

Recovery Strategy for the Aweme Borer (*Papaipema aweme*) in Canada

Aweme Borer



2016



Recommended citation:

Environment and Climate Change Canada. 2016. Recovery Strategy for the Aweme Borer (*Papaipempa aweme*) in Canada [Proposed]. *Species at Risk Act* Recovery Strategy Series. Environment and Climate Change Canada, Ottawa. 15 pp. + Annex.

For copies of the recovery strategy, or for additional information on species at risk, including the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) Status Reports, residence descriptions, action plans, and other related recovery documents, please visit the [Species at Risk \(SAR\) Public Registry](http://www.registrelep-sararegistry.gc.ca)¹.

Cover illustration: © Agriculture and Agri-Food Canada. Photo: Jocelyn Gill

Également disponible en français sous le titre
« Programme de rétablissement du perce-tige d'Aweme (*Papaipempa aweme*) au Canada [Proposition] »

© Her Majesty the Queen in Right of Canada, represented by the Minister of the Environment and Climate Change, 2016. All rights reserved.

ISBN

Catalogue no.

Content (excluding the illustrations) may be used without permission, with appropriate credit to the source.

¹ <http://www.registrelep-sararegistry.gc.ca>

RECOVERY STRATEGY FOR THE AWEME BORER (*Papaipempa aweme*) IN CANADA

2016

Under the Accord for the Protection of Species at Risk (1996), the federal, provincial, and territorial governments agreed to work together on legislation, programs, and policies to protect wildlife species at risk throughout Canada.

In the spirit of cooperation of the Accord, the Government of Ontario has given permission to the Government of Canada to adopt the *Recovery Strategy for the Aweme Borer Moth (Papaipempa aweme) in Ontario* (Part 2) under Section 44 of the *Species at Risk Act* (SARA). Environment and Climate Change Canada has included a federal addition (Part 1) which completes the SARA requirements for this federal recovery strategy.

The federal recovery strategy for the Aweme Borer in Canada consists of two parts:

Part 1 – Federal Addition to the *Recovery Strategy for the Aweme Borer Moth (Papaipempa aweme) in Ontario*, prepared by Environment and Climate Change Canada.

Part 2 – *Recovery Strategy for the Aweme Borer Moth (Papaipempa aweme) in Ontario*, prepared by Judith Jones for the Ontario Ministry of Natural Resources and Forestry.

Table of Contents

Part 1 – Federal Addition to the *Recovery Strategy for the Aweme Borer Moth* (*Papaipempa aweme*) in Ontario, prepared by Environment and Climate Change Canada.

Preface	2
Acknowledgements.....	4
Additions and Modifications to the Adopted Document.....	5
1. Recovery Feasibility Summary	5
2. COSEWIC Species Assessment Information	7
3. Species Status Information.....	8
4. Threats	9
5. Population and Distribution Objectives	9
6. Broad Strategies and General Approaches to Meet Objectives	10
7. Critical Habitat.....	11
7.1 Identification of the Species' Critical Habitat	11
7.2 Schedule of Studies to Identify Critical Habitat	12
8. Measuring Progress	13
9. Statement on Action Plans	13
10. Effects on the Environment and Other Species.....	13
References	14

Part 2 – *Recovery Strategy for the Aweme Borer Moth* (*Papaipempa aweme*) in Ontario, prepared by Judith Jones for the Ontario Ministry of Natural Resources and Forestry.

Part 1 – Federal Addition to the *Recovery Strategy for the Aweme Borer Moth (Papaipempa aweme)* in Ontario, prepared by Environment and Climate Change Canada

Preface

The federal, provincial, and territorial government signatories under the [Accord for the Protection of Species at Risk \(1996\)](#)² agreed to establish complementary legislation and programs that provide for effective protection of species at risk throughout Canada. Under the *Species at Risk Act* (S.C. 2002, c.29) (SARA), the federal competent ministers are responsible for the preparation of recovery strategies for listed Extirpated, Endangered, and Threatened species and are required to report on progress within five years after the publication of the final document on the SAR Public Registry.

The Minister of the Environment and Climate Change is the competent minister under SARA for the Aweme Borer and has prepared the federal component of this recovery strategy (Part 1), as per section 37 of SARA. To the extent possible, it has been prepared in cooperation with the province of Ontario as per section 39(1) of SARA. SARA section 44 allows the Minister to adopt all or part of an existing plan for the species if it meets the requirements under SARA for content (sub-sections 41(1) or (2)). The Province of Ontario led the development of the attached recovery strategy for the Aweme Borer (Part 2) in cooperation with Environment and Climate Change Canada.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy and will not be achieved by Environment and Climate Change Canada, or any other jurisdiction alone. All Canadians are invited to join in supporting and implementing this strategy for the benefit of the Aweme Borer and Canadian society as a whole.

This recovery strategy will be followed by one or more action plans that will provide information on recovery measures to be taken by Environment and Climate Change Canada and other jurisdictions and/or organizations involved in the conservation of the species. Implementation of this strategy is subject to appropriations, priorities, and budgetary constraints of the participating jurisdictions and organizations.

The recovery strategy sets the strategic direction to arrest or reverse the decline of the species, including identification of critical habitat to the extent possible. It provides all Canadians with information to help take action on species conservation. When the recovery strategy identifies critical habitat, there may be future regulatory implications, depending on where the critical habitat is identified. SARA requires that critical habitat identified within a national park named and described in Schedule 1 to the *Canada National Parks Act*, the Rouge National Urban Park established by the *Rouge National Urban Park Act*, a marine protected area under the *Oceans Act*, a migratory bird sanctuary under the *Migratory Birds Convention Act, 1994* or a national wildlife area under the *Canada Wildlife Act* be described in the *Canada Gazette*, after which prohibitions against its destruction will apply. For critical habitat located on other federal lands, the competent minister must either make a statement on existing legal protection

² <http://registrelep-sararegistry.gc.ca/default.asp?lang=en&n=6B319869-1#2>

or make an order so that the prohibition against destruction of critical habitat applies. For any part of critical habitat located on non-federal lands, if the competent minister forms the opinion that any portion of critical habitat is not protected by provisions in or measures under SARA or other Acts of Parliament, or the laws of the province or territory, SARA requires that the Minister recommend that the Governor in Council make an order to prohibit destruction of critical habitat. The discretion to protect critical habitat on non-federal lands that is not otherwise protected rests with the Governor in Council.

Acknowledgements

The initial draft of the federal addition was prepared by Judith Jones (Winter Spider Eco-Consulting). Additional preparation and review of the document was completed by Allison Foran and Justine Mannion (Environment and Climate Change Canada, Canadian Wildlife Service – Ontario Region). Krista Holmes, Liz Sauer, Lesley Dunn (Environment and Climate Change Canada, Canadian Wildlife Service – Ontario Region); Kathy St. Laurent (Environment and Climate Change Canada, Canadian Wildlife Service – Formerly Ontario Region); Medea Curteanu (Environment and Climate Change Canada, Canadian Wildlife Service – Prairie and Northern Region). Vivian Brownell, Jay Fitzsimmons and Kristina Hubert (Ontario Ministry of Natural Resources and Forestry) reviewed and provided comments and advice during the development of this document. Eric Quinter (American Museum of Natural History), Kyle E. Johnson (University of Wisconsin, Madison) and Don Lafontaine (Agriculture and Agri-food Canada) shared their expertise with the Noctuidae and with the genus *Papaipema*. The late J.K. Morton's comments to Judith Jones are also gratefully acknowledged.

Acknowledgement and thanks is given to all other parties that provided advice and input used to help inform the development of this recovery strategy including various Aboriginal organizations and individuals, landowners, citizens and stakeholders who provided input and/or participated in consultation meetings.

Additions and Modifications to the Adopted Document

The following sections have been included to address specific requirements of the federal *Species at Risk Act* (SARA) that are not addressed in the Province of Ontario's *Recovery Strategy for the Aweme Borer Moth (Papaipempa aweme) in Ontario* (Part 2) and to provide updated or additional information.

Environment and Climate Change Canada is adopting the provincial recovery strategy, including section 2, Recovery; which outlines the approaches necessary to meet the population and distribution objective. Environment and Climate Change Canada has established its own population and distribution objective that is consistent with the provincial recovery goal.

Under SARA, there are specific requirements and processes set out regarding the protection of critical habitat. Therefore, statements in the provincial recovery strategy referring to protection of the species' habitat may not directly correspond to federal requirements. Recovery measures dealing with the protection of habitat are adopted; however, whether these measures will result in protection of critical habitat under SARA will be assessed following publication of the final federal recovery strategy.

1. Recovery Feasibility Summary

Based on the following four criteria that Environment and Climate Change Canada uses to establish recovery feasibility, there are unknowns regarding the feasibility of recovery of the Aweme Borer. In keeping with the precautionary principle, this recovery strategy has been prepared as per section 41(1) of SARA, as would be done when recovery is determined to be feasible. This recovery strategy addresses the unknowns surrounding the feasibility of recovery.

1. Individuals of the wildlife species that are capable of reproduction are available now or in the foreseeable future to sustain the population or improve its abundance.

Unknown. Despite search efforts, the species has never been reconfirmed at any of the collection sites in Canada or the United States. The species presence is difficult to confirm given uncertainties in habitat use, host plant(s) and survey methodology. The existence, size and viability (probability of persistence) of the global and Canadian populations of the Aweme Borer are unknown. In Canada, only five specimens of the Aweme Borer have been observed at three locations: one location in Manitoba (Aweme, 1905) and two locations in Ontario (Grand Bend, 1936, and Manitoulin Island, 2005). The Aweme Borer was observed on Manitoulin Island during severe weather conditions (i.e., heavy rainfall and strong winds) therefore it is possible that the individual was blown in from adjacent habitat. Consequently, the Manitoulin collection site may not be representative of the species' preferred habitat (Jones 2015). The exact locations of the Aweme and Grand Bend collection sites are unknown and considered historic (COSEWIC 2006). The most recent sightings of the species were made in northern Minnesota in 2015 (11 specimens) and Pine

Creek, Minnesota in 2014 (one specimen) (Table 1; Johnson pers. comm. 2015), and McMillan, Michigan in 2009 (one specimen; Quinter pers. comm. 2014; Jones pers. comm. 2015). The 2014 Pine Creek observation was made along the border path between Minnesota and Manitoba (Johnson pers. comm. 2015). The habitat in the Pine Creek area extends northward into Canada, therefore it is possible that search efforts may reveal new sites in the area of Manitoba adjacent to Pine Creek, Minnesota (Johnson pers. comm. 2015; Jones 2015).

Experts are unsure whether the lack of observations is due to an actual extreme rarity or due to a lack of knowledge on how or where to survey for the species (Morton pers. comm. 2006; Quinter pers. comm. 2014; Lafontaine pers. comm. 2014). Previous efforts to locate the larvae and host plant(s) were based on the assumption that the species occurred in sand dune habitats. The two most recent observations suggest that the species may be found in peatlands (fens) and bogs. Targeted searches of wetland habitats in Manitoba and the border region of northwestern Ontario may lead to new observations in Canada (Jones 2015). Methods for locating the Aweme Borer must be developed to determine if the species is extant in Canada and whether the number of individuals is sufficient to sustain recovery efforts.

2. Sufficient suitable habitat is available to support the species or could be made available through habitat management or restoration.

Unknown. The specific habitat(s) (including the species' larval host plant(s)) that supports the Aweme Borer is not known. However, based on the two most recent collections from the United States, it is suggested that the host plant is likely located in wet habitats and may occur in habitats that contain peatland communities, such as fens (Jones 2015). The Aweme Borer may be restricted to a single larval host plant or the larvae may use several species. In addition, it is possible that the host plant(s) occurs in more than one habitat type. For example, Bog Goldenrod (*Solidago uliginosa*) occurs in fens and poor fens as well as interdunal wetlands and damp fields with calcareous substrate (Brownell pers. comm. 2015; Jones 2015). The host plant must be identified before it is possible to determine if sufficient suitable habitat is available in Canada.

3. The primary threats to the species or its habitat (including threats outside Canada) can be avoided or mitigated.

Unknown. The threats to the Aweme Borer and its habitat are unknown, but threats to native, herbaceous plants, fens and moths in general can be presumed. Based on this assumption, primary threats may include deer browse and livestock grazing, changes in drainage patterns, all-terrain vehicles (ATV's), shoreline development, introduced parasites and pesticide use (Jones 2015). Climate change and peat harvesting may be potential threats to the species. Some habitat is conserved near the recent and historical collection sites at Manitoulin Island and Grand Bend, Ontario. Threats in these areas are presumably low or can be controlled.

4. Recovery techniques exist to achieve the population and distribution objectives or can be expected to be developed within a reasonable timeframe.

Unknown. Due to the lack of information including the identity of the host plant(s), suitable habitat and the presence and distribution of the Aweme Borer in Canada, the primary goal of this recovery strategy is to fill knowledge gaps. Searches for the larvae and adults (including bait or light trapping) may be used to try to locate the Aweme Borer and management and stewardship actions can be used to maintain natural vegetation at Canadian collection sites. Without knowledge of the distribution and extent of the species in Canada, the potential for recovery techniques to be effective is difficult to determine. It is possible that the knowledge gaps cannot be filled within a reasonable timeframe, and the presence and distribution of the species will remain unknown; recovery may not be feasible.

In Canada, only five specimens of the Aweme Borer have been observed. It is possible that the species was never widespread globally and in Canada (Jones 2015), and will likely continue to be considered rare in Canada despite research to fill knowledge gaps. If the species is extremely rare, it will likely always be vulnerable to human-caused stressors and natural, random events.

2. COSEWIC^{*} Species Assessment Information

Date of Assessment: April 2006

Common Name (population): Aweme Borer

Scientific Name: *Papaipema aweme*

COSEWIC Status: Endangered

Reason for Designation: Prior to the collection of one specimen in Ontario in 2005, this moth was last collected 70 years earlier. It is known from only five localities globally, three of which are in Canada. Although the species is poorly known, it is apparently restricted to a rare, fragmented and threatened habitat. Repeated collecting at all of the historic locations has not resulted in relocation of the species, and intensive collecting in the vicinity of the recent record has not yielded any additional specimens.

Canadian Occurrence: Ontario

COSEWIC Status History: Designated Endangered in April 2006.

^{*}COSEWIC (Committee on the Status of Endangered Wildlife in Canada)

3. Species Status Information

Globally, the Aweme Borer is known from only seven locations (twenty specimens in total): Aweme, Manitoba (1905); Beaver Island, Michigan (1925); Rochester, New York (1932); Grand Bend, Ontario (1936); Manitoulin Island, Ontario (2005); McMillan, Michigan (2009); Pine Creek, Minnesota (2014) and across northern Minnesota (2015) (Table 1; Jones pers. comm. 2015). The Canadian collection sites account for three of the seven global sites, and five of the twenty known specimens (COSEWIC 2006; Quinter pers. comm. 2014). In Canada, the Aweme Borer is ranked Critically Imperilled³ (N1; NatureServe 2013a). In Ontario and Manitoba, it is ranked Critically Imperilled (S1) and Possibly Extirpated⁴ (SH), respectively (NatureServe 2013a). The Aweme Borer is listed as Endangered⁵ on Schedule 1 of the *Species at Risk Act* (SARA) and as Endangered⁶ under the Ontario *Endangered Species Act, 2007* (ESA). The Aweme Borer is not designated in Manitoba under provincial legislation.

Table 1. Global collection history of the Aweme Borer (Jones 2015, Jones pers. comm. 2015).

Collection Location	Collection Year	Number of Specimens
Aweme, Manitoba	1905	3
Beaver Island, Michigan	1925	1
Rochester, New York	1932	1
Grand Bend, Ontario	1936	1
Manitoulin Island, Ontario	2005	1
McMillan, Michigan	2009	1
Pine Creek, Minnesota	2014	1
Minnesota*	2015	11

*Specimens were collected from fens in northern Minnesota.

Globally, the Aweme Borer has a conservation rank of Critically Imperilled (G1) (NatureServe 2013a). The national conservation rank in the United States is Possibly Extirpated (NH). It is ranked Possibly Extirpated in the states of Michigan and New York (SH; NatureServe 2013a) and has not yet been ranked in Minnesota. Recent

³ Critically Imperilled (S1/N1/G1): At very high risk of extirpation in the jurisdiction (i.e., G-global, N - nation, or S -state/province) due to very restricted range, very few populations or occurrences, very steep declines, severe threats, or other factors (NatureServe 2013b).

⁴ Possibly Extirpated (SH/NH/GH): (Historical) - Species or community occurred historically in the state/province, and there is some possibility that it may be rediscovered. Its presence may not have been verified in the past 20-40 years. A species or community could become SH without such a 20-40 year delay if the only known occurrences in a nation or state/province were destroyed or if it had been extensively and unsuccessfully looked for. The SH rank is reserved for species or communities for which some effort has been made to relocate occurrences, rather than simply using this status for all elements not known from verified extant occurrences (NatureServe 2013b).

⁵ A wildlife species facing imminent extirpation or extinction in Canada.

⁶ A species that is native to the wild in Ontario but is facing imminent extinction or extirpation.

sightings in McMillan, Michigan in 2009 (Quinter pers. comm. 2014) and Pine Creek, Minnesota in 2014 and 2015 (Jones 2015, Jones pers. comm. 2015) may warrant re-assessment of the ranking in those states.

4. Threats

In addition to the potential threats outlined in Part 2 - *Recovery Strategy for the Aweme Borer Moth (Papaipema aweme) in Ontario*, additional potential threats to the Aweme Borer may include climate change, pesticide exposure (specifically neonicotinoids) and peat harvesting. Climate change may result in the degradation or long-term loss of wetland habitats. A number of factors are suspected to be contributing to the decline in insect pollinator populations globally and in Canada, including loss of habitat and food sources, overgrazing by deer, diseases, viruses, pests, and pesticide exposure (Collen et al. 2012; Wagner 2012; Dirzo et al. 2014). Global declines in pollinator populations are mainly attributed to parasites, lack of food sources and pesticides (Goulson et al. 2015). Although little is known about the status of moths specifically, North American assessments suggest that up to 38% of the *Papaipema* stem borers are considered threatened (Collen et al. 2012). Notably, there is growing evidence to suggest that pesticides, including neonicotinoids, may be having negative effects on pollinator populations due to their toxic properties and persistence in soil and water (van der Sluijs et al. 2013; Pisa et al. 2015). Currently, the extent to which neonicotinoids may impact the Aweme Borer is not known.

Peat harvesting, if it occurs within the range of the Aweme Borer, may result in the degradation or loss of habitat for the species and its host plant(s). Peat harvesting is known to occur in southern Manitoba and northern Ontario (Daigle and Gautreau-Daigle 2001).

5. Population and Distribution Objectives

The provincial recovery strategy contains the following recovery goal for the recovery of the Aweme Borer in Ontario:

- The recovery goal is to attempt to fill knowledge gaps and to maintain existing vegetation at collection sites with broad measures until better information allows specific actions, such as habitat protection and threat mitigation, to be undertaken.

Under SARA, a population and distribution objective for the species must be established. Consistent with the goal set out in the Government of Ontario's Recovery Strategy, Environment and Climate Change Canada's population and distribution objective for the Aweme Borer in Canada is to:

- Attempt to fill knowledge gaps and ensure the persistence of populations where they are confirmed to exist in Canada.

Since only five specimens of the Aweme Borer have been recorded in Canada (at three sites), the short-term recovery goal must be to determine if and where the species still occurs in Canada. The Aweme Borer has not been seen in more than 100 years at the Aweme site and in almost 80 years at the Grand Bend site. It is unknown if the species is extant at these sites. Despite research on moths since the 1970s at the Manitoulin Island site, the species has only been seen once with one individual collected in 2005. There is a possibility that the Manitoulin Island collection site did not contain the source population of the individual Aweme Borer that was trapped there (i.e., the specimen may have been blown in during severe weather conditions) (Jones 2015). Nothing is known about the population size or distribution of this species at the Manitoulin Island site or elsewhere.

The specimen collected at Pine Creek Minnesota in 2014 was collected along the international border between Minnesota and Manitoba. It is possible that the individual was collected on the Canadian side of the border (Johnson pers. comm. 2015). Therefore, this occurrence gives reason to believe that the species and its suitable habitat may currently be present in Canada. Given that the Aweme Borer has only been observed at three sites in Canada, surveys focused in proximity to the most recent observations in the United States (the regions of Manitoba and Ontario proximate to Pine Creek, Minnesota and McMillan, Michigan) may be needed to confirm the existence of the species in Canada (See Section 5). Partnerships to share information with other jurisdictions will be important, specifically any research in the United States that may support recovery efforts in Canada.

If the species is found to exist at historical or new locations, recovery efforts will aim to ensure persistence of the population(s). Stewardship actions can be used to maintain existing vegetation and support any potentially extant population(s).

Extensive knowledge gaps concerning the Aweme Borer in Canada exist, including: distribution, dispersal, abundance and population trends, habitat needs (e.g., host plant, sufficient area for establishment, growth, and dispersal of host plants), threats to survival and recovery and species' biology. These knowledge gaps contribute to an inability to set a quantitative population and distribution objective. It is recognized that it may not be possible to fill the knowledge gaps within a reasonable timeframe as it is dependent on additional observations of adults or the larva. Knowledge gaps may also be filled through the processing of unidentified specimens in museums and other collections (e.g., Canada's National Collection). It is unknown whether the lack of observations is due to an extreme rarity or lack of information on how and where to survey for the species. As the knowledge gaps are filled, the population and distribution objective may be updated.

6. Broad Strategies and General Approaches to Meet Objectives

Environment and Climate Change Canada is partially adopting the approaches identified in section 2.3 of the *Recovery Strategy for the Aweme Borer Moth (Papaipema aweme) in Ontario* (Part 2) as the broad strategies and general approaches to meet the population and distribution objective; with the exception of Approaches 1.2, 1.4, 2.2 and

3.1, where the General Description of Research and Management Approaches have been modified, for the purposes of this recovery strategy, as follows:

1.2 Identify the larval and adult host plant(s) and its habitat by:

- searching for the Aweme Borer larvae at the Manitoulin Island site and the region of Manitoba adjacent to Pine Creek Minnesota;
- searching for ovipositioning⁷ females to indicate larval host plant(s);
- searching for the adult host plant(s) to inform habitat needs.

1.4 Search for additional populations of the Aweme Borer by:

- developing appropriate survey protocol so that presence and occupancy can be determined;
- reviewing floristic inventories from places with similar habitats and searching for the moths where host plants are present;
- reviewing insect collections to identify the Aweme Borer and fill knowledge gaps including species distribution, phenology and other information.

2.2 Where biologically and technically feasible, manage land around Canadian collection sites and the Manitoba site adjacent to Pine Creek Minnesota to remain in a natural state.

3.1 Liaise with Michigan and Minnesota researchers to learn of any new information that may come from the McMillan, Michigan or Pine Creek, Minnesota collection sites.

- If host plant is identified in Michigan or Minnesota, use this information to refine searches in Ontario and Manitoba.

In addition, the following broad strategy and general approach are added to assist with meeting the population and distribution objective:

3.5 Liaise with DNA-based monitoring programs (e.g., the Global Malaise Trap Program) to identify specimens and fill knowledge gaps.

7. Critical Habitat

7.1 Identification of the Species' Critical Habitat

Section 41(1)(c) of SARA requires that recovery strategies include an identification of the species' critical habitat, to the extent possible, as well as examples of activities that are likely to result in its destruction. Under SARA, critical habitat is "the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species".

Identification of critical habitat is not a component of provincial recovery strategies under the Province of Ontario's ESA. Under the ESA, when a species becomes listed as endangered or threatened on the Species at Risk in Ontario List, it automatically receives

⁷ Depositing or laying eggs.

general habitat protection. The Aweme Borer currently receives general habitat protection under the ESA; however, a description of the general habitat has not yet been developed. In some cases, a habitat regulation may be developed that replaces the general habitat protection. A habitat regulation is a legal instrument that prescribes an area that will be protected as the habitat of the species by the Province of Ontario. A habitat regulation has not been developed for Aweme Borer under the ESA. The provincial recovery strategy (Part 2) recommends that a habitat regulation not be developed until such a time that the identity of the host plant becomes known.

Critical habitat for the Aweme Borer in Canada is not identified in this federal recovery strategy due to the need to confirm habitat use and habitat suitability at Canadian locations (Aweme, Manitoba; Grand Bend, Ontario; Manitoulin Island, Ontario). The main factor determining habitat suitability is the presence of the host plant to feed and shelter the larvae (Jones 2015). As the host plant is not known for the Aweme Borer, it is not possible to determine the biophysical attributes of suitable habitat for the species. Despite repeated surveys, the species has never been re-confirmed on Manitoulin Island and has not been seen in 80 to 100 years in Aweme, Manitoba and Grand Bend, Ontario (Jones 2015).

A schedule of studies has been developed to provide the information necessary to begin the identification of critical habitat for the Aweme Borer in Canada. Critical habitat may be identified in the future, either in a revised recovery strategy or action plan(s), if the host plant becomes known and information about habitat suitability and occupancy becomes available.

7.2 Schedule of Studies to Identify Critical Habitat

Table 2. Schedule of Studies to Identify Critical Habitat

Description of Activity	Rationale	Timeline
Conduct targeted surveys at the Manitoulin Island site and the Manitoba site adjacent to Pine Creek Minnesota for adult and larvae Aweme Borer and document habitat use if and where it occurs.	Fill knowledge gaps including species presence and distribution in Canada, identity of the host plant and suitable habitat. Reassess recovery feasibility.	2016-2022
If the species' presence in Canada is confirmed, conduct research to quantify habitat requirements (biophysical attributes of suitable habitat) for adults, larva, and host plants.	Ensure critical habitat is identified to support all life stages. Currently no adequate information exists to identify critical habitat for any of the life stages.	2016-2025
If knowledge gaps are filled, conduct targeted surveys for the Aweme Borer at potential sites where host plant and suitable habitat are located.	Determine species presence and distribution in Canada. Identify critical habitat if deemed to be feasible.	2016-2025

8. Measuring Progress

Every five years, success of recovery strategy implementation will be measured against the following performance indicators:

- Activities have been undertaken to fill knowledge gaps;
- Populations persist where they are confirmed to exist in Canada.

9. Statement on Action Plans

One or more action plans will be completed for the Aweme Borer and posted on the Species at Risk Public Registry by 2022.

10. Effects on the Environment and Other Species

A strategic environmental assessment (SEA) is conducted on all SARA recovery planning documents, in accordance with the [Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals](#)⁸. The purpose of a SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally sound decision-making and to evaluate whether the outcomes of a recovery planning document could affect any component of the environment or any of the [Federal Sustainable Development Strategy](#)'s⁹ (FSDS) goals and targets.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond the intended benefits. The planning process based on national guidelines directly incorporates consideration of all environmental effects, with a particular focus on possible impacts upon non-target species or habitats. The results of the SEA are incorporated directly into the strategy itself, but are also summarized below in this statement.

Recovery work on the ground for the Aweme Borer consists of filling knowledge gaps on the species' ecology and maintaining vegetation in its existing state using management that is already in place. As such, no changes to the environment are expected to result from this recovery strategy. The use of search techniques aimed at the Aweme Borer, such as light trapping and sugar baiting¹⁰, may result in the collection of a small number of other moth species, but the loss of a small number of individuals of mostly common species is not expected to have a significant impact, and the information collected would likely provide a beneficial trade-off.

⁸ <http://www.ceaa.gc.ca/default.asp?lang=En&n=B3186435-1>

⁹ www.ec.gc.ca/dd-sd/default.asp?lang=En&n=CD30F295-1

¹⁰ Light trapping and sugar baiting are techniques used to attract and trap moths

REFERENCES

- Brownell, V. 2015. Personal communication to the Canadian Wildlife Service via email. October 8, 2015. Senior Species at Risk Biologist, Ministry of Natural Resources and Forestry, Peterborough, Ontario.
- COSEWIC 2006. COSEWIC assessment and status report on the Aweme Borer *Papaipema aweme* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 25 pp. www.sararegistry.gc.ca/status/status_e.cfm
- Collen B, M., Böhm, R. Kemp and J.E.M. Baillie. 2012. Spineless: status and trends of the world's invertebrates. Zoological Society of London, United Kingdom.
- Daigle J. and H. Gautreau-Daigle. 2001. Canadian Peat Harvesting and the Environment 2nd ed. Issues Paper No. 2001.
- Dirzo, R., H.S. Young, M. Galetti, G. Ceballos, N.J.B. Isaac, and B. Collen. 2014. Defaunation in the Anthropocene. *Nature* 345(6195): 401.
- Goulson, D., E. Nicholls, C. Botías, and E. L. Rotheray. 2015. Bee declines driven by combined stress from parasites, pesticides, and lack of flowers. *Science* 347:1435.
- Health Canada. 2014. Pollinator Health and Pesticides. Website: <http://www.hc-sc.gc.ca/cps-spc/pest/agri-commerce/pollinators-pollinisateurs/index-eng.php>. [accessed: November 14, 2014].
- Johnson, K.E. 2015. Personal communication with A. Foran via email. July 28, 2015. Entomologist on contract with Minnesota Biological Survey, St. Paul, MN.
- Jones, J. 2015. Recovery strategy for the Aweme Borer Moth (*Papaipema aweme*) in Ontario. Ontario Recovery Strategy Series. Prepared for the Ontario Ministry of Natural Resources and Forestry, Peterborough, Ontario. vi + 21 pp.
- Jones, J. 2015. Personal communication with A. Foran via email. October 8, 2015. Ecologist, Manitowaning, Ontario.
- Lafontaine, J. Donald 2014. Personal communication with J. Jones by telephone on January 6, 2014. Noctuid specialist, Canadian National Collection of Insects and Arthropods, Agriculture and Agri-food Canada, Ottawa, Ontario.
- Lee, H.T., W.D. Bakowsky, J. Riley, J. Bowles, M. Puddister, P. Uhlig and S. McMurray 1998. Ecological Land Classification for Southern Ontario: First Approximation and Its Application. OMNR, Southcentral Science Section, Science Development and Transfer Branch. SCSS Field Guide FG-02. 225 pp.

- Morton, J.K. 2000 and 2006. [Deceased, 2011] Personal communication with J. Jones in person. Summer, 2000 and September, 2006. Professor Emeritus, University of Waterloo, Dept. of Biology.
- NatureServe. 2013a. The Aweme Borer *in* NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia. www.natureserve.org/explorer [Accessed January 3, 2014].
- NatureServe 2013b. Population/Occurrence Delineation and Viability Criteria, NatureServe, Arlington, Virginia. <http://explorer.natureserve.org/popviability.htm> [accessed March 21, 2014].
- Pisa, L.W., V. Amaral-Rogers, L. P. Belzunces, J. M. Bonmatin, C. A. Downs, D. Goulson, D. P. Kreutzweiser, C. Krupke, M. Liess, M. McField, C. A. Morrissey, D. A. Noome, J. Settele, N. Simon-Delso, J. D. Stark, J. P. Van der Sluijs, H. Van Dyck, and M. Wiemers. 2015. Effects of neonicotinoids and fipronil on non-target invertebrates. *Environ Sci Pollut Res* 22:68–102.
- Quinter, Eric 2014. Personal communication to J. Jones by telephone on January 7, 2014. Retired entomologist and expert on the genus *Papaipema*, American Museum of Natural History, New York, NY.
- Wagner, D.L. 2012. Moth decline in the Northeastern United States. *News of the Lepidopterists' Society* 54(2):52-56.

**Part 2 – *Recovery Strategy for the Aweme Borer Moth*
(*Papaipema aweme*) in Ontario, prepared by Judith Jones for
the Ontario Ministry of Natural Resources and Forestry**



Aweme Borer Moth

(*Papaipema aweme*) in Ontario

Ontario Recovery Strategy Series

Recovery strategy prepared under the *Endangered Species Act, 2002*

2015

Natural. Valued. Protected.

About the Ontario Recovery Strategy Series

This series presents the collection of recovery strategies that are prepared or adopted as advice to the Province of Ontario on the recommended approach to recover species at risk. The Province ensures the preparation of recovery strategies to meet its commitments to recover species at risk under the Endangered Species Act (ESA) and the Accord for the Protection of Species at Risk in Canada.

What is recovery?

Recovery of species at risk is the process by which the decline of an endangered, threatened, or extirpated species is arrested or reversed, and threats are removed or reduced to improve the likelihood of a species' persistence in the wild.

What is a recovery strategy?

Under the ESA a recovery strategy provides the best available scientific knowledge on what is required to achieve recovery of a species. A recovery strategy outlines the habitat needs and the threats to the survival and recovery of the species. It also makes recommendations on the objectives for protection and recovery, the approaches to achieve those objectives, and the area that should be considered in the development of a habitat regulation. Sections 11 to 13 of the ESA outline the required content and timelines for developing recovery strategies published in this series.

Recovery strategies are required to be prepared for endangered and threatened species within one or two years respectively of the species being added to the Species at Risk in Ontario list. There was a transition period of five years (until June 30, 2013) to develop recovery strategies for those species listed as endangered or threatened in the schedules of the ESA. Recovery strategies are required to be prepared for extirpated species only if reintroduction is considered feasible.

What's next?

Nine months after the completion of a recovery strategy a government response statement will be published which summarizes the actions that the Government of Ontario intends to take in response to the strategy. The implementation of recovery strategies depends on the continued cooperation and actions of government agencies, individuals, communities, land users, and conservationists.

For more information

To learn more about species at risk recovery in Ontario, please visit the Ministry of Natural Resources and Forestry Species at Risk webpage at:
www.ontario.ca/speciesatrisk

RECOMMENDED CITATION

Jones, J. 2015. Recovery strategy for the Aweme Borer Moth (*Papaipema aweme*) in Ontario. Ontario Recovery Strategy Series. Prepared for the Ontario Ministry of Natural Resources and Forestry, Peterborough, Ontario. vi + 21 pp.

Cover illustration: The Aweme Borer from Moths of Canada (CBIF 2003) used with permission from Agriculture and Agri-foods Canada. This photo may not be reproduced separately from this document without permission from the source.

© Queen's Printer for Ontario, 2015
ISBN 978-1-4606-5716-4

Content (excluding the cover illustration) may be used without permission, with appropriate credit to the source.

Cette publication hautement spécialisée « recovery strategies prepared under the endangered species act, 2007 », n'est disponible qu'en anglais en vertu du règlement 411/97 qui en exempte l'application de la Loi sur les services en français. Pour obtenir de l'aide en français, veuillez communiquer avec recovery.planning@ontario.ca.

AUTHORS

Judith Jones, Winter Spider Eco-Consulting, Sheguiandah, Ontario

ACKNOWLEDGMENTS

Eric Quinter (American Museum of Natural History), Kyle E. Johnson (University of Wisconsin, Madison) and Don Lafontaine (Agriculture and Agri-food Canada) are thanked for generously sharing their information on the Noctuidae and the genus *Papaipema*. The late J.K. Morton's comments to Judith Jones are also gratefully acknowledged. Thanks to Jocelyn Gill, Agriculture and Agri-Food Canada, for the use of her photo.

DECLARATION

The recovery strategy for the Aweme Borer Moth was developed in accordance with the requirements of the *Endangered Species Act, 2007* (ESA). This recovery strategy has been prepared as advice to the Government of Ontario, other responsible jurisdictions and the many different constituencies that may be involved in recovering the species.

The recovery strategy does not necessarily represent the views of all of the individuals who provided advice or contributed to its preparation, or the official positions of the organizations with which the individuals are associated.

The goals, objectives and recovery approaches identified in the strategy are based on the best available knowledge and are subject to revision as new information becomes available. Implementation of this strategy is subject to appropriations, priorities and budgetary constraints of the participating jurisdictions and organizations.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the directions set out in this strategy.

RESPONSIBLE JURISDICTIONS

Ontario Ministry of Natural Resources and Forestry
Environment Canada – Canadian Wildlife Service, Ontario

EXECUTIVE SUMMARY

The Aweme Borer (*Papaipema aweme*) is a moth in the owlet family (Noctuidae). It is listed as endangered under Ontario's *Endangered Species Act, 2007*. It is listed as endangered on Schedule 1 of the federal *Species at Risk Act*. It has a conservation rank of G1S1 in Ontario. The adult has a wingspan of 33 to 37 mm, with light brown, distinctly-marked forewings and paler, plainer, yellow-white hind wings. The egg, larval, and pupal stages have never been observed.

Larvae in the genus *Papaipema* are borers, meaning they chew into fleshy plants and feed inside the roots, stems, or rhizomes. Many *Papaipema* moths are restricted to a single host plant species. Thus, the primary habitat need of the Aweme Borer is the presence of the correct host plants to feed and shelter the larvae. However, no larva of the Aweme Borer has ever been observed, and the identity of the host is not known. It is possible that Aweme Borer is a species associated with wetlands. Two recent collections are from peatland and bog habitats and a third is from a wet part of an old pasture. Locations of historical collections are not well known but could include fens and interdunal wetlands, which could have some plant species in common with peatlands and bogs.

The complete global range of the Aweme Borer is not known. The species has been collected only nine times ever at seven locations: Aweme, Manitoba (1905); Beaver Island, Michigan (1925); Rochester, New York (1932); Grand Bend, Ontario (1936); Manitoulin Island, Ontario (2005); McMillan, Michigan (2009); and Pine Creek, Minnesota (2014). Given the decades of collecting effort and the very small number of collections, it is possible the Aweme Borer has always been rare. However, it is also possible that this species is not very attracted to light and so is rarely trapped. A third possibility is that it occurs in areas that are not often studied, such as bogs.

The Aweme Borer may be limited by its restriction to a single host species. Suitable habitat may be limited if the host plant is restricted to a rare vegetation community. Specific threats to the Aweme Borer are not known, but threats to native, herbaceous plants, to moths and to wetlands in general, can be inferred. These may include browsing and grazing, changes in drainage, all-terrain vehicle use, shoreline development, and introduced parasites and pesticide use.

Very little is known about the Aweme Borer including whether any Canadian populations are extant. Nothing is known about population size, habitat requirements, habitat dynamics, or threats. Therefore, the recovery goal for the Aweme Borer is to attempt to fill knowledge gaps and to maintain existing vegetation at collection sites with broad measures until better information allows specific actions, such as threat mitigation, to be undertaken. Protection and recovery objectives include the following:

1. Conduct research to fill knowledge gaps.
2. Use stewardship actions to maintain existing vegetation.
3. Create partnerships and share information with other jurisdictions.

Several approaches to recovery are presented in the text. Performance measures are presented so that if knowledge gaps cannot be filled, unsuccessful searches and other attempts to collect data may be tracked as work towards achieving the recovery objectives.

The most important habitat need for the Aweme Borer is the presence of the host plant. However, the identity of the host(s) for the Aweme Borer is not known. If the identity of the host plant becomes known, it is suggested that a habitat regulation be developed based on the presence of host plants and their biological requirements. As such, it is suggested that the area to be considered for a habitat regulation would probably need to include:

1. the area where Aweme Borers (of any life stage) are found;
2. from the locations in (1), all of the contiguous area where host plants are present;
3. sufficient area for establishment, growth, and dispersal of host plants; and
4. a consideration of any dynamics required to maintain habitat suitability for the host plant. For example, if the host requires habitat maintained by fire, then it is suggested that the amount of area required for adequate burning may need to be determined and prescribed. If the host requires active dune processes, then inclusion of a dynamic area (even if not occupied by the Aweme Borer) may also need to be considered.

TABLE OF CONTENTS

RECOMMENDED CITATION.....	i
AUTHORS.....	ii
ACKNOWLEDGMENTS.....	ii
DECLARATION.....	iii
RESPONSIBLE JURISDICTIONS	iii
EXECUTIVE SUMMARY.....	iv
1.0 BACKGROUND INFORMATION	7
1.1 Species Assessment and Classification.....	7
1.2 Species Description and Biology	7
1.3 Distribution, Abundance and Population Trends.....	9
1.4 Habitat Needs.....	11
1.5 Limiting Factors	14
1.6 Threats to Survival and Recovery.....	14
1.7 Knowledge Gaps	16
1.8 Recovery Actions Completed or Underway	16
2.0 RECOVERY	17
2.1 Recovery Goal	17
2.2 Protection and Recovery Objectives.....	17
2.3 Approaches to Recovery.....	18
2.4 Performance Measures.....	21
2.5 Area for Consideration in Developing a Habitat Regulation.....	22
GLOSSARY	23
REFERENCES.....	25

LIST OF FIGURES

Figure 1. The Aweme Borer collected on Manitoulin Island.	8
Figure 2. Historical and current distribution of the Aweme Borer in Ontario and range-wide.....	10

LIST OF TABLES

Table 1. Global collection history of the Aweme Borer	10
Table 2. Protection and recovery objectives.....	17
Table 3. Approaches to recovery of the Aweme Borer in Ontario	18

1.0 BACKGROUND INFORMATION

1.1 Species Assessment and Classification

COMMON NAME: Aweme Borer Moth

SCIENTIFIC NAME: *Papaipema aweme*

SARO List Classification: Endangered

SARO List History: Endangered (2008)

COSEWIC Assessment History: Endangered (2006)

SARA Schedule 1: Endangered (2007)

CONSERVATION STATUS RANKINGS:

GRANK: G1

NRANK: N1

SRANK: S1

The glossary provides definitions for the abbreviations above and for other technical terms in this document.

1.2 Species Description and Biology

Species Description

The Aweme Borer (*Papaipema aweme*) (Figure 1) is a moth in the owlet family (Noctuidae). The adult moth has a wingspan of 33 to 37 mm, with pale, yellow-white hind wings, and light brown, distinctly-marked forewings. The head and thorax¹ (middle part of the body) are darker brown. On the forewing, the post-median line curves toward the thorax as it nears the front edge of the forewing (the costa), and the subterminal line is not solid but appears as a series of dashes. The fringes and margins of the forewings are darker brown. Adults of both sexes appear superficially alike. A more technical description of the species is found in COSEWIC (2006).

The egg, larval, and pupal stages of the Aweme Borer have never been observed. In the genus *Papaipema* (borer moths), larvae generally have a dark background colour with white lines along the back and the top of the sides. As they grow, the larvae may become translucent with the markings faint or absent (Hessel 1954). See Covell (1984) for an understanding of the basic anatomy of moths in easy-to-understand terms.

Even with a key, some species in the genus *Papaipema* may be difficult to identify. *Papaipema* is one of the largest genera of noctuids in North America. There are more than 50 known species, and at least 26 occur in Canada (CBIF 2003; Goldstein and

¹ Technical terms are defined in the glossary.

Quinter 2003). As well, the Aweme Borer is not listed in most popular field guides due to its rarity. Compared to other species in this genus, the adult Aweme Borer is a rather small, very pale, plain, light brown moth. Any moth suspected to be the Aweme Borer should be confirmed by an expert.



Figure 1. The Aweme Borer collected on Manitoulin Island. (Photo Jocelyn Gill, Agriculture and Agri-Food Canada, used with permission. This image may not be reproduced separately from this document without permission of the photographer.)

Species Biology

There is no information on the egg, larva, or pupa as these life stages of the Aweme Borer have never been seen. However, information about the genus *Papaipema* as a whole is relevant. Moths in this genus are termed borers because the larvae chew into fleshy plants to feed and shelter inside the roots, stems, or rhizomes. The full life cycle in *Papaipema* takes one year (Covell 1984). The adult females lay eggs in late summer, securely attaching them to the larval host plant and leaving the eggs to overwinter (NatureServe 2014; E. Quinter pers. comm. 2014). Larvae emerge the following spring and are present generally from about late May-early June to mid-July and then pupate for about a month. Some species of *Papaipema* pupate inside the host plant while others pupate in the ground. Adults are nocturnal. The flight period of the adult Aweme Borer is reported to be from the first week to the fourth week of August (Michigan Natural Features Inventory 2007), but recent collections of adults have occurred between mid-August and mid-September. Adult *Papaipema* have functional mouthparts and are attracted to sugar baits (sweet and sticky substances sometimes used to attract and trap moths) and may obtain nectar from one or more species of plants within the habitat (COSEWIC 2006).

Some moths are highly restricted to specific host plants. These species often use hosts that have a very distinctive smell to help the larvae locate the host (J.D. Lafontaine pers. comm. 2014). Larvae in the genus *Papaipema* probably recognize their host plants by the chemicals in the plant, especially hydroxycoumarins and furanocoumarins which have strong odours (E. Quinter pers. comm. 2014). The identity of the host plant used by the Aweme Borer has not been determined as the larvae have never been observed.

The genus *Papaipema* as a whole uses a wide variety of host plants, including ferns, asters, pitcher plants, and many other species. Thus, the host for the Aweme Borer could be any of a large number of plant species. Some species of *Papaipema* feed on more than one plant species, but most are restricted to one species or a group of closely related species (Hessel 1954). According to Eric Quinter, an expert on the genus *Papaipema*, the Aweme Borer belongs to a section of the genus that arose more recently and is highly developed, and most of the species in this section are specialized on plants of the aster family (Asteraceae) (E. Quinter pers. comm. 2014). As a member of this section, the Aweme Borer is likely to be highly specialized on a particular plant species or a group of closely related plant species that all have the same chemistry.

Light trapping is a common technique for collecting moths at night. A light (usually behind a white sheet) attracts moths to the trap, which may consist of a container with a killing agent into which the moths fall. Based on locations where they have been trapped, male moths in the genus *Papaipema* normally do not travel very far from the host plants and are usually found within a few hundred metres from where they hatch. The females lay eggs near the host plants but afterwards a few may travel randomly up to several kilometres from the initial site (observations of E. Quinter pers. comm. 2014). J.D. Lafontaine (pers. comm. 2014) has observed that lights (including UV and mercury vapour) will only draw moths from a short distance away, so the location where a male is trapped is probably within or very close to suitable habitat, and it is unlikely that light trapping would attract a male Aweme Borer into an unsuitable area.

1.3 Distribution, Abundance and Population Trends

The complete global range of the Aweme Borer is not known. The species has been collected only nine times ever and is only known from seven locations in North America (Table 1; Figure 2). Collection sites include: Aweme, Manitoba; Grand Bend and Manitoulin Island, Ontario; Beaver Island and McMillan, Michigan; Rochester, New York; and Pine Creek, Minnesota (COSEWIC 2006; Michigan Natural Features Inventory 2007; New York Department of Environmental Conservation 2013; NatureServe 2014; E. Quinter pers. comm. 2014; K.E. Johnson pers. comm. 2014). At each location, only a single specimen was collected, except in Manitoba where three specimens were collected over a three day period in 1905.

Table 2. Global collection history of the Aweme Borer (COSEWIC 2006; E. Quinter pers. comm. 2014; K.E. Johnson pers. comm. 2014).

Collection Location	Collection Date
Aweme, MB	1905-08-24
Aweme, MB	1905-08-25
Aweme, MB	1905-08-26
Beaver Island, MI	1925-08-13
Rochester, NY	1932-08-07
Grand Bend, ON	1936-08-15
Manitoulin Island, ON	2005-08-19
McMillan, MI	2009-09-10
Pine Creek, MN	2014-09-08



Figure 2. Historical and current distribution of the Aweme Borer in Ontario and range-wide (COSEWIC 2006; E. Quinter pers. comm. 2014; K.E. Johnson pers. comm. 2014). Black circles: species collected 2005 (Manitoulin Island, Ontario), 2009 (northern Michigan) and 2014 (Pine Creek, Minnesota). Open circles: species not seen for more than 70 years (collection date 1936 or earlier).

The Aweme Borer has been observed three times in the last ten years with three recent collections: in 2005 on Manitoulin Island, Ontario (COSEWIC 2006; J.K. Morton pers. comm. 2006), in 2009 near McMillan, Michigan (in the Upper Peninsula) (E. Quinter pers. comm. 2014), and in 2014 near Pine Creek, Minnesota on the Minnesota-Manitoba border (K.E. Johnson pers. comm. 2014). The location where the most recent collection was made straddles the border, and the habitat extends into Manitoba. Similar areas are also found in the border region of northwestern Ontario, so there is the potential that the Aweme Borer may be discovered at new sites in Canada in the future.

At four other collection sites, the Aweme Borer has not been seen for more than 70 years despite targeted trapping (COSEWIC 2006). The most recent collection at any of those sites was in 1936. All specimens collected range-wide were adult moths, and the larva has never been observed anywhere. As such, nothing is known about potential population size or distribution of this species in Ontario or elsewhere.

Despite decades of collecting effort, very few collections of the Aweme Borer have ever been made and these have only been single specimens, so it is possible the species has always been rare. On the other hand, it is also possible that the Aweme Borer occurs in locations that are rarely studied. Eric Quinter (pers. comm. 2014) pointed out that collection sites for the Aweme Borer span a wide geographic range, but that very little of that range has actually been searched for the species. If the identity of the host plant can be determined, it will become easier to find the species because researchers will know where to look. It is also possible that this species is not very attracted to light and thus is rarely trapped by commonly-used methods (J.K. Morton pers. comm. 2006). It is known that some species of *Papaipema* are not attracted to light and are not caught in light traps even where abundant (J.D. Lafontaine pers. comm. 2014). Some examples are the Pitcher Plant Borer (*P. appassionata*) and the Chain Fern Borer (*P. stenocelis*) which are not usually collected at lights. However, all collections of the Aweme Borer to date have been made with light traps, and most species in this genus will come to light if the light is right beside them (E. Quinter pers. comm. 2014). At the Minnesota collection site, bait traps were also used at the same time as light, but no other individuals of the Aweme Borer were caught (K.E. Johnson pers. comm. 2014).

1.4 Habitat Needs

The main factor that determines habitat suitability for the Aweme Borer is the presence of host plants to feed and shelter the larvae. Habitat conditions must support the host plants as well as the larvae themselves. So far, no larva has been observed, and the identity of the host plant species has not been determined, so the exact habitat of the Aweme Borer is unknown. Nevertheless, the locations of collections of Aweme Borer adults provide some clues, and inferences on the needs of the Aweme Borer can be made from looking at the genus *Papaipema* as a whole.

Looking at the recent collection sites, the McMillan and Minnesota locations were both in wetlands, while the Manitoulin Island location was in a damp part of an old pasture field. In addition, the specimens collected in Minnesota and on Manitoulin Island were both males, suggesting these individuals had been larvae in host plants very close to where they were trapped as adults (E. Quinter pers. comm. 2014). This makes it likely that the host plant for the Aweme Borer is a species associated with wet areas. The McMillan and Minnesota sites are in bog or fen vegetation in large peatland complexes that contain a mosaic of vegetation including areas of Black Spruce (*Picea mariana*) trees, open areas of peat substrates (*Sphagnum* spp.) with shrubs of the heath family, areas with White Cedar (*Thuja occidentalis*) and Tamarack (*Larix laricina*) with a ground cover of diverse graminoids, and spring-fed seeps and water channels (K.E. Johnson pers. comm. 2014). The Manitoulin collection site has scattered trees of Balsam Poplar (*Populus balsamifera*), occasional tall willows (*Salix discolor* and *S. bebbiana*), and a ground flora predominantly of Bluejoint Grass (*Calamagrostis canadensis*) with a large diversity of common Eurasian weed species as associates (J. Jones unpublished data).

Looking at the historical sites, the exact locations of the Manitoba, Rochester, and Grand Bend collections are not known precisely (Roughley 2000; COSEWIC 2006). The localities for these collections were reported only with general geographic names with no habitat information, making it impossible to determine the exact location and habitat where the specimens were trapped. The Beaver Island specimen was collected at the lights of a boat anchored offshore, also with no habitat information. Still, some inferences about habitats at these sites can be drawn. There is no information at all about the Rochester, NY site.

The 1905 Manitoba specimens of the Aweme Borer were collected by Norman Criddle at Aweme Manitoba, in the vicinity of today's Criddle/Vane Homestead Provincial Heritage Park, about 40 km southeast of Brandon. According to Roughley (2000), annotations on Criddle's collections show that he used the locality "Aweme" to refer to an area with a circumference of up to 10 km out from the homestead. This circle includes a variety of upland habitats as well as the bank of the Assiniboine River and springs and fens along some tributaries. Thus, the specimens could have come from any of several habitats, but fens (which would have species in common with the peatlands of Minnesota and Michigan) are a possibility.

The 1925 Beaver Island, Michigan specimen was collected offshore from a shoreline complex of dunes, cobble beach, and interdunal wetlands (low, wet areas between the dry sandy ridges). The surrounding inland vegetation was a mix of hardwoods, coniferous swamp, and cultivated fields (Michigan Natural Features Inventory 2007; J.D. Lafontaine pers. comm. 2014). The moth was a female and thus may have come from any of these types of vegetation, but at least the coniferous swamps and possibly also the interdunal wetlands could contain some species in common with the Minnesota and McMillan sites. The vegetation of the interdunal wetlands in Michigan is also much the same as that at Grand Bend, Ontario (Kost et al. 2007).

At Grand Bend, Ontario, the 1936 collection site was likely similar to the natural areas that today are within Pinery Provincial Park. These include large dunes and interdunal wetlands along the Lake Huron shore, and wetlands along the old Ausable River channel inland (Advisory Board on Parks and Recreation 1953; Pinery Provincial Park 2014). Given the continued presence of large natural habitats, there remains a small possibility that the Aweme Borer is still present although it has not been seen in decades. Several other rare and at-risk species remain present, including the endangered plant Bluehearts (*Buchnera americana*) found in the interdunal wetlands, and some very rare moths such as the Bleeding Flower Moth (*Schinia sanguinea*, S1 or critically imperilled in Ontario), and the noctuid moth *Cobubatha dividua* (S1 or critically imperilled in Ontario and only known in Canada from Grand Bend) (Hardwick and Stead 1998; NHIC 2013; Pinery Provincial Park 2014).

Suitable host plants for *Papaipema* are usually fleshy dicots although some species of *Papaipema* use ferns or lilies (Hessel 1954; Covell 1984; Goldstein 1999). The roots or stems of the host plants must be large enough to contain a maturing larva (a few centimetres long and possibly more than a centimetre in diameter). Many species of *Papaipema* are restricted to a specific host plant although the larvae of some species are generalists and use several plant species (Hessel 1954).

According to Eric Quinter (pers. comm. 2014), the species most closely related to the Aweme Borer is the Seaside Goldenrod Borer Moth (*P. duovata*). This maritime species is restricted to feeding on the stem and roots of the endemic Seaside Goldenrod (*Solidago sempervirens*). Quinter visited the Manitoulin Island collection site and noted that the roots of a broad-leaved goldenrod there had a strong odour that he found very similar to that of the Seaside Goldenrod. At the Michigan site, he found that the Bog Goldenrod (*S. uliginosa*) also had a similar odour. It may be that a particular goldenrod is the host for the Aweme Borer. However, Quinter also notes that closely related moths do not necessarily feed on closely related plants.

Looking at the collection history as a whole, it appears that the Aweme Borer has been collected in very different types of places. There are at least two ways to explain this. It is possible the larvae use a group of closely related plant species within one genus that all have similar chemistry but that occur in slightly different habitats (which would be possible within the goldenrod genus, *Solidago*). There are also many plant species that grow in more than one kind of habitat and would occur in bogs as well as in interdunal wetlands and damp fields. The Bog Goldenrod is one such species, but there are many others including many species of sedge (*Carex* spp.).

Given that two of the recent collections were from bogs or peatlands, it could be asked whether the Aweme Borer on Manitoulin Island was perhaps drawn from an adjacent bog habitat. However, the nearest such habitat is seven km to the east of the collection site, and the fact that the Manitoulin specimen was a male (which would not have travelled far) would seem to argue against this hypothesis. However, there was severe weather with exceptionally heavy rainfall and strong winds from the east during the day on August 19, 2005 (Environment Canada 2005). Thus, it is possible the weather may have blown the Aweme Borer into the vicinity of the Manitoulin Island collection site

from an adjacent habitat. This hypothesis would perhaps explain why J.K. Morton trapped the Aweme Borer only once in more than 20 years of sampling the collection site (J.K. Morton pers. comm. 2006). He also never found the Aweme Borer on any Manitoulin Island dunes despite extensive sampling work there (Morton undated report).

1.5 Limiting Factors

The Aweme Borer may be limited by its specialization on a particular host plant if the host plant is not a widespread species. Furthermore, if the host plant is a species restricted to vegetation in a particular successional stage, for example open bogs or interdunal wetlands with little shrub cover, available habitat for the Aweme Borer and its host may be limited and highly localized. Thus, specialization on a particular host plant may be a limitation if the host is also limited.

Succession and changes in water levels in Lake Huron cause natural changes in dune vegetation. As a result of succession, inland parts of dunes grow up with vegetation, eventually becoming covered with shrubs or trees (Lichter 1998). Changes in lake levels are one factor involved in the dynamics that create new areas of dune or interdunal wetland (Davidson-Arnott and Law 1990). Thus, natural dynamics may play a role in the suitability and presence of interdunal wetland habitats. Most other wetlands also undergo natural succession, eventually becoming more vegetated with woody species. Depending on the needs of the host plant, natural succession may gradually eliminate suitable habitat for the Aweme Borer.

Nieminen (1996) found that moths whose larvae feed on only a single plant species have a higher risk of extinction than those that can feed on more than one. Extinction risk was also found to be higher if larvae require habitat-specialist plants, annual plants, or woody deciduous species. It was concluded that the risk of extinction of herbivorous moths is much more affected by host plant characteristics than by characteristics of the moths themselves.

Burke et al. (2011) found Canadian butterfly species with low mobility tended to use fewer host plant species and tended to be at greater conservation risk. It is possible low mobility may create a higher risk to the Aweme Borer since some members of the genus remain within a few hundred metres of the host plant throughout their life cycle.

1.6 Threats to Survival and Recovery

Although little is known about the Aweme Borer, threats to the species can be hypothesized as factors that negatively affect the abundance and extent of the host plant as well as affecting the moth itself. As the identity of the host plant is not known, it is difficult to know exactly what may constitute a threat. Still, threats to native, herbaceous plants and to wetlands and moths in general can be presumed. Some threats specific to the location on Manitoulin Island, to interdunal wetlands at Grand

Bend (if this population turns out to be extant), and to peatlands (e.g., in northwestern Ontario) may also be inferred. For example, general threats could include browsing if the host plant is a species favoured by deer, rabbits, geese (on dunes), or grazing livestock. All-terrain vehicle (ATV) use and shoreline development are threats to dune areas, such as at Grand Bend (Parks Canada Agency 2011).

Browsing and Grazing

Browsing by White-tailed Deer (*Odocoileus virginianus*) or other wildlife may potentially reduce the availability of the host plant or affect the vegetation as a whole. Populations of deer are exceptionally large in the area of the Manitoulin Island collection site, and heavy browsing of gardens and domestic fruit trees by deer is a problem (J. Jones pers. obs. 2014). At Pinery Provincial Park prior to 1997, the cover of native ground species was significantly reduced by deer browsing (Bakowsky 1999), and it became necessary to reduce the number of deer to reduce negative effects on the vegetation and rare plant species (COSEWIC 2010). Deer browsing is considered a (potential) threat for Aweme Borer, rather than a natural limitation, because the number of deer present may be unnaturally high in this part of Manitoulin Island and the effects may be significant.

Livestock may eat host plants and other native species, introduce weed species, and reduce the overall quality of the surrounding natural vegetation. Historically, the Manitoulin Island collection site was used as livestock pasture but has not had any significant grazing by livestock for at least 30 years. The current owners have no plans to have livestock on the property (D. Morton pers. comm. 2014) and the likelihood of this threat is low.

Changes in Drainage

Anything that affects moisture levels or the flow of water nearby may affect a wetland. Common human activities that may change moisture levels and drainage in wetlands include ditching, bringing in fill, and diverting creeks and streams. Depending on where the Aweme Borer may be discovered in the future, these could be potential threats.

All-terrain Vehicles

In one shoreline area near Grand Bend, all-terrain vehicles (ATVs) are a threat to dune vegetation (J. Jones pers. obs. 2008). All-terrain vehicles are a widespread threat to dunes in many other locations as well (COSEWIC 2010; Parks Canada Agency 2011). All-terrain vehicles may trample vegetation, which could damage host plants, and may also cause rutting and displacement of wet soil or sand creating potentially unsuitable conditions for the host plant.

Shoreline Development

In the Grand Bend area, development has occurred along much of the Lake Huron shoreline surrounding Pinery Provincial Park, with homes, cottages, businesses, lawns, roads, driveways and parking lots present outside of the park area. Some undeveloped dune habitat remains that is not protected and which could be subject to future development (J. Jones pers. obs. 2008).

Introduced Parasites and Pesticide Use

The parasitoid fly *Compsilura concinnata* was introduced to North America in 1906 to control the Gypsy Moth (*Lymantria dispar*), a non-native pest that attacks oak trees. This fly is a generalist that lays its eggs in the larvae of a wide variety of moth species including many in the owl family (Elkinton and Boettner 2012). Whether it affects *Papaipema* species is unknown. Lepidoptera-targeting pesticides, including Btk (*Bacillus thuringiensis* var. *kurstaki*) spores, are sometimes used to control Gypsy Moth and would also pose a threat to the Aweme Borer. The current likelihood of pesticide use in the habitat of the Aweme Borer is unknown, but historical use of pesticides at Pinery Provincial Park to control Gypsy Moth may have caused the reduction of some rare species including the Karner Blue Butterfly (*Lycaeides melissa samuelis*) (Jeffords 2009). Gypsy Moth is present on Manitoulin Island (J. Jones pers. obs. 2013).

1.7 Knowledge Gaps

Very little is known about the Aweme Borer, so knowledge gaps for this species are large. Filling them may be difficult and may take a number of years.

The species has not been seen in almost 80 years at the Grand Bend site (COSEWIC 2006), and it is unknown whether this population may still be extant. At the Manitoulin Island site, despite work on moths since the 1970s, only one Aweme Borer has ever been seen (COSEWIC 2006; J.K. Morton pers. comm. 2006). Nothing is known about population size, habitat requirements, habitat dynamics, or threats at this site or anywhere else.

The identity of the host plant is a key knowledge gap to be filled. If the identity of host plant is determined, information on the parameters of habitat suitability can begin to be filled. Until a larva is found, which would allow determination of the host plant, it may continue to be difficult to find and study the Aweme Borer. It is recognized that it may not be possible to fill the knowledge gaps.

1.8 Recovery Actions Completed or Underway

Extensive search effort has been made at the Grand Bend and Manitoulin Island sites to try to find another Aweme Borer, so far without success (COSEWIC 2006). At the Manitoulin Site, J.K. Morton trapped moths from 1985 to 2005, but only trapped one Aweme Borer in that time (J.K. Morton pers. comm. 2006). At Grand Bend, Ken Stead trapped moths between 1990 to 2004 and found 1560 species but no Aweme Borer (COSEWIC 2006). See COSEWIC (2006) for a list of locations, researchers, dates, and collecting methods that have been used range-wide to try to relocate the Aweme Borer. Eric Quinter made a trip to the Manitoulin Island collection site in 2011 to search for Aweme Borer larvae but did not find any.

The owners of the Manitoulin Island site continue to manage the land to keep it in a natural state. Other than the work listed above, very few actions have been undertaken because of the large gaps in knowledge about this species.

2.0 RECOVERY

2.1 Recovery Goal

The recovery goal for the Aweme Borer is to attempt to fill knowledge gaps and to maintain existing vegetation at collection sites with broad measures until better information allows specific actions, such as threat mitigation, to be undertaken.

2.2 Protection and Recovery Objectives

Table 3. Protection and recovery objectives

No.	Protection or Recovery Objective
1	Conduct research to fill knowledge gaps.
2	Use stewardship actions to maintain existing vegetation.
3	Create partnerships and share information with other jurisdictions.

2.3 Approaches to Recovery

Table 4. Approaches to recovery of the Aweme Borer in Ontario

Relative Priority	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
1. Conduct research to fill knowledge gaps				
Critical	On-going	Research and Inventory	1.1 Determine if any populations are extant by: <ul style="list-style-type: none"> – trapping for the Aweme Borer adults at Grand Bend and Manitoulin Island in wetland habitats; – trapping for the Aweme Borer in bog habitat near the Manitoulin Island collection site; – continuing to search for the larvae at the Manitoulin Island site; and – trapping in other areas that may have vegetation similar to the McMillan and Minnesota sites; and – if host plant is identified (Approach 1.2), searching for Aweme Borer where host plants are common at the two known sites. 	<ul style="list-style-type: none"> • Whether any populations are extant • Where species occurs • Size and distribution of populations • Types of threats • Protection needs
Critical	On-going	Research and Inventory	1.2 Identify the host plant and its habitat by: <ul style="list-style-type: none"> – searching for the Aweme Borer larvae at the Manitoulin Island site. 	<ul style="list-style-type: none"> • Where species occurs • Habitat requirements • Types of threats • Protection needs
Necessary	Long-term	Research	1.3 Determine parameters and ecology of the Aweme Borer and its suitable habitat including: <ul style="list-style-type: none"> – conditions and dynamics required by the host plants; – habitat management needs/tools; – potential threats. 	<ul style="list-style-type: none"> • Habitat requirements • Management needs • Protection needs • Types of threats

Relative Priority	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
Beneficial	Long-term	Research and Inventory	1.4 Search for additional populations of the Aweme Borer by: <ul style="list-style-type: none"> – developing appropriate survey protocol so that presence and occupancy can be determined; – reviewing floristic inventories from places with similar habitats and searching for the moths where host plants are present. 	<ul style="list-style-type: none"> • Size and distribution of populations • Habitat requirements • Types of threats
2. Use stewardship actions to maintain existing vegetation				
Critical	Long-term	Protection, Management, Stewardship	2.1 Once knowledge gaps are filled and parameters of suitable habitat are known, re-evaluate management and protection needs.	<ul style="list-style-type: none"> • Any or all threats
Necessary	On-going	Stewardship	2.2 Manage land around Ontario collection sites to remain in a natural state by: <ul style="list-style-type: none"> – assisting landowners of the Manitoulin Island site with stewardship if requested; – liaising with Pinery Provincial Park on management of habitats as per Approach 3.2; and – assessing habitat maintenance needs such as weed removal, reduction of woody growth, or fencing out deer. 	<ul style="list-style-type: none"> • Browsing and grazing • Changes to drainage
3. Create partnerships and share information with other jurisdictions				
Critical	Short-term	Communications, Research	3.1 Liaise with Michigan and Minnesota researchers to learn of any new information that may come from the McMillan or Minnesota collection sites. <ul style="list-style-type: none"> – If host plant is identified in Michigan or Minnesota, use this information to refine searches in Ontario. 	<ul style="list-style-type: none"> • Identity of the host plant • Parameters of suitable habitat • Global distribution of the species

Relative Priority	Relative Timeframe	Recovery Theme	Approach to Recovery	Threats or Knowledge Gaps Addressed
Beneficial	On-going	Communications, Research	3.2 Liaise with Pinery Provincial Park about management of dunes and wetlands, and about searches for the Aweme Borer; – ensure park receives any new information that may help with searches in the Grand Bend area.	<ul style="list-style-type: none"> • Whether Grand Bend population is extant • Size and distribution of the Ontario and Canadian populations
Beneficial	On-going	Communications, Research	3.3 Liaise with Manitoba researchers to learn of any new information that may come from the Aweme collection site.	<ul style="list-style-type: none"> • Whether Aweme population is extant • Size and distribution of Canadian and global population.
Beneficial	On-going	Communications, Education	3.4 Include the Aweme Borer in public-facing resources and in citizen science initiatives which could contribute to reporting and monitoring.	<ul style="list-style-type: none"> • Additional observers to fill knowledge gaps • New potential recovery stewards

Narrative to Support Approaches to Recovery

Trapping for the Aweme Borer is needed in the peatlands in northwestern Ontario and southeastern Manitoba, in habitat that is similar to the Minnesota collection site, as well as in the bog habitat near to the Manitoulin Island collection site. In addition, more searches are needed at the Manitoulin Island site (the most recent Canadian collection site) to look for the larvae to identify the host plant. Comparisons of plant species, in particular goldenrods, present at the various collection sites may also help determine plants that would be suitable as hosts and which should be checked for larvae.

If the identity of host plants can be determined at any location, targeted searches around host plants at the known Ontario sites should be undertaken to determine if the populations are extant and to try to fill knowledge gaps on population size, threats, and habitat needs. Other areas with similar habitats can also be searched to attempt to locate additional populations.

In the meantime, the Manitoulin Island site and the habitats within the Pinery Provincial Park are expected to remain in a natural state. If succession appears to be causing significant change at either site, the use of additional stewardship measures, such as manually cutting shrubs and tree seedlings, may need to be considered.

The table of approaches, above, does not address all of the presumed threats. Without knowing if the populations are extant and what the host plant is, it is difficult to design approaches to specific threats. Once the host plant is identified, it is expected that the parameters that make habitat suitable for the Aweme Borer will be determined. From this, threats can be assessed, recovery approaches can be refined, and protection and management actions may be implemented.

2.4 Performance Measures

Performance measures provide a way to track progress toward achieving recovery. In the case of the Aweme Borer, even with a high degree of effort, it is possible that knowledge gaps will not be filled and recovery actions will not be able to go ahead. Therefore, for the Aweme Borer, unsuccessful searches and other attempts to fill knowledge gaps may need to be considered as work towards achieving the recovery objectives. The following measures may be used to evaluate progress:

- Searches should be done at least twice for the larvae and twice for adults of the Aweme Borer in two different years at the Manitoulin Island site and nearby bog habitat by 2020.
- If the host plant is identified: searches should be done in at least two different years at Grand Bend for both the larvae and the adults of the Aweme Borer by 2020.

2.5 Area for Consideration in Developing a Habitat Regulation

Under the ESA, a recovery strategy must include a recommendation to the Minister of Natural Resources and Forestry on the area that should be considered in developing a habitat regulation. A habitat regulation is a legal instrument that prescribes an area that will be protected as the habitat of the species. The recommendation provided below by the author will be one of many sources considered by the Minister when developing the habitat regulation for this species.

Considerations

The most important habitat need for the Aweme Borer is the presence of the host plant. However, the identity of the host(s) for the Aweme Borer is not known. As a result, it is not possible to know what habitat would be suitable for the Aweme Borer. The extent of habitat that would need to be prescribed, the factors needed to maintain the habitat, and the types of threats that would degrade or destroy the habitat are also not known.

In addition, the Aweme Borer has been collected in different vegetation types and the host plant may be a species that lives in more than one vegetation type. Therefore, it is suggested that, without more specific information, vegetation polygons defined according to the Ecological Land Classification (Lee et al. 1998) are probably not a useful guide to suitable habitat. It is suggested that even a blanket protection of area around the collection site would probably not be useful as it would not be certain to include the ecological factors required to support the host plants. There is a possibility that the Manitoulin Island collection site did not contain the source population of the individual Aweme Borer that was trapped there.

Therefore, it is recommended that a habitat regulation not be developed at this time due to the lack of information. However, if the identity of the host plant becomes known, it is suggested that a habitat regulation be developed based on the presence of host plants and their biological requirements. As such, it is suggested that the area to be considered for a habitat regulation would probably need to include:

1. the area where Aweme Borers (of any life stage) are found;
2. from the locations in (1), all of the contiguous area where host plants are present;
3. sufficient area for establishment, growth, and dispersal of host plants; and
4. a consideration of any dynamics required to maintain habitat suitability for the host plant. For example, if the host requires habitat that must have a specific moisture regime, then the sources of moisture in the wetland may need to be considered. As well, if the host requires active dune processes, then inclusion of a dynamic area (even if not occupied by the Aweme Borer) may also need to be considered.

GLOSSARY

Committee on the Status of Endangered Wildlife in Canada (COSEWIC): The committee established under section 14 of the *Species at Risk Act* that is responsible for assessing and classifying species at risk in Canada.

Committee on the Status of Species at Risk in Ontario (COSSARO): The committee established under section 3 of the *Endangered Species Act, 2007* that is responsible for assessing and classifying species at risk in Ontario.

Conservation status rank: A rank assigned to a species or ecological community that primarily conveys the degree of rarity of the species or community at the global (G), national (N) or subnational (S) level. These ranks, termed G-rank, N-rank and S-rank, are not legal designations. The conservation status of a species or ecosystem is designated by a number from 1 to 5, preceded by the letter G, N or S reflecting the appropriate geographic scale of the assessment. The numbers mean the following:

- 1 = critically imperilled
- 2 = imperilled
- 3 = vulnerable
- 4 = apparently secure
- 5 = secure.

Dicot: A plant that emerges with two small seed leaves, as opposed to a monocot which emerges with one seed leaf.

Endangered Species Act, 2007 (ESA): The provincial legislation that provides protection to species at risk in Ontario.

Endemic: Native of and restricted to a defined area.

Graminoid: A grass or other plant with a grass-like shape, such as a sedge, rush, etc.

Host: A species in which another organism lives. In this document, the plant that feeds and shelters the developing larvae of the Aweme Borer.

Larva (plural, larvae): The juvenile, growing stage of an insect; a caterpillar.

Post-median: After the middle. On the wings of the Aweme Borer, further out than the middle, measured from the body to the edge of the wings.

Pupa (plural, pupae): The developmental stage of an insect in which the larva becomes an adult inside a casing (a cocoon or chrysalis).

Species at Risk Act (SARA): The federal legislation that provides protection to species at risk in Canada. This act establishes Schedule 1 as the legal list of wildlife

species at risk. Schedules 2 and 3 contain lists of species that at the time the Act came into force needed to be reassessed. After species on Schedule 2 and 3 are reassessed and found to be at risk, they undergo the SARA listing process to be included in Schedule 1.

Species at Risk in Ontario (SARO) List: The regulation made under section 7 of the *Endangered Species Act, 2007* that provides the official status classification of species at risk in Ontario. This list was first published in 2004 as a policy and became a regulation in 2008.

Succession: The increase and filling-in of vegetation that result from natural growth over a number of years. Succession usually leads to an increase in shrubs and woody vegetation, and ultimately to mature trees and a closing of the canopy.

Thorax: The middle of the body of an insect, bearing the legs and wings. The thorax is located between the head and the abdomen.

REFERENCES

- Advisory Board on Parks and Recreation. 1953. The Pinery. Unpublished report submitted to the Ausable River Conservation Authority, hard copy on file at the Ontario Natural Heritage Information Centre of the Ontario Ministry of Natural Resources and Forestry, Peterborough, ON. 27 pp.
- Bakowsky, W.D. 1999. The impact of deer grazing on the vegetation of Pinery Provincial Park. Natural Heritage Information Centre, Ontario Ministry of Natural Resources, Peterborough, ON. 78 pp.
- Burke, R.J., J.M. Fitzsimmons and J.T. Kerr 2011. A mobility index for Canadian butterfly species based on naturalists' knowledge. *Biodiversity and Conservation* 20:2273-2295.
- Canadian Biodiversity Information Facility (CBIF). 2003. Moths of Canada website http://www.cbif.gc.ca/spp_pages/misc_moths/phps/mothindex_e.php [accessed January 3, 2014]
- COSEWIC. 2006. COSEWIC assessment and status report on the Aweme Borer *Papaipema aweme* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 25 pp.
<http://www.sararegistry.gc.ca/default.asp?lang=En&n=5927FC7C-1>
- COSEWIC. 2010. COSEWIC assessment and status report on the Pitcher's Thistle *Cirsium pitcheri* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 32 pp.
<http://www.sararegistry.gc.ca/default.asp?lang=En&n=DC9B688E-1>
- Covell, C.V. Jr. 1984. A Field Guide to the Moths of Eastern North America. Peterson Field Guide Series, Houghton Mifflin Company, Boston, MA. 496 pp.
- Davidson-Arnott, R.G.D. and M.N. Law. 1990. Seasonal patterns and controls on sediment supply to coastal foredunes, Long Point, Lake Erie. In: Nordstrom, K.F., N.P. Psuty and R.W.G. Carter (Eds.), *Coastal Dunes: Form and Process*. Wiley, London, pp. 177 – 200.
- Elkinton, J.S. and G.H. Boettner. 2012. Benefits and harm caused by the introduced generalist tachinid, *Compsilura concinnata*, in North America. *BioControl* 57:277-288.
- Environment Canada 2005. Daily data report for August 2005; Gore Bay, Ontario.
http://climate.weather.gc.ca/climateData/dailydata_e.html?timeframe=2&Prov=ON&StationID=30240&dlyRange=2005-01-01%7C2011-07-06&Year=2005&Month=8&Day=01 [accessed October 2, 2014]

- Goldstein, P.Z. 1999. Molecular systematics and the macroevolution of host plant use in the endophagous moth genus *Papaipema* Smith, 1899 (Lepidoptera: Noctuidae). Ph.D. dissertation, University of Connecticut, Storrs, CT, USA. Paper AAI9942574. <http://digitalcommons.uconn.edu/dissertations/AAI9942574>
- Goldstein, P.Z. and E.L. Quinter. 2003. Host plant associations of western species of *Papaipema* (Noctuidae) with particular reference to the Apiaceous plants. *Journal of the Lepidopterists' Society* 57(2):153-156.
- Hardwick, D.F. and K. Stead. 1998. The life history of *Schinia sanguinea* (Geyer) (Noctuidae; Heliothentinae) with a report on a survey for Heterocera in southwestern Ontario. *Journal of the Lepidopterists' Society* 52(4):381-355.
- Hessel, S.A. 1954. A guide to collecting the plant-boring larvae of the genus *Papaipema* (Noctuidae). *Lepidoptera News* 8:57-63.
- Jeffords, S. 2009. To spray or not to spray. *The Sarnia Observer*, Wednesday, March 11, 2009. <http://www.theobserver.ca/2009/03/11/to-spray-or-not-to-spray> [accessed November 12, 2014].
- Johnson, Kyle E. pers. comm. 2014. *Telephone correspondence to J. Jones*. October 2, 2014. Entomologist on contract with Minnesota Biological Survey, St. Paul, MN.
- Kost, M.A., D.A. Albert, J.G. Cohen, B.S. Slaughter, R.K. Schillo, C.R. Weber, and K.A. Chapman. 2007. Natural Communities of Michigan: Classification and Description. Michigan Natural Features Inventory, Report No. 2007-21, Lansing, MI. <http://mnfi.anr.msu.edu/communities/community.cfm?id=10699> [accessed January 13, 2014].
- Lafontaine, J. Donald. pers. comm. 2014. *Telephone correspondence to J. Jones*. January 6, 2014. Noctuid specialist, Canadian National Collection of Insects and Arthropods, Agriculture and Agri-food Canada, Ottawa, Ontario.
- Lee, H.T., W.D. Bakowsky, J. Riley, J. Bowles, M. Puddister, P. Uhlig, and S. McMurray. 1998. Ecological Land Classification for Southern Ontario: First Approximation and Its Application. OMNR, Southcentral Science Section, Science Development and Transfer Branch. SCSS Field Guide FG-02. 225 pp.
- Lichter, J. 1998. Primary succession and forest development on coastal Lake Michigan sand dunes. *Ecological Monographs* 68(4):487-510.
- Michigan Natural Features Inventory. 2007. Aweme Borer abstract. Rare Species Explorer. <http://mnfi.anr.msu.edu/explorer/species.cfm?id=11987> [accessed December 27, 2013].
- Morton, David. pers. comm. 2014. *Telephone correspondence to J. Jones*. January 15,

2014. Son of J.K. Morton and current owner of the Manitoulin Island collection site. Waterloo, ON.
- Morton, John K. pers. comm. 2006. [Deceased, 2011] *In person correspondence to J. Jones*. September, 2006. Professor Emeritus, University of Waterloo, Dept. of Biology.
- Morton, J.K. undated. The Butterflies and Moths (Lepidoptera) of dune systems on Manitoulin and adjacent islands. Unpublished report prepared for the Lake Huron Dune Grasslands Recovery Team.
- Natural Heritage Information Centre (NHIC). 2013. List of Ontario Tracked Species. Ontario Ministry of Natural Resources, Peterborough, ON.
http://www.mnr.gov.on.ca/en/Business/NHIC/2ColumnSubPage/STDU_138221.html [accessed February 4, 2014].
- NatureServe 2014. The Aweme Borer *in* NatureServe Explorer: An online encyclopedia of life. Version 7.1. NatureServe, Arlington, Virginia.
<http://www.natureserve.org/explorer> [Accessed January 3, 2014]
- New York Department of Environmental Conservation. 2013. New York state species of greatest conservation need.
http://www.dec.ny.gov/docs/wildlife_pdf/sgcnbyhabitat.pdf [Accessed January 3, 2014]
- Nieminen, M. 1996. Risk of population extinction in moths: effect of host plant characteristics. *Oikos* 76:475-484.
- Parks Canada Agency. 2011. Recovery Strategy for Pitcher's Thistle (*Cirsium pitcheri*) in Canada. *Species at Risk Act* Recovery Strategy Series. Parks Canada Agency. Ottawa. x + 31 pp.
http://www.sararegistry.gc.ca/virtual_sara/files/plans/rs_pitchers_thistle_0311_e.pdf
- Pinery Provincial Park. 2014. What Lives in Pinery; checklists for species and coastal dune habitat description sheet. http://www.pinerypark.on.ca/lives_pinery.html [accessed January 3 and February 4, 2014].
- Quinter, Eric. pers. comm. 2014. *Telephone correspondence to J. Jones*. January 7, 2014. Retired entomologist and expert on the genus *Papaipema*, American Museum of Natural History, New York, NY.
- Roughley, R.E. 2000. Aweme, Manitoba – An important historical grassland site. *Arthropods of Canadian Grasslands* 6:8-14.