COSEWIC
Assessment and Status Report

on the

Bobolink
Dolichonyx oryzivorus

in Canada

SPECIAL CONCERN
2022

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. 2010. COSEWIC assessment and status report on the Bobolink *Dolichonyx oryzivorus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 42 pp. (https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html).

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Bobolink — Photograph by Barbara Frei.

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COSEWIC
Assessment Summary

Assessment Summary – May 2022

Common name
Bobolink

Scientific name
Dolichonyx oryzivorus

Status
Special Concern

Reason for designation
This grassland songbird undertakes an annual round-trip migration of approximately 20,000 km between its breeding grounds in southern Canada and wintering range in central South America. Over 25% of the global population breeds in Canada, mostly from Saskatchewan to Quebec. Population size decreased sharply throughout the 1980s and 1990s, and has since continued to decline, but at a slower rate. Based on improved analytical techniques, the ten-year decline reported in the 2010 status report is now believed to have been -26%, similar to the -25% change between 2009 and 2019. Key threats to the species occur throughout its life cycle, including incidental mortality and nest failure from haying and other agricultural activities, habitat loss and fragmentation and pesticide exposure in all seasons, and persecution at winter feeding and roosting sites. If these threats are not managed effectively, the species may become Threatened.

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

Status history
Designated Threatened in April 2010.

COSEWIC
Executive Summary

Bobolink
Dolichonyx oryzivorus

Wildlife Species Description and Significance

Bobolink is a medium-sized songbird in the blackbird family. During the breeding season, males are black, splashed with white and gold on their upperparts. Females, juveniles, and males outside the breeding season, are beige, streaked with brown, and are frequently mistaken for a large sparrow. No subspecies or genetic distinctions are recognized. Bobolink is an obligate grassland specialist and a consumer of agricultural insect pests.

Distribution

The breeding range of Bobolink includes parts of southern Canada from British Columbia to the island of Newfoundland, and south to the northern United States. It winters in South America, primarily east of the Andes in Bolivia, Paraguay, and Argentina.

Habitat

Prior to European settlement, the breeding range of Bobolink coincided with the tall-grass prairie of the mid-western United States and south-central Canada. Most of this prairie was converted to agricultural land over a century ago. At roughly the same time, large swaths of forest in eastern North America were cleared for hayfields and pastures that provided alternate habitat for the birds. Since then, Bobolink has mostly nested in hayfields and pastures, although it also uses wet prairie, grassy peatlands, alvars, abandoned fields dominated by tall grasses, remnants of native prairie, and even sedge and grass meadows of marshes and bogs. It is generally less common in dry shorter-grasslands, intensively grazed pastures, alfalfa fields, or in row crop monocultures.

Biology

Bobolink is a semi-colonial species that is often polygynous. Birds arrive back in Canada from their South American wintering grounds in mid-May. Males establish their breeding territories by performing elaborate courtship flights, chases, and songs. Females construct nests on the ground. Clutches contain 3-7 eggs. Nestlings are fed by both parents for 10-11 days and fledglings are fed for at least 1 week.

Population Sizes and Trends

In Canada, the Bobolink population is estimated at about 2.6 million adults, which represents 26% of the global population. North American Breeding Bird Survey (BBS) data for the period 1970 to 2019 indicate a significant annual population trend of -2.63% in Canada (95% CI = -2.99%, -2.27%), amounting to a loss of 73% of the population over 49 years. The annual rate of decline in Canada has been slightly steeper over the most recent 10-year period (2009 to 2019), at -2.87% (95% CI = -4.08, -1.47), corresponding to a cumulative population loss of 25% during this time. The United States population has also undergone both long- and short-term declines, although not quite as severe.

Threats and Limiting Factors

The main causes of the decline in Bobolink abundance have been identified as: 1) habitat loss on both the breeding and wintering grounds, primarily caused by the conversion of native prairie and forage crops (hay and pasture) to intensive row crops (corn, soybean), 2) incidental mortality from hay-mowing operations that destroy nests, and 3) pesticide use on the breeding and wintering grounds, which causes both direct and indirect mortality. Overall, the impact of threats likely to affect Bobolink over the next decade is considered to be high.

Protection, Status and Ranks

Bobolink, its nest, and its eggs are protected in Canada under the *Migratory Birds Convention Act 1994*. It is currently protected as a Threatened species under Schedule 1 of the *Species at Risk Act, 2002,* and by various provincial pieces of legislation. It is ranked as Secure globally (G5) and nationally (N5) in Canada and the United States by NatureServe, although at a provincial scale it ranks as high as S2 (Imperilled) in Alberta and Prince Edward Island, and S1 (Critically Imperilled) in Newfoundland and Labrador.

TECHNICAL SUMMARY

Dolichonyx oryzivorus

Bobolink

Goglu des prés

Range of Occurrence in Canada: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador

Demographic Information

Generation time (average age of parents in the population)	2.9 years (Bird *et al.* 2020)
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes, estimated
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Estimated 15% over 2 generations, based on average annual 2.87% decline over the past 10 years
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Estimated 25% 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 continuing decline is anticipated given long-term trend in population and habitat
[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 decline is apparent given long-term trend in population and habitat
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a) yes, in part b) yes c) no
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	>3 million km^2 within the Canadian breeding range
Index of area of occupancy (IAO)	IAO based on a 2x2 km grid cannot be calculated, but would be much 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”∗	Unknown, but at minimum hundreds, based on the key threat of agricultural land management being under the control of many land owners.
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?	Unknown
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Not applicable
Is there an [observed, inferred, or projected] decline in number of “locations”?	Unknown
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, observed and projected declines in area, extent and quality of breeding habitat, and perhaps also wintering habitat
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of “locations”∗?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each subpopulation)

Subpopulations	**N Mature Individuals**
Total	~2.6 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 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, overall threat impact is considered high, and key factors identified as: • Annual and perennial non-timber crops (IUCN 2.1) – high threat impact, relating to loss of agricultural grasslands on both the breeding and wintering grounds, plus high rates of loss of nests from mowing/harvesting operations. • Agricultural and forestry effluents (IUCN 9.3) – medium-low threat impact, primarily related to insecticide exposure. Additional threats anticipated to pose a low threat impact are: • Residential and commercial development (IUCN 1) – primarily due to collisions with buildings, communications towers, and other tall structures). • Livestock farming and ranching (IUCN 2.3) – overgrazing of pastures. • Energy production and mining (IUCN 3) – habitat disturbance and loss. • Hunting and collecting terrestrial animals (IUCN 5.1) – targeted control programs and unregulated hunting outside Canada. • Fire and fire suppression (IUCN 7.1) – fire control on both the breeding and wintering grounds allowing forest succession to replace grassland habitat. • Invasive and other problematic species and genes (IUCN 8) – including predation of nests by domestic cats and dogs, increasing populations of “human-subsidized” native avian and mammalian predators, effects of invasive plants on quality of breeding habitat, and cowbird parasitism.

Rescue Effect (from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Declining in all states bordering Canada, consistent with overall U.S. decline of 1.5%/year (1970-2019), accelerating in the short-term (2009-2019) to a loss of about 2.8%/year. Considered Critically Imperilled (S1) to Vulnerable (S3) in 23 states, and Secure (S5) only in New York and Vermont.
Is immigration known or possible?	Yes
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes, but declining
Are conditions deteriorating in Canada?	Yes
Are conditions for the source population deteriorating?	Probably
Is the Canadian population considered to be a sink?	No
Is rescue from outside populations likely?	Unlikely, given long- and short-term declines in the U.S.

Data Sensitive Species

Is this a data sensitive species?	No

Status History

COSEWIC Status History: Designated Threatened in April 2010. Status re-examined and designated as Special Concern in May 2022.

Status and Reasons for Designation:

Status: Special Concern	**Alpha-numeric codes:** Not applicable
Reasons for designation: This grassland songbird undertakes an annual round-trip migration of approximately 20,000 km between its breeding grounds in southern Canada and wintering range in central South America. Over 25% of the global population breeds in Canada, mostly from Saskatchewan to Quebec. Population size decreased sharply throughout the 1980s and 1990s, and has since continued to decline, but at a slower rate. Based on improved analytical techniques, the ten-year decline reported in the 2010 status report is now believed to have been -26%, similar to the -25% change between 2009 and 2019. Key threats to the species occur throughout its life cycle, including incidental mortality and nest failure from haying and other agricultural activities, habitat loss and fragmentation and pesticide exposure in all seasons, and persecution at winter feeding and roosting sites. If these threats are not managed effectively, the species may become Threatened.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Rate of reduction in number of mature individuals of 25% over the past ten years is below the threshold for Threatened, and threats are largely ongoing, with potential for some to be mitigated.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. EOO of >3 million km^2 and IAO of >2000 km^2 exceed thresholds for Threatened.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Number of mature individuals is approximately 2.6 million, exceeding threshold for Threatened.
Criterion D (Very Small or Restricted Population): Not applicable. Estimate of 2.6 million mature individuals exceeds thresholds for D1, and population is widespread and not vulnerable to rapid and substantial decline.
Criterion E (Quantitative Analysis): Analysis not conducted.

PREFACE

Many studies have been undertaken on Bobolink since it was first assessed by COSEWIC (2010) as Threatened. These have included research aimed at identifying important wintering regions (Renfrew *et al.* 2013), and understanding migration routes and linkages to breeding areas (e.g., Renfrew *et al.* 2020a). Other research has focused on habitat needs on both the breeding grounds and the wintering grounds to provide direction to conservation planning (e.g., Davis *et al.* 2013; Diemer and Nocera 2016; Ethier 2016; Campomizzi *et al.* 2019). Collectively, these and other studies provide an improved understanding of the ecological needs of Bobolink and the potential threats facing it. There is also updated population trend information available, most notably from the Breeding Bird Survey, which now uses hierarchical analysis to generate more reliable estimates than previously (Smith unpubl. data), and from various breeding bird atlases (Blaney 2015; Siddle 2015; McCracken *et al.* 2018; Jobin *et al.* 2019).

The past decade has seen publication of a provincial recovery strategy for Ontario (McCracken *et al.* 2013), and a national recovery strategy for Canada is in development. Greater recognition of the plight of Bobolink has also prompted conservation planning efforts at international scales (e.g., Renfrew *et al.* 2019).

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
(2022)

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

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

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

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

Environment and Climate Change Canada
Canadian Wildlife Service

Environnement et Changement climatique Canada
Service canadien de la faune

Canada

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

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Scientific name: *Dolichonyx oryzivorus*

English name: Bobolink

French name: Goglu des prés

Classification:

Class: Aves

Order: Passeriformes

Family: Icteridae

Bobolink is a songbird in the blackbird (Icteridae) family (AOU 1998; Chesser *et al.* 2019). It is the only species in the genus *Dolichonyx*.

Morphological Description

Bobolink is a medium-sized songbird (length: 15.2 - 20.5 cm) with a short, conical bill (Renfrew *et al.* 2020b). The sexes differ only in breeding plumage during spring and summer, when males are highly distinct, with a black bill, head, and underparts, contrasting sharply with a white rump and scapulars, and a buffy-golden to yellow patch on the back of the head. Females and juveniles are quite different, resembling large sparrows, with a mostly buff to brown, streaked, plumage, and light pink bills. Prior to fall migration, adults moult into non-breeding plumage, after which males closely resemble females; on their South American wintering grounds they moult back into their distinctive breeding plumage prior to spring migration (Renfrew *et al.* 2020b). Bobolink is one of very few bird species that undergoes two complete moults per year (Renfrew *et al*. 2020b).

Population Spatial Structure and Variability

Bobolink has been included in genetic studies examining New World oscine bird relationships (Klicka *et al.* 2000), but no studies specifically examine spatial structure or variability within the species. There is no significant clinal variation in appearance or body size across the breeding range (Renfrew *et al.* 2020b).

Designatable Units

No subspecies have been recognized for Bobolink (Renfrew *et al.* 2020b), and research into genetic structure of the population indicates only slight regional differences that are largely clinal, and are believed to be relatively recent in origin (Renfrew *et al.* 2022). In the absence of evidence that any populations are discrete or evolutionarily significant based on COSEWIC (2021) guidelines, the species is therefore assessed as a single designatable unit.

Special Significance

Bobolink is an indicator species for the plight of North American grassland birds (e.g., McCracken 2005). For the most part, it is a beneficial species in agricultural areas within its breeding grounds, because it feeds on a wide variety of insect pests (Renfrew *et al.* 2020). Specific Aboriginal Traditional Knowledge is not available, but Bobolink is part of an ecosystem that is important to Indigenous people who recognize the interconnectedness of all species.

DISTRIBUTION

Global Range

The breeding range of Bobolink currently includes much of southern Canada, extending from southern British Columbia to the island of Newfoundland, south to the northwestern, north-central, and northeastern U.S. (Figures 1 and 2). Its breeding density is greatest in North and South Dakota, Minnesota, southern Manitoba, southern Ontario, southwestern Quebec, and western New York (Figure 3).

Bobolink winters primarily in northeastern Argentina, south to northern Buenos Aires province, eastern Bolivia, and to a lesser extent in Paraguay (Figure 1; Renfrew *et al.* 2019, 2020a). Very small numbers have been reported wintering along the coast of Peru (Renfrew *et al.* 2020b) and as far south as northern Chile (Howell 1975).

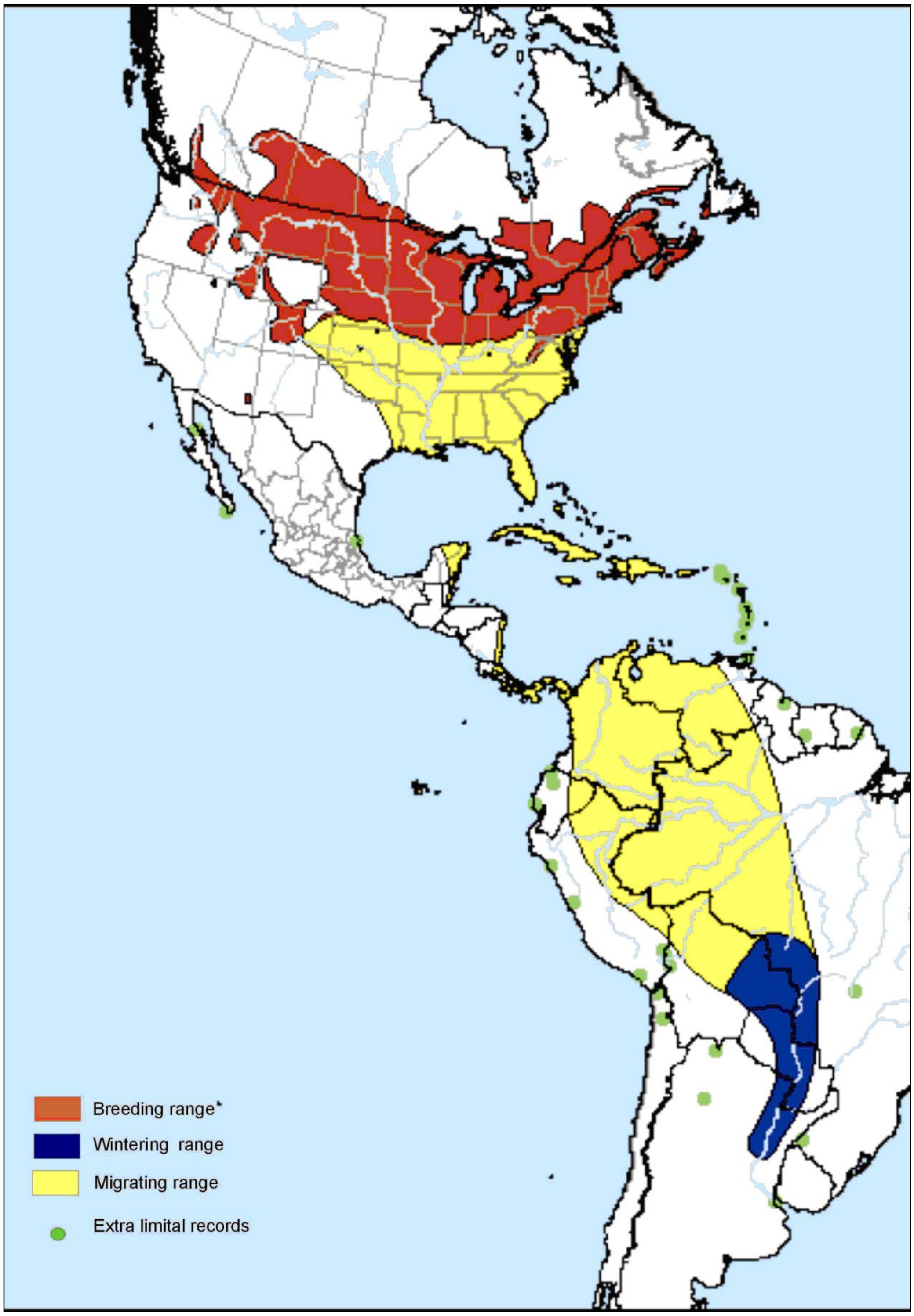

Figure 1. Global range of Bobolink (from Ridgely *et al.* 2005); see Figure 2 for slightly more accurate mapping for eastern Canada.

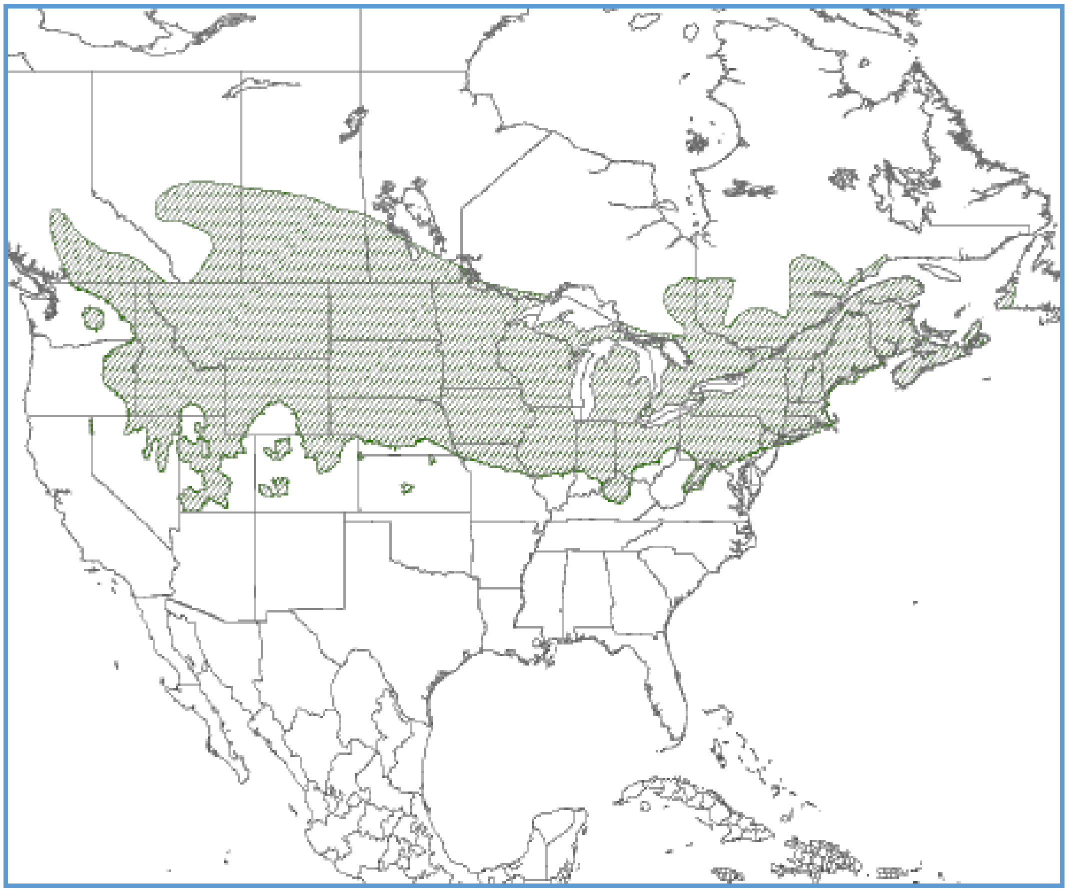

Figure 2. Updated breeding distribution of Bobolink in North America (from Renfrew *et al.* 2019). For more detailed Canadian mapping, see Godfrey (1986); Smith (1996); Campbell *et al.* (2001); Cadman *et al.* (2007); Federation of Alberta Naturalists (2007); Stewart *et al.* (2015); McCracken (2018); Jobin (2019); Bird Studies Canada (2020).

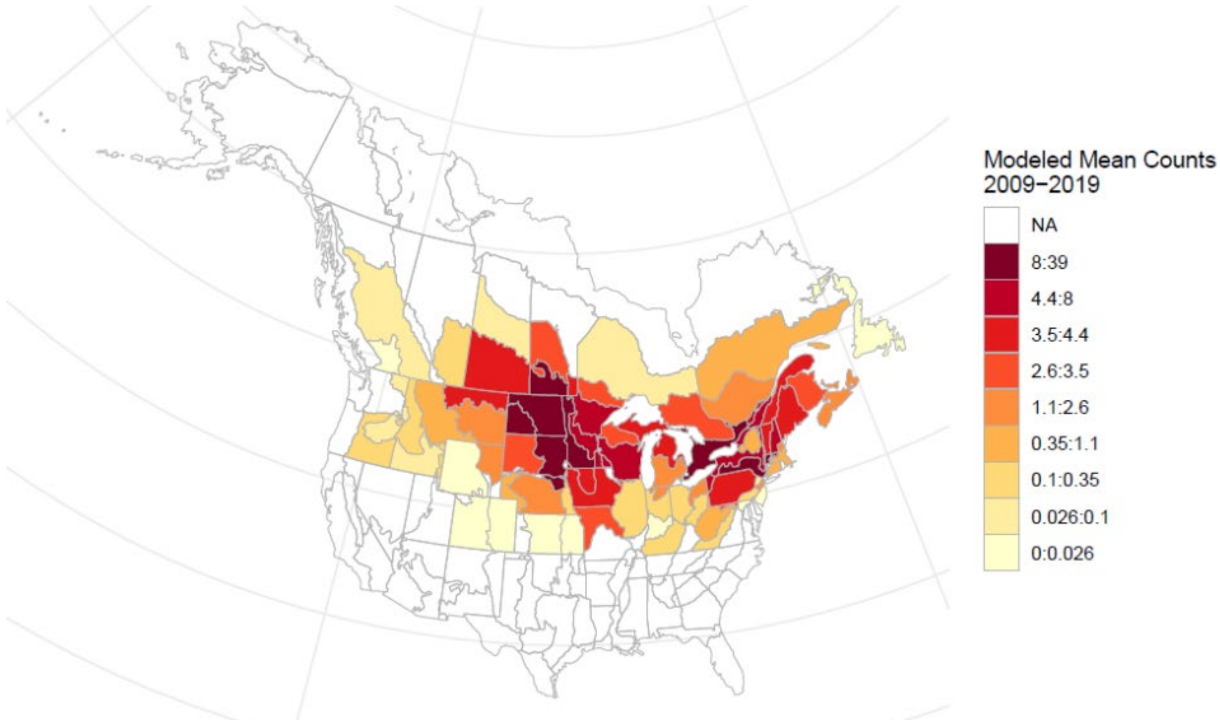

Figure 3. Relative breeding abundance of Bobolink in provincial and state Bird Conservation Regions, based on BBS data from 2009 to 2019 (Smith unpubl. data). White areas indicate regions surveyed where no Bobolinks were observed.

Canadian Range

About 26% of the total breeding population is in Canada (Partners in Flight 2019), occurring in south-central and southeastern British Columbia (Siddle 2015), central and southern Alberta (Federation of Alberta Naturalists 2007), central and southern Saskatchewan (Smith 1996; Bird Studies Canada 2020), southern Manitoba (McCracken 2018), central and southern Ontario (Gahbauer 2007), southern Quebec (Jobin 2019), New Brunswick, Prince Edward Island, and Nova Scotia (Blaney 2015), and southwestern Newfoundland (Godfrey 1986; St. Laurent pers. comm. 2020).

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EOO) in Canada was estimated by COSEWIC (2010) to be over 3 million km^2, and has not changed appreciably since then. The index of area of occupancy (IAO) cannot be calculated, but based on the number of breeding pairs in Canada and the size of the breeding range, IAO undoubtedly greatly exceeds COSEWIC's minimum threshold of 2000 km^2. The second generation breeding bird atlases in Ontario (2001-2005) and the Maritimes (2006-2010) indicated reductions in occupancy compared with 20 years earlier, but it is unknown whether these trends have continued over the past decade. The only more-recent results are from the second Quebec Breeding Bird Atlas (2010-2014), which reported a modest 5% increase in the number of occupied atlas squares compared with 25 years earlier, but notably there was greater coverage in the second atlas and the percentage of atlas squares with Bobolink was considerably lower than in the first period (Jobin 2019).

Search Effort

Data on the current Canadian breeding distribution of Bobolink come primarily from breeding bird atlas projects carried out in British Columbia (Davidson *et al.* 2015), Alberta (Federation of Alberta Naturalists 2007), Saskatchewan (Smith 1996; Bird Studies Canada 2020), Manitoba (Artuso *et al.* 2018), Ontario (Cadman *et al.* 2007), Quebec (Robert *et al.* 2019), and the Maritimes (Stewart *et al.* 2015). Bird checklists submitted to eBird (Fink *et al.* 2019) also provide valuable data on relative abundance and distribution, including during the non-breeding period. The North American Breeding Bird Survey provides good information on abundance and population trends, but contributes relatively little additional information on breeding distribution.

HABITAT

Habitat Requirements

<u>Breeding habitat</u>

Bobolink currently shows a preference for non-native grasslands in much of its breeding range (Nocera *et al.* 2007; Davis *et al.* 2013; Greer *et al.* 2016). It nests primarily in hayfields and pastures (Bollinger and Gavin 1992; Jobin *et al.* 1996; Renfrew *et al.* 2020b) dominated by non-native herbaceous plants such as clover (*Trifolium spp.*), Timothy (*Phleum pratense*), tall grasses (e.g., Kentucky Bluegrass, *Poa pratensis*), and broad-leaved plants (Dale *et al.* 1997; Van Damme 1999).

Bobolink also nests in wet prairie, grassy peatlands, and abandoned fields dominated by tall grasses, remnants of uncultivated native prairie (tall-grass prairie), small-grain fields, and reed beds (Martin 1971; Van Damme 1999; Dechant *et al.* 2001; Renfrew *et al.* 2020b), as well as the upper reaches of tidal marshes (Bull 1985; Blaney 2015). It will readily occupy suitable sites that have been restored to grassland habitat (Ingold 2002; Fletcher and Koford 2003). Presumably because it favours taller grass elements, it is relatively uncommon in the short-grass areas of Saskatchewan and Alberta (Federation of Alberta Naturalists 2007; Partners in Flight 2019; Bird Studies Canada 2020).

During the breeding season, Bobolink is sensitive to micro-habitat scale vegetation structure and composition (Wiens 1969; Wittenberger 1980; Bollinger and Gavin 1989; 1992; Nocera *et al.* 2007). Bobolink abundance and density are positively associated with moderate vegetative litter depth (Wiens 1969; Herkert 1994; Schneider 1998; Renfrew and Ribic 2002; Johnson *et al.* 2004; Warren and Anderson 2005), high lateral litter cover and high grass-to-legume ratios (Bollinger 1988; Bollinger and Gavin 1989; Patterson and Best 1996; Fritcher *et al.* 2004), and small shrubs as perches (Schneider 1998). These characteristics are often found in old (≥ 8 years) hayfields (Bollinger 1988; Bollinger and Gavin 1989; Fritcher *et al.* 2004). Bobolink avoids nesting in areas dominated by dense shrubs (Bollinger 1988; Bollinger and Gavin 1992), with an overly deep litter layer (> 1-2 cm, Wiens 1969; Herkert 1994; Renfrew and Ribic 2002; Johnson *et al.* 2004; Warren and Anderson 2005), with a high percentage of bare soil (Schneider 1998; Warren and Anderson 2005), or with intensive grazing (Renfrew *et al.* 2020b). Bobolink does not nest in row crops like corn and soybean, but occasionally does in wheat, rye, and alfalfa (*Medicago sativa*) crops, depending on the region (Sample 1989; Bollinger and Gavin 1992; Bollinger 1995; Jobin *et al.* 1996; Corace *et al.* 2009; McCracken *et al.* 2013; Renfrew *et al.* 2020).

Bobolink is sensitive to grassland patch size (Fletcher and Koford 2003; Murphy 2003; Bollinger and Gavin 2004; Horn and Koford 2006; Renfrew and Ribic 2008). Reproductive success tends to be lower in small grasslands (Kuehl and Clark 2002; Winter *et al.* 2004) than larger ones. Bobolink also avoids forest edges surrounding grasslands (Helzer and Jelinski 1999; Fletcher 2003; Fletcher and Koford 2003). Studies are somewhat contradictory with regard to the sensitivity of Bobolink to road edges (Fletcher and Koford 2003; Bollinger and Gavin 2004). In the Canadian prairies, Bobolink abundance increased in planted grasslands when these parcels were surrounded by native prairie (Davis *et al.* 2013).

<u>Migration habitat</u>

During migration, Bobolink is found primarily in grasslands, rice fields (wild and domestic varieties), small-grain fields (e.g., wheat), and grass beds bordering freshwater and saltwater marshes (Sick 1993; Renfrew *et al.* 2020b).

<u>Winter habitat</u>

On the wintering grounds, Bobolink primarily occupies the temperate grasslands of South America, but also marshes, riverbanks, and rice fields (Sick 1993; Di Giacomo *et al.* 2005; Lopez-Lanus *et al.* 2007; Renfrew *et al.* 2020b). Indeed, Renfrew *et al*. (2019) showed that its winter distribution is strongly tied to the distribution of cultivated rice.

Habitat Trends

Historically, Bobolink populations have responded to the supply and quality of grassland habitats, both native and anthropogenic. Current population sizes and trajectories are strongly linked to habitat shifts that affect the species at all stages in its life-cycle – on the breeding and wintering grounds and at migration stop-over points.

The long-term history of Bobolink distribution is largely unknown. Immediately prior to European settlement, most grassland areas in eastern North America resulted from disturbances by fire, wind, tree diseases, insect damage to trees, and flooding from American Beaver (*Castor canadensis*) activity (Askins *et al.* 2007; Catling 2008). In addition, Indigenous firewood harvesting and burning to enhance hunting areas created ephemeral grasslands (Askins *et al.* 2007). The extent to which suitable habitat was created by Indigenous peoples in Canada prior to the 16th century is uncertain, but Campbell and Campbell (1994), Riley (2013), and Birch and Williamson (2015) provide useful insights into the considerable size of Indigenous communities at that time, and the amount of land that needed to be cleared to support them.

Later, after European settlers began to arrive in southern Ontario in the late 1700s and early 1800s, populations of Indigenous peoples experienced significant declines. At that time, southern Ontario was described as predominantly forest-dominated; only a small proportion of habitat would have been available for grassland-obligate species. Estimates of the amount of native tallgrass prairie, open savannah and open "plains" that were present at that time are not well documented, but Catling (2008) estimated them to amount to at least 200,000 ha, which is well below the present-day extent of agricultural grassland habitat.

Bobolink was present in eastern North America at least as far back as the mid-1700s (Pettingill 1983; Askins 1999; Askins *et al.* 2007), and likely long before that. In the 19th century, the species became more widespread and common in the region because of wide-scale deforestation and the subsequent spread of agricultural practices that provided ample 'surrogate' (planted) grassland habitat, mostly in the form of hayfields and pasturelands (Bent 1958; Gauthier and Aubry 1996; Askins 1999; Brennan and Kuvlesky 2005; Cadman *et al.* 2007; Renfrew *et al.* 2020b). Around the same time, similar landscape changes are thought to have allowed Bobolink's breeding range to expand to northwestern North America, including British Columbia (McAtee 1919; Bent 1958; Pettingill 1983), although Hamilton (1962) questioned this supposition. Availability and quality of surrogate grassland habitat began to decline in the early 1900s because of increased mechanization (e.g., for haying operations) and conversion of forage crops to other crops (Herkert 1991; Warner 1994; Rodenhouse *et al.* 1995; Jobin *et al.* 1996; Murphy 2003; Podulka *et al.* 2004; Serecon Management Consulting Inc. 2005; Corace *et al.* 2009; Renfrew *et al.* 2020b).

Prior to that period, Bobolink was historically most common in the vast tallgrass and mixed-grass prairies of the Great Plains in midwestern Canada and the United States (Bent 1958**;** Askins *et al.* 2007). Following European settlement, the conversion of massive expanses of native prairie to agriculture, and the loss of natural disturbance regimes such as frequent fires and grazing by large populations of American Bison (*Bison bison*), severely altered these ecosystems (Askins 1993, 1999; Askins *et al.* 2007). For example, only about 14% of native grassland remains in Saskatchewan, with losses ongoing, e.g., 1.3 million ha of grassland were converted to cropland in Saskatchewan between 1990 and 2015 (Sawatzky 2019). Overall, only 2.4% of tallgrass prairie remains in North America, with less than 2% remaining in Canada (Samson and Knopf 1994; Samson *et al.* 2004). These figures do not account for more recent changes in the amount of non-native agricultural grassland that Bobolink now frequently uses. That said, even these non-native anthropogenic grasslands have been strongly declining across most of the species' breeding range in recent decades (see **Threats and Limiting Factors** below).

In addition to loss of breeding habitat, the Canadian Prairies have also experienced extreme fragmentation of grassland habitat (Roch and Jaeger 2014). Loss of grassland breeding habitat in North America is also reflected by similar reductions of grassland habitat that would be needed for stop-overs during migration.

Few studies exist on habitat trends on the wintering grounds in South America. The area of native prairie is known to have declined throughout South America due to conversion to agriculture, forestry plantations, and urban areas (Di Giacomo *et al.* 2005; Renfrew and Saavedra 2007; Renfrew *et al.* 2019). This decline, however, may be somewhat offset by an increase in rice fields in several countries (Vickery *et al.* 2003; Renfrew and Saavedra 2007).

BIOLOGY

The species account for Bobolink in the Birds of the World (Renfrew *et al.* 2020b; a republished but not updated version of the 2015 Birds of North America account) 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.

Life Cycle and Reproduction

Like most other small songbirds, Bobolink is short-lived, largely because of high mortality by first-year birds on migration (Terres 1980). The longevity record is 10 years (Renfrew *et al.* 2020b), but the average age of mature birds in the population (generation length) is estimated to be 2.9 years, using modelled values of age-of-first-breeding, maximum longevity, and annual adult survival (Bird *et al.* 2020).

Bobolink typically nests semi-colonially in loose groups and exhibits a mixed reproductive strategy, forming monogamous and polygynous pair bonds (Martin 1971; Wittenberger 1978; Wootton *et al.* 1986; Moskwik and O'Connell 2006). Males can mate with up to three females per year (Perlut 2013).

Breeding densities vary regionally and by habitat. Examples of situations that encompass typical breeding habitat include means of 26 territorial males/km^2 (n = 9) in tallgrass prairie; 33 males/km^2 (n = 12) in mixed-grass prairie; and 91 males/km^2 (n = 81) in hayfields (Renfrew *et al.* 2020b). The 'highest-quality' hayfields in New York were capable of supporting a mean density of up to 120 territorial males/km^2. Territory size is also related to habitat quality, with smaller territories / higher densities of Bobolink occurring at 'high-quality' sites. Reports of mean territory size range from about 0.4 ha to about 2.0 ha (Wiens 1969; Martin 1971; Wittenberger 1978; Bollinger and Gavin 1992; Lavallée 1998). Older males tend to concentrate in relatively small territories in better quality habitat, while first-year breeders typically hold larger, peripheral territories in lower-quality habitat (Nocera *et al.* 2009).

Nests are built on the ground, usually well-hidden at the base of tall forbs (Bent 1958; Renfrew *et al.* 2020b). Egg-laying begins within about 10 days after pair formation (Wittenberger 1978; Renfrew *et al.* 2020b). In Ontario, this usually begins during the last week of May (Frei 2009), although egg-laying has been reported as early as 19 May (Peck and James 1987). In western New York, Norment *et al.* (2010) reported an average clutch initiation date of 25 May (n = 74). Nest initiation date increases with latitude. Average clutch size ranges from four eggs in British Columbia (Campbell *et al.* 2001) to five in Ontario (Peck and James 1987). Eggs are incubated by the female (Renfrew *et al.* 2020b). Incubation lasts about 12 days and young remain in the nest for 10 to 11 days (Renfrew *et al.* 2020b).

Normally, only one brood is produced each year. However, second clutches are attempted if the first nest is destroyed early enough in the breeding season to allow sufficient time for fledging before the onset of fall migration (Perlut *et al.* 2006; Renfrew *et al.* 2020b). When nests fail in hayfields due to mowing, second nesting attempts are contingent upon the availability of suitable, un-mowed nesting habitat nearby (see Shustack *et al.* 2010).

Eggs from first nest attempts start to hatch in mid-June, and most young have left the nest by early July. In western New York, Norment *et al.* (2010) reported an average fledge date of 22 June (n = 55) for first clutches. In eastern Ontario and western Quebec, later hatch dates for second nesting attempts ranged from 21 to 30 June, while fledge dates ranged from 1 to 12 July (Frei 2009). After leaving the nest, fledglings are fed by the parents for at least a week (Renfrew *et al.* 2020b), during which time they remain poor fliers and are vulnerable to hay mowing.

Nesting success is highly variable, depending particularly on timing of haying (e.g., Diemer and Nocera 2016), but also on habitat type, predation intensity, weather conditions, and the nature of agricultural operations (e.g., grazing, haying). Reproductive success is also lower in small habitat fragments than large ones (Kuehl and Clark 2002; Winter *et al.* 2004). There also appear to be regional differences, seemingly with a pattern of higher nesting success occurring in eastern hayfields than in the central prairies (see Norment *et al.* 2010). Although sometimes calculated differently among studies and not always strictly comparable, regional examples of nest success rates are as follows: mixed-grass prairies of North Dakota (3.5%, n = 108; Kerns *et al.* 2010); tallgrass prairies of Minnesota and North Dakota (21.9%, n = 315; Winter *et al.* 2004); uncut hayfields of Ontario/Quebec (43.0%, n = 53; Frei 2009); and uncut hayfields in New York (48.3%, n = 91; Norment *et al.* 2010). These regional differences appear to largely stem from differential rates of nest predation, which can sometimes be high (e.g., Kerns *et al.* 2010).

Survival rates of adults are higher for adults using late-hayed fields than those using early-hayed and grazed fields (Perlut *et al.* 2008a). The apparent annual survival rate of adults in New England ranged from 52% to 70% for males and 35% to 54% for females; these rates are considered relatively low (Perlut *et al.* 2008a). In the United States Midwest, Scheiman *et al.* (2007) reported adult male survival rates ranging from 57% to 90%. Adult survival rate has not been studied in Canada.

Physiology and Adaptability

During the breeding season, adult Bobolinks feed on insects and weed seeds (Renfrew *et al.* 2020b). Insect prey most commonly includes caterpillars and adult moths and butterflies (Lepidoptera), grasshoppers (Orthoptera), and beetles (Coleoptera) (Wittenberger 1978, 1980; Lavallée 1998). Nestlings are fed insects exclusively (Renfrew *et al.* 2020b). During migration and on the wintering grounds, the diet switches largely to seeds (Meanley and Neff 1953; Wittenberger 1978; Pettingill 1983; Di Giacomo *et al.* 2005; Renfrew and Saavedra 2007; Renfrew *et al.* 2020b). This dietary transition begins to take place just before fall migration, while the birds are still in Canada.

Bobolink showed considerable ability to take advantage of changes in its breeding habitat following European settlement, which resulted in the creation of large areas of pasture and hayfield (Bollinger and Gavin 1992; Van Damme 1999; Madden *et al.* 2000). On its wintering grounds, Bobolink has similarly taken advantage of the conversion of native pampas to non-native rice crops (Renfrew and Saavedra 2007). In addition, Bobolink can adapt to low or moderate levels of livestock grazing, but not intensive grazing (Kantrud and Kologiski 1982; Temple *et al.* 1999). Bobolink also responds favourably to prescribed burning carried out in forage crops outside the nesting season (Bollinger and Gavin 1992; Herkert 1994; Madden *et al.* 2000). Generally, it also responds positively to agricultural land retirement and set-aside programs (Renken and Dinsmore 1987; Patterson and Best 1996; Lavallée 1998), natural prairie restoration programs (Volkert 1992), and mine site grassland restoration (Ingold 2002). However, Bobolink has not been able to adapt to hay cutting during the breeding period or to the conversion of forage crops to row crop monocultures (Herkert 1997; Van Damme 1999; Renfrew *et al.* 2020b).

Dispersal and Migration

Bobolink makes a remarkable 20,000 km trans-equatorial roundtrip flight between its nesting and wintering grounds (Renfrew *et al.* 2020b), one of the longest migrations of all North American landbirds. Individuals are capable of routinely covering distances of >1000 km within a 12-hour period (Renfrew *et al.* 2019, 2020a).

Spring and fall migration routes overlap, but spring migration occurs at a much faster pace than in fall (Renfrew *et al.* 2020a). After the breeding season, adults and immatures form flocks prior to their southbound departure. As fall migration proceeds southward, flock size grows, and can reach into the tens of thousands of individuals (Renfrew *et al.* 2020b).

Based on data from the Canadian Migration Monitoring Network, 90% of spring Bobolink migration in Canada occurs between 3 and 27 May (Bird Studies Canada, unpubl. data); males typically arrive about one week before females (Renfrew *et al.* 2020). In fall, 90% of the migration period in Canada falls between 12 August and 27 September (Birds Canada unpubl. data).

The timing of the onset of fall migration varies geographically across the breeding range. However, southbound birds arrive at their first major stopover area in the Llanos grassland region of Venezuela and Colombia at similar times regardless of breeding origin (Renfrew *et al.* 2020a).

Most southbound Bobolinks leave the eastern seaboard via Florida, crossing the Caribbean to reach South America (Renfrew *et al.* 2020b). Once on their wintering grounds, Bobolinks remain highly gregarious (e.g., flocks of up to ~140,000 birds), and may move 100+ km per day in search of food (Renfrew and Saavedra 2007).

Immature birds of both sexes initially captured on their natal sites were recaptured in subsequent years at distances of between 19 and 742 km away (Brewer *et al.* 2000). The return rate of adults to breeding sites varies considerably among studies in the United States. In common with other songbirds, Bobolink return rates are higher for males (21-70%) than females (5-44%) (Wittenberger 1978; Bollinger and Gavin 1989; Fletcher *et al.* 2006; Scheiman *et al.* 2007). In one study in Indiana, returning colour-banded adult Bobolinks were observed a maximum of 14.2 km from their previous breeding sites (Scheiman *et al.* 2007). Breeding site fidelity also appears to be influenced by past experience (Bollinger and Gavin 1989; Fajardo *et al*. 2009). This is especially apparent at poor quality sites that have low reproductive success. Successful birds return to breed at both good and poor quality sites, but unsuccessful birds are more likely to return to good quality sites than poor ones (Bollinger and Gavin 1989).

Prior to fall migration, young Bobolinks also appear to actively scout for their following year's breeding sites. They effectively explore their surrounding natal landscape and gather advance 'knowledge' of the number and density of territory-holding males, which allows them to gauge the potential suitability of future breeding locations (Nocera *et al.* 2006). This suggests that Bobolinks may discern a site's apparent 'quality' despite an individual's lack of breeding familiarity with the site, based on habitat explorations outside the nesting season (i.e., during pre-migration aggregations in late summer; Bollinger and Gavin 1989).

Interspecific Interactions

Predators

As a ground nester in open landscapes, Bobolink is vulnerable to a variety of predators, including hawks, snakes, and mammals (Van Damme 1999; Campbell *et al.* 2001; Renfrew *et al*. 2020b). In Wisconsin pastures, Bobolink nests are depredated by many species, including Northern Raccoon (*Procyon lotor*), ground squirrels (*Urocitellus* spp.), and several species of snakes (*Thamnophis* spp. and *Pantherophis* spp.; Renfrew and Ribic 2003). In southern Quebec, known and potential predators include Northern Harrier (*Circus hudsonius*), Short-eared Owl (*Asio flammeus*), Ring-billed Gull (*Larus delawarensis*), American Crow (*Corvus brachyrhynchos*), Northern Raccoon, Striped Skunk (*Mephitis mephitis*), and Red Fox (*Vulpes vulpes*; Lavallée 1998; Jobin and Picman 2002). Feral cats (*Felis catus*) are also reported to depredate Bobolink on its breeding grounds (Van Damme 1999).

<u>Non-predatory interspecific interactions</u>

During the breeding period, territorial males are aggressive and chase away other songbirds and raptors (Renfrew *et al.* 2020b). Bobolink is exposed to nest parasitism from Brown-headed Cowbird (*Molothrus ater*; Herkert *et al*. 2003; Patten *et al*. 2006; Rahmig *et al*. 2008). In Argentina, Bobolink is associated with other blackbirds that forage in wetland grasslands (Di Giacomo *et al.* 2005).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

<u>North American Breeding Bird Survey (BBS)</u>

The BBS is aimed at monitoring numbers of 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 US (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 covered 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 are analyzed using a hierarchical generalized additive model.

The BBS is well-suited to surveying Bobolink because the species is easily detected by its song and aerial courtship displays, the BBS samples virtually the entire range of the species in Canada, and many routes are surveyed in open habitat where the species occurs. Overall, the BBS is judged to have high reliability for detecting population trends of this species in Canada.

<u>Breeding Bird Atlas projects</u>

Provincial and regional 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. The second Ontario breeding bird atlas compared the province's distribution of breeding birds between 1981-1985 and 2001-2005 (Cadman *et al.* 2007). The percent change in the distribution of Bobolink in Ontario over the period of 20 years was then calculated by comparing the percentage of the 10 x 10-km squares with breeding evidence in the first atlas period to the percentage of squares with breeding evidence in the second atlas, adjusting for observation effort (Cadman *et al*. 2007). In both iterations, the atlas projects covered the entire breeding range of the species in Ontario. Ontario's second breeding bird atlas also harnessed results from more than 60,000 point counts to allow for the mapping of relative abundance of Bobolink.

Second breeding bird atlas projects in the Maritimes (2006-2010; Stewart *et al.* 2015) and Quebec (2010-2014; Robert *et al.* 2019) were based on similar methods to those used in Ontario. Meanwhile, first atlas projects have been recently completed in Manitoba and British Columbia, and are currently underway in Saskatchewan and Newfoundland and Labrador.

Canadian Migration Monitoring Network (CMMN)

This program monitors populations of migratory birds at approximately 25 observatories across Canada. The primary activities carried out at these stations are daily bird banding and visual counts of birds during spring and/or fall migration. The program assumes that the number of birds detected at each station is proportional to the actual number of birds migrating on the days monitored. Fall migration reflects the annual productivity and abundance of birds as they move from their northern breeding grounds in Canada to their southern wintering areas elsewhere (Crewe *et al.* 2008). Major limitations of CMMN data are that the geographic origin of birds is seldom well understood, and that the program assumes that the number of birds tallied during the daytime is proportional to the number of birds that are aloft during nocturnal migration. Bobolink is largely a nocturnal migrant (e.g., Bent 1958; Beason 1987; Renfrew *et al.* 2013) that rests and feeds in large wetlands or grasslands during the day, areas which tend not to be monitored well by most CMMN stations. There is also large statistical uncertainty in trend results computed for this species at CMMN stations, reflecting at least in part high variability in numbers among years.

Abundance

The Canadian Bobolink population was recently estimated at roughly 2.6 million adults, representing 26% of the global population (Partners in Flight 2019). It is concentrated in Ontario (38.2% of the Canadian population), Manitoba (21.8%), Quebec (21.4%), and Saskatchewan (11.5%), with the remainder scattered in relatively small numbers across the other provinces (Table 1). This is consistent with BBS data from 2009 to 2019 indicating that Bobolink abundance in Canada is highest in southern Saskatchewan, southern Manitoba, southern Ontario, and southwestern Quebec (Figure 3). The estimate is somewhat higher than the range of 1.8 to 2.2 million reported in the previous status report (COSEWIC 2010), but rather than an actual increase, this is believed to be a function of refinements to population estimation methods that are now based on 1000 iterations of the calculation with independent random draws of each model component (Stanton *et al.* 2019; Will *et al.* 2019).

Table 1. Population estimates of Bobolink in Canada based on 2006-2015 Breeding Bird Survey data (Partners in Flight 2019).

Province / Territory	Population estimate*	% of Canadian population	% of global population	Lower 95% bound	Upper 95% bound
Ontario	1,000,000	38.2	9.9	650,000	1,600,000
Manitoba	570,000	21.8	5.6	350,000	880,000
Quebec	560,000	21.4	5.5	370,000	820,000
Saskatchewan	300,000	11.5	3.0	160,000	550,000
New Brunswick	91,000	3.5	0.9	43,000	160,000
Nova Scotia	61,000	2.3	0.6	26,000	120,000
British Columbia	15,000	0.6	0.2	3,000	37,000
Prince Edward Island	7,500	0.3	0.1	2,000	16,000
Alberta	7,000	0.3	0.1	1,900	16,000
Newfoundland and Labrador	3,300	0.1	<0.1	0	12,000
Canada Total	**2,614,800**	**100%**	**26%**	**1,605,900**	**4,211,000**

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

Fluctuations and Trends

Historical trends

There is no information about Bobolink abundance or distribution prior to European settlement. By the 1800s, its abundance and range had begun to change considerably because of the increasingly widespread destruction of native prairie in the Great Plains region, coupled with the increasingly widespread planting of anthropogenic grasslands farther east. Both of these massive landscape changes occurred at around the same time. As such, habitat declines in the west were effectively being compensated by corresponding positive habitat increases in the east.

Within the historical record, continental declines in Bobolink abundance began to be noticed by the late 1800s and early 1900s (Bollinger and Gavin 1992). At that time, the species was considered a pest of rice fields in the southeastern United States, where it was routinely shot (Renfrew *et al.* 2020b). It was also intensively hunted for its meat (Bent 1958). Following protection under the *Migratory Birds Convention Act* in 1917 and the banning of market hunting, together with expansion of hay and pasture lands, Bobolink abundance increased in eastern North America, including Ontario, Quebec, New Brunswick, Nova Scotia, and Prince Edward Island (e.g., Robbins *et al.* 1986; Sabine 2010), and expanded into British Columbia (Campbell *et al.* 2001). Since the mid-1980s, however, abundance has declined across most of the breeding range (see below).

Breeding Bird Survey

BBS data indicate a long-term average annual trend estimate of -2.63% in Canada between 1970 and 2019 (95% Credible Interval [CI]: -2.99, -2.27; Table 2; Figure 4), which corresponds to a population loss of 72.9% (95% CI: -77.4, -67.5) over 49 years (Smith unpubl. data; Table 2). Over the most recent 10-year period (2009-2019), there has been a slightly greater average annual decline of -2.87% (95% CI: -4.08, -1.47), equivalent to a cumulative loss of -25.2% of the population, with only a small probability (0.16) of the 10-year decline exceeding 30% (Table 2).

Table 2. Short-term (2009-2019) and long-term (1970-2019) population trends for Bobolink 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 (Smith unpubl. data).

Region	Annual % Rate of Change (95% Lower/Upper CI)	Cumulative % Change (95% Lower/Upper CI)	Probability of decline >30%	# routes	Reliability
Short-term					
Canada	**-2.87 (-4.08, -1.47)**	**-25.2 (-34.1, -13.8)**	0.16	432	High
United States	**-2.75 (-3.70, -1.61)**	**-24.3 (-31.4, -15.0)**	0.07	1030	High
North America	**-2.78 (-3.56, -1.86)**	**-24.6 (-30.4, -17.1)**	0.04	1462	High

Region	Annual % Rate of Change (95% Lower/Upper CI)	Cumulative % Change (95% Lower/Upper CI)	Probability of decline >30%	# routes	Reliability
British Columbia	**-17.30 (-26.10, -7.72)**	**-85.0 (-95.1, -55.2)**	1.00	18	Low
Alberta	**12.08 (3.54, 22.33)**	**212.9 (41.6, 650.6)**	0.00	34	Low
Saskatchewan	**6.18 (1.87, 10.52)**	**82.1 (20.4, 171.9)**	0.00	54	Low
Manitoba	**-7.22 (-9.16, -5.19)**	**-52.7 (-61.7, -41.3)**	1.00	56	Medium
Ontario	**-4.50 (-5.83, -3.17)**	**-36.9 (-45.1, -27.5)**	0.93	112	High
Quebec	-3.55 (-6.30, 0.18)	-30.3 (-47.8, 1.8)	0.51	91	Medium
Newfoundland & Labrador	-10.00 (-21.93, 2.09)	-65.2 (-91.6, 22.9)	0.85	5	Low
New Brunswick	-0.08 (-3.29, 3.43)	-0.8 (-28.5, 40.2)	0.02	33	Medium
Nova Scotia / Prince Edward Island	**-4.80 (-7.96, -1.62)**	**-38.9 (-56.4, -15.0)**	0.79	29	Medium
Long-term					
Canada	**-2.63 (-2.99, -2.27)**	**-72.9 (-77.4, -67.5)**	1.00	512	High
United States	**-1.50 (-1.78, -1.22)**	**-52.4 (-58.4, -45.3)**	1.00	1183	High
North America	**-1.90 (-2.12, -1.67)**	**-60.9 (-65.0, -56.1)**	1.00	1695	High
British Columbia	**-4.15 (-7.08, -1.33)**	**-86.9 (-97.0, -47.3)**	0.99	18	Medium
Alberta	0.41 (-2.30, 3.30)	22.1 (-68.0, 391.0)	0.20	37	Medium
Saskatchewan	1.11 (-1.25, 2.68)	71.6 (-46.1, 265.2)	0.05	78	Medium
Manitoba	**-1.95 (-2.83, -1.10)**	**-61.9 (-75.6, -41.9)**	1.00	57	High
Ontario	**-2.75 (-3.13, -2.36)**	**-74.5 (-79.0, -68.9)**	1.00	135	High
Quebec	**-3.82 (-4.53, -2.88)**	**-85.2 (-89.7, -76.1)**	1.00	108	High
Newfoundland & Labrador	-4.52 (-10.11, 1.01)	-89.6 (-99.5, 64.0)	0.91	5	Low
New Brunswick	**-3.63 (-4.33, -2.89)**	**-83.7 (-88.6, -76.2)**	1.00	41	High
Nova Scotia / Prince Edward Island	**-4.56 (-5.32, -3.83)**	**-89.9 (-93.1, -85.2)**	1.00	33	High

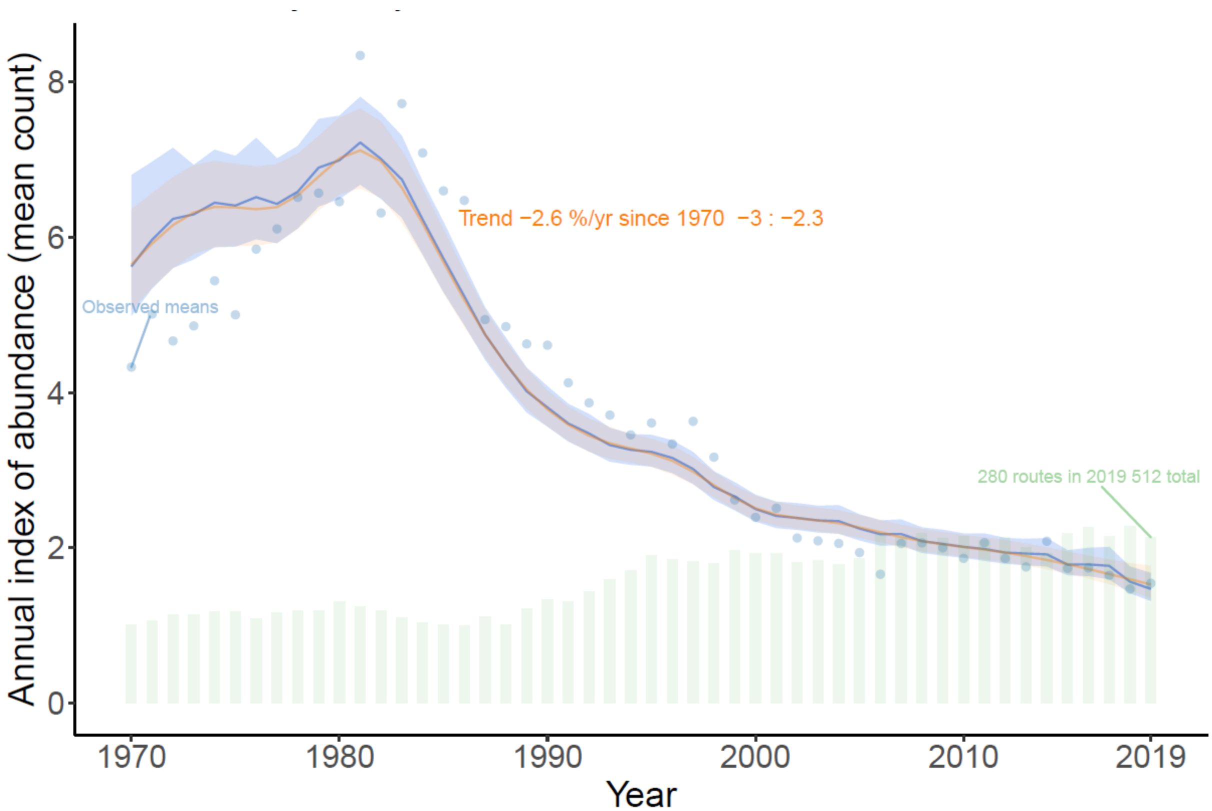

Figure 4. Annual index of population abundance for Bobolink in Canada, based on Breeding Bird Survey data from 1970-2019 (n=512 routes), with blue dots indicating observed means. The GAM (generalized additive model) trend in orange represents the best curvilinear fit of data, whereas the slope trend in blue incorporates effects of annual variation. Orange (appearing grey 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 Bobolink detections (Smith unpubl. data).

Bobolink numbers in British Columbia, Manitoba, Nova Scotia/Prince Edward Island, Quebec, and Ontario show both long- and short-term declines (Table 2). Numbers declined over the long term in New Brunswick but have been stable over the past ten years. Both Alberta and Saskatchewan show substantial short-term increases, consistent with positive long-term trends, perhaps reflecting a growing use of hayfields in these provinces (Table 2; Figure 5). Reliability of trend estimates is heavily influenced by sample size, and therefore is lowest for short-term estimates in regions with relatively few BBS routes and small to modest Bobolink numbers.

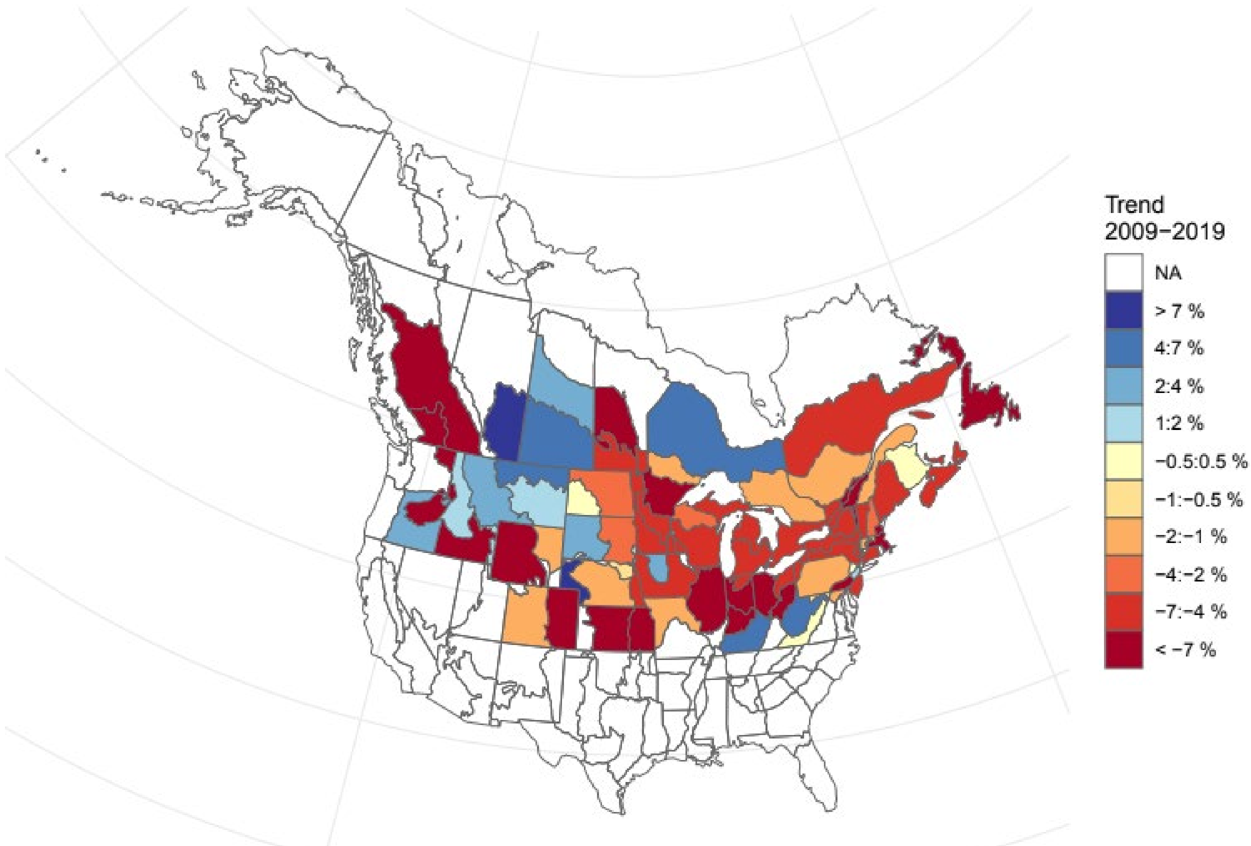

Figure 5. Regional variation in short-term (2009-2019) annual Breeding Bird Survey trends for Bobolink in North America, at the scale of Bird Conservation regions within provinces, territories, and states (Smith unpubl. data 2020).

Rolling 10-year population trends for Canada based on BBS data from 1980-2019 are also informative. They show that the COSEWIC threshold of 30% decline has not been exceeded since 2002, although the trend has been gradually accelerating toward it since 2012 (Figure 6). Overall, the majority of ten-year trend estimates from 1980 to 2019 show strong declines (peaking just beyond 50% in the early 1990s); no positive trend signals have occurred since the early 1980s. Note that at the time of the previous status report, BBS trends were derived using the slope between end-points of a time series, which indicated a 38% decline between 1998 and 2008 (COSEWIC 2010). However, using the current hierarchical approach that reduces the weight on results from individual years, the ten-year trend ending in 2008 would have been -26% (Smith unpubl. data).

Figure 6. Rolling 10-year trends of Bobolink population change in Canada based on Breeding Bird Survey data from 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 three-generation decline rates, which represent COSEWIC thresholds for assessing a species as Threatened and Endangered, respectively. Vertical bars depict 50% (broad, dark blue) and 95% (narrow, light blue) credible intervals.

Breeding Bird Atlas projects

Second-generation breeding bird atlas projects have generally shown declines in Bobolink occupancy rates compared to initial efforts approximately 20 years earlier (see Table 3), but most were completed prior to the most recent 10-year period, so they collectively provide little insight into recent trends. Only the Quebec breeding bird atlas had a data collection period substantially overlapping the most recent 10-year period; although it reported a modest increase in the absolute number of atlas squares with Bobolink, the percentage of surveyed atlas squares with Bobolink records declined appreciably, except in the Abitibi region (Jobin 2019).

Table 3. Changes in Bobolink occurrence across two time periods for breeding bird atlas projects in North America.

Region	Time Period	% Change in Occurrence	Reference
Ontario	1981-85 vs 2001-05 (20 yr)	-28%	Gahbauer (2007)
Quebec	1984-89 vs 2010-14 (26 yr)	+5%	Jobin (2019)
Maritimes	1986-90 vs 2006-10 (20 yr)	-24%	Stewart *et al.* (2015)
Alberta	1987-91 vs 2001-05 (14 yr)	unspecified decline	Federation of Alberta Naturalists (2007)
Ohio	1982-87 vs 2006-11 (24 yr)	-41%	Rodewald (2016)
New York	1980-85 vs 2000-05 (20 yr)	-8%	McGowan and Corwin (2008)
Vermont	1977-81 vs 2003-07 (26 yr)	-6%	Perlut (2013)
Pennsylvania	1984-89 vs 2004-09 (20 yr)	+14%	Wilson *et al.* (2012)

Canadian Migration Monitoring Network

Just four CMMN stations detected Bobolink in sufficient numbers to calculate trends (Table 4). Long-term data are available only for Long Point Bird Observatory, where statistically non-significant trends of -3.0%/year in fall and -2.9%/year in spring were recorded from 1988 to 2018. Statistically significant negative trends for the ten-year period from 2008 to 2018 were observed in fall at McGill Bird Observatory (Quebec) and in spring at Prince Edward Point Bird Observatory (Ontario).

Table 4. Bobolink 10-year population trends and associated 95% credible intervals (CIs) based on data from Canadian Migration Monitoring Network stations during spring and/or fall migration for the period 2008-2018 (Ethier pers. comm. 2020). Trends considered statistically significant appear in bold.

Station Name	Province	Season	Average annual % change (95% Lower/Upper CI)	Cumulative % change (95% Lower/Upper CI)
Long Point Bird Observatory	Ontario	Spring	-10.3 (-23.3, 10.4)	-66.3 (-92.9, 169.0)
		Fall	-9.1 (-26.4, 16.6)	-61.5 (-95.3, 364.5)
Pelee Island Bird Observatory	Ontario	Fall	-25.3 (-49.2, 13.1)	-94.6 (-99.9, 242.5)
Prince Edward Point Bird Observatory	Ontario	Spring	**-17.5 (-25.7, -8.9)**	**-85.4 (-94.9, -60.6)**
		Fall	7.0 (-4.6, 24.9)	96.7 (-37.6, 823.9)
McGill Bird Observatory	Quebec	Fall	**-29.1 (-44.0, -10.9)**	**-96.8 (-99.7, -68.5)**

eBird

Although trend analyses are not yet routinely conducted for eBird records, this program has capacity to monitor Bobolink population trends. In a test of the system, eBird data from southern Ontario for the period 1970-2015 showed a statistically significant decline in Bobolink records amounting to -4.60% per year (95% CI: -4.83, -4.36). This correlates strongly with the BBS trend for this region (Walker and Taylor 2017).

Summary of trends

This report's assessment is based on quantitative information that originates largely from within the past 50 years, and with a particular focus on the most recent 10 years. Although there are multiple sources of population data, the BBS has the most extensive and consistent coverage and provides the best basis for trend estimation. The estimated -25% decline over the most recent 10-year period is close to the -30% threshold COSEWIC uses for Threatened status, but because of large sample size and high reliability of the survey data, the uncertainty bounds are fairly narrow, and there is only a 0.16 probability of the decline exceeding that threshold. Although this rate of decline is substantially lower than the -38% reported in the previous status report (COSEWIC 2010), it is virtually identical to the rate of -26% retroactively estimated for that period using the current analytical approach. Results of other monitoring programs in both Canada and the United States are largely consistent with the BBS trends.

Rescue Effect

Long-term BBS data (1970-2019) show an average annual decline of 1.50% in the United States (95% CI: -1.76 to -1.22; Table 2). This corresponds to an overall population decline of 52% over 49 years. In the short-term (2009-2019), the annual trend in the United States has worsened to -2.75% (95% CI: -3.70 to -1.61; Table 2). Moreover, both long- and short-term declines are apparent in all states bordering Canada, in most cases with 95% CIs entirely below zero, suggesting high confidence in the decreasing trend. Therefore, although there is almost certainly immigration and emigration across the border, rescue from the United States is unlikely.

THREATS AND LIMITING FACTORS

Threats

Bobolink is vulnerable to the cumulative effects of various threats throughout its annual cycle. As with other migratory species, it is important to distinguish between threats on the breeding grounds and those on the wintering grounds. 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. Some of the threats considered to be Negligible or Unknown are mentioned in the text below as examples, with details provided in Appendix 1.

The overall threat impact is considered High, corresponding to an anticipated decline of between 10 to 70% over the next 10 years (see Appendix 1 for details). The actual rate of change is expected to be closer to the lower end of this range, given the current population trajectory, the fact that most threats are ongoing, and potential for some threats to be mitigated by conservation actions.

<u>IUCN 2, Agriculture and aquaculture (high threat impact):</u>

IUCN 2.1, Annual & perennial non-timber crops (high threat impact)

Habitat loss and degradation are considered the greatest threats to Bobolink. Expansion and intensification of agricultural crops on both breeding and wintering grounds has contributed significantly to past declines, and in many areas remains an ongoing concern (see Herkert 1991; Bollinger and Gavin 1992; Askins 1993; Warner 1994; Rodenhouse *et al.* 1995; Jobin *et al.* 1996; Wang *et al*. 2002; Murphy 2003; Brennan and Kuvlesky 2005; Johnson 2005; Askins *et al*. 2007; Cadman *et al*. 2007; Sample and Mossman 2008; Perlut 2014; Rosenberg *et al.* 2016; WWF 2016). On the breeding grounds, this includes conversion of hayfields and pasture into grain and oilseed crops (e.g., wheat, corn, and soybean) that are largely or wholly unsuitable for Bobolink.

For example, the amount of hayland in Ontario has declined strongly over the past century (McCracken *et al.* 2013). Early declines resulted from the shift to mechanization on farms, reducing demand for forage for horses. Moreover, there has been an increasing trend since the 1960s towards the use of alfalfa and alfalfa-grass mixtures in eastern hayfields, which are less attractive to Bobolink than grass-dominated fields (Bollinger and Gavin 1992; Warner 1994; Patterson and Best 1996). Pastureland has also declined, for example by at least 77% in Ontario since 1966 (McCracken *et al.* 2013). Similar trends are also apparent elsewhere in Canada (e.g., Sawatzky 2019; Sawatzky and Piwowar 2019).

The extent of native grassland on Bobolink's South American wintering grounds has also declined due to conversion to agriculture (Krapovickas and Di Giacomo 1998; Di Giacomo *et al*. 2005; Renfrew and Saavedra 2007; Azpiroz *et al*. 2012). Quantitative data across the region are sparse, but in Argentina, over 90% of the historical native grassland had been converted by 2005 (Di Giacomo *et al*. 2005). Because wintering Bobolinks also forage in rice crops, the decline in natural grassland habitat in South America may have been offset somewhat by increases in the area planted to rice, although this remains poorly understood (Vickery *et al*. 2003; Renfrew and Saavedra 2007).

Incidental loss of nests to early cutting of hayfields is another major ongoing threat (Bollinger and Gavin 1989, 1992; Jobin *et al*. 1996; Kershner and Bollinger 1996; Herkert 1997; Ingold 2002; Nocera *et al*. 2005, 2007; Perlut *et al*. 2006; With *et al*. 2008; Renfrew *et al.* 2020b). Over 90% of nests can be lost to haying operations (e.g., Bollinger *et al*. 1990). A modelling exercise estimated that Bobolink productivity (measured as the number of fledged young that would otherwise be expected to survive to migrate south and adjusted for natural mortality) was reduced by about 321,000 birds per year as a consequence of haying operations in Canada (Tews *et al*. 2013).

Nest losses from haying occur directly through the physical destruction of nest contents during routine mowing/raking operations and indirectly through increased predation exposure that follows mowing. For example, in Vermont, of the nests that remained active just prior to haying activity, haying machinery was responsible for 78% of Bobolink nest failures; predation following mowing (mostly by gulls, crows and ravens) accounted for the remaining 22% (Perlut 2007).

Changes in hay harvesting techniques and equipment (e.g., greater mechanization, lower mowing heights, faster tractor speeds, and changes in raking and baling operations) have likely contributed to an increased proportion of nest losses. Hay crops are also cut more frequently now than historically (e.g., Troy *et al*. 2005). In addition, hay cutting in parts of eastern North America is carried out about 2-3 weeks earlier compared to 50 years ago (Warner and Etter 1989; Bollinger *et al*. 1990; Giuliano and Daves 2002; Troy *et al*. 2005). Nest losses due to “early” haying are not entirely a recent phenomenon, and have been known since at least the early 1900s (Eaton 1914).

IUCN 2.3, Livestock farming and ranching (low threat impact)

Overgrazing by livestock affects habitat quality on the breeding grounds. Cattle grazing at low to moderate densities diversifies vegetation structure within a pasture (Baker and Guthery 1990; Bock *et al*. 1993; Patterson and Best 1996; Delisle and Savidge 1997; Temple *et al*. 1999; Powell 2008), which is associated with greater numbers of successfully nesting Bobolinks (Bock *et al*. 1993; Bélanger and Picard 1999; Renfrew and Ribic 2001). However, overgrazing (grass <10 cm tall) limits vegetation structure (Kantrud 1981; Kantrud and Kologiski 1982; Baker and Guthery 1990; Bock *et al*. 1993; Scheiman *et al*. 2007) and alters abundance of insect prey (Jepson-Innes and Bock 1989; Quinn and Walgenbach 1990), degrading habitat suitability for Bobolink. Likewise, intensive grazing can result in trampled nests and/or frequent disturbance that can lead to nest abandonment (see Jensen *et al*. 1990; Lavallée 1998; Temple *et al*. 1999; Renfrew *et al*. 2005; Perlut and Strong 2011).

IUCN 9, Pollution (low to medium threat impact):

IUCN 9.3, Agricultural & forestry effluents (low to medium threat impact)

Pesticide exposure is suspected of contributing to the decline of many bird species associated with farmlands in North America (Mineau 2009). However, for Bobolink, most of this threat occurs outside the breeding range, particularly in South America (Renfrew *et al.* 2019), given that it is generally not economically viable to apply pesticides to hay or pasture in Canada. Pesticides include herbicides and insecticides. The effects of insecticides can be more serious, both directly (e.g., causing mortality) and indirectly (e.g., physiological impairment and reduction of insect food supplies as noted under IUCN 7.3).

Pesticide regulations, types, usage, and application rates vary among countries and are poorly documented. Some insecticides that have never been registered in Canada and the United States, due to their toxicity to wildlife and/or humans, are used in some countries in Latin America and the Caribbean. For Bobolink, a potentially large source of exposure comes from pesticides applied to rice fields that the species commonly feeds in during the non-breeding period (Renfrew and Saavedra 2007). For example, in Bolivia, blood samples reveal that 40% of Bobolinks feeding on rice were exposed to lethal or sublethal insecticide levels (Parsons *et al.* 2010), although no direct mortalities were reported.

IUCN 1, Residential and commercial development (low threat impact):

As a nocturnal migrant, Bobolink frequently falls victim to night-time collisions with tall lighted structures, such as skyscrapers, communication towers, and lighthouses (Evans Ogden 1996; Shire *et al*. 2000; Long Point Bird Observatory unpubl. data). Overall, the scope of collision threat from all sources is increasing, but probably still small at this time; severity is believed to be moderate based on the population-level implications of mortalities from collisions.

In addition, ongoing loss of grassland areas to expansion of housing and urban areas (IUCN #1.1) is likely similar in scope and severity.

IUCN 3, Energy production and mining (low threat impact):

IUCN 3.1, Oil and gas drilling (low threat impact)

Oil and gas development in the western portion of Bobolink range can be a source of habitat loss and degradation, in the form of fragmentation, noise, increased predation rates, and direct mortality due to heavy equipment and increased vehicular traffic (e.g., Thompson *et al.* 2015). A study in southeastern Saskatchewan found that Bobolink abundance decreased in the vicinity of oil wells (Unruh 2015).

IUCN 3.2, Mining and quarrying (low threat impact)

Especially in Ontario, the creation and expansion of rock quarries results in the loss of grasslands (McCracken *et al.* 2013).

IUCN 3.3, Renewable energy (low threat impact)

When situated in grasslands, wind turbines can cause Bobolink mortality (Committee on Environmental Impacts of Wind-Energy Projects 2007; Stantec Consulting Ltd. 2011; Anonymous 2012), presumably because aerial displays put them in the path of turbine blades. This threat applies to a negligible portion of the breeding range, but if migrants are considered, a small part of the population may be exposed. Solar farms are increasingly being built in grasslands, but their extent is even smaller.

<u>IUCN 5, Biological resource use (low threat impact):</u>

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

Historically, market hunters took great numbers of Bobolinks during fall migration. For example, Forbush (1927 in Bent 1958) estimated that over 700,000 were killed for market in a single year in South Carolina. Although hunting in the United States and Canada is no longer a threat, it is unknown to what extent Bobolink is still hunted or captured in South America and the Caribbean, either for market, sustenance, or the pet trade (Bent 1958; Di Giacomo *et al*. 2005; Renfrew *et al.* 2020b). The species is potentially quite vulnerable because of its propensity to occur in very large flocks outside the breeding season.

Considered a pest in rice crops in some regions during fall migration and winter, Bobolink is sometimes intentionally poisoned (Renfrew and Saavedra 2007; Blanco and López-Lanús 2008; Parsons *et al*. 2010), and killed by other methods. The extent to which lethal control measures are currently in place during the non-breeding period is unknown.

<u>IUCN 7, Natural system modifications (low threat impact):</u>

IUCN 7.1, Fire and fire suppression (low threat impact)

Grasslands in pre-European settlement times were both created and maintained by natural fires (e.g., from lightning strikes) and fires used by Indigenous people to manage habitat for game and crops (Askins 1993; Vickery *et al.* 2000; Askins *et al.* 2007). Natural wildfires in tall grass prairies are now rare because of deliberate fire suppression; remnant native grasslands continue to suffer from shrub and tree encroachment in the absence of fire (Patterson and Sassaman 1988; Vickery *et al.* 2005; Askins *et al.* 2007). Burns that are used as a prairie management tool can benefit Bobolink (Johnson 1997; Davis *et al.* 2017).

IUCN 7.3, Other ecosystem modifications (unknown threat impact)

Invasive “weedy” forbs (e.g., *Solidago* spp.) out-compete grasses and significantly change plant composition in both native and surrogate grasslands (Fleischner 1994; Morgan and Burger 2008). The corresponding loss of grass cover produces habitat conditions that are no longer structurally suitable for Bobolink. Indirect effects on insect food availability (e.g., through invasive plant species and use of pesticides) are also captured by this threat, but there is no clear evidence of how this may affect Bobolink.

Many farms and ranches on non-productive agricultural lands have been abandoned and undergone natural succession to forest, while urban sprawl and various development activities have reduced agricultural grassland habitat. This is particularly the case in northeastern North America, where grasslands continue to be lost through regrowth of forests on large areas of former native prairie, while large acreages of hayland and pasture have been abandoned or left unmanaged to succeed into shrubland and forest (e.g., Askins 1993; Ontario Ministry of Natural Resources 1997; Cadman *et al*. 2007). When they occur within grasslands, tree-planting programs are additional sources of habitat loss (McCracken *et al.* 2013).

<u>IUCN 8, Invasive and other problematic species and genes (low threat impact):</u>

IUCN 8.2, Problematic native species (low threat impact)

The rate of Brown-headed Cowbird nest parasitism varies regionally in relation to cowbird densities (e.g., Herkert *et al*. 2003; Patten *et al*. 2006; Rahmig *et al*. 2008). For this reason, parasitism rates of Bobolink are lowest in eastern North America (Norment *et al*. 2010). They range from lows of 0% in New York (Norment *et al*. 2010) and 0-6% in Ontario (Peck and James 1987; Frei 2009), to about 11% in Minnesota and North Dakota (Winter *et al*. 2004), 18% in Iowa (Fletcher *et al*. 2006), and up to 37% in Wisconsin (Johnson and Temple 1990), 43% in Nebraska (Skipper 2008), and 50% in Manitoba (Davis and Sealy 2000). As Brown-headed Cowbird has been declining in abundance in Canada (Smith unpubl. data), its impact on Bobolink is likely also being reduced overall, but may vary by region.

IUCN 8.1, Invasive non-native plants and animals (unknown threat impact)

A large proportion of Canada’s Bobolink population is likely exposed to feral cats, which have been recognized as a threat to many songbirds (Blancher 2013). However, the rate and effects of cat predation on Bobolink have not been specifically studied, and therefore severity of this threat is unknown.

IUCN 11, Climate change and severe weather (unknown threat impact):

Climate change is predicted to increase the frequency and intensity of extreme weather events, including droughts and heavy precipitation, which can cause mortality of eggs and nestlings (Martin and Gavin 1995). Bobolink is also sensitive to variation in annual precipitation, which could impact quality of seed crops (food quality), vegetation cover (nesting habitat quality), and emergence of insects (prey availability; Thogmartin *et al.* 2006; COSEWIC 2010). Because Bobolinks migrate in very large flocks in the fall over the Gulf of Mexico, they could also be exposed to high mortality events associated with anticipated increases in the frequency and intensity of hurricanes. Nearly all Bobolinks are likely to be exposed to climate change threats, but the severity of effects at this point remains unknown (Brinker *et al.* 2018).

Limiting Factors

Bobolink population size is chiefly limited by habitat supply throughout the life cycle. Although Bobolink can nest in relatively small patches of grassland, relative abundance and productivity are higher in large patches (>10 ha) and in patches surrounded by other open habitats (e.g., Ribic and Sample 2001; Herkert *et al*. 2003; Bollinger and Gavin 2004; Keyel *et al*. 2011).

Outside the breeding season, this highly gregarious species feeds, migrates and roosts in very large flocks (Renfrew and Saavedra 2007; Blanco and López-Lanús 2008). This trait exposes large numbers to localized hazards (e.g., hurricanes during migration, and lethal-control measures in rice crops), making the species vulnerable to rapid population declines (Renfrew *et al.* 2020b).

In a study of restored, un-mowed grasslands in Iowa, Fletcher *et al.* (2006) suggested that adult survival during the non-breeding season may be the most important parameter contributing to population viability. Population viability analysis (PVA) modelling in the Champlain Valley region in the northeastern United States also found adult survival to be important, but nesting productivity was an even stronger determinant of population viability (Perlut *et al.* 2008b). The relative importance of adult survivorship versus productivity to long-term population persistence likely varies regionally depending on differences in factors such as predation pressure, land use, and habitat fragmentation.

Number of Locations

The number of locations for Bobolink in Canada is primarily a function of the number of land owners who have influence over the primary threat to the species, which is management of annual and perennial non-timber crops, specifically conversion of lands, and mowing practices. Although this number cannot be easily estimated, the number of locations is certain to number in the thousands.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

In Canada, Bobolink and its nests and eggs are protected under the *Migratory Birds Convention Act, 1994* (Government of Canada 2017). It is also currently listed as Threatened under Schedule 1 of Canada's *Species at Risk Act, 2002*. Provincially, it is listed under the *Endangered Species Acts* of Ontario (Threatened), New Brunswick (Threatened), Nova Scotia (Vulnerable), and Newfoundland and Labrador (Vulnerable). It is also protected under various provincial wildlife acts. Bobolink 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

Globally, Bobolink is considered Secure (G5; NatureServe 2020). Nevertheless, under the United Nations *Convention on the Conservation of Migratory Species of Wild Animals,* Bobolink is on the list of species requiring special international conservation efforts (UNEP/CMS 2012). In Canada, it is Secure (N5B) nationally, but at the provincial scale ranges from Critically Imperilled (S1B) in Newfoundland and Labrador to Secure (S5B) in Saskatchewan (NatureServe 2020; Figure 7). In the United States, it is also Secure (N5B) nationally, but is Critically Imperilled (S1B) or Imperiled (S2B) in 11 states, and Imperiled to Vulnerable (S2S3B or S3B) in 12 others (NatureServe 2020; Figure 7).

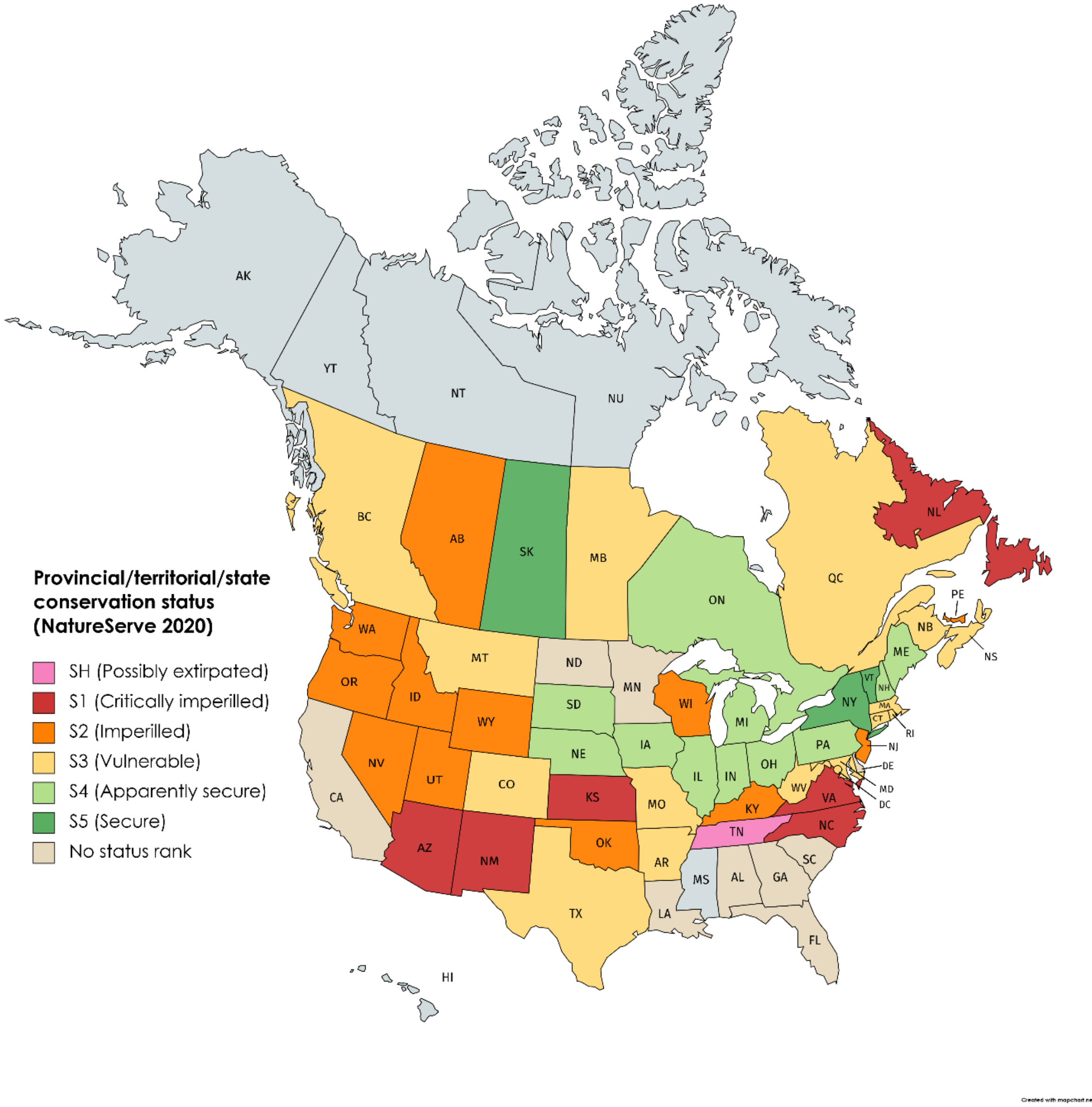

Figure 7. Map showing the conservation status of Bobolink in each province, territory, and state within its range in Canada and the United States (NatureServe 2020). In the case of ranges of status, the lower value is mapped (e.g., S2 for S2S3).

Habitat Protection and Ownership

In Canada, the vast majority of breeding habitat is located on private agricultural land (COSEWIC 2010) dominated by pastures and hayfields. Habitat protection is accomplished primarily through voluntary conservation programs. Various government and non-government entities have also provided funding for grassland habitat stewardship activities in recent years.

Little information is available on the quantity of suitable breeding habitat protected on public lands in Canada. Some breeding habitat occurs in federal protected areas, such as national parks, migratory bird sanctuaries, and national wildlife areas (COSEWIC 2010; S. Davis pers. comm. 2020). Bobolink breeds in 12 protected areas managed by Parks Canada (S. Pruss pers. comm. 2019). It also breeds on some Department of National Defence properties, including Canadian Forces Base Gagetown, New Brunswick (St-Pierre 2010); CFB Trenton, Ontario; CFB Petawawa, Ontario; and CFB Meaford, Ontario (R. McDonald pers. comm. 2020). The species also occurs, albeit in small numbers, in several provincial parks and provincially protected areas, especially in the Prairie provinces. It also occurs in small numbers in some protected areas managed by non-government organizations (e.g., Nature Conservancy of Canada's "Old Man on his Back Prairie and Heritage Conservation Area" in Saskatchewan and Ducks Unlimited Canada's Oak Hammock Marsh in Manitoba).

Until recently, Canada's Prairie Farm Rehabilitation Administration (PFRA) had been a highly successful federal program that promoted protection of more than 700,000 ha of pasture land in Alberta, Manitoba, and Saskatchewan. As a partnership between ranchers and the federal government, the objectives of the program had been to "manage a productive, biodiverse rangeland and promote environmentally responsible land use practice"; and to "utilize the resource to complement livestock production." However, after about 80 years of operation, control of all of these pasture lands was turned over to the provinces in 2013.

The Manitoba government is maintaining the pasture program and has provided funding for the newly formed Association of Manitoba Community Pastures. A Range Management Implementation Committee was also formed to oversee pasture management and to ensure ecological integrity. Saskatchewan was responsible for the largest percentage of PFRA pastures in Canada (over 300,000 ha), including some of the largest patches of native prairie in the Americas (Renfrew *et al.* 2019). In 2020, after its initial divestment, the federal government (through Environment and Climate Change Canada) reacquired three large patches of pastureland to protect in southwestern Saskatchewan (St. Laurent pers. comm. 2020). In return, the province will manage the balance of former federal community pasturelands for sustainable beef production and biodiversity.

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INFORMATION SOURCES

Allen, M.C., J. Burger, and J.L. Lockwood. 2019. Evaluation of unharvested refugia for grassland bird conservation within active hayfields. Avian Conservation and Ecology 14(2):15. Website: https://doi.org/10.5751/ACE-01457-140215 [accessed January 2020].

Anonymous. 2012. Wind energy bird and bat monitoring database summary of the findings from post-construction monitoring reports. Unpublished report from Environment Canada, Canadian Wind Energy Association, Bird Studies Canada, and Ontario Ministry of Natural Resources. 22 pp.

AOU (American Ornithologists' Union). 1998. Check-list of North American birds: the species of birds of North America from the Arctic through Panama, including the West Indies and Hawaiian Islands. Seventh edition. American Ornithologists' Union, Washington, DC. iv + 829 pp.

Artuso, C., A.R. Couturier, K.D. De Smet, R.F. Koes, D. Lepage, J. McCracken, R.D. Mooi, and P. Taylor (eds.). 2018. The Atlas of the Breeding Birds of Manitoba, 2010-2014. Bird Studies Canada. Winnipeg, Manitoba. Website: http://www.birdatlas.mb.ca/accounts/speciesaccount.jsp?sp=CAWA&lang=en [accessed June 2019].

Askins, R.A. 1993. Population trend in grassland, shrubland, and forest birds in eastern North America. Current Ornithology 11:1-34.

Askins, R.A. 1999. History of grassland birds in eastern North America. Studies in Avian Biology 19:60-71.

Askins, R.A., F. Chavez-Ramirez, B.C. Dale, C.A. Haas, J.R. Herkert, F.L. Knopf, and P.D. Vickery. 2007. Conservation of grassland birds in North America: understanding ecological processes in different regions. Ornithological Monographs 64:1-46.

Azpiroz, A.B., J.P. Isacch, R.A. Dias, A.S. Di Giacomo, C.S. Fontana, and C.M. Palarea. 2012. Ecology and conservation of grassland birds in southeastern South America: a review. Journal of Field Ornithology 83:217-246.

Baker, D.L., and F.S. Guthery. 1990. Effects of continuous grazing on habitat and density of ground-foraging birds in south Texas. Journal of Range Management 43:2-5.

Beason, R.C. 1987. Interaction of visual and non-visual cues during migratory orientation by the Bobolink (*Dolichonyx oryzivorus*). Journal of Ornithology 128:317-324.

Bélanger, L., and M. Picard. 1999. Cattle grazing and avian communities of the St. Lawrence River Islands. Journal of Range Management 52:332-338.

Bent, A.C. 1958. Family Icteridae, Meadowlarks, Blackbirds and Troupials. *Dolichonyx oryzivorous* (Linnaeus) Bobolink. Pp. 28–52 *in* Life histories of North American blackbirds, orioles, tanagers, and allies. U.S. National Museum Bulletin 211.

Birch, J., and R.F. Williamson. 2015. The Mantle Site: An archaeological history of an ancestral Huron-Wendat community. Rowman and Littlefield Publishers, Lanham, Maryland. 208 pp.

Bird, J.P., R. Martin, H.R. Akçakaya, J. Gilroy, I.J. Burfield, S. Garnett, A. Symes, J. Taylor, C.H. Şekercioğlu, and S.H.M. Butchart. 2020. Generation lengths of the world's birds and their implications for extinction risk. Conservation Biology 34:1252-1261.

Bird Studies Canada. 2020. Saskatchewan Breeding Bird Atlas. Website: https://sk.birdatlas.ca/# [accessed January 2020].

Blancher, P. 2013. Estimated number of birds killed by house cats (*Felis catus*) in canada. Avian Conservation and Ecology 8(2):3. Website: http://dx.doi.org/10.5751/ACE-00557-080203 [accessed April 2022].

Blanco, D.E., and B. López-Lanús. 2008. Ecologia no reproductive y conservación del Charlatán (*Dolichonyx oryzivorus*) en el noreste de Argentina. Fundación Humedales/Wetlands International, Buenos Aires, Argentina.

Blaney, S. 2015. Bobolink, pp. 492-493 *In* Stewart, R.L.M., K.A. Bredin, A.R. Couturier, A.G. Horn, D. Lepage, S. Makepeace, P.D. Taylor, M.-A. Villard, and R.M. Whittam (eds.). Second Atlas of Breeding Birds of the Maritime Provinces. Bird Studies Canada, Environment Canada, Natural History Society of Prince Edward Island, Nature New Brunswick, New Brunswick Department of Natural Resources, and Prince Edward Island Department of Agriculture and Forestry, Sackville, New Brunswick. 555 pp.

Bock, C.E., V.A. Saab, T.D. Rich, and D.S. Dobkin. 1993. Effects of livestock grazing on neotropical migratory landbirds in western North America. Pp. 296-309 *in* D.M. Finch and P.W. Stangel (eds.). Status and Management of Neotropical Migratory Birds. USDA Forest Service, General Technical Report RM-229.

Bollinger, E.K. 1988. Breeding dispersion and reproductive success of Bobolinks in an agricultural landscape. Ph.D. thesis. Cornell University, Ithaca, New York. 189 pp.

Bollinger, E.K. 1995. Successional changes and habitat selection in hayfield bird communities. Auk 112:720-732.

Bollinger, E.K., and T.A. Gavin. 1989. The effects of site quality on breeding-site fidelity in Bobolinks. Auk 106:584-594.

Bollinger, E.K., and T.A. Gavin. 1992. Eastern Bobolink populations: Ecology and conservation in an agricultural landscape. Pp. 497–506 *in* J.M. Hagan III and D.W. Johnston (eds.). Ecology and Conservation of Neotropical Migrant Landbirds. Smithsonian Institute Press, Washington, DC.

Bollinger, E.K., and T.A. Gavin. 2004. Responses of nesting Bobolinks (*Dolichonyx oryzivorus*) to habitat edge. Auk 121:767–776.

Bollinger, E.K., P.B. Bollinger, and T.A. Gavin. 1990. Effects of hay-cropping on eastern populations of the Bobolink. Wildlife Society Bulletin 18:142-150.

Brennan, L.A., and W.P. Kuvlesky, JR. 2005. North American grassland birds: an unfolding conservation crisis? Journal of Wildlife Management 69:1-13.

Brewer, D., A. Diamond, E.J. Woodsworth, B.T. Collins, and E.H. Dunn. 2000. Canadian Atlas of Bird Banding. Volume 1: Doves, Cuckoos, and Hummingbirds through Passerines 1921-1995, Occasional Paper, Canadian Wildlife Service, Environment Canada.

Brinker, S.R., M. Garvey, and C.D. Jones. 2018. Climate change vulnerability assessment of species in the Ontario Great Lakes Basin. Climate Change Research Report CCRR-48. Ontario Ministry of Natural Resources and Forestry, Science and Research Branch, Peterborough, Ontario. 85 p. + appendices.

Bull, J. 1985. Birds of New York State, including the 1975 Supplement. Cornell University Press, Ithaca, New York. 703 pp.

Cadman, M.D., D.A. Sutherland, G.G. Beck, D. Lepage, and A. Couturier (eds.). 2007. Atlas of the Breeding Birds of Ontario, 2001-2005. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature, Toronto, Ontario. xxii + 706 pp.

Campbell, I.D., and C. Campbell. 1994. The impact of Late Woodland land use on the forest landscape of southern Ontario. Great Lakes Geographer 1:21-29.

Campbell, R.W., N.K. Dawe, I. McTaggart-Cowan, J.M. Cooper, G.W. Kaiser, A.C. Stewart, and M.C.E. McNall. 2001. The Birds of British Columbia. Vol. IV. Passerines: Wood-Warblers through Old World Sparrows. UBC Press. Vancouver, British Columbia.

Campomizzi, A.J., Z.M. Lebrun-Southcott, L.D. Van Vliet, and G.A. Morris. 2019. Rotational grazing of beef cattle to support Bobolink breeding success. Avian Conservation and Ecology 14(2):13. https://doi.org/10.5751/ACE-01420-140213

Catling, P.M. 2008. The extent and floristic composition of the Rice Lake Plains based on remnants. Canadian Field-Naturalist 122:1-20.

Catling, P.M., and V.R. Brownell. 1999. Additional notes on the vegetation of dry openings along the Trent River, Ontario. Canadian Field-Naturalist 113:506-509.

Chesser, R.T., K.J. Burns, C. Cicero, J.L. Dunn, A.W. Kratter, I.J. Lovette, P.C. Rasmussen, J.V. Remsen Jr., D.F. Stotz, and K. Winker. 2019. Sixtieth Supplement to the American Ornithological Society's Check-list of North American Birds. Auk 3:1-23.

Committee on Environmental Impacts of Wind-Energy Projects. 2007. Environmental Impacts of Wind-Energy Projects. National Academy of Sciences, National Academies Press, Washington, DC. 394 pp. Website: http://www.nap.edu/catalog/11935.html [accessed January 2020].

Corace, R.G. III, D.J. Flaspohler, and L.M. Shartell. 2009. Geographical patterns in openland cover and hayfield mowing in the Upper Great Lakes region: implications for grassland bird conservation. Landscape Ecology 24:309-323.

COSEWIC. 2010. COSEWIC assessment and status report on the Bobolink *Dolichonyx oryzivorus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario.vi + 42 pp.

COSEWIC. 2021. Guidelines for Recognizing Designatable Units. Appendix F5 of the COSEWIC Operations and Procedures Manual. February 2021. Committee on the Status of Endangered Wildlife in Canada. Ottawa, Ontario. 7 pp.

Crewe, T.L., J.D. McCracken, P.D. Taylor, D. Lepage, and A.E. Heagy. 2008. The Canadian Migration Monitoring Network - Réseau canadien de surveillance des migrations: Ten-year Report on Monitoring Landbird Population Change. CMMN-RCSM Scientific Technical Report #1. Produced by Bird Studies Canada, Port Rowan, Ontario. 69 pp.

Dale, B.C., P.A. Martin, and P.S. Taylor. 1997. Effects of hay management on grassland songbirds in Saskatchewan. Wildlife Society Bulletin 25:616-626.

Davidson, P.J.A., R.J. Cannings, A.R. Couturier, D. Lepage, and C.M. Di Corrado (eds.). 2015. The Atlas of the Breeding Birds of British Columbia, 2008-2012. Bird Studies Canada, Delta, British Columbia. Website: http://www.birdatlas.bc.ca/ [accessed June 2020].

Davis, S., pers. comm. 2020. *Email correspondence to J. McCracken*. January 2020. Wildlife Biologist, Canadian Wildlife Service. Regina, Saskatchewan.

Davis, S.K., and S.G. Sealy. 2000. Cowbird parasitism and nest predation in fragmented grasslands of Southwestern Manitoba. Pp. 220-228 *in* J.N.M. Smith, T.L. Cook, S.I. Rothstein, S.K. Robinson, and S.G. Sealey (eds.). Ecology and Management of Cowbirds and their Hosts: Studies in the Conservation of North American Passerine Birds. University of Texas, Austin, Texas.

Davis, S.K., R.J. Fisher, S.L. Skinner, T.L. Shaffer, and A.M. Brigham. 2013. Songbird abundance in native and planted grassland varies with type and amount of grassland in the surrounding landscape. Journal of Wildlife Management 77:908-919.

Davis, S.K., J.H. Devries, and L.M. Armstrong. 2017. Variation in passerine use of burned and hayed planted grasslands. Journal of Wildlife Management 81:1494-1504.

Dechant, J.A., M.L. Sondreal, D.H. Johnson, L.D. Igl, C.M. Goldade, A.L. Zimmerman, and B.R. Euliss. 2001. Effects of management practices on grassland birds: Bobolink. Northern Prairie Wildlife Research Center, Jamestown, North Dakota. 24 pp. Website: http://www.npwrc.usgs.gov/resource/literatr/grasbird/bobo/bobo.htm [accessed January 2020].

Delisle, J.M., and J.A. Savidge. 1997. Avian use and vegetation characteristics of Conservation Reserve Program fields. Journal of Wildlife Management 61:318-325.

Diemer, K.M., and J.J. Nocera. 2016. Bobolink reproductive response to three hayfield management regimens in southern Ontario. Journal for Nature Conservation 29:123-131.

Di Giacomo, A.S., A.G. Di Giacomo, and J.R. Contreras. 2005. Status and conservation of the Bobolink (*Dolichonyx oryzivorus*) in Argentina. Pp. 519-524 *in* C.J. Ralph and T.D. Rich (editors). Bird Conservation Implementation and Integration in the Americas: Proceedings of the Third International Partners in Flight Conference. 2002 March 20-24; Asilomar, California, General Technical Report PSW-GTR-191. Albany, California; U.S. Dept. of Agriculture, Forest Service, Pacific Southwest Research Station.

Eaton, E.H. 1914. Birds of New York. Part 2. 2nd edition. University of the State of New York, New York State Museum Memoir 12. 719 pp.

Ethier, D.A. 2016. Factors affecting the abundance of a declining grassland bird: implications for recovery strategy planning and implementation. Ph.D. thesis. University of Guelph, Ontario. 155 pp.

Ethier, D., pers. comm. 2020. *Email correspondence to J. McCracken*. February 2020. Bird Population Scientist, Birds Canada, Port Rowan, Ontario.

Evans Ogden, L.J. 1996. Collision Course: The Hazards of Lighted Structures and Windows to Migrating Birds. World Wildlife Fund Canada and the Fatal Light Awareness Program, Toronto. 46 pp.

Fajardo, N., A.M. Strong, N.G. Perlut, and N.J. Buckley. 2009. Natal and breeding dispersal of Bobolinks (*Dolichonyx oryzivorus*) and Savannah Sparrows (*Passerculus sandwichensis*) in an agricultural landscape. The Auk 126:310-318.

Federation of Alberta Naturalists. 2007. The Atlas of Breeding Birds of Alberta: A second look. Federation of Alberta Naturalists. Edmonton, Alberta. vii + 626 pp.

Fink, D., T. Auer, A. Johnston, M. Strimas-Mackey, M. Iliff, and S. Kelling. 2019. eBird Status and Trends. Version: November 2019. Cornell Lab of Ornithology, Ithaca, New York. Website: https://ebird.org/science/status-and-trends [accessed January 2020].

Fleischner, T. 1994. Ecological costs of livestock grazing in western North America. Conservation Biology 8:629-644.

Fletcher, R.J., Jr. 2003. Spatial and temporal scales of distribution and demography in breeding songbirds: implications of habitat fragmentation and restoration. Dissertation, Iowa State University, Ames, Iowa.

Fletcher, R.J., and R. Koford. 2003. Spatial responses of Bobolinks (*Dolichonyx oryzivorus*) near different types of edges in northern Iowa. Auk 120:799-810.

Fletcher, R.J., R. Koford, and D.A. Seaman. 2006. Critical demographic parameters for declining songbirds breeding in restored grasslands. Journal of Wildlife Management 70:145–157.

Forman, R.T.T., B. Reineking, and A.M. Hersperger. 2002. Road traffic and nearby grassland bird patterns in a suburbanizing landscape. Environmental Management 29:782-800.

Frei, B. 2009. Ecology and management of Bobolinks in hayfields of Quebec and Ontario. M.Sc. thesis, McGill University, Montreal, Quebec.

Fritcher, S.C., M.A. Rumble, and L.D. Flake. 2004. Grassland bird densities in seral stages of mixed-grass prairie. Journal of Range Management 57:351-357.

Gahbauer, M.A. 2007. Bobolink. Pp. 586-587 *in* M.D. Cadman, D.A. Sutherland, G.G. Beck, D. Lepage, and A.R. Couturier (eds.). Atlas of the Breeding Birds of Ontario, 2001-2005. Bird Studies Canada, Environment Canada, Ontario Field Ornithologists, Ontario Ministry of Natural Resources, and Ontario Nature. Toronto, Ontario.

Gauthier, J., and Y. Aubry. 1996. The Breeding Birds of Quebec: Atlas of the Breeding Birds of Southern Quebec. Association québécoise des groupes d'ornithologues, Province of Quebec Society for the Protection of Birds, Canadian Wildlife Service, Environment Canada, Montreal, Quebec.

Galligan, E.W., T.L. Devault, and S.L. Lima. 2006. Nesting success of grassland and savanna birds on reclaimed surface coal mines of the midwestern United States. The Wilson Journal of Ornithology 118:537-546.

Giuliano, W.M., and S.E. Daves. 2002. Avian response to warm-season grass use in pasture and hayfield management. Biological Conservation 106:1-9.

Godfrey, W.E. 1986. The Birds of Canada. National Museum of Natural Sciences, National Museums of Canada, Ottawa, Ontario. 595 pp.

Government of Canada. 2017. Birds protected under the Migratory Birds Convention Act. Website: https://www.canada.ca/en/environment-climate-change/services/migratory-birds-legal-protection/convention-act.html [accessed December 2020].

Government of Canada. 2018. Breeding Bird Survey Overview. Website: https://www.canada.ca/en/environment-climate-change/services/bird-surveys/landbird/north-american-breeding/overview.html [Accessed November 2019].

Greer, M.J., K.K. Bakker, and C.D. Dieter. 2016. Grassland bird response to recent loss and degradation of native prairie in central and western South Dakota. The Wilson Journal of Ornithology 128:278-289.

Hamilton, W.J. 1962. Bobolink migratory pathways and their experimental analysis under night skies. Auk 79:208-233.

Helzer, C.J., and D.E. Jelinski. 1999. The relative importance of patch area and perimeter-area ratio to grassland breeding birds. Ecological Applications 9:1448-1458.

Herkert, J.R. 1991. Prairie birds of Illinois: population response to two centuries of habitat change. Illinois Natural History Survey Bulletin 34:393-399.

Herkert, J.R. 1994. The effects of habitat fragmentation on midwestern grassland bird communities. Ecological Applications 4:461-471.

Herkert, J.R. 1997. Bobolink, *Dolichonyx oryzivorus*, population decline in agricultural landscapes in the midwestern USA. Biological Conservation 80:107-112.

Herkert, J.R., D.L. Reinking, D.A. Wiedenfeld, M. Winter, J.L. Zimmerman, W.E. Jensen, E.J. Finck, R.R. Koford, D.H. Wolfe, S.K. Sherrod, M.A. Jenkins, J. Faaborg, and S.K. Robinson. 2003. Effects of prairie fragmentation on the nest success of breeding birds in the mid-continental United States. Conservation Biology 17:587-594.

Horn, D.J., and R.R. Koford. 2006. Could the area-sensitivity of some grassland birds be affected by landscape composition? Pp. 109–116 *in* Egan D, Harrington J.A. (eds.). Proceedings of the 19th North American Prairie Conference, University of Wisconsin.

Howell, T.R. 1975. Bank Swallow (*Riparia riparia*), Bobolink (*Dolichonyx oryzivorus*) and other birds at a desert reservoir in Chile. Condor 77:105-106.

Ingold, D.J. 2002. Use of a reclaimed stripmine by grassland nesting birds in east-central Ohio. Ohio Journal of Science 102:56-62.

Jensen, H.P., D. Rollins, and R.L. Gillen. 1990. Effects of cattle stock density on trampling loss of simulated ground nests. Wildlife Society Bulletin 18:71-74.

Jepson-Innes, K. and C.E. Bock. 1989. Response of grasshoppers (Orthoptera: Acrididae) to livestock grazing in southeastern Arizona: differences between seasons and subfamilies. Oecologia 78:430-431.

Jobin, B. 2019. Bobolink. Pp. 504-505 *in* M. Robert, M.-H. Hachey, D. Lepage, and A.R. Couturier (eds.). Second Atlas of the Breeding Birds of Southern Quebec, Regroupment QuébecOiseaux, Canadian Wildlife Service (Environment and Climate Change Canada), and Bird Studies Canada, Montreal, Quebec. xxv + 694 pp.

Jobin, B., and J. Picman. 2002. Predation on artificial nests in upland habitats adjacent to freshwater marshes. American Midland Naturalist 147:305-314.

Jobin, B., J.-L. Desgranges, and C. Boutin. 1996. Population trends in selected species of farmland birds in relation to recent developments in agriculture in the St. Lawrence Valley. Agriculture, Ecosystems and Environment 57:103-116.

Johnson D.H. 1997. Effects of fire on bird populations in mixed-grass prairie. Pp. 181-286 *In*: Knopf F.L., and Samson F.B. (eds) Ecology and Conservation of Great Plains Vertebrates. Ecological Studies (Analysis and Synthesis), vol 125. Springer, New York. Website: https://doi.org/10.1007/978-1-4757-2703-6_8 [accessed January 2020].

Johnson, D.H. 2005. Grassland bird use of Conservation Reserve Program fields in the Great Plains: 2000-2005 Update *in* J. B. Haufler, editor. Fish and Wildlife Benefits of Farm Bill Programs: 2000-2005 Update. Wildlife Society Technical Review:05-2.

Johnson, R.G., and S.A. Temple. 1990. Nest predation and brood parasitism of tallgrass prairie birds. Journal of Wildlife Management 54:106-111.

Johnson, D.H., L.D. Igl, and J.A. Dechant Shaffer. 2004. Effects of management practices on grassland birds. Northern Prairie Wildlife Research Center, Jamestown, North Dakota. Website: http://www.npwrc.usgs.gov/resource/literatr/grasbird [accessed January 2020].

Kantrud, H.A. 1981. Grazing intensity effects on the breeding avifauna of North Dakota native grasslands. Canadian Field-Naturalist 95:404-417.

Kantrud, H.A., and R.L. Kologiski. 1982. Effects of soils and grazing on breeding birds of uncultivated upland grassland of the Northern Great Plains. United States Fish and Wildlife Service, Wildlife Research Report 15:1-33.

Kerns, C.K., M.R. Ryan, R.K. Murphy, F.R. Thompson III, and C.S. Rubin. 2010. Factors affecting songbird nest survival in northern mixed-grass prairie. Journal of Wildlife Management 74:257-264.

Kershner, E.L., and E.K. Bollinger. 1996. Reproductive success of grassland birds at east-central Illinois airports. The American Midland Naturalist 136:358-366.

Keyel, A.C., C.M. Bauer, C.R. Lattin, L.M. Romero, and J.M. Reed. 2011. Testing the role of patch openness as a causal mechanism for apparent area sensitivity in a grassland specialist. Oecologia 169:407-418.

Klicka, J., K.P. Johnson, and S.M. Lanyon. 2000. New World nine-primaried oscine relationships: constructing a mitochondrial DNA framework. Auk 117:321-336.

Krapovickas, S., and A. Di Giacomo. 1998. Conservation of pampas and campos grasslands in Argentina. Parks 8:47-53.

Kuehl, A.K., and W.R. Clark. 2002. Predator activity related to landscape features in northern Iowa. Journal of Wildlife Management 66:1224-1234.

Lavallée, J. 1998. Effet de l’aménagement du couvert végétal pour la nidification de la sauvagine sur la reproduction et l’alimentation des oisillons du Goglu des prés (*Dolichonyx oryzivorus*) dans les îles de Varennes, Québec. M.Sc. Thesis, Université du Québec à Montréal. 94 pp.

Lopez-Lanus, B., I. Roesler, D.E. Blanco, P.F. Petracci, M. Serra, and M.E. Zaccagnini. 2007. Bobolink (*Dolichonyx oryzivorus*) numbers and non breeding ecology in the rice fields of San Javier, Santa Fe Province, Argentina. Ornitologia Neotropical 18:493-502.

Madden, E.M., R.K. Murphy, A.J. Hansen, and L. Murray. 2000. Models for guiding management of prairie bird habitat in northwestern North Dakota. American Midland Naturalist 144:377-392.

Martin, S.G. 1971. Polygyny in the Bobolink: habitat quality and the adaptative complex. Ph.D. thesis. Oregon State University, Corvallis, Oregon. 181 pp.

Martin, S.G. 1974. Adaptations for polygynous breeding in the Bobolink, *Dolichonyx oryzivorus.* Integrative and Comparative Biology 14:109-119.

Martin, S.G., and T.A. Gavin. 1995. Bobolink. *In* A. Poole and F. Gill (eds.). The Birds of North America. No. 176. The Academy of Natural Sciences of Philadelphia, Philadelphia, Pennsylvania. 24 pp.

McAtee, W.L. 1919. Observations on the shifting range, migration and economic value of the Bobolink. Auk 36:430-431.

McCracken, J.D. 2018. Bobolink. *In* C. Artuso, A.R. Couturier, K.D. De Smet, R.F. Koes, D. Lepage, J. McCracken, R.D. Mooi, and P. Taylor (eds.). The Atlas of the Breeding Birds of Manitoba, 2010-2014. Bird Studies Canada. Winnipeg, Manitoba. Website: http://www.birdatlas.mb.ca/accounts/speciesaccount.jsp?sp=CAWA&lang=en [accessed June 2019].

McCracken, J. 2005. Where the Bobolinks roam: The plight of North America's grassland birds. Biodiversity 6:20–29.

McCracken, J.D., R.A. Reid, R.B. Renfrew, B. Frei, J.V. Jalava, A. Cowie, and A.R. Couturier. 2013. Recovery Strategy for the Bobolink (*Dolichonyx oryzivorus*) and Eastern Meadowlark (*Sturnella magna*) in Ontario. Ontario Recovery Strategy Series. Prepared for the Ontario Ministry of Natural Resources, Peterborough, Ontario. viii + 88 pp.

McDonald, R., pers. comm. 2020. *Email correspondence to J. McCracken*. January 2020. Senior Environmental Advisor, National Defence, Ottawa. Ontario.

McGowan, K.J., and K. Corwin. 2008. The Second Atlas of Breeding Birds in New York State. Cornell University Press, Ithaca, New York. 688 pp.

Meanley, B., and J.A. Neff. 1953. Food habitats of the Bobolink in Arkansas rice fields. Auk 70:211-212.

Mineau, P. 2009. Avian mortality from pesticides used in agriculture in Canada. Unpublished Report to Environment Canada. Ottawa, Ontario. (unpaginated).

Morgan, M., and M. Burger. 2008. A Plan for Conserving Grassland Birds in New York: Final Report to the New York State Department of Environmental Conservation. Audubon New York, Ithaca, New York. 140 pp.

Moskwik, M.P., and M.A. O'Connell. 2006. Male and female reproductive strategies in the polygynous Bobolink. Northwest Science 80:108-115.

Murphy, M.T. 2003. Avian population trends within the evolving agricultural landscape of eastern and central United States. Auk 120:20-34.

NatureServe. 2020. NatureServe Explorer: An online encyclopedia of life [web application]. NatureServe, Arlington, Virginia. Website: https://explorer.natureserve.org [accessed March 2020].

Nocera J.J., G.J. Parsons, G.R. Milton, and A.H. Fredeen. 2005. Compatibility of delayed cutting regime with bird breeding and hay nutritional quality. Agriculture, Ecosystems and Environment 107:245-253.

Nocera, J.J., G.J. Forbes, and L.-A. Giraldeau. 2006. Inadvertent social information in breeding site selection of natal dispersing birds. Proceedings of the Royal Society of London Biological Sciences 273:349-355.

Nocera, J.J., G. Forbes, and G. Milton 2007. Habitat relationships of three grassland breeding bird species: broadscale comparisons and hayfield management implications. Avian Conservation and Ecology 2(1):7. Website: http://www.ace-eco.org/vol2/iss1/art7/ [accessed January 2020].

Nocera, J.J., G.J. Forbes, and L.-A. Giraldeau. 2009. Aggregations from using inadvertent social information: a form of ideal habitat selection. Ecography 32:143-452.

Norment, C.J., M.C. Runge, and M.R. Morgan. 2010. Breeding biology of grassland birds in western New York: conservation and management implications. Avian Conservation and Ecology 5(2):3. Website: http/www.ace-eco.org/vol5/iss2/art3 [accessed January 2020]..

Ontario Ministry of Natural Resources. 1997. Extension Notes: Forest History in Eastern Ontario. Landowner Resource Centre, Ontario Ministry of Natural Resources and the Eastern Ontario Model Forest. Queen's Printer for Ontario. Ottawa.

Parsons, K.C., P. Mineau, and R.B. Renfrew. 2010. Effects of pesticide use in rice fields on birds. Waterbirds 33 (Special Publication 1):193-218.

Partners in Flight. 2019. Population Estimates Database, version 3.0. Website: http://pif.birdconservancy.org/PopEstimates [accessed January 2020]

Patten, M.A., E. Shochat, D.L. Reinking, D.H. Wolfe, and S.K. Sherrod. 2006. Habitat edge, land management, and rates of brood parasitism in tallgrass prairie. Ecological Applications 16:687-695.

Patterson, M.P., and L.B. Best. 1996. Bird abundance and nesting success in Iowa CRP fields: the importance of vegetation structure and composition. American Midland Naturalist 135:153-167.

Patterson, W.A., and K.E. Sassaman. 1988. Indian fires in the prehistory of New England. Pp. 107-135 *In* G.P. Nicholas (ed.). Holocene human ecology in northeastern North America. Plenum Press, New York, New York.

Peck, G.K., and R.D. James. 1987. Breeding Birds of Ontario: Nidiology and Distribution. Vol. 2. Royal Ontario Museum, Toronto, Ontario.

Perlut, N.G. 2007. Effects of hayfield management on grassland songbirds: behavioral responses and population processes. Ph.D. dissertation, University of Vermont, Burlington, Vermont. 138 pp.

Perlut, N. 2013. Bobolink. Pp. 434-435 *in* R.B. Renfrew (ed.). The Second Atlas of Breeding Birds of Vermont. University Press of New England, Lebanon, New Hampshire.

Perlut, N.G. 2014. Grassland birds and dairy farms in the Northeastern United States. Wildlife Society Bulletin 38:574-579.

Perlut, N.G., and A.M. Strong. 2011. Grassland birds and rotational grazing in the northeast: breeding ecology, survival and management opportunities. Journal of Wildlife Management 75:715-720.

Perlut, N.G., A.M. Strong, T.M. Donovan, and N.J. Buckley. 2006. Grassland songbirds in a dynamic management landscape: Behavioral responses and management strategies. Ecological Applications 16:2235-2247.

Perlut, N.G., A.M. Strong, T.M. Donovan, and N.J. Buckley. 2008a. Grassland songbird survival and recruitment in agricultural landscapes: implications for source-sink demography. Ecology 89:1941-1952.

Perlut, N.G., A.M. Strong, T.M. Donovan, and N.J. Buckley. 2008b. Regional population viability of grassland songbirds: effects of agricultural management. Biological Conservation 141:3139-3151.

Pettingill, O.S., Jr. 1983. Winter of the Bobolink. Audubon 85:102-109.

Podulka, S., R. Rohrbaugh, Jr., and R. Bonney (eds.). 2004. Handbook of Bird Biology. Cornell Lab of Ornithology. Ithaca, New York. 1248 pp.

Powell, A.L.A. 2008. Responses of breeding birds in tallgrass prairie to fire and cattle grazing. Journal of Field Ornithology 79:41-52.

Pruss, S., pers. comm. 2019. *Email correspondence to J. McCracken*. December 2019. Species Conservation Specialist, Elk Island National Park, Parks Canada. Fort Saskatchewan, Alberta.

Quinn, M.A., and D.D. Walgenbach. 1990. Influence of grazing history on the community structure of grasshoppers of a mixed-grass prairie. Environmental Entomology 19:1756-1766.

Rahmig, C.J., W.E. Jensen, and K.A. With. 2008. Grassland bird responses to land management in the largest remaining tallgrass prairie. Conservation Biology 23:420-432.

Renfrew, R.B., and C.A. Ribic. 2001. Grassland birds associated with agricultural riparian practices in southwestern Wisconsin. Journal of Range Management 54:546-552.

Renfrew, R.B., and C.A. Ribic. 2002. Influence of topography on density of grassland passerines in pastures. American Midland Naturalist 147:315-325.

Renfrew, R.B., and C.A. Ribic. 2003. Grassland passerine nest predators near pasture edges identified on videotape. Auk 120:371-383.

Renfrew, R.B., and A.M. Saavedra. 2007. Ecology and conservation of Bobolink in rice production regions of Bolivia. Ornitologia Neotropical 18:61-73.

Renfrew, R.B., and C.A. Ribic. 2008. Multi-scale models of grassland passerine abundance in a fragmented system in Wisconsin. Landscape Ecology 23:181-193.

Renfrew R.B., C.A. Ribic, and J.L. Nack. 2005. Edge avoidance by nesting grassland birds: a futile strategy in a fragmented landscape. Auk 122:618-636.

Renfrew, R.B., D. Kim, N. Perlut, J. Smith, J. Fox, and P.P. Marra. 2013. Phenological matching across hemispheres in a long-distance migratory bird. Diversity and Distributions 19:1008-1019.

Renfrew, R.B., K.A. Peters, J.R. Herkert, K.R. VanBeek, and T. Will. 2019. A full life cycle conservation plan for Bobolink (*Dolichonyx oryzivorus*). United States Fish and Wildlife Service. 216 pp.

Renfrew, R., D. Kim, N. Perlut, and M. Cadman. 2020a. Migration tactics of a long-distance migratory songbird from across a continental breeding range. The Wilson Journal of Ornithology 131:735-749.

Renfrew, R.B., N. Perlut, L.M. Maxwell, M. Cadman, D.H. Kim, G.V. Clucas, and A.I. Kovach. 2022. Population structure of a grassland songbird (*Dolichonyx oryzivorus*) to inform conservation units. Biodiversity and Conservation 31:77-96.

Renfrew, R., A.M. Strong, N.G. Perlut, S.G. Martin, and T.A. Gavin. 2020b. Bobolink (*Dolichonx oryzivorus*), version 1.0. *In* Birds of the World (P.G. Rodewald, Editor). Cornell Lab of Ornithology, Ithaca, New York. Website: https://doi.org/10.2173/bow.boboli.01 [accessed January 2020].

Renken, R.B., and J.J. Dinsmore. 1987. Nongame bird communities on managed grasslands in North Dakota. Canadian Field-Naturalist 101:551-557.

Ribic, C.A., and D.W. Sample. 2001. Associations of grassland birds with landscape factors in southern Wisconsin. The American Midland Naturalist 146:105-121.

Ridgely, R.S., T.F. Allnutt, T. Brooks, D.K. McNicol, D.W. Mehlman, B.E. Young, and J.R. Zook. 2005. Digital Distribution Maps of the Birds of the Western Hemisphere, version 2.1. NatureServe, Arlington, Virginia.

Riley, J.L. 2013. The once and future Great Lakes country: An ecological history. McGill-Queen's University Press. Montreal, Quebec, and Kingston, Ontario. 488 pp.

Robbins, C.S., D. Bystrak, and P.H. Geissler. 1986. The Breeding Bird Survey: Its First Fifteen years 1965-1979. U.S. Fish and Wildlife Service Research Publication No. 157. 196 pp.

Robert, M., M.-H. Hachey, D. Lepage, and A.R. Couturier (eds.). 2019. Second Atlas of the Breeding Birds of Southern Quebec, Regroupment QuébecOiseaux, Canadian Wildlife Service (Environment and Climate Change Canada), and Bird Studies Canada, Montreal, Quebec. xxv + 694 pp.

Roch, L., and J.A.G. Jaeger. 2014. Monitoring an ecosystem at risk: What is the degree of grassland fragmentation in the Canadian Prairies? Environmental Monitoring and Assessment 186:2505-2534.

Rodewald, P.G. 2016. Bobolink. Pp. 438-439, *in* P.G. Rodewald, M.B. Shumar, A.T. Boone, D.L. Slager, and J. McCormac (eds.). The Second Atlas of Breeding Birds in Ohio. Pennsylvania State University Press, University Park, Pennsylvania.

Rodenhouse, N.L., L.B. Best, R.J. O’Connor, and E.K. Bollinger. 1995. Effects of agricultural practices and farmland structure. Pp. 269–293 *in* T.E. Martin and D.M. Finch (eds.). Ecology and Management of Neotropical Migratory Birds. Oxford University Press, New York.

Rosenberg, K.V., J A. Kennedy, R. Dettmers, R.P. Ford, D. Reynolds, J.D. Alexander, C.J. Beardmore, P.J. Blancher, R.E. Bogart, G.S. Butcher, A.F. Camfield, A. Couturier, D.W. Demarest, W.E. Easton, J.J. Giocomo, R.H. Keller, A.E. Mini, A.O. Panjabi, D.N. Pashley, T.D. Rich, J.M. Ruth, H. Stabins, J. Stanton, and T. Will. 2016 Partners in Flight Landbird Conservation Plan: 2016 revision for Canada and continental United States. Partners in Flight Science Committee, Washington, DC.

Sabine, D.L. 2020. Birds of the Atlantic Maritime Ecozone. Pp. 633-691 *in* D.F. McAlpine and I.M. Smith (eds.). Assessment of species diversity in the Atlantic Maritime Ecozone. National Research Council Research Press, Ottawa, Ontario.

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

Sample, D.W. 1989. Grassland birds in southern Wisconsin: habitat preference, population trends, and response to land use changes. M.Sc. thesis. University of Wisconsin, Madison, Wisconsin. 588 pp.

Sample, D.W., and M.J. Mossman. 2008. Two centuries of changes in grassland bird populations and their habitats in Wisconsin. Pp. 301-330 *in* D. M. Waller, and T. P. Rooney (editors). The Vanishing Present: Wisconsin’s Changing Land, Water, and Wildlife. University of Chicago Press, Chicago, Illinois.

Samson, F., and F. Knopf. 1994. Prairie conservation in North America. BioScience 44:418–421.

Samson, F.B., F.L. Knopf, and W.R. Ostlie. 2004. Great Plains ecosystems: past, present, and future. Wildlife Society Bulletin 32:6-15.

Sawatzky, K.D., and J.M. Piwowar. 2019. Changes in prairie grassland extent in Saskatchewan from 1990 to 2015. Prairie Perspectives: Geographical Essays 21:1-8.

Sawatzky, K.D. 2019. The state of native prairie in Saskatchewan. Blue Jay 77:24-28.

Scheiman, D.M., J.B. Dunning JR., and K.A. With. 2007. Metapopulation dynamics of Bobolinks occupying agricultural grassland in the Midwestern United States. American Midland Naturalist 158:415-423.

Schneider, N.A. 1998. Passerine use of grasslands managed with two grazing regimes on the Missouri Coteau in North Dakota. M.Sc. thesis. South Dakota State University, Brookings, South Dakota. 94 pp.

Serecon Management Consulting Inc. 2005. Canadian Food Trends to 2020 - A Long Range Consumer Outlook. Report prepared for Agriculture and Agri-Food Canada Ottawa, Ontario. 80 pp. + appendices.

Shire, G.G., K. Brown, and G. Winegrad. 2000. Communications Towers: A Deadly Hazard to Birds. American Bird Conservancy, Washington, D.C. 23 pp.

Shustack, D.P., A.M. Strong, and T.M. Donovan. 2010. Habitat use patterns of Bobolinks and Savannah Sparrows in the northeastern United States. Avian Conservation and Ecology 5(2):11. Website: http://www.ace-co.org/vol5/iss2/art11 [accessed January 2020].

Sick, H. 1993. Birds in Brazil. Princeton University Press, Princeton, New Jersey.

Siddle, C.R. 2015. Bobolink *in* Davidson, P.J.A., R.J. Cannings, A.R. Couturier, D. Lepage, and C.M. Di Corrado (eds.). The Atlas of the Breeding Birds of British Columbia, 2008-2012. Bird Studies Canada. Delta, British Columbia. Website: http://www.birdatlas.bc.ca/accounts/speciesaccount.jsp?sp=BOBO&lang=en [accessed January 2020].

Skipper, B.R. 2008. Influence of parental provisioning and Brown-headed Cowbird (*Molothrus ater*) parasitism on Bobolink (*Dolichonyx oryzivorus*) nestling mass. M.Sc. thesis, University of Nebraska, Kearney, Nebraska. 59 pp.

Smith, A. pers. comm. 2020. *Email correspondence with J. McCracken and M. Gahbauer*. January and November 2020. Senior Biostatistician, Canadian Wildlife Service, Environment and Climate Change Canada, Ottawa, Ontario.

Smith, A.R. 1996. Atlas of Saskatchewan Birds. Saskatchewan Natural History Society Special Publication No. 22. 456 pp.

Stantec Consulting Ltd. 2011. Wolfe Island Wind Plant Post-construction Followup Plan Bird and Bat Resources. Monitoring Report No. 3; January – June 2010. File No. 160960494. Unpublished report to TransAlta Corporation’s wholly owned subsidiary Canadian Renewable Energy Corporation.

Stanton, J.C., P. Blancher, K.V. Rosenberg, A.O. Panjabi, and W.E. Thogmartin. 2019. Estimating uncertainty of North American landbird population sizes. Avian Conservation and Ecology 14(1):4.

St. Laurent, K., pers. comm. 2020. *Email correspondence to J. McCracken*. December 2020. Species at Risk Recovery Biologist, Canadian Wildlife Service, Environment and Climate Change, Sackville, New Brunswick.

St-Pierre, J. 2010. An Assessment of Grassland Bird Conservation at CFB Gagetown. Draft report, Faculty of Forestry and Environmental Management, University of New Brunswick. Frederiction, New Brunswick. 31 pp.

Stewart, R.L.M., K.A. Bredin, A.R. Couturier, A.G. Horn, D. Lepage, S. Makepeace, P.D. Taylor, M.-A. Villard, and R.M. Whittam (eds.). 2015. Second Atlas of Breeding Birds of the Maritime Provinces. Bird Studies Canada, Environment Canada, Natural History Society of Prince Edward Island, Nature New Brunswick, New Brunswick Department of Natural Resources, Nova Scotia Bird Society, Nova Scotia Department of Natural Resources, and Prince Edward Island Department of Agriculture and Forestry, Sackville, New Brunswick. 528 + 28 pp.

Temple, S.A., B.M. Fevold, L.K. Paine, D.J. Undersander, and D.W. Sample. 1999. Nesting birds and grazing cattle: accommodating both on midwestern pastures. Pp. 196–202 *in* P.D. Vickery and J.R. Herkert (eds.). Ecology and conservation of grassland birds of the Western Hemisphere. Studies in Avian Biology 19.

Terres, J.K. 1980. The Audubon Society Encyclopedia of North American birds. Alfred A. Knopf, New York. 1109 pp.

Tews, J., D.G. Bert, and P. Mineau. 2013. Estimated mortality of selected migratory bird species from mowing and other mechanical operations in Canadian agriculture. Avian Conservation and Ecology 8(2):8. Website: http://dx.doi.org/10.5751/ACE-00559-080208 [accessed January 2020].

Thogmartin, W.E., M.G. Knutson, and J.R. Sauer. 2006. Predicting regional abundance of rare grassland birds with a hierarchical spatial count model. Condor 108:25-46.

Thompson, S.J., D.H. Johnson, N.D. Niemuth, and C.A. Ribic. 2015. Avoidance of unconventional oil wells and roads exacerbates habitat loss for grassland birds in the North American great plains. Biological Conservation 192:82-90.

Troy, A.R., A.M. Strong, S.C. Bosworth, T.M. Donovan, N.J. Buckley, and M.L. Wilson. 2005. Attitudes of Vermont dairy farmers regarding adoption of management practices for grassland songbirds. Wildlife Society Bulletin 33:528-538.

UNEP/CMS (United Nations Environment Programme / Secretariat of the Convention on the Conservation of Migratory Species of Wild Animals). 2012. Proceedings of the Tenth Meeting of the Conference of the Parties, Bergen, Norway. 20-25 November 2011. 485 pp. Website: https://www.cms.int/en/publication/conference-parties-proceedings-10th-meeting [accessed January 2020].

Unruh, J.H. 2015. Effects of oil development on grassland songbirds and their avian predators in southeastern Saskatchewan. M.Sc. thesis, University of Regina, Regina, Saskatchewan.

USC (United Stated Code Annotated). 1918. Migratory Bird Treaty Act of 1918. Title 16: Conservation of the United States Code: 703-712. Amended April 16, 2020.

USFWS (United States Fish and Wildlife Service). 2019. Environmental Conservation Online System. Website: https://www.fws.gov/endangered/species/us-species.html [accessed November 2019].

Van Damme, L.M. 1999. Status of the Bobolink in British Columbia. Wildlife Working Report No. WR-93. Ministry of Environment, Lands and Parks Wildlife Branch, Victoria. British Columbia. 11 pp.

Vickery, P.D., J.R. Herkert, F.L. Knopf, J.M. Ruth, and C.E. Keller. 2000. Grassland birds: an overview of threats and recommended management strategies. Pp. 74-77 *In* Strategies for Bird Conservation: The Partners in Flight Planning Process. Proceedings of the Third Partners in Flight Workshop. Cornell Lab of Ornithology. Cape May, New Jersey.

Vickery, P.D., H.E. Casanas, and A.S. Di Giacomo. 2003. Effects of altitude on the distribution of Nearctic and resident grassland birds in Cordoba province, Argentina. Journal of Field Ornithology 74:172-178.

Vickery, P.D., B. Zuckerberg, A.L. Jones, W.G. Shriver, and A.P. Weik. 2005. Influence of fire and other anthropogenic practices on grassland and shrubland birds in New England. Studies in Avian Biology 30:139-146.

Volkert, W.K. 1992. Response of grassland birds to a large-scale prairie planting project. Passenger Pigeon 54:190-196.

Walker, J., and P.D. Taylor. 2017. Using eBird data to model population change of migratory bird species. Avian Conservation and Ecology 12(1):4. Website: https://doi.org/10.5751/ACE-00960-120104 [accessed January 2020].

Wang, H., T.N. McCaig, R.M. DePauw, F.R. Clarke, and J.M. Clarke. 2002. Physiological characteristics of recent Canada western red spring wheat cultivars: yield components and dry matter production. Canadian Journal of Plant Science 82:299-306.

Warner, R.E. 1994. Agricultural land use and grassland habitat in Illinois: future shock for Midwestern birds? Conservation Biology 8:147-156.

Warner, R.E., and S.L. Etter. 1989. Hay cutting and the survival of pheasants: a long term perspective. Journal of Wildlife Management 53:455-461.

Warren, K.A., and J.T. Anderson. 2005. Grassland songbird nest-site selection and response to mowing in West Virginia. Wildlife Society Bulletin 33:285-292.

Wiens, J.A. 1969. An approach to the study of ecological relationships among grassland birds. Ornithological Monographs 8:1-93.

Will, T., J.C. Stanton, K.V. Rosenberg, A.O. Panjabi, A.F. Camfield, A.E. Shaw, W.E. Thogmartin, and P.J. Blancher. 2019. Handbook to the Partners in Flight Population Estimates Database, Version 3.0. PIF Technical Series No 7. Website: http://pif.birdconservancy.org/PopEstimates/ [accessed November 2019].

Wilson, A.M., D.W. Brauning, and R.S. Mulvihill. 2012. Second Atlas of Breeding Birds in Pennsylvania. Penn State University Press, University Park, Pennsylvania.

Winter, M., D.H. Johnson, J.A. Shaffer, and W.D. Svedarsky. 2004. Nesting biology of three grassland passerines in the northern tallgrass prairie. Wilson Bulletin 116:211-223.

With, K.A., A.W. King, and W.E. Jensen. 2008. Remaining large grasslands may not be sufficient to prevent grassland bird declines. Biological Conservation 141:3152-3167.

Wittenberger, J.F. 1978. The breeding biology of an isolated Bobolink population in Oregon. Condor 80:355-371.

Wittenberger, J.F. 1980. Vegetation structure, food supply, and polygyny in Bobolinks (*Dolichonyx oryzivorus*). Ecology 61:140-150.

Wootton, J.T., E.K. Bollinger, and C.J. Hibbard. 1986. Mating systems in homogeneous habitats: the effects of female uncertainty, knowledge costs, and random settlement. American Naturalist 128:499-512.

WWF (World Wildlife Fund). 2016. Plowprint annual report 2016. World Wildlife Fund, Northern Great Plains Program. Bozeman, Montana.

BIOGRAPHICAL SUMMARY OF REPORT WRITER

For over 30 years, Jon McCracken worked as a senior manager at Bird Studies Canada (BSC), now Birds Canada – a non-profit institution dedicated to the research, monitoring, and conservation of Canada's birds. He graduated from the University of Western Ontario with an Honours Bachelor of Science in zoology in 1977, and then worked as a contract biologist and environmental consultant for government and non-government agencies. He worked on a large variety of projects, with a particular focus on site and regional assessments of breeding birds. After joining BSC in 1989, he developed, implemented, and oversaw a variety of volunteer-based, bird monitoring programs, including the Canadian Migration Monitoring Network, the Marsh Monitoring Program, and the second Ontario Breeding Bird Atlas. He was extensively involved in a large variety of species at risk assessments and species recovery programs, including writing several COSEWIC status reports. He served as Co-chair of COSEWIC's Bird Specialist Sub-committee for 8 years, co-chaired the province of Ontario's Bobolink Round Table for 6 years, was the lead author on Ontario's Bobolink recovery strategy, and contributed to the production of the Canadian and international recovery strategies.

COLLECTIONS EXAMINED

No museum specimens needed to be examined for the preparation of this status report.

Appendix 1. IUCN threats calculator for Bobolink.

Species or Ecosystem Scientific Name	Bobolink *Dolichonyx oryzivorus*
Species' Generation Time (years)	2.9 years
Date	01/03/2018 (comments modified in March 2020 and March 2021 by Jon McCracken and Marcel Gahbauer)
Assessor(s):	Dwayne Lepitzki (Facilitator), Kathy St. Laurent (CWS-Atlantic), Gordon Court (Alberta); Nicky Koper (University of Manitoba), Joanne Tuckwell (Parks Canada), Steven Davis (CWS-Prairie), Mike Cadman (CWS-Ontario), Jon McCracken (Bird Studies Canada), François Schaffer (CWS-Quebec), Maureen Toner (New Brunswick), Rosalind Renfrew (Vermont Center for Ecostudies), Marc-André Cyr (CWS-NCR), and Kimberly Dohms (CWS-BC, post-call).

	Overall Threat Impact		**Level 1 Threat Impact Counts**	
	Threat Impact		**high range**	**low range**
	A	Very High	0	0
	B	High	1	1
	C	Medium	1	0
	D	Low	5	6

Calculated Overall Threat Impact:	High	High
Assigned Overall Threat Impact:	**B = High**	
Impact Adjustment Reasons:	No reason to adjust calculated impact of high; 10-70% predicted decline (median 40%) in the next 10 years (= 3 generations) is realistic given current 24-25% decline.	
Overall Threat Comments:	Percentages of birds in each province for scoring Scope: Ontario (38%), Manitoba (22%), Quebec (21%) and Saskatchewan (12%), leaving 7% in the remaining provinces. Most recent 10 year trend indicates 25% decline.	

		Impact (calculated)		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	
1.1	Housing & urban areas	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	Urban sprawl into natural and agricultural habitat (and corresponding reduction in patch size and increase in edge effects) is of concern in both the breeding and wintering ranges. Over the next ten years the scope is likely to be small; severity likely varies in proportion to availability of other habitat (e.g., probably serious in British Columbia but only slight in parts of the east; likely moderate overall).
1.2	Commercial & industrial areas	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	Tall lighted structures pose an important collision risk during nocturnal migration. The scope of this threat is increasing but probably still small at this time. Severity is believed to be moderate, given the potential for population-level implications of mortalities from collisions.
1.3	Tourism & recreation areas		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Recreational developments such as golf courses may result in some loss of habitat, but scope is negligible. Severity is only slight, as no mortality expected although there may be some impact from displacement.

		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2	Agriculture & aquaculture	B	High	Pervasive (71-100%)	Serious (31-70%)	High (Continuing)	
2.1	Annual & perennial non-timber crops	B	High	Pervasive (71-100%)	Serious (31-70%)	High (Continuing)	Conversion of hayfields, pastures and native grassland to grain, oilseed, and alfalfa mix crops is a concern in the breeding and wintering ranges, and during migration (e.g., the Llanos region of Colombia). Of even greater importance though, Bobolink now nests primarily in actively managed hayfields, where nests are highly vulnerable to mowing/harvesting because the species nests relatively late in the season. As second clutches are rare, such reproductive failure can have serious population implications. Best Management Practices to adjust timing of haying could reduce severity of threat. This threat is pervasive in eastern Canada, where nearly two-thirds of the Canadian population breeds; in the Prairies hayfields often have just one cut relatively late in summer, and scope there may be only restricted, but taking into consideration as well the exposure to winter habitat loss, the overall scope is likely to be pervasive.
2.2	Wood & pulp plantations		Negligible	Negligible (<1%)	Moderate (11-30%)	High (Continuing)	Negative effects from tree and shelterbelt planting in existing grasslands; also reduction in patch size (fragmentation and edge effects). Conversion of existing grasslands and fields into Christmas tree farms occurs in Quebec, but scope is negligible overall.
2.3	Livestock farming & ranching	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Overgrazing and degradation of habitat from trampling by cattle occurs in parts of the Prairies, but scope is likely small overall. Although some displacement may occur and nest loss is possible from trampling, severity is unlikely to be greater than slight. Increased rates of cowbird brood parasitism correlated with grazing are addressed under 8.2.
2.4	Marine & freshwater aquaculture						
3	Energy production & mining	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	
3.1	Oil & gas drilling	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	This threat is almost entirely limited to British Columbia, Alberta, and Saskatchewan, which account for less than 13% of the Canadian population; considering distribution within these provinces, scope is small, and likely closer to the low end of the range. At minimum, there appears to be some avoidance of well sites; effects on reproductive success are also possible but undocumented. Severity is presumed to be within the range of moderate.

		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3.2	Mining & quarrying	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	This threat mostly applies to pits and quarrying in grasslands and alvars, primarily in Ontario. Considering the size of most such projects, scope is likely negligible in other provinces, and toward the lower end of small overall. Although operators are responsible for offsetting habitat loss, no information is available on success of such measures. The resulting loss of habitat and reduction in patch size (fragmentation and edge effects) are similar to the effects of other threats above, and therefore severity is also scored as moderate.
3.3	Renewable energy	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	Bobolink is among the top ten species most frequently reported to collide with wind turbines, likely because of their aerial courtship displays; loss of habitat to wind turbine footprints is also a concern. Scope ranges from negligible to small across Canada, likely lower in Quebec (where most wind farms are on mountains) and the Prairies (where many are in agricultural land), and relatively higher in Ontario. Scope is likely to increase in the future. As with building collisions (see 1.2), severity is likely moderate.
4	Transportation & service corridors		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
4.1	Roads & railroads		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Road construction and widening removes habitat, and Bobolink is also vulnerable to vehicle collisions. Bobolink breeding density appears to be negatively affected by roads in grassland landscapes; Bobolink notably avoids heavily-travelled roads, probably owing to highway traffic noise (Forman *et al.* 2002). Edge effects associated with habitat fragmentation such as forest edges and road edges are recognized as concerns (Helzer and Jelinski 1999; Fletcher 2003; Fletcher and Koford 2003; Bollinger and Gavin 2004). In part, edges may facilitate nest predation and cowbird parasitism (Johnson and Temple 1990; Lavallée 1998; Van Damme 1999; Ribic and Sample 2001; Herkert *et al.* 2003; Bollinger and Gavin 2004; Galligan *et al.* 2006; Patten *et al.* 2006). All individuals are likely exposed to roads at some point in their annual cycle, but population reduction from roads is negligible.
4.2	Utility & service lines		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Collisions with phone lines, power lines and communication towers occur across the entire breeding, migration, and wintering range. While most individuals are potentially exposed to this threat, population impact is thought to be negligible. Most mortality is related to lighted communication towers, addressed under 1.2.
4.3	Shipping lanes						

		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.4	Flight paths						Because Bobolink prefers long grass, the short grass at airports is generally not attractive, so flight paths are not considered a threat.
5	Biological resource use	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Bobolink is targeted for lethal control on wintering grounds because it is considered a pest in rice crops; less so during migration, but it can also be a victim of more general blackbird control programs. However, only a small part of the population is likely targeted, and mortality among those exposed is probably infrequent enough for severity to be considered slight. The scope and severity of hunting and capture for the pet trade in South America and the Caribbean are unknown.
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						Widespread historical logging in eastern North America was beneficial to Bobolink, through creating hayfields and pasture. Although current logging is apt to convert forests to row crops, it is not currently threatening the Bobolink population.
5.4	Fishing & harvesting aquatic resources						
6	Human intrusions & disturbance		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
6.1	Recreational activities		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	All Terrain Vehicle (ATV) use and to some extent, hikers, can destroy nests and create disturbance at nest sites. However, both scope and severity are likely to be minimal relative to the population.
6.2	War, civil unrest & military exercises		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Department of National Defence sites represent a negligible portion of the Canadian breeding range, and site management with attention to species at risk suggests that severity is also negligible.
6.3	Work & other activities		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Bobolink will abandon nests if disturbed during the incubation period; threat includes routine research activities, but these apply to a negligible part of the population, and likely have a negligible effect.
7	Natural system modifications	D	Low	Small (1-30%)	Moderate (11-30%)	High (Continuing)	

		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
7.1	Fire & fire suppression	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	Fires when nests are active would be detrimental, but few burns occur during the nesting season, and fire suppression is a greater concern overall. Large areas of grassland are burned in Bolivia, but there is no direct mortality of Bobolink there during winter. Prescribed burns are used to manage Manitoba tallgrass prairie, but overlap with Bobolink nesting occurrence is low.
7.2	Dams & water management / use						
7.3	Other ecosystem modifications		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Some invasive plants outcompete native species and change grassland composition, although this is not necessarily detrimental for Bobolink. Declines in insect abundance are pervasive, but implications for Bobolink remain unclear. Abandonment of previously-farmed lands, loss of small farms, and reduction in grazing especially in the east has resulted in natural succession of grasslands to forest, with both direct implications and indirect reductions in suitability of remaining habitat as patch size shrinks and edge effects increase.
8	Invasive & other problematic species & genes	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	
8.1	Invasive non-native/alien plants & animals		Unknown	Large (31-70%)	Unknown	High (Continuing)	Many Bobolinks are exposed to cat/dog predation in Ontario and Quebec, which account for over half of the Canadian population; fewer are likely at risk in other provinces, but overall the scope is likely large. However, this threat has not been studied for Bobolink, and severity is therefore unknown. Effects of invasive non-native plants are addressed under 7.3.
8.2	Problematic native plants & animals	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	Brown-headed Cowbird parasitism of Bobolink nests is lowest in the east (0-5.9%), low to moderate in the midwest (0-20%), and fairly high in the west (35-50%). Human-subsidized native predators (e.g., Northern Raccoon, gulls) could also be a threat, but are likely more of a limiting factor. Based on cowbird parasitism rates, scope is likely restricted overall; severity is slight, partly because birds can re-nest.
8.3	Introduced genetic material						
8.4	Pathogens & microbes		Unknown	Unknown	Unknown	Unknown	Very little data available for Bobolink.
9	Pollution	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	

		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9.1	Household sewage & urban waste water		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Household pesticides, herbicides, and pollution (salt, oils, sediments) from roads all potentially affect Bobolink, and virtually all individuals are likely to be exposed at some point. However, there is no evidence to suggest severity is more than negligible.
9.2	Industrial & military effluents						
9.3	Agricultural & forestry effluents	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	Pesticide, herbicide, and insecticide exposure can cause mortality or toxicity, but there is some uncertainty as to severity of effects on the population. Exposure is particularly high outside the breeding season, when almost all Bobolinks feed in rice fields that are treated with highly toxic pesticides. Indirect effects through affecting abundance of insect prey are dealt with in 7.3.
9.4	Garbage & solid waste						
9.5	Air-borne pollutants						
9.6	Excess energy						
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Scope is considered pervasive for all aspects of climate change as it is occurring to some extent through all parts of Bobolink's year-round range.
11.1	Habitat shifting & alteration						This may be a future threat (beyond the next 10 years); potentially positive, with grasslands moving northward over the long term.
11.2	Droughts		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Predictions are for greater precipitation/drought events and not so much of a temperature change in the wintering areas. Unknown effects.
11.3	Temperature extremes		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Includes mismatch theory, which entails a disruption in timing of insect prey availability that is out of alignment with the nesting season.
11.4	Storms & flooding		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Increased vulnerability to hurricanes due to flocking behaviour during fall migration across the Gulf of Mexico. Severe weather/frost/heavy rains during nesting could also result in chick mortality and flooding of nests.
11.5	Other impacts						