.

<u>Summary of trends</u>

At a national scale, the Barn Swallow population has fluctuated around a largely similar level since the early 2000s (Figure 9), but despite the long-term decline abating, it has not yet shown any short-term increases (Figure 10). Short-term trends vary considerably by region, so although the national trend for Canada is close to stable (Table 2), there are far more areas reporting declines than increases, a pattern which holds for North America overall (Figure 11). Results from the majority of Canadian breeding bird atlas projects are largely to entirely limited to before the most recent ten-year period, and therefore provide limited insights into current trends.

Rescue Effect

Barn Swallow breeds in all US states along the Canadian border and is considered common in most of them (PIF 2019). The US population is considered to be common and secure (see **Non-Legal Status and Ranks**), but recent (10-year) declines for the species have been observed in most states that border Canada (Table 3). Although Barn Swallow is highly mobile and immigration into Canada from the United States very likely occurs, it is probable that any drastic future decline in the Canadian population would also be reflected in the United States population, and rescue therefore would be improbable.

Table 3. Barn Swallow population estimates (PIF 2019) and short-term (2009-2019) population trends in US states bordering Canada from west to east, based on Breeding Bird Survey results (Smith unpubl. data). Bolded trends have 95% credible intervals that do not cross zero and are highly likely to represent a substantial rate of change.

State	Population estimate	Annual % Rate of Change (95% lower/upper credible intervals)	Cumulative % Change (95% lower/upper credible intervals)	Probability of decline >30%	Number of routes	Reliability
Washington	970,000	-0.44 (-2.42, 1.53)	-4.3 (-21.8, 16.4)	0	75	Medium
Idaho	640,000	-1.25 (-4.10, 1.80)	-11.8 (-34.2, 19.5)	0.06	44	Medium
Montana	870,000	-0.85 (-3.25, 1.69)	-8.1 (-28.1, 18.2)	0.01	86	Medium
North Dakota	1,200,000	**-2.01 (-3.81, -0.23)**	**-18.3 (-32.2, -2.3)**	0.05	48	Medium
Minnesota	1,400,000	-1.46 (-3.10, 0.16)	-13.7, -27.0, 1.6)	<0.01	79	High
Michigan	750,000	**-2.88 (-4.79, -0.91)**	**-25.3 (-38.8, -8.7)**	0.26	70	Medium
Pennsylvania	1,000,000	**-1.64 (-2.76, -0.49)**	**-15.2 (-24.4, -4.8)**	<0.01	100	High
Ohio	1,100,000	0.96 (-0.65, 2.58)	10.0 (-6.3, 29.1)	0	59	High
New York	710,000	**-2.07 (-3.46, -0.65)**	**-18.9 (-29.7, -6.4)**	0.02	96	High
Vermont	53,000	**-5.73 (-9.89, -2.76)**	**-44.6 (-60.1, -24.4)**	0.93	23	Medium
New Hampshire	39,000	0.07 (-2.54, 2.75)	0.7 (-22.7, 31.2)	<0.01	24	Medium
Maine	85,000	-2.89 (-6.12, 0.12)	-25.4 (-46.8, 1.2)	0.35	47	Medium

THREATS AND LIMITING FACTORS

Threats

Barn Swallow is among the aerial insectivores that has experienced significant population declines in North America since the 1980s (Nebel *et al.* 2010; Smith *et al.* 2015; Sauer *et al.* 2017; Spiller and Dettmers 2019). It is vulnerable to the cumulative effects of various threats, especially the intensification of agriculture, decline of flying insect prey, loss of nest sites, and climate change. Threats 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. Threats to Barn Swallow across its range are complex, asynchronous, and may be region- or site-specific. This is perhaps most evident in the migratory divide noted between Barn Swallows in eastern and western Canada (Garcia-Perez and Hobson 2014; Hobson *et al.* 2015; Hobson and Kardynal 2016; Imlay *et al.* 2018a). Barn Swallows that breed in eastern Canada migrate considerably farther than those in the west, which may exacerbate the effects of some threats, as reflected by BBS and breeding bird atlas data that indicate greater declines in eastern Canada.

This threats assessment is an update of the one undertaken for development of the federal Recovery Strategy; key differences include a greater understanding of how threats such as pesticides and habitat loss affect the availability of aerial insect prey, further insight on the impact of climate change, and a downgrading of threats related to the perceived loss of suitable nest sites. The overall threat impact is considered to be Medium, corresponding to an anticipated decline of between 3 and 30% over the next ten years (Master *et al.* 2012; see **Appendix 1** for details).

<u>IUCN 7, Natural System Modifications (medium-low threat impact):</u>

Other ecosystem modifications (IUCN 7.3)

In recent decades, broad-scale ecosystem modifications within the breeding, migratory, and wintering ranges may have contributed to reductions in the abundance of flying insects. These notably include widespread pesticide use (Hallman *et al.* 2014; Spiller and Dettmers 2019), intensification of agricultural practices (Rioux Paquette *et al.* 2013; Evans *et al.* 2007), and increasingly frequent cold snaps in spring that limit insect availability. Direct effects on Barn Swallow from these threats are captured under IUCN 9 (pollution), IUCN 2 (agriculture and agriculture), and IUCN 11 (climate change)

Some studies have reported large global declines in insect populations, including considerable losses among Lepidoptera, Hymenoptera, Coleoptera, and aquatic emergent insects (Sánchez-Bayo and Wyckhuys 2019; Stepanian *et al.* 2020). However, critics have noted biases in taxonomic sampling and analytical methods and urge caution in interpreting declines, especially at a global scale (Wagner *et al.* 2019; Saunders *et al.* 2020). To date, research on aerial insect declines has been focused more on Europe than North America (Saunders *et al.* 2020).

Neonicotinoid pesticides have been specifically linked to declining insect populations in Europe and North America, and are noted as particularly effective against Diptera (Morrisey *et al.* 2015). They are associated with changes in the timing of aquatic insect emergence and a decline in the populations of mayflies (*Hexagenia* spp.) in North America (Stepanian *et al.* 2020). In the United States, increased use of neonicotinoids between 2008 and 2014 has been linked to statistically significant reductions in bird biodiversity (Li *et al.* 2020).

Changes in land use related to agricultural practices (see IUCN 2, below) are also thought to be a factor reducing aerial invertebrate abundance (Evans *et al.* 2007). In Britain, invertebrate abundance in pastures was two to three times greater than in hay fields and up to seven times greater than in cereal crops, and Barn Swallow abundance was positively correlated with invertebrate abundance (Evans *et al.* 2007). Hedgerows or vegetated boundaries between fields support greater flying invertebrate abundance than field centres, particularly in inclement weather (i.e., high winds and precipitation; Wilson *et al.* 1999; Evans *et al.* 2003); such areas tend to be lost with crop intensification. A study in Quebec found that insect abundance in intensive agricultural landscapes was similar to other landscapes in June, but declined in intensive agricultural landscapes as summer progressed, creating a potential ecological trap for Barn Swallows breeding in these areas (Rioux Paquette *et al.* 2013).

Despite the apparent alterations to prey populations, several recent studies have found that intensification of farming and conversion of pasture to row crop has no discernible effect on Barn Swallow fecundity or survival. A study near Vancouver, British Columbia, found that Barn Swallow fledglings favoured crops, including berries, potatoes, peas, beans, corn, alfalfa, and barley, over all other available habitat types, including marsh and pasture (Boynton *et al.* 2020). Additional studies in Canada have shown a positive effect of the conversion of pasture to row crop on nestling and pre-fledging condition, as well as the number of young fledged (Lansdorp 2017; Kusack *et al.* 2020). Other studies have shown that although the diversity of available prey decreases as agricultural intensification increases, dipteran abundance was unaffected by such changes, and may buffer Barn Swallow from declines in the overall diversity of available prey (Kusack 2018).

The evidence of insect quantity affecting Barn Swallow breeding performance and nestling quality is mixed (Berzins 2020). In Denmark, reduced prey availability was found to sometimes result in smaller clutches, longer nesting periods and nestlings with lower body mass (Teglhøj 2017). A study on Tree Swallow (*Tachycineta bicolor*) in British Columbia and Saskatchewan found that late-breeding pairs faced a decline in environmental quality and insect biomass, resulting in nestlings with poor body condition, smaller size, shorter bills and shorter, slower growing flight feathers, causing an overall reduction in their likelihood of surviving to fledge (Harriman *et al.* 2017). A study in New Brunswick found no connection between insect abundance and nestling survival and mass (Imlay *et al.* 2017). Similarly, McClenaghan *et al.* (2019a) found that limited prey availability did not affect Barn Swallow colony size, timing of reproduction or reproductive output in Ontario. Tree Swallow breeding success and nestling quality have been closely linked to the quality of insect prey, particularly aquatic emergent insects which have higher levels of long-chain omega-3 polyunsaturated fatty acid than their terrestrial counterparts (Twining *et al.* 2016), but it is not known what effect insect quality, particularly among aquatic emergent insects, has on Barn Swallow breeding performance. Barn Swallow has a highly flexible diet and could potentially adapt to changes in insect prey quality and abundance (McClenaghan *et al.* 2019b). Additional research is needed to explore the relationship between changes in agricultural land use, pesticides, invertebrate abundance and diversity, and effects on Barn Swallow survival.

Increasingly volatile spring and early summer weather can include periods of cold that limit availability of insect prey and lead to swallow mortality (Anthony and Ely 1976; Stokke *et al.* 2005). In the United Kingdom, Facey *et al.* (2020) found that weather (wind, rain, and temperature) was correlated with availability of flying insects and nest site microclimate; Barn Swallow nestling mass was negatively correlated with temperature, especially under wet and calm conditions. A literature review by Imlay and Leonard (2019) found inclement weather to be associated with a 13-53% decline in adult survival of several swallow species, including Barn Swallow. Møller (2011) reported a 20-50% decline in Barn Swallow numbers in Central Europe following a period of unusually cold weather during fall migration that resulted in reduced prey availability.

<u>IUCN 11, Climate change (medium-low threat impact):</u>

Changes in temperature regimes (IUCN 11.3), Changes in precipitation and hydrological regimes (IUCN 11.4), Severe / extreme weather events (IUCN 11.5)

Climate change has been identified as a possible driver in the decline of Barn Swallow populations, given its potential to affect spatial and temporal patterns of invertebrate availability (addressed under IUCN 7.3), timing of migration, initiation of breeding, and direct mortality through increased extreme weather events (Turner 2006; Nebel *et al.* 2010; Brown and Brown 2020). However, there has been little direct study of the impacts of climate change on Barn Swallow populations.

Long-distance migrants are likely to be particularly vulnerable to climate change because their complex annual phenology is dependent on temperature conditions and food availability in different geographic regions (Both *et al.* 2010). Average Barn Swallow clutch initiation dates in North America were 8-10 days earlier in 2006-2016 compared to 1962-1972, but this corresponded with a slight increase in breeding performance (Imlay *et al.* 2018b). There is little evidence that advanced egg laying dates have resulted in a phenological mismatch between insect availability and Barn Swallow peak food demands. However, earlier clutch initiation dates may expose nestlings to more adverse weather conditions, which may result in reduced body condition or nestling survival (Nebel *et al.* 2010), as has been observed in Tree Swallow (Cox *et al.* 2020). During a cold snap on the night of May 8, 2010 at Long Point, Ontario, Barn Swallows were observed entering an enclosed porch for warmth. Most died overnight, and researchers estimated that dozens to hundreds of swallows likely died during the event (Burrell pers. comm. 2020; Government of Canada 2020).

Adult survival rates and fecundity in migratory insectivores tend to be lower in years with high El Niño Southern Oscillation (ENSO) or high North Atlantic Oscillation (NAO) values (Sillett *et al.* 2000; Stokke *et al.* 2005; Nebel *et al.* 2010). However, a study in Seattle, Washington found higher Barn Swallow survival rates in years preceded by ENSO winters and in years with higher NAO values, whereas an Ontario population had similar survival rates in years with and without the influence of the ENSO and NAO (García-Pérez *et al.* 2014). The differences among these results highlight the variability in response among populations and the difficulty in predicting impacts.

Climate change has potential to increase mortality risk for Barn Swallow through greater severity and frequency of hurricanes and other severe weather events (Dionne *et al.* 2008). Eastern North American Barn Swallows may be particularly vulnerable to the effects of climate change, as they migrate longer distances than their western counterparts, and may cross the Gulf of Mexico in fall, exposing them to a greater risk of severe storms (Hobson *et al.* 2015; Hobson and Kardynal 2016; Imlay *et al.* 2018a).

Climate change can cause changes in the temporal phenology and abundance of ectoparasites as a result of changing temperatures (Møller 2010). Different parasite species are affected in diverse ways by climate change, which may alter the composition of parasite communities. These phenological changes can result in both positive and negative effects on their hosts' (Barn Swallow) breeding dates and annual fecundity (Møller 2010). Studies have shown that increased presence of ectoparasites at Barn Swallow nest sites can lead to delayed reproduction and reduced reproductive success (Møller 1990, 2010).

IUCN 1, Residential and Commercial Development (low threat impact):

Housing and urban areas (IUCN 1.1), Commercial and industrial areas (IUCN 1.2)

Unusual among birds, Barn Swallow benefits from houses and other built structures that provide substrates for nests. However, modern buildings rarely have suitable surfaces, as they increasingly have steel, aluminum, vinyl, or concrete sidings and lack beams or ledges (Brown and Brown 2020). As older houses and cottages are replaced, there is a net loss of available nesting structures for Barn Swallow, which in some areas may play a role in population declines (Turner 2006). Barn Swallows are often attracted to nesting sites by the presence of old nests. The loss or inaccessibility of these sites has been linked to declines in the number of immigrants settling and the number of breeding pairs (Safran 2004), similar to the effect of targeted removal of nests (see IUCN 5). However, there are also large parts of the Canadian breeding range where suitable buildings remain available for nesting, but Barn Swallow density is low, suggesting that the importance of this factor varies regionally.

Collisions with buildings and windows appear to be less of a concern for Barn Swallow than most other passerine species (Brown and Brown 2020).

IUCN 2, Agriculture and Aquaculture (low threat impact):

Annual and perennial non-timber crops (IUCN 2.1), Livestock farming and ranching (IUCN 2.3)

Wooden barns, with their rough texture, provide an ideal substrate for Barn Swallows to affix their nests (Turner 2006). Modernized construction of barns with metal and concrete becoming the preferred construction materials may be restricting the availability of nest sites for Barn Swallows (Erskine 1992; Nicholson 1997; Cadman *et al.* 2007; Brown and Brown 2020). In some areas Barn Swallows have preferentially nested on concrete substrates rather than wood, but irregularities in the substrate are still necessary for the nest to be affixed securely (Jackson and Burchfield 1975). Although old wooden barns may not often be actively demolished, many are decaying due to neglect and abandonment. Despite the decrease in available nest sites, many suitable structures remain, yet are unoccupied, suggesting that nest site availability may be a minor factor in population declines (Burrell pers. comm. 2020). A study on Cliff Swallows comparing nestling survival for pairs nesting on barns with wooden roofs and metal roofs found that the temperature of the eaves where nests were affixed increased with ambient temperature and was higher at high temperatures and lower at cool temperatures under metal roofs than wood roofs (Imlay *et al.* 2018c). Nestling survival was lower during periods of high ambient temperature and both nestling survival and mass were lower under metal roofs (Imlay *et al.* 2018c). Metal-roofed buildings may therefore act as an ecological trap, as they appear suitable early in the breeding season, but result in greater nestling mortality (Imlay *et al.* 2018c).

Modern barns, out-buildings, and grain storage facilities are also well-sealed to prevent wildlife from entering, which may limit access to preferred nesting areas for Barn Swallow (Evans and Robinson 2004). Barn Swallows nesting in buildings that house livestock have been shown to have greater rates of nestling survival, have larger clutches, and are more likely to produce second broods than those nesting in structures without livestock present (Møller 2001; Grüebler *et al.* 2010).

In British Columbia, use of greenhouses for agriculture has intensified greatly in the past 20 years. At a study area for Barn Swallow near Vancouver, British Columbia, the area occupied by greenhouses increased from 21 ha in 1995 to 271 ha in 2018 (Boynton 2020). Greenhouses do not typically provide suitable nesting sites and may also reduce availability and quality of foraging habitat.

Farming has intensified substantially in Canada over the past 70-80 years, with the number of farms decreasing by nearly 75% (732,000 farms in 1941 to 194,000 farms in 2016; Chen *et al.* 2019), while the average size has increased by about 194% (113 ha in 1951 to 332 ha in 2016; Chen *et al.* 2019). There has also been a switch from smaller mixed-farming systems to large farms which specialize in either crops or livestock (Stanton *et al.* 2018). Advances in agriculture and tile drainage have meant that crop fields are larger, with removal of hedgerows and field margin vegetation to maximize arable land (Conover *et al.* 2014). All of these factors reduce the diversity of habitat in farmland and decrease the quality of foraging habitat (Stanton *et al.* 2018). These patterns are also reflected on the wintering grounds throughout Central and South America, where agricultural practices have both expanded and intensified resulting in the loss of wetlands, savannah, and smaller farms that provide optimal foraging habitat for Barn Swallow (Imlay *et al.* 2018a).

Overall, the effects of changing agricultural practices on Barn Swallow remain poorly understood, but are likely only a contributing factor in the overall decline of the species in North America (Spiller and Dettmers 2019). More research is needed to understand the differences in land-use changes in areas with stable or increasing populations compared to those with continuing declines.

IUCN 4, Transportation and Service Corridors (low threat impact):

Roads and railroads (IUCN 4.1)

Roads exist throughout most of Barn Swallow range and are likely encountered at some point by all individuals. Bridges and culverts associated with roads have become a favoured Barn Swallow nest site, perhaps second only to buildings (Peck and James 1987). However, nests are sometimes removed from bridges and culverts during construction and maintenance, and new and renovated bridges or culverts are often designed specifically to prevent Barn Swallow from nesting to avoid future conflict with maintenance activities (OMNRF 2017). In Ontario, artificial Barn Swallow structures (or kiosks) are usually provided when work is proposed on a bridge known to be used by Barn Swallows (OMNRF 2016). These mimic other anthropogenic nesting structures, and a recent study found they are somewhat effective, although rarely occupied by multiple pairs, despite the availability of additional nest spots (BSC 2019).

The proximity of Barn Swallows nesting on bridges and culverts to vehicular traffic can result in mortality due to collisions with vehicles (Brown and Brown 2020). A study in Britain found that juvenile Barn Swallows were more susceptible to being struck by vehicles than were adults (Mead 2002). Research in Poland documented a positive correlation between Barn Swallow road mortalities and the presence of trees or hedgerows along roadways. Individuals foraged closer to vegetation corridors in poor weather, increasing mortality risk, amounting to >1 million swallows annually across Europe (Orlowski 2005). Road mortality has been shown to impact the quality of avian populations: it randomly removes healthy individuals from the population, and their loss could exacerbate declines of species that are already at risk (Bujoczek *et al.* 2011). Although road mortality is not believed to be a significant driver of Barn Swallow population declines, it likely plays a contributing role.

IUCN 5, Biological resource use (unknown threat impact):

Hunting and collecting terrestrial animals (IUCN 5.1)

Barn Swallow is generally well-liked, and often encouraged to nest on residences and other human-made structures in some parts of the world; despite this, some people remove nests because they consider the noise and associated feces to be a nuisance (Turner 2006; Brown and Brown 2020). The removal of active nests has immediate and clear effects on nesting success. Removal of old nests outside the nesting season also reduces the potential for Barn Swallows to return to the nest site in subsequent years, as these nests play an important role in site selection, particularly for first-time breeders (Safran 2004; Turner 2006). It is not known how much of an impact the removal of nests has on Barn Swallow populations or whether population declines correlate with an increase in persecution.

In North America, widespread hunting of Barn Swallows for use in the hat-making trade largely ceased by the early 1900s, and illegal hunting is considered to be a negligible threat today (Brown and Brown 2020). Hunting of Barn Swallows for human consumption on their over-wintering grounds in Central and South America is not well documented, but is unlikely to be a significant threat (Brown and Brown 2020).

IUCN 9, Pollution (unknown threat impact):

Industrial and military effluents (IUCN 9.2), agricultural and forestry effluents (IUCN 9.3), airborne pollutants (IUCN 9.5)

Pollutants and pesticides may be contributing to the decline in Barn Swallow populations through consumption of contaminated insect prey (Turner 2006; Spiller and Dettmers 2019). However, indirect effects of pesticides on prey availability (see IUCN 7) are thought to be more detrimental to aerial insectivores than direct accumulation (Turner 2006; Hallman *et al.* 2014). In Europe, polychlorinated biphenyls (PCBs) and other organochlorines have been found in high concentrations in the muscle tissue of Barn Swallows (Kannan *et al.* 2002). The effects of these contaminants have not been studied in Barn Swallows; however, high concentrations of PCBs in Tree Swallow have been correlated with poor nest construction, desertion of nests, failure of eggs to hatch, and early breeding (McCarty and Secord 1999a,b, 2000).

Neonicotinoid pesticides, such as imidacloprid, have become the most widely used group of insecticides across the globe; recent studies have shown them to be moderately to highly toxic in small-bodied bird species (Gibbons *et al.* 2015). Direct accumulation of neonicotinoids seems to have the greatest impact on granivorous species consuming crops treated with the pesticides. However, the extent to which it bioaccumulates in insectivores is not yet well understood, and more study is needed to understand its potential impact on Barn Swallow (Gibbons *et al.* 2015; Spiller and Dettmers 2019). A study of Tree Swallow in the Canadian prairies did not find any correlation between neonicotinoid concentrations and nestling health (Elgin 2019). In the Netherlands, a study found that where imidacloprid was present in surface water in concentrations above 20 ng/l, bird populations declined by 3.5% on average annually (Hallman *et al.* 2014). The widespread use of neonicotinoids began in the 1990s and does not directly correlate with the observed start of aerial insectivore decline in North America. It thus does not appear to have initiated negative population trends (Spiller and Dettmers 2019), but is considered likely to be a contributing factor.

Pesticides are also still widely used on wintering grounds of Barn Swallow, where they are generally less regulated than in Canada. Insectivorous neotropical migrants have significantly higher organochloride pesticide levels than non-insectivorous species, and declines in aerial insectivores are most acute in species that migrate to South America (Klemens *et al.* 2000; Nebel *et al.* 2010). Further research is required to understand the effects that pesticide exposure on wintering grounds may have on Barn Swallow populations.

Toxic metals have also been detected in Barn Swallow, with exposure found to be higher for this species in cropland habitats (Orlowski *et al.* 2015). To date, there has been no evidence of effects on breeding success resulting from exposure to toxic metals. A study on Tree Swallows with mercury, selenium, strontium, and thallium detected in their blood and eggs did not find any influence on nestling quality or reproductive success (Beck *et al.* 2015).

Limiting Factors

The dietary dependence of Barn Swallow on aerial insects is a limiting factor for the species. Despite a relatively flexible diet, the species is an obligate insectivore, requiring insect prey at all life stages to survive (McClenaghan *et al.* 2019b). Significant and pervasive declines have been observed amongst many aerial insectivores. Although there are multiple, complex drivers for this decline, aerial insectivores' dependence on insect prey is a commonality that likely relates to many threats contributing to their overall decline (Spiller and Dettmers 2019). As a long-distance migrant, Barn Swallow is vulnerable to loss of prey in multiple regions throughout its life cycle.

Number of Locations

Barn Swallow is distributed widely across Canada. Given the large number of geographically and ecologically distinct areas in which it occurs, it is improbable that a single threatening event would affect a significant portion of the Canadian population. As a consequence, although the number of locations for this species in Canada cannot be quantified, it is certainly much higher than the COSEWIC threshold of 10.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

In Canada, Barn Swallow and its nest and eggs are protected under the *Migratory Birds Convention Act, 1994* (Government of Canada 2017). Barn Swallow is also listed as Threatened under Schedule 1 of the *Species at Risk Act* (Government of Canada 2019). It is also considered a species at risk in Ontario (Threatened), New Brunswick (Threatened), and Nova Scotia (Endangered), and is flagged as Sensitive in Alberta. Barn Swallow is not afforded protection under the *Endangered Species Act* in the United States (USFWS 2019), but is protected under the *Migratory Bird Treaty Act* (USC 1918).

Non-Legal Status and Ranks

Barn Swallow is considered globally Secure (G5) and a species of Least Concern (BirdLife International 2016), despite a declining population trend (BirdLife International 2017). In Canada, Barn Swallow is considered Vulnerable to Apparently Secure (N3N4B, N3N4M; NatureServe 2020). At a provincial/territorial level, Barn Swallow status ranges from Imperilled (S2) in Yukon, Northwest Territories, New Brunswick, Prince Edward Island, and Newfoundland and Labrador, to Secure (S5) in Saskatchewan and Ontario (NatureServe 2020; Figure 12). In the case of Yukon, Northwest Territories, and Newfoundland and Labrador, the status reflects the scarcity of records at the limits of the species' range, rather than concern over trends. In the United States, Barn Swallow is considered Secure (N5B), but in states bordering Canada, it is listed as Apparently Secure (S4) in two states, S5 in nine states and SNR (unranked) in two states (NatureServe 2020; Figure 12).

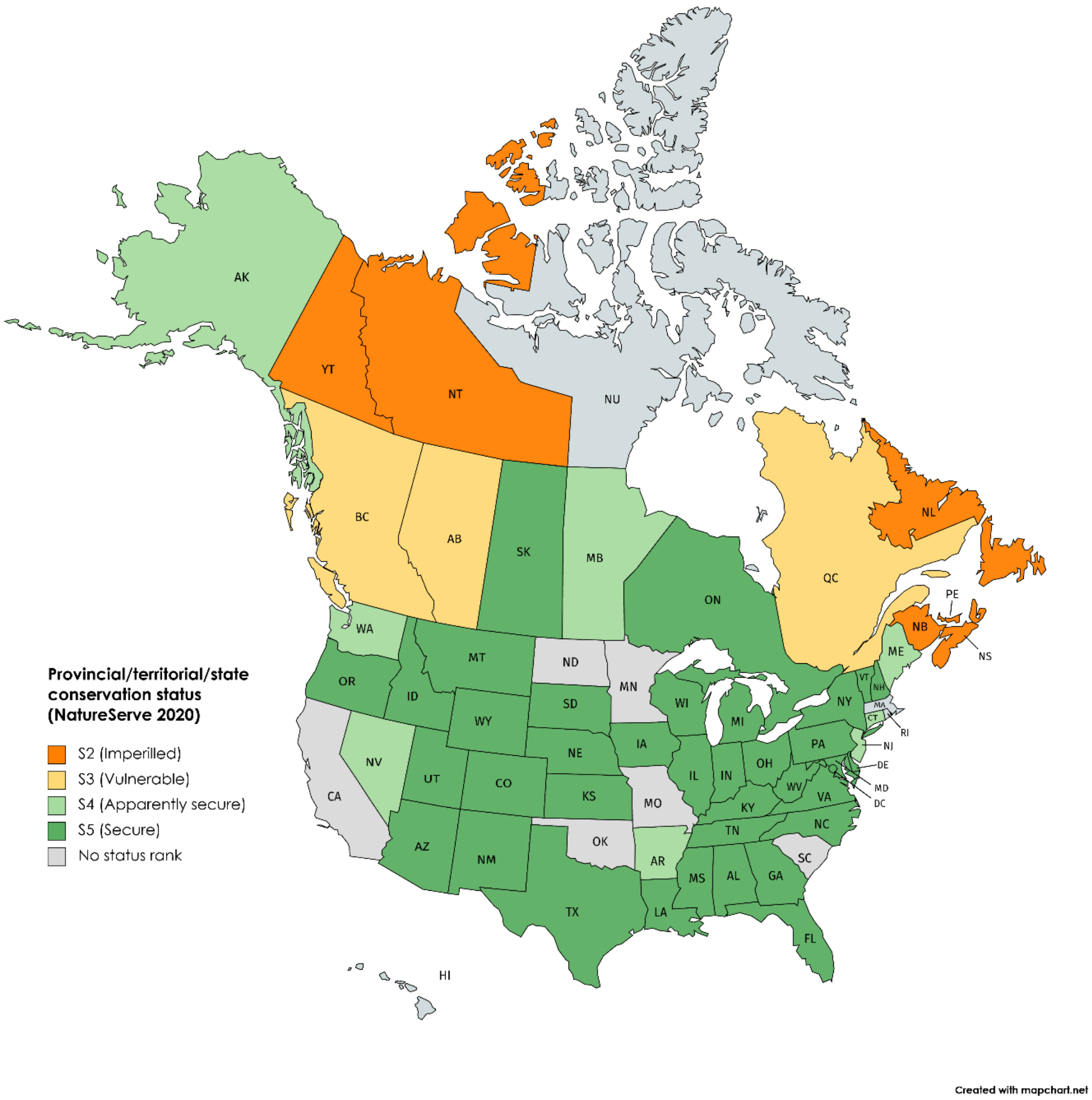

Figure 12. Map showing the conservation status of Barn Swallow in each province, territory, and state within its range in Canada and the United States (NatureServe 2020). In the case of ranges of status, the lower value is mapped (e.g., S2 for S2S3).

Habitat Protection and Ownership

The majority of Barn Swallows in Canada likely nest on privately owned lands. There is limited information available regarding the presence of suitable habitat for Barn Swallow on publicly managed lands and buildings in Canada; however, given its widespread range it is considered likely that many public lands would provide breeding habitat for Barn Swallows. Barn Swallow is considered present at 53 sites managed by Parks Canada (national parks, national park reserves, national historic sites, and national marine parks; Parks Canada 2018). It also occurs at many provincial parks, conservation areas, nature reserves, and other public lands across Canada.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER(S)

Daniel Riley is a Terrestrial and Wetland Biologist with Natural Resource Solutions Incorporated (NRSI), an environmental consulting firm located in Waterloo, Ontario. At NRSI, Daniel is a bird specialist and leads natural resource inventories and evaluations, environmental impact studies and research. Daniel is active in the Ontario birding community and is currently serving as secretary of the Ontario Bird Records Committee.

Since graduating with a Bachelor of Landscape Architecture from the University of Guelph, Daniel has worked on a number of projects focused on species at risk. These include the Windsor-Essex Parkway Project (Butler's Gartersnake and Eastern Fox Snake) and Bird Studies Canada's Swiftwatch Program (Chimney Swift).

Kenneth Burrell is a Biologist at NRSI, where he specializes in ornithology. Kenneth has been studying birds for over 20 years and has conducted many field research and monitoring studies throughout Canada. He is actively involved in the Ontario birding community and publishes widely on topics in field ornithology, ranging from species at risk to meteorological impacts on bird migration, and has recently published a book on the *Best Places to Bird in Ontario*. Kenneth volunteers widely for bird conservation programs, including the CBC, BBS, and various species at risk recoveries.

Nathan Miller is a Terrestrial and Wetland Biologist at NRSI who regularly conducts surveys and studies on birds and their habitats at sites across Canada. Nathan has nearly 20 years of experience carrying out migration monitoring, breeding bird point counts/transects, behavioural monitoring, nest searches, and targeted surveys for Species at Risk on numerous projects. Nathan is also actively involved in the bird watching community within Ontario and Canada, and regularly contributes data to eBird and other databases.

COLLECTIONS EXAMINED

No collections were examined for the preparation of this report.

Appendix 1. IUCN threats calculator for Barn Swallow.

Species or Ecosystem Scientific Name	Barn Swallow *Hirundo rustica*			
Generation time	3 yrs		**Elcode**	
Date:	2018-05-25			
Assessor(s):	Facilitator: Dwayne Lepitzki. Attendees: Mike Cadman (CWS-Ontario), Marc-André Cyr (CWS-NCR), Leah de Forest (Parks Canada Agency), Mark Elderkin (Province of Nova Scotia), David Fraser (Province of British Columbia), Andrew Huang (CWS-Pacific), Liette Laroche (Province of Quebec), Scott Makepeace (NBDERD), Kristyn Richardson (Long Point Land Trust), François Shaffer (CWS-Québec), Pam Sinclair (CWS-Northern), Peter Thomas (CWS-Atlantic), Maureen Toner (NBDERD). Modified December 2020 by Daniel Riley and Marcel Gahbauer, incorporating feedback from reviewers of COSEWIC status report update drafts.			
References:	Draft calculator (17 May 2018) prepared by Marc-André Cyr (CWS) in support of development of the federal Recovery Strategy; 25 May 2018 teleconference based on draft calculator, COSEWIC (2011), ON RS (2014), and PIF population estimates for 1998-2007.			
		Overall Threat Impact	**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	3	5
		Calculated Overall Threat Impact:	High	Medium
		Assigned Overall Threat Impact:	**C = Medium**	
		Impact Adjustment Reasons:	There is some overlap among threats, especially with respect to issues considered under other ecosystem modifications (7.3). As well, some threats are considered to be near the lower end of assessed scope. Given also that there has been a slight (3%) increase in the number of mature individuals over the past decade despite most of the identified threats being ongoing, overall threat impact was adjusted to medium.	
		Overall Threat Comments		

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development	D	Low	Small (1-10%)	Moderate - Slight (1-30%)	High (Continuing)	
1.1	Housing & urban areas	D	Low	Small (1-10%)	Moderate - Slight (1-30%)	High (Continuing)	The scope of urban development is likely near the low end of the range of small. Large parts of the Canadian breeding range are unoccupied or have low densities even though some nesting sites are available, suggesting that loss of old buildings may have little impact on the population, but severity is scored moderate-slight to reflect uncertainty and regional variability.
1.2	Commercial & industrial areas		Negligible	Negligible (<1%)	Moderate - Slight (1-30%)	High (Continuing)	Scope is considered negligible as this threat is expected to impact a very small portion of the Barn Swallow population in Canada; severity as above.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1.3	Tourism & recreation areas		Not a Threat	Negligible (<1%)	Neutral or Potential Benefit	High (Continuing)	Scope is considered negligible as this threat is expected to impact a very small portion of the Barn Swallow population in Canada; severity is scored neutral or potential benefit as it is possible that new structures could provide nesting opportunities.
2	Agriculture & aquaculture	D	Low	Small (1-10%)	Moderate - Slight (1-30%)	High (Continuing)	Effects of agricultural practices on insect prey are considered under 7.3; loss of habitat is considered here. Mixed farms are addressed under 2.1, whereas 2.3 includes dairy farms and ranches.
2.1	Annual & perennial non-timber crops	D	Low	Small (1-10%)	Moderate - Slight (1-30%)	High (Continuing)	Scope is small, considering that in most areas some suitable nesting options remain even if old barns are being removed or replaced. Severity is considered moderate-slight as more research is needed to clarify the impact of this threat.
2.2	Wood & pulp plantations						Not a threat.
2.3	Livestock farming & ranching	D	Low	Small (1-10%)	Moderate - Slight (1-30%)	High (Continuing)	Similar scores, and uncertainty, as for 2.1.
2.4	Marine & freshwater aquaculture						Not a threat.
3	Energy production & mining		Negligible	Restricted (11-30%)	Negligible (<1%)	High (Continuing)	
3.1	Oil & gas drilling						Not a threat.
3.2	Mining & quarrying						Not a threat.
3.3	Renewable energy		Negligible	Restricted (11-30%)	Negligible (<1%)	High (Continuing)	Wind farms occupy a negligible portion of Barn Swallow's range, but a restricted proportion of the population likely encounters them at some point in their life cycle. Loss of habitat is probably not a concern, but mortality is possible. Zimmerling *et al.* (2013) noted that some other aerial insectivores experienced negligible impact from wind turbine mortality (e.g., Chimney Swift, 0.048% of population, Tree Swallow, 0.008%, and Purple Martin, 0.089%); data were not available for Barn Swallow, but severity is presumably also 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)	Scope is considered pervasive as nearly all Barn Swallows are expected to encounter roads at some point in their life cycle. Collision mortality may be locally important, but overall severity is unlikely to be more than slight.
4.2	Utility & service lines						Not a threat.
4.3	Shipping lanes						Not a threat.
4.4	Flight paths						Not a threat.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5	Biological resource use		Unknown	Unknown	Unknown	High (Continuing)	
5.1	Hunting & collecting terrestrial animals		Unknown	Unknown	Unknown	High (Continuing)	Although destruction of nests in Canada and consumption of birds in South America are known to occur, scope of both is unclear, and little is known about the severity of these actions, although they seem unlikely to have much impact on the population.
5.2	Gathering terrestrial plants						Not a threat.
5.3	Logging & wood harvesting						Not a threat.
5.4	Fishing & harvesting aquatic resources						Not a threat.
6	Human intrusions & disturbance		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
6.1	Recreational activities						Not a threat – generally quite tolerant of human activities.
6.2	War, civil unrest & military exercises						Information provided by Department of National Defense (1994-2017) reports incidental sightings and nesting ranging from 1 individual to 200 pairs of Barn Swallows in military bases. Any reported losses of nests from building demolition, renovation, and maintenance would go under 1.2 Commercial & industrial areas. Some unspecified stresses to the birds related to military exercises and aircraft are reported. Not a threat.
6.3	Work & other activities		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Research activities are rare relative to population size and have negligible effect on nest success. Barn Swallow is generally tolerant of human activities, and in Canada measures are taken to mitigate impacts of any work on or near structures used for nesting. Scope and severity are therefore both considered negligible.
7	Natural system modifications	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
7.1	Fire & fire suppression						Likely not a threat.
7.2	Dams & water management/use						Likely not a threat.
7.3	Other ecosystem modifications	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	Scope is pervasive, as Barn Swallow is dependent on insect prey and all individuals are expected to be exposed to declines in insect abundance. There is uncertainty regarding the severity of this threat, but it is likely in the range of moderate to slight.
7.4	Removing / Reducing Human Maintenance		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Abandoned farms are being reforested through natural succession, but scope is likely negligible, and given the gradual rate of change, severity is likely slight at most.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8	Invasive & problematic species, pathogens & genes		Negligible	Large - Restricted (11-70%)	Negligible (<1%)	High (Continuing)	
8.1	Invasive non-native/alien plants and animals		Negligible	Large - Restricted (11-70%)	Negligible (<1%)	High (Continuing)	A restricted to large proportion of Barn Swallows may be exposed to feral and domestic cats. Cats in monitored barns in Ontario kill a fair number of nestlings, but also remove small mammals that predate eggs/young. Overall severity for Barn Swallow appears negligible (Blancher 2013).
8.2	Problematic native plants and animals						High rates of ectoparasites, perhaps associated with larger colonies in some areas. Red Squirrel, Barn Owl, Cooper's Hawk, and other native predators known to have destroyed nests, but are not broadly above natural background levels, and therefore not considered a threat.
8.3	Introduced genetic material						Likely not a threat.
8.4	Pathogens & microbes						Likely not a threat.
9	Pollution		Unknown	Large (31-70%)	Unknown	High (Continuing)	
9.1	Household sewage & urban waste water						Likely not a threat.
9.2	Industrial & military effluents		Unknown	Unknown	Unknown	High (Continuing)	Scope and severity considered unknown due to lack of quantifiable data on the effects of chemical and metal toxins on Barn Swallow, and aerial insectivores in general.
9.3	Agricultural & forestry effluents		Unknown	Large (31-70%)	Unknown	High (Continuing)	Scope is considered large as a significant proportion of Barn Swallows spend at least part of their year in agricultural landscape where they may be exposed to these contaminants. Severity is considered unknown due to uncertainty regarding direct effects of neonicotinoids on Barn Swallow and birds in general.
9.4	Garbage & solid waste						Likely not a threat.
9.5	Air-borne pollutants		Unknown	Large (31-70%)	Unknown	High (Continuing)	Airborne contamination from vehicles close to highways. Exposure to mercury and acid rain likely similar in scope to that of other insectivores, but severity is unknown.
9.6	Excess energy						Likely not a threat.
10	Geological events						
10.1	Volcanoes						Not a threat.
10.2	Earthquakes/tsunamis						Not a threat.
10.3	Avalanches/landslides						Not a threat.
11	Climate change	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.1	Ecosystem encroachment						Likely not a threat.
11.2	Changes in geochemical regimes						Likely not a threat.
11.3	Changes in temperature regimes	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	Severe spring cold spells can cause substantial mortality, but at a population level severity is on average likely to be within the range of moderate to slight. More research needed regarding both direct and indirect effects of changes in temperature regimes on Barn Swallow, and how these may vary regionally.
11.4	Changes in precipitation & hydrological regimes	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	Uncertainty regarding severity, but likely in the range of moderate to slight.
11.5	Severe / Extreme Weather Events	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	Severity likely moderate to slight overall; probably higher on average for eastern North American populations, given a fall migration route with greater exposure to hurricanes.

Classification of Threats adopted from CMP Direct Threats Classification Version 2.0 (Conservation Measures Partnership, 2016).