Aweme Borer Moth (Papaipema aweme) in Ontario

Ontario Recovery Strategy Series

Recovery strategy prepared under the Endangered Species Act, 2007

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 15 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


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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.
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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 thorax \(^1\) (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

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\(^1\) Technical terms are defined in the glossary.
than 50 known species, and at least 26 occur in Canada (CBIF 2003; Goldstein and 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>
<thead>
<tr>
<th>Collection Location</th>
<th>Collection Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aweme, MB</td>
<td>1905-08-24</td>
</tr>
<tr>
<td>Aweme, MB</td>
<td>1905-08-25</td>
</tr>
<tr>
<td>Aweme, MB</td>
<td>1905-08-26</td>
</tr>
<tr>
<td>Beaver Island, MI</td>
<td>1925-08-13</td>
</tr>
<tr>
<td>Rochester, NY</td>
<td>1932-08-07</td>
</tr>
<tr>
<td>Grand Bend, ON</td>
<td>1936-08-15</td>
</tr>
<tr>
<td>Manitoulin Island, ON</td>
<td>2005-08-19</td>
</tr>
<tr>
<td>McMillan, MI</td>
<td>2009-09-10</td>
</tr>
<tr>
<td>Pine Creek, MN</td>
<td>2014-09-08</td>
</tr>
</tbody>
</table>

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 owlet 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 2. Protection and recovery objectives

<table>
<thead>
<tr>
<th>No.</th>
<th>Protection or Recovery Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Conduct research to fill knowledge gaps.</td>
</tr>
<tr>
<td>2</td>
<td>Use stewardship actions to maintain existing vegetation.</td>
</tr>
<tr>
<td>3</td>
<td>Create partnerships and share information with other jurisdictions.</td>
</tr>
</tbody>
</table>
## 2.3 Approaches to Recovery

Table 3. Approaches to recovery of the Aweme Borer in Ontario

<table>
<thead>
<tr>
<th>Relative Priority</th>
<th>Relative Timeframe</th>
<th>Recovery Theme</th>
<th>Approach to Recovery</th>
<th>Threats or Knowledge Gaps Addressed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Critical</td>
<td>On-going</td>
<td>Research and Inventory</td>
<td>1.1 Determine if any populations are extant by:</td>
<td>• Whether any populations are extant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>– trapping for the Aweme Borer adults at Grand Bend and Manitoulin Island in wetland</td>
<td>• Where species occurs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>habitats;</td>
<td>• Size and distribution of populations</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>– trapping for the Aweme Borer in bog habitat near the Manitoulin Island collection</td>
<td>• Types of threats</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>site;</td>
<td>• Protection needs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>– continuing to search for the larvae at the Manitoulin Island site; and</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>– trapping in other areas that may have vegetation similar to the McMillan and</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>Minnesota sites; and</td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>– if host plant is identified (Approach 1.2), searching for Aweme Borer where host</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>plants are common at the two known sites.</td>
<td></td>
</tr>
<tr>
<td>Critical</td>
<td>On-going</td>
<td>Research and Inventory</td>
<td>1.2 Identify the host plant and its habitat by:</td>
<td>• Where species occurs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>– searching for the Aweme Borer larvae at the Manitoulin Island site.</td>
<td>• Habitat requirements</td>
</tr>
<tr>
<td>Necessary</td>
<td>Long-term</td>
<td>Research</td>
<td>1.3 Determine parameters and ecology of the Aweme Borer and its suitable habitat</td>
<td>• Protection needs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>including:</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>– conditions and dynamics required by the host plants;</td>
<td>• Habitats requirements</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>– habitat management needs/tools;</td>
<td>• Management needs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>– potential threats.</td>
<td>• Protection needs</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Types of threats</td>
</tr>
<tr>
<td>Relative Priority</td>
<td>Relative Timeframe</td>
<td>Recovery Theme</td>
<td>Approach to Recovery</td>
<td>Threats or Knowledge Gaps Addressed</td>
</tr>
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<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Beneficial</td>
<td>Long-term</td>
<td>Research and Inventory</td>
<td>1.4 Search for additional populations of the Aweme Borer by:</td>
<td>• Size and distribution of populations</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>– developing appropriate survey protocol so that presence and occupancy can be determined;</td>
<td>• Habitat requirements</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>– reviewing floristic inventories from places with similar habitats and searching for the moths where host plants are present.</td>
<td>• Types of threats</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>2. Use stewardship actions to maintain existing vegetation</td>
<td></td>
</tr>
<tr>
<td>Critical</td>
<td>Long-term</td>
<td>Protection, Management, Stewardship</td>
<td>2.1 Once knowledge gaps are filled and parameters of suitable habitat are known, re-evaluate management and protection needs.</td>
<td>• Any or all threats</td>
</tr>
<tr>
<td>Necessary</td>
<td>On-going</td>
<td>Stewardship</td>
<td>2.2 Manage land around Ontario collection sites to remain in a natural state by:</td>
<td>• Browsing and grazing</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>– assisting landowners of the Manitoulin Island site with stewardship if requested;</td>
<td>• Changes to drainage</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>– liaising with Pinery Provincial Park on management of habitats as per Approach 3.2;</td>
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<td></td>
<td>and</td>
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<td></td>
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<td></td>
<td>– assessing habitat maintenance needs such as weed removal, reduction of woody growth, or fencing out deer.</td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>3. Create partnerships and share information with other jurisdictions</td>
<td></td>
</tr>
<tr>
<td>Critical</td>
<td>Short-term</td>
<td>Communications, Research</td>
<td>3.1 Liaise with Michigan and Minnesota researchers to learn of any new information that may come from the McMillan or Minnesota collection sites.</td>
<td>• Identity of the host plant</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>– If host plant is identified in Michigan or Minnesota, use this information to refine searches in Ontario.</td>
<td>• Parameters of suitable habitat</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>• Global distribution of the species</td>
</tr>
<tr>
<td>Relative Priority</td>
<td>Relative Timeframe</td>
<td>Recovery Theme</td>
<td>Approach to Recovery</td>
<td>Threats or Knowledge Gaps Addressed</td>
</tr>
<tr>
<td>-------------------</td>
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<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| 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;  
เฉลี่ย– ensure park receives any new information that may help with searches in the Grand Bend area. | • 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.                                                                                                 | • 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.                                                                            | • 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


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.


