

COSEWIC
Assessment and Status Report

on the

Aweme Borer
Papaipema aweme

in Canada



DATA DEFICIENT
2020

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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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le Perce-tige d'Aweme (*Papaipema aweme*) au Canada.

Cover illustration/photo:

Aweme Borer — Cover photo: Adult resting on host plant leaf, St. Labre Creek Peatlands, Manitoba, August 24, 2019 (specimen not collected); photo by K.E. Johnson.

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COSEWIC Assessment Summary

Assessment Summary – November 2020

Common name

Aweme Borer

Scientific name

Papaipema aweme

Status

Data Deficient

Reason for designation

Until 2009, this moth was known from only a few sites in Canada. Misinterpreted habitat associations and assumptions with known collection sites led to many years of searching inaccurate habitats. In 2015, Bog Buckbean (*Menyanthes trifoliata*) was confirmed as the larval host plant, the moth's primary habitat narrowed to fens or peatlands with quaking mats, and it was learned that the larvae live inside the stem, making detection difficult. New records from east-central Saskatchewan to the Ottawa Valley in Ontario, extended the geographic range of the species, suggesting the species is likely more common and widespread than previously understood. However, there is much unsurveyed suitable habitat within the moth's range. The population size and trends are unknown. Given these unknowns its status has changed from Endangered to Data Deficient.

Occurrence

Saskatchewan, Manitoba, Ontario

Status history

Designated Endangered in April 2006. Species considered in November 2020 and placed in the Data Deficient category.



COSEWIC Executive Summary

Aweme Borer *Papaipema aweme*

Wildlife Species Description and Significance

Aweme Borer (*Papaipema aweme*) is a noctuid moth with a wingspan of 33–37 mm. The forewing is light brown with darker brown markings and the hindwings are pale yellow white. Larvae have pale unbroken lateral stripes.

Distribution

The global range of Aweme Borer extends from central Saskatchewan east through Manitoba to Ontario and southwards into the United States through Minnesota, Wisconsin, Michigan and New York. Globally, there are 22 subpopulations. The global range could be much larger due to extensive potential habitat that has not been surveyed.

The Canadian range is from southern Ontario west through Manitoba and Saskatchewan. In Canada, there are 13 subpopulations (12 extant and one presumed extirpated due to lack of suitable habitat). The species is likely in Alberta, although there have yet to be records to confirm this possibility.

Search Effort

Prior to 2005, Aweme Borer habitat was poorly known, and the species had not been documented for 70 years. Between 2009 and 2015, the species' dependence on peatland habitat became apparent, and its host plant, Bog Buckbean (*Menyanthes trifoliata*), confirmed. Since 2015, nine new subpopulations have been recorded in Canada.

Habitat

Aweme Borer inhabits open to sparsely treed rich graminoid fen with a quaking mat or with shallow standing water. Habitats are variable and include large open fens, fen channels through treed wetlands, and lake shoreline peatlands. All habitats contain the larval host plant, Bog Buckbean, and are dominated by Woolly-fruited Sedge (*Carex lasiocarpa*) and other sedges. Some habitats are within peatland complexes over 15 km² in size.

Biology

Aweme Borer has an annual life cycle and one flight period per year, starting in late August and lasting longer in the United States. The eggs overwinter and larvae hatch sometime in the spring. Larvae are monophagous on Bog Buckbean and are presumed to pupate on or inside the host plant stems. Adults, mainly females, can disperse several kilometres from larval habitat. It is unlikely the population is severely fragmented.

Population Sizes and Trends

There are insufficient data on Aweme Borer abundance or distribution to assess fluctuations or trends in Canada or elsewhere in the species' global range. Evidence for large abundance is limited; however, at one collection site more than 150 adults were observed during one survey date. Rescue is considered possible due to dispersal potential and proximity of one subpopulation that straddles the international border. The number of subpopulations and the extent of Canadian and global ranges are expected to increase with additional search effort.

Threats and Limiting Factors

Aweme Borer has a wide range and most subpopulations are in natural areas with few immediate threats. The main threats to the southernmost Aweme Borer subpopulation (#11) include ecosystem modifications that change due to the spread of native and non-native plants. The impacts of climate change or development that alter peatland and fen hydrology have the potential to impact larval development. Habitat that is too dry can induce premature host plant senescence and larval mortality because the larvae are borers and rely on the host plant moisture to remain alive while in the stem. Alternately, prolonged flooding drowns the plants and the larvae. Some of these impacts could occur through habitat shifting and drought as a result of climate change, which at present is a likely threat with unknown scope and severity.

Protection, Status and Ranks

Aweme Borer is listed as Endangered on Schedule 1 of the federal *Species at Risk Act* (SARA), and listed under the *Ontario Endangered Species Act 2007* (ESA). The species is not legally protected under provincial acts in Saskatchewan or Manitoba.

Aweme Borer is ranked globally and nationally vulnerable to apparently secure (G3G4 and N3N4, respectively). The species is ranked Unknown in Ontario (SU) and Manitoba (SU). In Saskatchewan the species has not been ranked (SNR). The host plant is not at risk. One subpopulation is in an Ontario provincial park, one is on a Canadian military base, one is on private property, and two are presumed to be on municipal property. Seven subpopulations are on provincial Crown land.

TECHNICAL SUMMARY

Papaipema aweme

Aweme Borer

Perce-tige d'Aweme

Range of occurrence in Canada: Saskatchewan, Manitoba, Ontario

Demographic Information

Generation time	1 year
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Unknown.
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline a. clearly reversible and b. understood, and c. ceased?	a. Unknown b. No c. Unknown
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	643 879 km ²
EOO = 643 879 km ² (based on minimum convex polygon around all known subpopulations, within Canada's jurisdiction)	
EOO = 663 748 km ² (based on minimum convex polygon around all known subpopulations)	
Index of area of occupancy (IAO)	52 km ² although this is likely larger based on potential habitat in north central portions of Alberta and northern Ontario

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. Yes, likely for most subpopulations.
Number of “locations”*	Not applicable
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Unknown
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Unknown
Is there an [observed, inferred, or projected] decline in number of “locations”**?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Unknown
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?	Unknown

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	N Mature Individuals
12 extant subpopulations	Unknown; greatest abundance observed for one night >150 adults
Total	Unknown

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]?	Not applicable; insufficient data
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Threats

* See Definitions and Abbreviations on [COSEWIC web site](#) and [IUCN](#) (2019) for more information on this term

Was a threats calculator completed for this species? Yes, see Table 4. Assigned Low impact.
 7.3 Ecosystem modifications from European and American Reed (Invasive & Native Phragmites) – Low impact
 11.1 Habitat shifting & alteration – Unknown impact
 11.2 Droughts – Unknown impact

What additional limiting factors are relevant?

- Dispersal capability, weather, factors that influence host plant abundance and distribution.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Mulligan Lake and Red Lake, Minnesota. See Table 2.
Is immigration known or possible?	Possible
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Are conditions deteriorating in Canada?*	No
Are conditions for the source (i.e., outside) population deteriorating?*	No
Is the Canadian population considered to be a sink?*	No
Is rescue from outside populations likely?	Yes, likely.

Data Sensitive Species

Is this a data sensitive species?	No
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Status History

COSEWIC: Designated Endangered in April 2006. Species considered in November 2020 and placed in the Data Deficient category.

Status and Reasons for Designation:

Status: Data Deficient	Not applicable.
Reasons for designation: Until 2009, this moth was known from only a few sites in Canada. Misinterpreted habitat associations and assumptions with known collection sites led to many years of searching inaccurate habitats. In 2015, Bog Buckbean (<i>Menyanthes trifoliata</i>) was confirmed as the larval host plant, the moth's primary habitat narrowed to fens or peatlands with quaking mats, and it was learned that the larvae live inside the stem, making detection difficult. New records from east-central Saskatchewan to the Ottawa Valley in Ontario, extended the geographic range of the species, suggesting the species is likely more common and widespread than previously understood. However, there is much unsurveyed suitable habitat within the moth's range. The population size and trends are unknown. Given these unknowns its status has changed from Endangered to Data Deficient.	

*See [Table 3 of COSEWIC Guidelines](#) (Guidelines for modifying status assessment based on rescue effect)

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals):
Not applicable. Insufficient data to detect a population decline and no compelling evidence of a decline in EOO, IAO or habitat quality in the last 10 years.

Criterion B (Small Distribution Range and Decline or Fluctuation):
Not applicable. Meets B2 for IAO (56 km²) but not severely fragmented and no evidence of continuing decline or extreme fluctuations.

Criterion C (Small and Declining Number of Mature Individuals):
Not applicable. Number of mature individuals is unknown.

Criterion D (Very Small or Restricted Population):
Not applicable. Number of mature individuals is unknown and IAO and number of locations exceed threshold for Threatened under D2.

Criterion E (Quantitative Analysis):
Not applicable. Insufficient data for quantitative analysis.

PREFACE

Aweme Borer was first assessed as Endangered by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) in April 2006 and listed on Schedule 1 of the federal *Species at Risk Act* (SARA) in December 2007.

Prior to the first COSEWIC (2006) status assessment, the moth had only been collected once since 1936 and was globally known from five additional historical sites (7 total). The lack of collection and habitat data associated with older museum specimens made it difficult to target search effort in habitats most likely to support the moth. Inaccurate habitat interpretations and assumptions associated with the seven known collection sites led to many years of searches in the wrong habitats. Inaccurate habitats surveyed included mixed grass prairie (Roughley 2000); degraded Bur Oak savanna (Jones pers. obs. 2016); oak savanna (Friends of Pinery Provincial Park 2019), and sand dune sites based on the sandy hills around Aweme and the sandy colour of the moth (COSEWIC 2006). In 2015, Bog Buckbean (*Menyanthes trifoliata*) was confirmed as the larval host plant (Johnson *et al.* 2016) and the moth's prime habitat was also narrowed to fens or peatlands with quaking mats (Johnson *et al.* 2016; Johnson 2019). These habitats are in great contrast to the habitats thought to be associated with the historical collection sites, although all the historical sites have the presence of the host plant (COSEWIC 2006; Johnson *et al.* 2016). Subsequent targeted search effort has recorded nine new sites in Canada, bringing the total to 12 extant subpopulations. The large potential range of the host plant and large areas of fen and peatland habitat throughout Boreal Canada, combined with lack of search effort for this moth throughout this Boreal range, suggest the status of the moth has changed since its initial assessment in 2006.



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 (2020)

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.

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

COSEWIC Status Report

on the

Aweme Borer *Papaipema aweme*

in Canada

2020

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Order: Lepidoptera (Moths and Butterflies)
Superfamily: Noctuoidea
Family: Noctuidae (Owlet or Cutworm Family)
Subfamily: Noctuinae (as per Lafontaine and Schmidt 2010)
Tribe: Apameini (Borers)
Genus: *Papaipema* Smith
Species: *Papaipema aweme* (Lyman 1908)

Scientific name: *Papaipema aweme*
English common name: Aweme Borer
French common name: Perce-tige d'Aweme

There are no named subspecies (Quinter 1983).

Synonyms: *Gortyna aweme* Lyman (1908)

Type specimen: Holotype female, from Aweme, Manitoba. Deposited in the Lyman Entomological Museum, McGill University, Macdonald Campus, Montréal, Quebec.

The genus *Papaipema* Smith is one of the largest noctuid genera endemic to North America, with at least 48 described species (Lafontaine and Schmidt 2010) and five undescribed species (Goldstein and Quinter 2003). Twenty-seven described species occur in Canada (CBIF 2014; Pohl *et al.* 2018). The genus achieves its greatest diversity in eastern North America (Goldstein and Quinter 2003), although is found throughout most of temperate North America.

Aweme Borer appears to have no closely related species and is not part of a species complex or a group of sibling species. There is no evidence to suggest the characteristics defining the species are questionable (Lafontaine pers. comm. 2006).

Morphological Description

Adults

Aweme Borer (*Papaipema aweme* (Lyman)) is a medium-sized moth with a wingspan of 33–37 mm (front cover photo). The forewings are light brown, darkening slightly near the base. There are also darker brown lines towards the base and one of these lines is solid and curves inward towards the wing base as it nears the front edge of the forewing. The other line is a series of non-solid bars. The fringes and adjacent terminal areas of the forewings are dark brown. Several dark brown spots, similar in size and shape, may be present, reduced to a small dark ring, or absent. The hind wings are a pale yellow-white and are unmarked or faintly marked (Lyman 1908). Both sexes appear similar (Johnson pers. comm. 2019).

Aweme Borer is similar in appearance to other *Papaipema*, which are difficult to identify. In general, Aweme Borer is smaller, paler, and has fainter markings than other species in the genus (cf.¹ photos in Handfield 2011). Similar species include the Pitcher Plant Borer (*P. apassionata*) which occurs in the same habitats as Aweme Borer and overlaps in flight period but has distinct orange and white forewing markings.

Larvae

Larvae (Figure 1) are 30–31 mm long and have pale dorsal and subdorsal stripes which are unbroken on abdominal segments 1–4 (Johnson *et al.* 2017; McBride and Wiker 2017). As the larvae mature, these markings fade (McBride and Wiker 2017), like development in other *Papaipema* species (Hessel 1954). Larvae have minute raised bumps on the integument and a pale overall colouration, two features that distinguish this species from other *Papaipema* (McBride and Wiker 2017).



Figure 1. Aweme Borer (*Papaipema aweme*) larva extracted from the stem of Bog Buckbean (*Menyanthes trifoliata*), Deschambault Lake (#1), Saskatchewan, July 19, 2019. Photograph by K.E. Johnson.

Pupae

Pupae are typical of the genus, with the thoracic section wider than the abdominal section (McBride and Wiker 2017).

¹ cf. is used in scientific works as an abbreviation for the Latin word confer/conferatur, which means to make a comparison; to refer the reader to other similar material.

Eggs

The eggs are 0.5 mm wide by 0.3 mm high, slightly flattened and have fine longitudinal ridges. They are white/cream when laid, and if fertile, darken to light tan in a few days (McBride pers. comm. 2020).

Population Spatial Structure and Variability

The population spatial structure and variability of Aweme Borer has not been studied in Canada or the United States. No genetic work has been done on the species.

Designatable Units

Aweme Borer has one designatable unit in Canada. The moth ranges through parts of the Boreal Plains and Boreal Shield ecozones, and the northern parts of the Prairies and Mixedwood Plains ecozones. There are no subspecies nor local phenotypical differences and no information on population genetic structure.

Special Significance

Aweme Borer is not an agricultural pest. There is no information to suggest that it has or has had any cultural or economic significance to Indigenous peoples. Due to its rarity and unknown life history, Aweme Borer has received a lot of attention by both amateur and professional lepidopterists (COSEWIC 2006; Morton pers. comm. 2006; Stead pers. comm. 2016).

DISTRIBUTION

Global Range

The global range of Aweme Borer extends from central Saskatchewan east to Manitoba, Ontario and southwards through northern Minnesota, Wisconsin, Michigan, and New York (Figure 2). The global range is uncertain and could be larger due to the potential habitat and range of the moth's larval host plant within the Canadian boreal regions (Scoggan 1979), most of which have not been surveyed for moths (Schmidt pers. comm. 2019).



Figure 2. Global range of Aweme Borer (*Papaipema aweme*). Data sources COSEWIC (2006), Jones (2015), Johnson (2017), Johnson *et al.* (2017), Johnson (2019), Johnson pers. comm. (2019). Map by Sydney Allen (COSEWIC Secretariat).

Globally, there are 23 known subpopulations²: 21 extant, one historical³ and two extirpated⁴ (Tables 1 and 2). Thirteen subpopulations are in Canada and ten in the United States. The global range and the number of subpopulations has increased since the first COSEWIC (2006) status report due in part to confirmation of the species' larval host plant, and specific fen and peatland habitat, and subsequent targeted search effort within those habitats.

²**Subpopulation:** geographically or otherwise distinct groups in the population between which there is little demographic or genetic exchange (typically one successful migrant individual or gamete per year or less). Subpopulation size is measured as numbers of mature individuals (e.g., adult moths) only (COSEWIC 2020).

³ **Historical:** Possibly Extirpated, known from only historical records but still some hope of rediscovery. There is evidence that the species may no longer be present in the jurisdiction, but not enough to state this with certainty. Examples of such evidence include (1) that a species has not been documented in approximately 20-40 years despite some searching and/or some evidence of significant habitat loss or degradation; (2) that a species has been searched for unsuccessfully, but not thoroughly enough to presume that it is no longer present in the jurisdiction (NatureServe 2020).

⁴ **Presumed Extirpated:** Species or ecosystem is believed to be extirpated from the jurisdiction (i.e., territory or province). Not located despite intensive searches of historical sites and other appropriate habitat, and virtually no likelihood that it will be rediscovered.

Canadian Range

The Canadian range of Aweme Borer extends from Deschambault Lake in central Saskatchewan east through central Manitoba and south to Manitoulin Island and Grand Bend, Ontario (Figure 3).

There are 13 Aweme Borer subpopulations in Canada: 12 extant/historical⁵ (#1 – 12) and 1 extirpated³ (#13) (Figure 3; Table 1). The 12 extant/historical subpopulations include one in Saskatchewan, eight in Manitoba and three in Ontario. The extirpated subpopulation is recorded from Grand Bend, Ontario.

Table 1. Summary of Canadian Aweme Borer subpopulation information (see Figure 3).

Subpopulation # (EO #)	Subpopulation Name	Date of first record	Intervening search effort and/or years recorded	Date of most recent record	Land tenure	Collector / Observer Name & Collection Museum ⁶	Reference	Status	Maximum abundance observed	Comments
1a and 1b (17342)	Deschambault Lake, Saskatchewan	Aug. 22, 2016	None	July 19, 2019	Crown; provincial	K.E. Johnson CNC	Johnson (2017, 2019)	extant	15 adults 2016 17 adults and 8 larvae (but likely many more) 2019	Potentially large subpopulation; large potential habitat.
2	First Central Lake, Manitoba	Aug. 21, 2016	None	Aug. 21, 2016	Crown; provincial	K.E. Johnson CNC	Johnson (2017)	extant	1 adult	
3	Katimik Lake, Manitoba	Aug. 15, 2017	July 20, 2019 larval search unsuccessful	Aug. 15, 2017	Crown; provincial	K.E. Johnson CNC	Johnson (2017)	extant	> 5 adults	Not all adults at sheet were counted

⁵ **Extant:** The species is known or thought very likely to occur currently in the area, which encompasses localities with current or recent (last 20-30 years) records where suitable habitat at appropriate altitudes remains. Extant ranges should be considered in the calculation of EOO.

⁶ LEMQ = Lyman Entomological Museum, McGill University Quebec, Ste. Anne de Bellevue; NHMUK = The Natural History Museum (formerly British Museum [Natural History]), United Kingdom, London; and CNC = Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, Ontario.

Subpopulation # (EO #)	Subpopulation Name	Date of first record	Intervening search effort and/or years recorded	Date of most recent record	Land tenure	Collector / Observer Name & Collection Museum ⁶	Reference	Status	Maximum abundance observed	Comments
4	Aweme, Manitoba	Aug. 24, 1905	Unknown, but likely extensive	Aug. 24, 1905	Unknown; likely private; presumed site is not at Criddle Homestead	N. Criddle collected 3 specimens, housed at LEMQ, CNC, NHMUK	COSEWIC (2006)	historical; presumed extant	3 adults collected on 3 nights	Charles Bird (pers. comm. 2019) spent time at the Criddle Homestead (home of the Aweme Borer collector) in his youth, including trapping moths with his father Ralph Bird and Norman Criddle (collector of 1905 Aweme #4). Charles Bird stated that the most likely site of the 1905 Aweme collection is a "tamarack bog" in an oxbow of the Assiniboine River which was a favourite place to visit and much closer to the Criddle Homestead than Epinette Creek Peatlands (#5), which is more than 20 km from Aweme (#4). The tamarack bog has not been resurveyed but suitable habitat is visible based on satellite imagery.
5	Epinette Creek, Manitoba (Canadian Forces Base Shilo)	Aug. 14, 2017	None	Aug. 14, 2017	Crown; federal; Canadian Forces Base Shilo (Department of National Defence)	K.E. Johnson; none deposited at museums	Johnson (2017)	extant	> 66	Not all adults at sheet or flying during netting were counted. This site was first surveyed in 2016 with no success (August 24, 2016); however, in 2017 the moth was recorded.
6	St. Labre Creek Peatlands, Manitoba	Aug. 24, 2019	None	Aug. 24, 2019	Crown; provincial	K.E. Johnson; none deposited at museums	Johnson (2019)	extant	>150 at sheet; 51 in trap	Mostly males but >20 females; trapping by UV and MV lights, as well as moth sheets.
7	Sundown Peatland, Manitoba	Aug. 13, 2017	None	Aug. 13, 2017	Crown; provincial	K.E. Johnson; none deposited at museums	Johnson (2017)	extant	1 adult	
8	Pine Creek Peatland, Manitoba	June 23, 2016	None	2019	Crown; provincial	K.E. Johnson CNC	Johnson <i>et al.</i> (2017); McBride & Wiker (2017); Johnson pers. data	extant	Data not available	One day of larval surveys and confirmation of Aweme Borer at Pine Creek Peatland (#8) in June (Johnson <i>et al.</i> 2016). Two additional sites for a minimum of one night sometime from 2005–2016 (date not specified) (Johnson <i>et al.</i> 2016).
9	Reed River Peatlands, Manitoba	Aug. 23, 2019	None	Aug. 23, 2019	Crown; provincial	K.E. Johnson	Johnson (2019)	extant	7 adults	
10 (117892)	Agassiz Peatlands, Ontario	Aug. 29, 2016	None	Aug. 29, 2016	Crown; provincial; Ontario Provincial Nature Reserve Park	K.E. Johnson	Johnson (2017)	extant	1 worn adult	Survey likely missed main flight period; worn specimen suggests the end of the flight period.

Subpopulation # (EO #)	Subpopulation Name	Date of first record	Intervening search effort and/or years recorded	Date of most recent record	Land tenure	Collector / Observer Name & Collection Museum ⁶	Reference	Status	Maximum abundance observed	Comments
11 (94959)	Pike Lake / Turtle Lake, Manitoulin Island, Ontario	Aug. 19, 2005 (Pike Lake)	2010 (Pike Lake) 2016 (Turtle Lake)	Aug. 19, 2005	Private	J.K. Morton CNC	Morton pers. data; COSEWIC (2006); Morton and Venn 2000; Jones pers. obs. 2016	extant	1 adult (male) collected in 2005	Specimen not collected within or near fen habitat; the closest habitat is Turtle Lake (~7 km east southeast), one of two places where the host plant grows in northeastern Manitoulin Island. The weather on the day prior to the collection date included severe thunderstorms and winds up to 37 kph from the east (Environment and Climate Change Canada 2019). This may have blown specimen. The vegetation at Turtle Lake is open and shrubby fens dominated by Woolly-fruited Sedge with localized Sphagnum (Jones pers. obs. 2016).
12	Richmond Fen, Ottawa, Ontario	2020	Not applicable.	2020	Municipal park (City of Ottawa)	C. Schmidt, CNC	Schmidt pers. comm. 2020	extant	Larvae (unknown number) observed in 2020	Eastern Ontario's largest fen. One day of visual surveys of host plants for signs of larvae yielded observations at this site (Schmidt pers. comm. 2020).
13 (94960)	Grand Bend, Ontario	Aug. 15, 1936	2016	Aug. 15, 1936	Unknown	Unknown CNC	COSEWIC (2006)	presumed extirpated	1 adult collected	The general area was surveyed for the host plant and suitable habitat in 2016 (Jones 2016). Thedford Bog was the likely collection site of this specimen (C. Jones pers. comm. 2020). No habitat or host plants are present in Pinery Provincial Park (Friends of Pinery Provincial Park 2019) or shoreline habitat adjacent to the park. The surrounding landscape is agricultural with little wetland habitat. The host plant occurs in a small private nature reserve (Crosthwaite pers. comm. 2020; iNaturalist 2020), but the plants appear too small to support developing larvae (Stead pers. comm. 2020). This private nature reserve and numerous additional sites throughout the Grand Bend/Lambton Shores have been moth trapped for decades without recording Aweme Borer (Stead pers. comm. 2020).

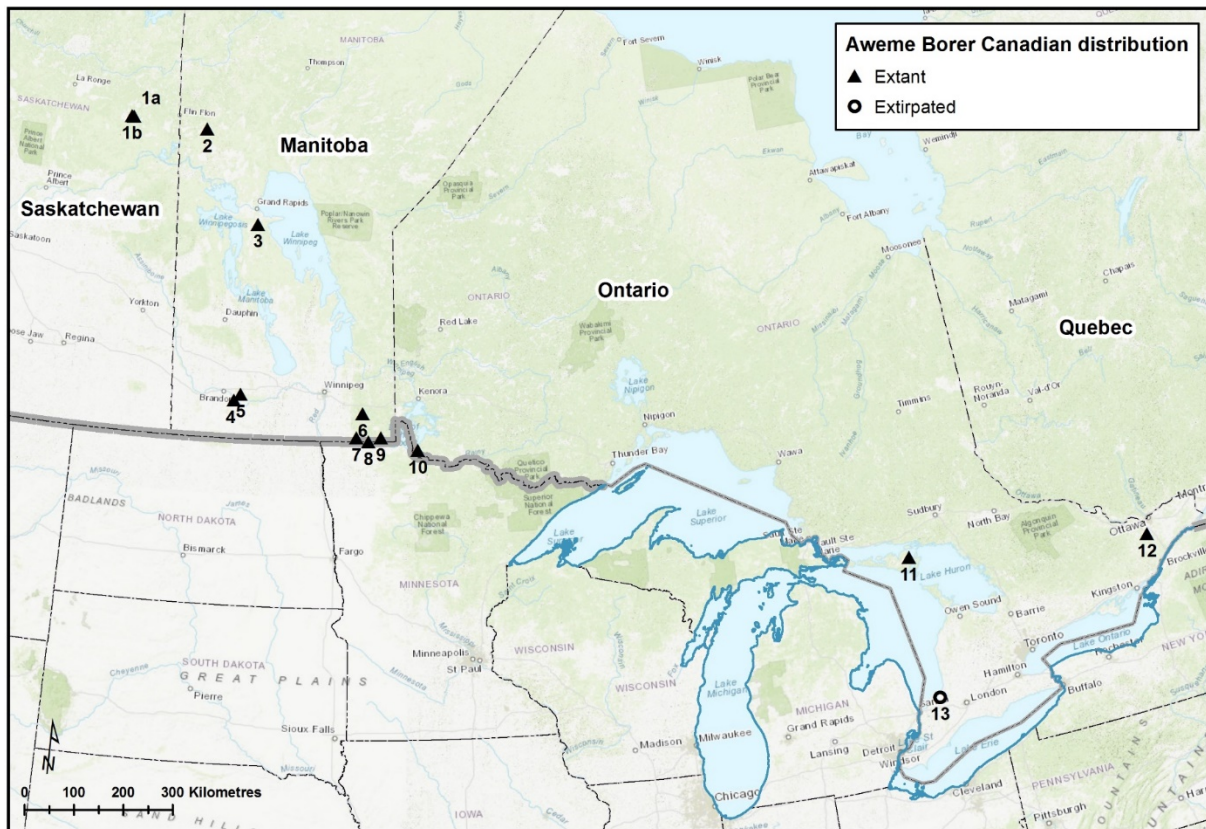


Figure 3. Canadian range and subpopulations of Aweme Borer (*Papaipema aweme*) (see Table 1). Data sources: COSEWIC (2006), Jones (2015), Johnson (2017), Johnson *et al.* (2017), Johnson (2019), Johnson pers. comm. (2019). Map by Sydney Allen (COSEWIC Secretariat).

There is one museum record from Aweme (#4) in 1905 that is technically historical³ however is considered extant. The site⁷ of the 1905 collection is unknown, but a tamarack bog in an oxbow of the Assiniboine River is known to have been frequented by the historical collector (Bird pers. comm. 2019). Apparently suitable habitat is shown on satellite imagery, and although not surveyed within the past 20-30 years, this subpopulation is considered extant based on the appearance of suitable habitat on this satellite imagery.

Subpopulations have been defined using a 5 km separation distance⁸; all collection sites within a 5 km diameter and linked by continuous habitat are considered one subpopulation unless there is a barrier of unsuitable habitat (see Habitat). Aweme Borer females are known to disperse at least 5 km from larval habitat (see Dispersal), although without records to confirm presence between habitats, subpopulations are considered separate. To date, all but two collecting points are separated by a minimum of 20 km. The

⁷ **Site**: a subpopulation can be composed of numerous habitat patches (e.g., sites) with confirmed presence of Aweme Borer and within the 5 km separation distance. These are all considered one subpopulation. Site also refers to a high-quality habitat where surveys have been completed (larval or adult surveys) and the moth may or may not have been recorded.

⁸ The **separation distance** between subpopulations is 5 km for natural and suitable habitat. When multiple records occur in a distinct natural habitat (see Habitat), these are considered one subpopulation, even if host plants are patchy (text modified from NatureServe 2020). In the case of Aweme Borer, all subpopulations are assumed to have a minimum 5 km separation distance.

collecting points at Deschambault Lake (#1a and 1b) are 3 km apart and located along a road through semi-continuous habitat and considered one subpopulation.

The host plant, Bog Buckbean (*Menyanthes trifoliata*) is Holarctic (Nylén 1993), and in Canada ranges in portions of all provinces and territories (Brouillet *et al.* 2010) and extends to the southern edge of the tundra around 70° N (Scoggan 1979). The Canadian range extent of Aweme Borer may be larger based on the range extent of the larval host plant, and a better understanding of the species' bog habitat (see Habitat). It is highly probable the species extends into the northcentral portions of Alberta (Johnson 2019) and more northerly boreal portions of Ontario. However, many lepidoptera have a geographic range that is much smaller than the range extent of their host plant: there are additional factors that limit a species' distribution.

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EOO) of Aweme Borer is approximately 663 748 km² using a minimum convex polygon encompassing all known subpopulations. The EOO within Canada's extent of jurisdiction is 643 879 km². The index of area of occupancy (IAO), based on the number of occupied 2 x 2 km grid squares, is 52 km² (Figure 4). There is potential for both EOO and IAO to increase with additional search effort (see Habitat and Search Effort).

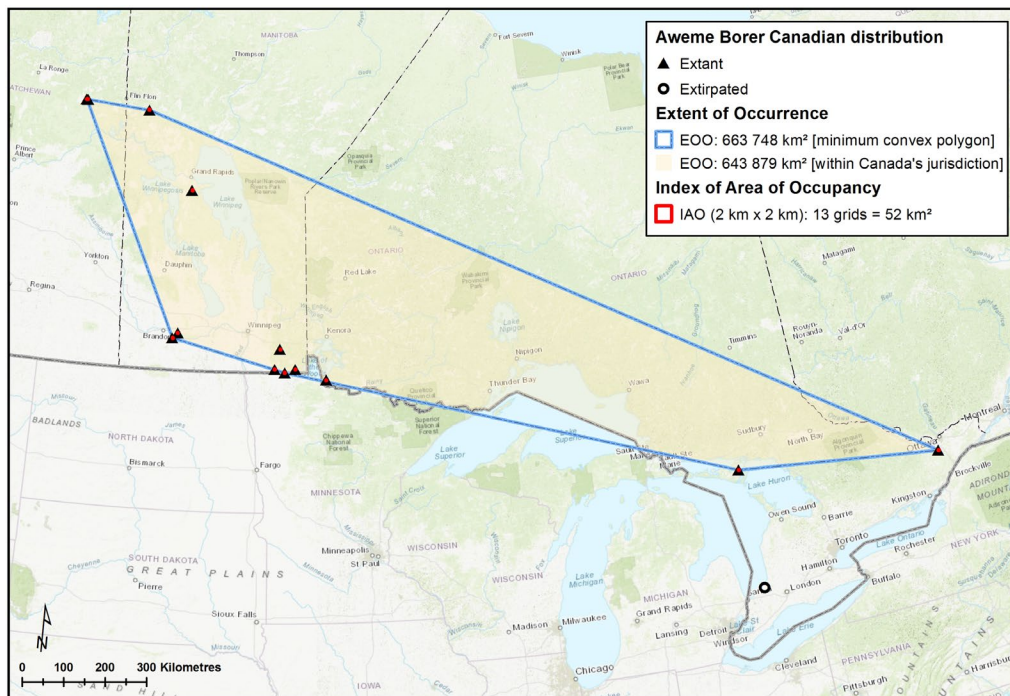


Figure 4. Global and Canadian extent of occurrence (EOO) and index of area of occupancy (IAO). Map by Sydney Allen (COSEWIC Secretariat).

Since the first status report (2006) and recent search effort (see Table 1, 2 and 3), global EOO has increased by approximately 78% and Canadian EOO by more than 120% (based on newly plotted minimum convex polygons of the former known range, not on values in COSEWIC (2006)).

The largest distance between known Canadian subpopulations is ~2300 km, the distance between Deschambault Lake (#1) and Richmond Fen (#12). The shortest distance between subpopulations is ~20 km between Aweme (#4) and Epinette Creek (#5).

Search Effort

Aweme Borer collection and sight records in Canada (both adult and larval observations) date from 1905 to 2020. Aweme Borer was first collected in 1905 at Aweme (#4), Manitoba and described from these specimens (Lyman 1908). Globally, the moth was collected at three additional sites: 1925 (Beaver Island, Michigan), 1932 (Rochester, New York) and 1936 (Grand Bend [#13], Ontario). The most recent records in Canada were collected in 2019 from Deschambault Lake (#1), Reed River Peatlands (#9), St. Labre Creek (#6) and in 2020 from Richmond Fen (#12) (Table 1 and 2).

For almost 70 years, Aweme Borer was not recorded in Canada until in 2005, the species was recorded from Pike Lake (#11), Manitoulin Island, Ontario (COSEWIC 2006; Jones 2015). In 2015, Bog Buckbean was confirmed as the larval host plant and the moth's primary habitat fens or peatland (see Habitat) (Johnson *et al.* 2016; Johnson 2019). Until this host plant and habitat knowledge was acquired, the lack of collection and habitat data associated with older museum specimens made it difficult to target specific habitats to survey for this moth. Misinterpretations and assumptions about habitats associated with the seven known collection sites⁷ led to many years of searching inaccurate habitat types. Inaccurate habitats included mixed grass prairie (#4 Aweme) (Roughley 2000); degraded Bur Oak (*Quercus macrocarpa*) savannah (#11 Pike Lake) (Jones pers. obs. 2016); oak savannah (#13 Grand Bend) (Friends of Pinery Provincial Park 2019), and sand dune sites based on the sandy hills around Aweme (#4) and the sandy colour of the moth (COSEWIC 2006). These habitats are in great contrast to the fen and peatland habitats where Aweme Borer is known to occur, although all have the presence of the host plant at or nearby the collection site (COSEWIC 2006; Johnson *et al.* 2016).

Search effort methods

Aweme Borer is surveyed using a variety of methods. Adults are trapped by bucket light traps⁹, light and sheet trapping¹⁰ or by hand-netting¹¹ during wandering transects. The

⁹ Moth trap with an 8 or 15-Watt ultraviolet (UV) or mercury vapour (MV) light, powered by 12-volt (V) batteries, suspended over a collecting bucket and containing a killing agent (usually ethyl acetate). Most traps are set up at dusk and retrieved in the morning, but some may be placed earlier and turned on automatically by photovoltaic timers.

¹⁰ White fabric or tarp-like sheets are suspended from a rope or frame and back-lit by an ultra-violet or mercury vapour light. The lights and sheet are monitored after dark. Moths are collected as they flutter against or alight on the sheet.

selection of trap sites is somewhat limited by the distance a person can carry awkward moth traps and heavy batteries into a fen, while walking in deep peat or on a quaking mat (e.g., typically less than 100 m from a trail or road). Larvae are surveyed by visual searches during wandering transects¹¹ that specifically target host plants. Larval surveys are completed from late June to mid-July and target wilted host plants with holes and frass on the stem (Figure 5 and 6) (Johnson 2019). Larval searches generally span a larger spatial area than light trap search effort. Although adults can also be surveyed by wandering transect, this method is not typical for this nocturnal moth.



Figure 5. Wilted leaves of Bog Buckbean (*Menyanthes trifoliata*) are a potential sign of Aweme Borer (*Papaipema aweme*) larval presence. Observation at Deschambault Lake (#1), Saskatchewan, July 19, 2019. Photograph by Kyle E. Johnson.

¹¹ Hand-netting or visual searching involves a surveyor wandering in suitable habitat, visiting host plant patches or nectar sources, changing course depending on habitat suitability. In the case of adult surveys, the surveyor would sweep a net across vegetation to catch moths that have alighted on flowers or by catching moths while in flight. In the case of larval searches, the surveyor would scan the host plant for evidence of chewed leaves, frass or larvae.



Figure 6. Frass outside the lower stem of Bog Buckbean (*Menyanthes trifoliata*) is a sign of Aweme Borer (*Papaipema aweme*) larval presence within the stem. Observation at Deschambault Lake (#1), Saskatchewan, July 19, 2019. Photograph by Kyle E. Johnson).

From 2014 to 2019, 34 sites in Canada were surveyed over at least 96 trap nights and at least 12 day-time larval searches (Tables 1, 2 and 3). During this time, more than 160 adult specimens were collected from 10 Canadian sites⁷ (Table 1). Searches span multiple years, and in the beginning the surveyors were not confident about the habitat, host plant or evidence left by larval activity. As surveys progressed (e.g., 2015 and 2016) these search factors were refined and search effort efficiency increased. Some of this recent (since the first COSEWIC [2006] status report) search effort is summarized below:

- Saskatchewan 2016:
 - Adult and larval surveys at 2 sites; 1 trap per site = 2 trap nights; 17 adult Aweme Borer confirmed over the two sites (#1a, 1b) (Johnson *et al.* 2016).
- Manitoba 2016:
 - Adult trapping, First Central Lake (#2), 1 light trap for one night and confirmation of Aweme Borer (Johnson *et al.* 2016).

- One day of larval surveys and confirmation of Aweme Borer at Pine Creek Peatland (#8) in June (Johnson *et al.* 2016).
- Adult trapping, two sites for a minimum of one night sometime from 2005 to 2016 (date not specified) (Johnson *et al.* 2016).
- Six sites within habitats with high suitability; 2 traps/site from Aug 30 to Sept 1 (2 nights) = 24 trap nights; no Aweme Borer (Murray and Friesen 2016).
- Ontario 2016:
 - Adult trapping at 18 sites (including Manitoulin Island, #11) from August 11 to September 9 recorded no Aweme Borer (Jones *et al.* unpubl. data). Poor weather and trapping outside the flight period may have contributed null results and experts believe the species may still be present.
 - In the same year, Aweme Borer adults were collected on August 28 on the Lake Superior shoreline in Bayfield County, Wisconsin (Johnson *et al.* 2017).
 - Agassiz Peatland (#10), one trap for one night; 1 adult moth recorded (Johnson *et al.* 2016). Two additional sites for a minimum of one night sometime from 2005 – 2016 (date unclear) (Johnson *et al.* 2016).
 - Surveys at Grand Bend Area (#13). The general area of the 1936 Grand Bend subpopulation (#13), which is presumed extirpated (Table 1), was surveyed for the host plant and suitable habitat in 2016 (Jones 2016). Thedford Bog was the likely collection site of this specimen (C. Jones pers. comm. 2020). No habitat or host plants are present in Pinery Provincial Park (Friends of Pinery Provincial Park 2019) or shoreline habitat adjacent to the park. The surrounding landscape is agricultural with little wetland habitat. The host plant occurs in a small private nature reserve (Crosthwaite pers. comm. 2020; iNaturalist 2020), but the plants appear too small to support developing larvae (Stead pers. comm. 2020). This private nature reserve and numerous additional sites throughout the Grand Bend/Lambton Shores have been moth trapped for decades without recording Aweme Borer (Stead pers. comm. 2020).
- Manitoba and Saskatchewan 2017:
 - Adult trapping at 35 sites. Aweme Borer was recorded at five sites (#1, 2, 3, 5, 7) (Johnson 2017). Presence at other sites is possible; null results may be due to poor weather and search effort outside the adult flight period.
- Alberta, Saskatchewan and Manitoba 2019:
 - Larval surveys at 16 sites from July 15 to 20 across a 1450 km span from central Alberta to southeastern Manitoba. Aweme Borer was recorded at 2 of 14 sites (#1a, 1b) (Johnson 2019).
- Manitoba 2019:
 - Adult trapping for one night (August 23-24) at two sites with two traps per site = 4 trap nights. Adults were recorded at both sites (#6, 9) (Johnson 2019).

- Ontario 2020:
 - Larval surveys in 2020 at Richmond Fen, eastern Ontario's largest fen complex and within the Ottawa area, recorded Aweme larvae (Schmidt pers. comm. 2020).

Potential range extent

In Ontario, no trapping is known from the vast wetlands in the boreal region or Hudson Bay lowlands during the flight period of Aweme Borer (Schmidt pers. comm. 2019). The host plant is abundant in the James and Hudson Bay lowlands and it is likely the moth could occur within these inaccessible and infrequently collected areas.

In Alberta, there are extensive areas of potential fen and peatland habitat within the Boreal portions of the province, including the northcentral regions and it is possible the moth could occur in these areas (Johnson 2019). Trapping during 2019 did not record the moth in Alberta; however, reconnaissance of various habitats suggests the moth is likely to be recorded with future search effort (Johnson 2019). The moth has not been recorded from Wagner Fen (one of few fens surveyed) during surveys from 1998 to 2000 and is unlikely to occur within this habitat (Schmidt pers. comm. 2019).

Aweme #4 historical/extant subpopulation

Charles Bird (pers. comm. 2019) spent time at the Criddle Homestead in his youth, including trapping moths with Ralph Bird (his father) and Norman Criddle, the collector of 1905 Aweme #4 record. Charles Bird recommends the most likely site of the 1905 Aweme collection is a "tamarack bog" in an oxbow of the Assiniboine River, which was a favourite place for Norman Criddle to visit. This habitat is much closer to the Criddle Homestead than the Epinette Creek Peatlands (#5), which is more than 20 km from Aweme (#4). The tamarack bog has not been resurveyed but suitable habitat is visible based on satellite imagery. Based on this information and the known habits of Aweme Borer, the subpopulation is considered extant.

HABITAT

Habitat Requirements

Aweme Borer habitat includes fens, peatland and muskeg with a deep, water-logged layer of dead and decaying plant material (peat). More specifically, the moth has been collected in open to sparsely treed, rich, graminoid fen, dominated by sedges in a quaking mat or in shallow standing water (Figure 7). The vegetation may be patterned, with ribs or "strings" of vegetation alternating with depressions or hollows (i.e., flarks) of shallow water.



Figure 7. Aweme Borer (*Papaipema aweme*) habitat; a graminoid rich fen with abundant Bog Buckbean (*Menyanthes trifoliata*), Deschambault Lake, Saskatchewan, July 19, 2019. Photograph by Kyle E. Johnson.

The classification of peat-based vegetation into either bog or fen community types depends on whether the water is from rain (bogs) or in part from ground water with greater mineral content (fens) (Glaser 1992; Lee *et al.* 1998). In the Canadian National Vegetation Classification (2019) the habitat may fall within vegetation community type M877 North American Boreal & Sub-boreal Alkaline Fen or type M876 North American Boreal & Sub-boreal Acidic Bog and Fen. In the Ontario ecological land classification system (see Lee *et al.* 1998; Banton *et al.* 2015; Webster *et al.* 2015), the habitat may fall within several Boreal or Great Lakes St. Lawrence fen types that range from semi-treed or shrubby to completely herbaceous and may also include shore fen types.

Aweme Borer requires the larval host plant Bog Buckbean and is likely monophagous on this plant. Captive-reared larvae placed on potato (often used as an alternate food on which to rear larvae) ceased feeding after a few days and until they had Bog Buckbean where they completed their development. Larvae have been observed on large (20–30 cm tall) Bog Buckbean plants rooted in a quaking sedge mat or sedge mat covered with shallow standing water. To date, larvae have not been found on host plants rooted in other substrates, such as *Sphagnum* or brown mosses (Amblystegiaceae) (Johnson *et al.* 2017).

The host plant is considered an indicator species for fens and minerotrophic¹² hydrology of the habitat (Banton *et al.* 2015).

Woolly-fruited Sedge (*Carex lasiocarpa*) is predominant, with a great diversity of other sedges. There are also raised hummocks of *Sphagnum* mosses with stunted Tamarack (*Larix laricina*) and Black Spruce (*Picea mariana*) as well as ericaceous and other shrubs. The structure of the habitat may vary and can be a large open area, an open channel through treed wetland (especially the spring-fen channel of Glaser [1992]) or a coastal peatland. Some habitats are in peatland complexes over 15 km² in size, while others were in smaller fens or channels. Habitat structure does not correlate with latitude as the different types of habitat structure are also found in Minnesota.

Although Bog Buckbean may be widespread in peatlands, larvae are often localized, perhaps the result of an unknown microhabitat parameter. Host plants are typically submerged in water, and water depth may be a factor in larval distribution. Larvae have been observed on the petioles of plants with only their tops above water. However, when the pith of the petiole was consumed these larvae likely drowned trying to abandon the plant or reach the larger stem. In shallower water, larvae that were able to enter the plant in the main stem continued boring down into the crown and the rhizome even though these parts of the plant were under water (McBride and Wiker 2017). In addition, water levels during and after oviposition may play a role in localization of larvae because eggs would need to be placed on the host plant or on the ground in situations that would remain above water from fall to late spring. It is possible that fens with floating mats which move up and down with the water table could be the most suitable habitat since the host plants are less likely to be inundated (Johnson pers. comm. 2019).

The Canadian range covers a great expanse of latitude, which must translate to broad differences in habitat parameters at the range extremes. Parameters that would vary with latitude might include amount of snow cover, spring thaw dates, depth of water after thaw, summer temperatures, day length, and date of first frost in the fall. These factors affect life history development.

Habitat Trends

Overall habitat trends

There is little recent habitat trend data for Aweme Borer habitats in Canada. In 2010, approximately 1.1 million km² of peatlands were mapped in Canada (12% of Canada's land area). Over 90% of Canadian peatland area was considered intact at that date (Federal, Provincial and Territorial Governments of Canada 2010). However, peatland habitat loss within the previous 20–40 years included areas flooded for hydroelectric dams, drained for forestry or peat mining, converted to agriculture, or heavily disturbed from oil sands mining. Climate change is predicted to impact peatlands by changing the ecosystems hydrology, thereby leading to prolonged or increased flooding or drying of these ecosystems (Federal, Provincial and Territorial Governments of Canada 2010).

¹² The main water supply to the vegetation and soils is from streams or springs. The water has often acquired dissolved chemicals from flowing through rocks and other minerals. This flow has reduced the acidity and raised the nutrient levels of the soil.

The Boreal Shield stretches from Saskatchewan to Newfoundland; five Aweme Borer subpopulations (#2, 6, 8, 9 and 10) are within this ecozone. Between 1980 and 2000 approximately 250 km² of peatlands were drained for forestry and some peatlands were converted to agriculture or used for cranberry cultivation (ESTR Secretariat 2014c).

In the Boreal Plains in Manitoba (#3, 7), a comparison of a Landsat imagery between 1986–1992 and 2000–2002 shows a loss of approximately 15% of marshes and fens and 10% of treed and open bogs. In this ecozone in Saskatchewan (#1) wetlands in general declined 5% between 1985–2001 and 52% of wetlands were observed to be unused by humans (ESTR Secretariat 2014a).

In the Prairie ecozone in Manitoba (#4, 5), there was extensive historical wetland loss from agricultural land conversion; 3% of original wetlands remain. More recently, in a study of a watershed southwest of Brandon, 21% of that watershed's wetland area was lost between 1968 and 2005 (ESTR Secretariat 2014b).

In the Mixedwood Plains ecozone, specifically in the Escarpment zone of Ontario which includes Manitoulin Island (#11), only 3.51% of wetland cover was peatlands (0.1% fen; 3.5% bog) in 2009 (ESTR Secretariat 2016). Manitoulin Island was not included in analyses of wetland loss in the ecozone, but from 1988 to 2000 at least two sites in shore fens containing the host plant were lost to cottage development (Morton and Venn 1984; Jones pers. obs. 1990–2019).

Overall, the range and extent of potential Aweme Borer habitat includes vast areas of intact peatlands, especially in northern ecozones. The general decline in wetlands probably has greater impact in southern regions where fen and peatland habitat are limited. However, with ample intact habitat still available in the north, conditions in Canada are not declining from resource extraction. Several other human activities currently affect peatlands (see Threats).

Subpopulation habitat trends

At Turtle Lake (#11) large areas of habitat have ingrown with *Phragmites* spp. (both *Phragmites australis* ssp. *australis* and ssp. *americanus*) (Jones pers. obs. 1997–2016) (see Threats). There has been an increase in bulrushes (*Schoenoplectus validus* and *S. acutus*) and a decrease in Woolly-fruited Sedge and other fen sedges. However, some areas of intact fen with the host plant were still present in 2016 (Jones pers. obs. 2016). It is unknown whether habitat loss or degradation has affected Aweme Borer habitat at this subpopulation.

At Grand Bend (#13), the 1936 collection site is assumed to be Thedford Bog, a 7000-ha wetland east of the Ausable River that contained 250–350 ha of floating bog. This wetland was drained for agriculture in 1955 (Lambton County Museums 2020). The historical loss of habitat may have caused the extirpation of this subpopulation.

At Aweme (#4) tamarack bog/fen habitat is visible on satellite imagery in oxbows of the Assiniboine River approximately 4 km from the presumed collection site (i.e., Criddle Homestead). However, there is also evidence of peat mining in the habitat at several places along the river. It is unknown whether or how much former habitat may have been lost.

BIOLOGY

Information below is summarized from Johnson (2017), Johnson *et al.* (2017), McBride and Wiker (2017; about the larvae) and Johnson (pers. comm. 2019). Information that applies to the genus *Papaipema* comes from sources cited in the text.

All *Papaipema* have larvae that are endophagous plant borers. The larvae chew into the roots, stems, or rhizomes of plants with soft, thick tissue to feed and shelter inside. Adults are nocturnal (Covell 1984). It is unknown whether Aweme Borer adults feed. However, adult *Papaipema* have functional mouthparts and have been netted on flowers, so most likely obtain nectar from one or more species of plants.

Life Cycle and Reproduction

Papaipema species have a one-year life cycle and grow through complete metamorphosis with four life stages; egg, larva, pupa, and adult (Covell 1984). Adult *Papaipema* moths live for approximately two weeks (Bird 1934) and have one flight period per year. The flight period of Aweme Borer in Canada is from August 13 to 29 based on museum and observation records (Table 1). The August 29 date is represented by a worn-out individual which is an indication this date is towards the end of the flight period in Canada. The flight period in the United States is from August 7 to September 10.

After mating, adult females loosely drop eggs in the vicinity of the host plant or oviposit the eggs directly on the host plant. Adults die following mating and oviposition. The eggs overwinter and hatch the following spring. Given the wetland habitat of Aweme Borer and the propensity for the host plant to be in standing water for parts of the year, eggs are likely oviposited on the host plant or somewhere above water where the larvae can reach the host plant without drowning.

Trapping events suggest adults are active at 7°–19°C although the highest abundance of moths observed was between 14°–17°C. Adults have been observed at light sheets between 9:30 pm and 5:30 am, suggesting they are active all through the night.

The larvae of Aweme Borer bore into the stem and upper petioles of Bog Buckbean, where they also pupate within or on the leaf sheaths. Captive observations from larvae reared indoors at 20°C show fast larval growth, entering the pupal phase 7–9 days after ceasing to feed, and pupation lasting 17–18 days (McBride and Wiker 2017). Aweme Borer larvae appear not to aestivate unlike other species of *Papaipema* that aestivate to delay adult emergence to fall. Larval growth and development in the wild have not been observed. Given the wet peat substrate, it seems unlikely that this species would pupate on or in the ground. See Table 1 for larval observation dates.

Physiology and Adaptability

There is no information about the physiology and adaptability of Aweme Borer. The moth primarily ranges in boreal regions, the egg can survive low winter temperatures, and the adult appears to tolerate cool temperatures during the later part of its flight period.

Dispersal and Migration

Male moths in the genus *Papaipema* generally do not travel far and are mostly found within a few hundred metres of the larval site, while females after laying eggs have been observed to travel five or more kilometres (Schweitzer 2001; Quinter pers. comm. 2014; Johnson pers. comm. 2020). In Minnesota, Aweme Borer has been recorded 8-10 km from host plant sites (Johnson pers. comm. 2019). The specimen from Pike Lake (#11) was a male and not collected in suitable habitat.

Female dispersal may influence the sex ratio captures and may be the reason historical collections, which were made outside the habitat, were mostly female. The sex ratio of captures between 2014-2019 is variable. Males are usually dominant within the habitat; for example, one light trap at Epinette Creek (#5) in 2017 caught a male-female ratio of 16:1. Females can be more prevalent later in the flight period or outside the habitat (Johnson pers. comm. 2019). Despite dispersal ability, in some subpopulations Aweme Borer seems to be localized within large peatland habitats with extensive, apparently suitable habitat.

Aweme Borer subpopulations are not considered severely fragmented¹³. Most known subpopulations are from large habitat polygons. It seems unlikely that most of the Canadian abundance could be in habitats too small to support a viable population.

Interspecific Interactions

Little is known about parasites and/or parasitoids that may affect the survival of Aweme Borer. A tachinid fly (Tachinidae) was collected from Aweme Borer in Minnesota, but the specimen was accidentally destroyed before it could be identified (Johnson pers. comm. 2019). The SARA-listed Endangered Bogbean Buckmoth (*Hemileuca* sp.) also uses Bog Buckbean as a host. Bogbean Buckmoth also occurs within Richmond Fen (#12). Other invertebrates use Bog Buckbean as a host plant, including an unidentified microlepidopteran that bores into the stem (Johnson 2019).

¹³ A taxon can be severely fragmented if most (>50%) of its total area of occupancy is in habitat patches that are (1) smaller than would be required to support a viable population, and (2) separated from other habitat patches by a large distance. Fragmentation must be assessed at a scale that is appropriate to biological isolation in the taxon under consideration (IUCN 2019).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Surveys to date for Aweme Borer have focused on recording the species' presence, habitat preferences and other natural history information. These surveys have not included methods that would provide estimates of population sizes or trends.

Abundance

Aweme Borer abundance estimates are not available. The few data available, including maximum counts, are from individual collection dates/events and not possible to compare across time (Table 1). Larval searches in 2019 at the American subpopulation at Red Lake, Minnesota found more than 100 larvae over several kilometres (Table 2; Johnson 2019), and more than 100 adults were recorded at St. Labre Peatlands (#6) (Table 1; Johnson 2019). Both collection events show evidence the species can be locally abundant.

Table 2. Known subpopulations of Aweme Borer in the United States.

Site Name	State ¹⁴	Most recent collection / collector	Status	Maximum abundance observed to date	Comments
Wanamaker Lake Peatlands	MI	2019 Badgero	extant	"Abundant" (>20) "Abundant" (>20)	Adults 2018; larvae 2019
Beaver Island	MI	1925 Moore	historical; presumed extant		Specimen collected came from the lights on a boat in the harbour
Pine Creek Peatland	MN	2019 Johnson	extant	Data not available	
Lost River Peatland	MN	2019 Johnson	extant	Extremely common; >10 larvae collected, and >100 larvae casually observed	Large subpopulation expected; one habitat patch >5 km long plus others in peatland complex
Mulligan Lake Peatland	MN	2019 Johnson	extant	>20 larvae collected, many more observed	Large subpopulation expected in >20 km linear distance of good habitat
Red Lake Peatland	MN	2018 Johnson	extant	44 adults at 3 trap sites; >100 larvae observed	
Oswego County	NY	2019 McBride	extant	"abundant" (>20)	Adults
Port Ontario	NY	2019 McBride	extant	"abundant" (>20)	Adults
Herbster shoreline	WI	2019 Ferge	extant	"abundant" (>20)	Adults

¹⁴ MI = Michigan; MN = Minnesota; NY = New York, WI = Wisconsin

Site Name	State ¹⁴	Most recent collection / collector	Status	Maximum abundance observed to date	Comments
Rochester	NY	1932 Richards	presumed extirpated	Data not available	Museum specimen

Table 3. Null search effort in Canada 2016–2019. Sites listed west to east by province then alphabetically by site name (compiled from Jones unpubl. data 2016; Johnson pers. comm. 2016; Johnson 2017, 2019).

Site Name (alphabetical in each region)	Prov. ¹⁵	Date	Trap nights	Person	Nearest town & jurisdiction	Trap type ¹⁶
Clyde Fen	AB	July 15 2019	N/A	K.E. Johnson	Clyde, Division 13	larval search
Cold Lake	AB	July 17 2019	N/A	K.E. Johnson	Cold Lake, Division 12	larval search
Hondo	AB	July 16 2019	N/A	K.E. Johnson	Hondo, Division 17	larval search
Saulteaux River #1	AB	July 16 2019	N/A	K.E. Johnson	Smith, Division 17	larval search
Saulteaux River #2	AB	July 16 2019	N/A	K.E. Johnson	Smith, Division 17	larval search
Smith # 1	AB	July 16 2019	N/A	K.E. Johnson	Smith, Division 17	larval search
Smith # 2	AB	July 16 2019	N/A	K.E. Johnson	Smith, Division 17	larval search
Smith # 3	AB	July 16 2019	N/A	K.E. Johnson	Smith, Division 17	larval search
Bedard Creek	SK	July 18 2019	N/A	K.E. Johnson	Smeaton, Division 14	larval search
Baker Lake	MB	Aug 20 2017	2	K.E. Johnson S. Bransky	Grand Rapids, Division 21	UV bucket traps, MV sheet, bait
Conlin Lake Camp	MB	Aug 19 2017	2	K.E. Johnson S. Bransky	Wabowden, Division 22	UV bucket traps, MV sheet, bait
Epinette Creek Peatland	MB	Aug 24 2016	3	K.E. Johnson	Shilo, Division 7	UV bucket traps
Katimik Lake	MB	July 20 2019	N/A	K.E. Johnson	Grand Rapids, Division 21	larval search
Loucks Lake	MB	July 19 2019	N/A	K.E. Johnson	Cranberry Portage, Division 21	larval search
Overflowing River Lowlands	MB	Aug 23 2016	1	K.E. Johnson	Overflowing River, Division 21	UV bucket trap
Saruk-Gormley Water Tracks - North Lake Winnipeg Lowlands	MB	July 19 2019	N/A	K.E. Johnson	Wabowden, Division 21	larval search

¹⁵ MB = Manitoba, SK = Saskatchewan, AB = Alberta, ON = Ontario.

¹⁶ Moth bucket light traps have an 8 or 15-Watt ultraviolet (UV) or mercury vapour (MV) light, powered by 12-volt (V) batteries. Sheets refer to a large white sheet placed next to or with an ultraviolet or mercury vapour light hung next to it. The surveyor stands next to the sheet and observes, records and/or collects the moth species attracted to the sheet over the course of the evening. Moth lights are typically set up at dusk and operated until dawn.

Site Name (alphabetical in each region)	Prov. ¹⁵	Date	Trap nights	Person	Nearest town & jurisdiction	Trap type ¹⁶
Sundance, Hudson Bay Lowlands	MB	Aug 16 2017	1	K.E. Johnson	Sundance, Division 23	UV bucket trap, MV sheet, bait
Sundance, Hudson Bay Lowlands	MB	Aug 17 2017	1	K.E. Johnson	Sundance, Division 23	UV bucket trap, MV sheet, bait
Sundance, Hudson Bay Lowlands	MB	Aug 18 2017	2	K.E. Johnson	Sundance, Division 23	UV bucket traps, MV sheet, bait, net
Wigle-Hargrave Peatlands - North Lake Winnipeg Lowlands	MB	Aug 20 2017	3	K.E. Johnson S. Bransky	Wabowden, Division 21	UV bucket traps
Black Bay Fen	ON	Sept 1-2, 2016	1	R. Foster	Thunder Bay, Thunder Bay District	UV bucket trap
Cottrill Lake	ON	Aug 22-23 2016	2	T. Eagalle	Miller Lake, Bruce Peninsula	UV bucket traps
Cottrill Lake	ON	Aug 23-24 2016	2	T. Eagalle	Miller Lake, Bruce Peninsula	UV bucket traps
Fort Frances Bog	ON	Aug 27-28, 2016	3	R. Foster	Fort Frances, Rainy River District	UV bucket traps
Highway 6 roadside	ON	Aug 21-22 2016	2	T. Eagalle	Tobermory, Bruce Peninsula	UV bucket traps
Highway 619 East Side	ON	Aug 28-29, 2016	3	R. Foster	Pinewood, Rainy River District	UV bucket traps
Marten Peatlands	ON	Sept 2-3 2016	2	K.E. Johnson	English River, Kenora District	UV bucket traps
Marten Peatlands	ON	Sept 3-4 2016	2	K.E. Johnson	English River, Kenora District	UV bucket traps, MV sheet, bait
Misery Bay	ON	Aug 29-30 2016	3	J. Jones M. Jones	Evansville, Manitoulin District	UV bucket traps
Misery Bay	ON	Sep 8-9 2016	4	C. Schmidt J. Jones	Evansville, Manitoulin District	UV bucket traps
Oakes Lake	ON	Aug 31-Sep 1 2016	2	J. Jones M. Jones	Spring Bay, Manitoulin District	UV bucket traps
Oakes Lake	ON	Sep 6-7 2016	4	C. Schmidt J. Jones	Spring Bay, Manitoulin District	UV bucket traps
Rita Lake, Sleeping Giant P.P.	ON	Aug 25-26, 2016	3	R. Foster	Thunder Bay, Thunder Bay District	UV bucket traps
Sand Lake Fen	ON	Sep 6-7 2016	5	C. Schmidt J. Jones	Providence Bay, Manitoulin District	UV bucket traps
Scotch Lake Fen	ON	Aug 23-24 2016	5	A. Harris	Martin, Thunder Bay District	UV bucket traps
Scugog Lake	ON	Aug 21-22 2016	2	T. Eagalle	Miller Lake, Bruce Peninsula	UV bucket traps & sheet
Scugog Lake	ON	Aug 22-23 2016	2	T. Eagalle	Miller Lake, Bruce Peninsula	UV bucket traps
Scugog Lake	ON	Aug 23-24 2016	3	T. Eagalle	Miller Lake, Bruce Peninsula	UV bucket traps & sheet
Spruce Islands Provincial Nature Reserve	ON	Aug 11-12 2016	2	K.E. Johnson	Pinewood, Rainy River District	UV bucket traps

Site Name (alphabetical in each region)	Prov. ¹⁵	Date	Trap nights	Person	Nearest town & jurisdiction	Trap type ¹⁶
Spruce Islands Provincial Nature Reserve	ON	Aug 28-29 2016	2	K.E. Johnson	Pinewood, Rainy River District	UV bucket traps
Spruce Islands Provincial Nature Reserve	ON	Aug 28-29, 2016	3	R. Foster	Pinewood, Rainy River District	UV bucket traps
Trewartha	ON	Sep 2-3 2016	2	A. Harris	Upsala, Thunder Bay District	UV bucket traps
Trewartha 2	ON	Sep 2-3 2016	2	A. Harris	Upsala, Thunder Bay District	UV bucket traps
Turtle Lake	ON	Aug 30-31 2016	2	J. Jones M. Jones	Sheguiandah, Manitoulin District	UV bucket traps
Turtle Lake	ON	Sep 7-8 2016	4	C. Schmidt J. Jones	Sheguiandah, Manitoulin District	UV bucket traps
Williams Bog	ON	Aug 19-20 2016	3	A. Harris	Thunder Bay, Thunder Bay District	UV bucket traps
Williams Bog	ON	Aug 21-22 2016	4	A. Harris	Thunder Bay, Thunder Bay District	UV bucket traps
Williams Bog	ON	Aug 25-26 2016	3	A. Harris	Thunder Bay, Thunder Bay District	UV bucket traps
Williams Bog	ON	Aug 30-31 2016	3	A. Harris	Thunder Bay, Thunder Bay District	UV bucket traps

Fluctuations and Trends

There is insufficient data to assess fluctuations or trends (Table 1). Few sites have been revisited and surveys to date have focused on confirming the species' presence, recording new subpopulations and natural history information.

Rescue Effect

Rescue from Aweme Moth subpopulations in the United States is likely. The Pine Creek subpopulation (#8, Figure 3 and 4) straddles the Manitoba-Minnesota has been recorded on both sides of the international border and habitat between the two collection sites is contiguous (Johnson pers. comm. 2015). The Aweme Borer site at Red Lake (Minnesota) is approximately 65 km from the Canadian subpopulation at Pine Creek (#8) and intervening habitat appears contiguous between these sites. Two other Canadian subpopulations (Sundown #7 and Reed River #9) are within 30 km of Pine Creek (#8) and there is the possibility intervening habitat could hold undocumented subpopulations and/or provide a habitat corridor.

THREATS AND LIMITING FACTORS

Threats

Threats to Aweme Borer were assessed based on the IUCN-CMP (International Union for Conservation of Nature-Conservation Measures Partnership) unified threats classification system (Master *et al.* 2012). Threats are defined as the proximate activities or processes that directly and negatively affect the Canadian population of Aweme Borer.

Aweme Borer has an extensive geographic range and most subpopulations are in natural areas with few direct threats. There are few threats to Aweme Borer. Threats to Aweme Borer include ecosystem modifications from the spread of native and non-native plants (7.3). The impacts of climate change that alter peatland and fen hydrology may affect the larvae by resulting in habitat that is too dry for host plant growth or in prolonged flooding which drowns the plants and the larvae. Some of these impacts could occur through habitat shifting (11.1) and drought as a result of climate change (11.2).

Results of the threats assessment including the impact, scope, severity and timing of threats are in Table 4 and threats specific to each subpopulation are in Table 5. The overall calculated and assigned threat impact to Aweme Borer is Low. Threats are discussed below in order of highest to lowest impact.

Table 4. Results for the Aweme Borer threats assessment in Canada. The classification is based on the IUCN-CMP (World Conservation Union–Conservation Measures Partnership) unified threats classification system. For a detailed description of the threat classification system, see the CMP web site (CMP 2019). Threats may be observed, inferred, or projected to occur in the near term. Threats are characterized here in terms of scope, severity, and timing. Threat “impact” is calculated from scope and severity. For information on how the values are assigned, see Master *et al.* (2009) and footnotes to this table.

Species Name	Aweme Borer, <i>Papaipema aweme</i>		
Date:	2020-01-25		
Assessor(s):	Medea Curteanu (Canadian Wildlife Service), Jeremy deWaard (Arthropods SSC member), Chris Friesen (Manitoba Conservation Data Centre), Jennifer Heron (Arthropods SSC Co-chair and moderator), Kyle Johnson (University of Wisconsin), Colin Jones (Ontario representative), Judith Jones, Dave McCorquodale (Arthropods SSC Co-chair), Rosana Nobre Soares (COSEWIC Secretariat), Jeff Ogden (Arthropods SSC member), Chris Schmidt (Canadian National Collection of Insects, Arachnids and Nematodes) and Ken Tuininga (Canadian Wildlife Service).		
Overall Threat Impact		Level 1 Threat Impact Counts	
Threat Impact		high range	low range
A	Very High	0	0
B	High	0	0
C	Medium	0	0
D	Low	1	1
Calculated Overall Threat Impact:		Low	Low
Assigned Overall Threat Impact:		D = Low	

Threat		Impact ¹⁷ (calculated)	Scope ¹⁸ (next 10 Yrs)	Severity ¹⁹ (10 Yrs or 3 Gen.)	Timing ²⁰	Comments
1	Residential & commercial development					
1.1	Housing & urban areas					Not applicable.
1.2	Commercial & industrial areas					Not applicable.
1.3	Tourism & recreation areas					Not applicable.
2	Agriculture & aquaculture					
2.1	Annual & perennial non-timber crops					Not applicable.
2.2	Wood & pulp plantations					Not applicable.
2.3	Livestock farming & ranching					Not applicable.
2.4	Marine & freshwater aquaculture					Not applicable.
3	Energy production & mining	Negligible	Negligible (<1%)	Serious (31-70%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	
3.1	Oil & gas drilling					Not applicable.

¹⁷ **Impact** – The degree to which a species is observed, inferred, or suspected to be directly or indirectly threatened in the area of interest. The impact of each stress is based on Severity and Scope rating and considers only present and future threats. Threat impact reflects a reduction of a species population or decline/degradation of the area of an ecosystem. The median rate of population reduction or area decline for each combination of scope and severity corresponds to the following classes of threat impact: very high (75% declines), high (40%), medium (15%), and low (3%). Unknown: used when impact cannot be determined (e.g., if values for either scope or severity are unknown).

¹⁸ **Scope** – Proportion of the species that can reasonably be expected to be affected by the threat within 10 years. Usually measured as a proportion of the species' population in the area of interest. (Pervasive = 71–100%; Large = 31–70%; Restricted = 11–30%; Small = 1–10%).

¹⁹ **Severity** – Within the scope, the level of damage to the species from the threat that can reasonably be expected to be affected by the threat within a 10-year or three-generation timeframe. Usually measured as the degree of reduction of the species' population (Extreme = 71–100%; Serious = 31–70%; Moderate = 11–30%; Slight = 1–10%).

²⁰ **Timing** – High = continuing; Moderate = only in the future (could happen in the short term [< 10 years or 3 generations]) or now suspended (could come back in the short term); Low = only in the future (could happen in the long term) or now suspended (could come back in the long term); Insignificant/Negligible = only in the past and unlikely to return, or no direct effect but limiting.

Threat		Impact ¹⁷ (calculated)	Scope ¹⁸ (next 10 Yrs)	Severity ¹⁹ (10 Yrs or 3 Gen.)	Timing ²⁰	Comments
3.2	Mining & quarrying	Negligible	Negligible (<1%)	Serious (31-70%)	Moderate (Possibly in the short term, < 10 yrs/3 gen)	Negligible. Satellite imagery from 2019 shows evidence of peat mining approximately 30 to 60 km from four Canadian subpopulations (#6, #7, #8 and #9) in Manitoba. Peat mining is also visible on 2011 satellite imagery in the habitat at Aweme (#4) on the Assiniboine River. Peat mining primarily targets areas with Sphagnum peat (rather than sedge peat) for sale to the gardening and agricultural industries (Peguis First Nation 2019) and may not directly harm Aweme Borer sedge peat habitat. However, large-scale extraction of peat could change the hydrology of the overall area even if it does not directly damage or remove host plants and moths. It is unknown if this threat applies to other subpopulations.
3.3	Renewable energy					Not applicable. Light pollution isn't considered a threat.
4	Transportation & service corridors	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	
4.1	Roads & railroads	Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Negligible. Ice roads occur through the habitat of Aweme Borer at Deschambault Lake, SK (#1). These winter roads may be used to reach remote communities and winter logging areas. Ice roads may change water dynamics in a localized area (near the road) because the roads stay frozen longer than the surrounding snow, and the substrate and plant species underneath become altered somewhat (Jones pers. obs.). However, after a few years Bog Buckbean may return to the cleared bed of the road (Johnson pers. comm. 2020). As a percentage of the total potential habitat, an ice road would affect only a small portion of any habitat.
4.2	Utility & service lines					Not applicable. There may be cleared power line cuts in habitat, and they may have buckbean. A lot of power line cuts are managed with herbicide, but unknown whether this would be needed in habitat because most areas have low vegetation that wouldn't need spraying. In ON, it is illegal to spray herbicide over water, so there should not be a threat.

Threat		Impact ¹⁷ (calculated)	Scope ¹⁸ (next 10 Yrs)	Severity ¹⁹ (10 Yrs or 3 Gen.)	Timing ²⁰	Comments
4.3	Shipping lanes					Not applicable.
4.4	Flight paths					Not applicable.
5	Biological resource use					
5.1	Hunting & collecting terrestrial animals					Not considered a threat. Collecting for research and for nature appreciation is not considered a direct threat except for the trampling of the habitat that may result. See 6.1.
5.2	Gathering terrestrial plants					Not applicable.
5.3	Logging & wood harvesting					Not applicable.
5.4	Fishing & harvesting aquatic resources					Not applicable.
6	Human intrusions & disturbance	Negligible	Negligible (<1%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs)	
6.1	Recreational activities	Negligible	Negligible (<1%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs)	Negligible. Trampling of host plants and fen habitat could occur from naturalists wanting to collect Aweme Borer, and the loose, muddy fen substrate is easily displaced. Foot trails imbedded into the peat after a 20-person field trip in the fen at Misery Bay Provincial Park (a potential Aweme Borer site) were visible for more than five years after the event (Jones pers. obs. 2000). Visitors may also introduce invasive species. However, subpopulations are in remote places with difficult walking.
6.2	War, civil unrest & military exercises					Not applicable. Occupied habitat at Epinette Creek (#5), Manitoba (on CFB Shilo) is in a buffer zone, not in active zone where military exercises would occur. Threats from these activities are unlikely.
6.3	Work & other activities					Not applicable.

Threat		Impact ¹⁷ (calculated)	Scope ¹⁸ (next 10 Yrs)	Severity ¹⁹ (10 Yrs or 3 Gen.)	Timing ²⁰	Comments
7	Natural system modifications	Low	Small (1-10%)	Extreme - Serious (31-100%)	High (Continuing)	
7.1	Fire & fire suppression					Not applicable. A few Manitoba sites apparently have some history of wildfire (Johnson pers. obs.), but this is likely part of a natural dynamic. In most subpopulations, larvae are at/below the water table, so they likely have low risk.
7.2	Dams & water management/use					Not applicable. Draining or alteration of the hydrology or nutrient load of wetlands would be a serious threat. It is unknown whether there is any potential for this to happen in the habitat of Aweme Borer as most habitats are part of large peatland complexes that are distant from human settlement. Historically, habitat was lost at Grand Bend (#13) due to conversion of wetlands, but with a large amount of habitat in the north, even if some is lost to drainage, the scope would be small. It is unknown whether this is currently occurring. Some habitat at Epinette Creek (#5) was impacted by construction of the railway which dried out a small portion of habitat. This is not considered a current threat.
7.3	Other ecosystem modifications	Low	Small (1-10%)	Extreme – Serious (31-100%)	High (Continuing)	Threats from Invasive Species are scored here because they impact habitat rather than directly impacting Aweme Borer individuals. European Reed (<i>Phragmites</i>) and American Reed (native <i>Phragmites</i> ; see text) occurs only at Turtle Lake (#11), Manitoulin Island, Ontario (small scope). Northern sites are remote and don't appear to be affected, but snow machines and other vehicles may be vectors for seeds in winter. Severity may be extreme because these grasses grow quickly and alter habitat. See text under Threats and Limiting Factors.
8	Invasive & other problematic species & genes					
8.1	Invasive non-native/alien species/diseases					European Reed (<i>Phragmites</i> spp.) is discussed in 7.3

Threat		Impact ¹⁷ (calculated)	Scope ¹⁸ (next 10 Yrs)	Severity ¹⁹ (10 Yrs or 3 Gen.)	Timing ²⁰	Comments
8.2	Problematic native species/diseases					American Reed (native <i>Phragmites</i>) may be a threat. See text under Threats and Limiting Factors. Threat is discussed in 7.3
8.3	Introduced genetic material					Not applicable.
8.4	Problematic species/diseases of unknown origin					Not applicable.
8.5	Viral/prion-induced diseases					Not applicable.
8.6	Diseases of unknown cause					Not applicable.
9	Pollution					
9.1	Domestic & urban wastewater					Not applicable.
9.2	Industrial & military effluents					Not applicable.
9.3	Agricultural & forestry effluents					Not applicable. Unlikely a fen would be sprayed for forest or agricultural Lepidoptera pests. Commercial cranberry production is not near occupied habitat, and only commercial areas would be sprayed. <i>Bacillus thuringiensis</i> (Btk), a commercial pesticide that is used to control pest lepidoptera and targets the larval life stage, may be sprayed to control Spruce Budworm in Jack Pine stands, but that would not be in wetlands. Also, the larvae bores inside the stem and BtK is on the plant surface, so it is unlikely to impact Aweme Borer.
9.4	Garbage & solid waste					Not applicable.
9.5	Air-borne pollutants					Not applicable.
9.6	Excess energy					Not applicable.
10	Geological events					
10.1	Volcanoes					Not applicable.
10.2	Earthquakes/ tsunamis					Not applicable.
10.3	Avalanches/ landslides					Not applicable.

Threat		Impact ¹⁷ (calculated)	Scope ¹⁸ (next 10 Yrs)	Severity ¹⁹ (10 Yrs or 3 Gen.)	Timing ²⁰	Comments
11	Climate change & severe weather	Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	The effects of climate change are unknown. Potential effects are considered here.
11.1	Habitat shifting & alteration	Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	See text under Threats and Limiting Factors.
11.2	Droughts	Unknown	Small (1-10%)	Unknown	Moderate (Possibly in the short term, < 10 yrs/3 gen)	See text under Threats and Limiting Factors.
11.3	Temperature extremes					Not applicable.
11.4	Storms & flooding					Not applicable.
11.5	Other impacts					Not applicable.

Table 5. Applicable threats to Aweme Borer subpopulations. P = potential; Y = confirmed; H = historical, U = unknown. A blank indicates threat does not apply to the subpopulation. Threat impact in Table 4.

Subpopulation #	Subpopulation Name	Date of first record	Date of most recent observation	Land Tenure	Comments	IUCN threats category					
						3.2 Mining and Quarrying	4.1 Roads and Railroads	6.1 Recreational Activities	7.3 Other ecosystem modifications	11.1 Habitat shifting and alteration	11.2 Droughts
Total number of subpopulations to which threat applies						5	1	3	1	12	12
1	Deschambault Lake, SK	August 22, 2016	July 19, 2019	Crown; provincial	4.1: visible on 2019 imagery		Y			U	U
2	First Central Lake, MB	August 21, 2016	July 19, 2019	Crown; provincial						U	U
3	Katimik Lake, MB	August 15, 2016	July 19, 2019	Crown; provincial						U	U
4	Aweme, MB	August 26, 1905	July 19, 2019	probably private (presumed site is not at Criddle Homestead)	3.2: visible on 2011 imagery at presumed collection site; unknown if activity is continuing	H / Y				U	U

Subpopulation #	Subpopulation Name	Date of first record	Date of most recent observation	Land Tenure	Comments	IUCN threats category					
						3.2 Mining and Quarrying	4.1 Roads and Railroads	6.1 Recreational Activities	7.3 Other ecosystem modifications	11.1 Habitat shifting and alteration	11.2 Droughts
Total number of subpopulations to which threat applies						5	1	3	1	12	12
5	EpINETTE Creek, MB	August 14, 2017	July 19, 2019	Crown; federal; Canadian Forces Base Shilo (Department of National Defence)					U	U	
6	St. Labre Creek Peatlands, MB	August 24, 2019	July 19, 2019	Crown; provincial	3.2: visible on 2019 imagery at other peatlands w/in 60 km	P			U	U	
7	Sundown Peatland, MB	August 13, 2017	July 19, 2019	Crown; provincial	3.2: visible on 2019 imagery at other peatlands w/in 60 km	P			U	U	
8	Pine Creek Peatland, MB (MN)	August 10, 2016		Crown; provincial	3.2: visible on 2019 imagery at other peatlands w/in 60 km	P		P	U	U	
9	Reed River Peatlands, MB	August 23, 2019	July 19, 2019	Crown; provincial	3.2: visible on 2019 imagery at other peatlands w/in 60 km	P			U	U	
10	Agassiz Peatlands, ON	August 29, 2016	July 19, 2019	Crown; provincial; Ontario Provincial Nature Reserve Park				P	U	U	
11	Pike Lake / Turtle Lake, ON	August 19, 2005	July 19, 2019	Private					U	U	
12	Richmond Fen, Ottawa, ON	August 2020	August 2020	Private Nature Reserve				P	U	U	

7. Natural system modifications (Low impact)

7.3 Other Ecosystem Modifications (Low Impact).

Invasive non-native and native plant species are scored under this category rather than in 8.1 and 8.2 because their impacts are to the habitat and not directly to Aweme Borer.

Non-native European Reed (*Phragmites australis* ssp. *australis*) and native American Reed (*P. australis* ssp. *americanus*) (Saltonstall 2002) have been spreading at Turtle Lake (#11) since 2005, when first observed within this habitat (Jones pers. ob. 1997-2019). These fast-spreading grasses (Ontario Ministry of Natural Resources 2011) have increased in area and abundance in these wetlands, outcompeted native plants, led to a change in plant species composition, and reduced the amount of Woolly-fruited Sedge, Bog Buckbean and other fen species at this site (Jones pers. obs. 2016).

Although a native plant, American Reed appears invasive on Manitoulin Island because it is spreading rapidly within these habitats (Jones pers. obs. 2011-2019). A recent genetic study has confirmed that these invasive plants are the native American Reed subspecies (Warren pers. comm. 2019). There is no information on whether American Reed is present or adversely impacting the habitat of other Aweme Borer subpopulations.

11 Climate Change and Severe Weather (Unknown impact)

11.1 Habitat Shifting and Alteration (Unknown impact).

The effects of climate change on Aweme Borer or its host plant are unknown, but hotter summers, more rain, and less snow are predicted for Canada (Bush *et al.* 2019), which may change peatland hydrology and lead to increased flooding or drying of these ecosystems (Federal, Provincial and Territorial Governments of Canada 2010).

Aweme Borer ranges predominantly within the boreal region of Canada and has a late summer/early fall flight period. Increased temperature within the boreal region may shift the range of the species further north or change the phenology of the adult moth, perhaps enabling a longer or later flight period. Temperature changes may also change larval phenology and shift the time periods for aestivation or larval development stages.

11.2 Droughts (Unknown impact).

Drought could impact Aweme Borer fen habitat. A lower water table within a peatland or fen could reduce or cause local host plant senescence and eventual mortality, or over the longer term alter the overall fen ecosystem. This threat is unlikely to simultaneously impact all subpopulations over the assessment time frame and some peatlands are continuously wet and unlikely to be impacted.

Limiting Factors

Limiting factors include innate characteristics that make a species less likely to respond to recovery and conservation efforts and may compound when combined with human-caused threats. The main limiting factors for Aweme Borer are speculative, but are likely a combination of: natural enemies such as predators, parasites, and parasitoids that likely attack moths at all life stages and limit subpopulation abundance; host plant specificity, although the host plant is not limited in its abundance or distribution throughout its Canadian range; and the moths' short adult lifespan which may limit their ability to find mates and lay eggs if weather is unsuitable (e.g., early/late season frost, extensive rainfall or wind). Localized microclimate may impact local habitat. For example, fen water depth may limit host plant abundance and distribution and/or if water levels remain high this may prevent caterpillars from dispersing to other nearby host plants should they consume all of a host plant.

Number of Locations

The location²¹ concept does not apply to Aweme Borer; there are few or low impact threats to extant subpopulations. At this time, the most plausible threat across all subpopulations are impacts from climate change in the form of droughts (11.2) and habitat shifting and alteration (11.1), both of which could impact the host plant abundance and distribution and overall hydrology of the moth's fen and peatland habitat. However, the threat impact of climate change is unknown. Impacts on the host plant are likely variable throughout both the moth's and plant's range, and overall are not applicable within the ten-year assessment horizon. If the location concept was to apply, and each extant subpopulation (Table 1) is impacted differently from climate change, then there would be more than 10 locations for Aweme Borer in Canada. The estimate is a minimum, because there are likely additional undocumented subpopulations within the northern Boreal areas of Alberta, Saskatchewan, Manitoba and Ontario.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Aweme Borer is listed as Endangered on Schedule 1 of the federal *Species at Risk Act* (SARA).

²¹ The term 'location' defines a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations. Where a taxon is affected by more than one threatening event, location should be defined by considering the most serious plausible threat. Where the most serious plausible threat does not affect all the taxon's distribution, other threats can be used to define and count locations in those areas not affected by the most serious plausible threat (IUCN 2010, 2011). In the absence of any plausible threat for the taxon, the term "location" cannot be used and the sub criteria that refer to the number of locations will not be met (IUCN 2010, 2011)

Aweme Borer is known from the provinces of Ontario, Manitoba and Saskatchewan.

- In Ontario, Aweme Borer is listed under the Ontario *Endangered Species Act 2007* (ESA). The habitats of all species listed on the ESA as Endangered or Threatened are automatically protected from damage or destruction, regardless of whether the habitat has been described. Aweme Borer habitat has not been described, nor regulated, although the species and its habitat has had general protection since 2013. This may result in some consideration for the habitat during development applications.
- In Manitoba, species at risk are listed and protected under the Manitoba *Endangered Species and Ecosystems Act*; this act prohibits destroying, disturbing or interfering with the species or its habitat. Aweme Borer is not listed under this provincial act.
- In Saskatchewan, provisions under the *Wildlife Act 1998* protect species at risk and their habitats from risks to their survival associated with human activity. The focus is directed at the needs of provincially threatened and endangered species and is integrated with the federal *Species at Risk Act*. Aweme Borer is not listed under this provincial act.

Bog Buckbean, the host plant, is not a species at risk in any jurisdiction in Canada or at the federal level and has no legal protection in Canada.

Recovery strategies have been prepared for Aweme Borer in Canada (Environment and Climate Change Canada 2017) and Ontario (Jones 2015). At the time these documents were written, the host plant was unknown. To date, neither federal nor provincial critical habitat has been identified, and habitat has not been regulated in Ontario.

Non-Legal Status and Ranks

The conservation status ranks for Aweme Borer (Natureserve 2020):

- Global Status: G3G4 (Vulnerable to Apparently Secure)
- Canada National status: N3N4 (Vulnerable to Apparently Secure)
- Manitoba status: SU (Unknown, due to lack of information)
- Saskatchewan status: SNR (Status Not Ranked)
- Ontario status: SU (Unknown)
- United States National Status: SH (Historical)
- United States subnational ranks: New York (SH), Minnesota (SNR), Michigan (S1).

In the United States, Aweme Borer is not protected under federal or state laws.

Bog Buckbean, the host plant, is considered globally Secure (G5), Apparently Secure (S4) in Saskatchewan and New York, and Secure (S5) in Manitoba and Ontario. It has not been ranked (SNR) in Michigan, Minnesota, and Wisconsin (NatureServe 2020).

Habitat Protection and Ownership

Habitat protection and ownership for areas with each subpopulation is listed in Table 1.

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Cover photograph by K.E. Johnson, adult resting on host plant leaf, St. Labre Creek Peatlands, Manitoba, August 24, 2019 (specimen not collected). Photos in this report are taken by K.J. Johnson.

Gary Anweiler wrote the first Aweme Borer COSEWIC status report.

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COLLECTIONS EXAMINED

United States National Museum, Washington, D.C.

Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, Ontario

Natural History Museum, London, UK