Recovery Plan for the Island Tiger Moth (*Grammia complicata*) in British Columbia

Prepared by the B.C. Ministry of Environment and Climate Change Strategy

BRITISH COLUMBIA

August 2017

About the British Columbia Recovery Series

This series presents the recovery documents that are prepared as advice to the Province of British Columbia on the general approach required to recover species at risk. The Province prepares recovery documents to ensure coordinated conservation actions and to meet its commitments to recover species at risk under the *Accord for the Protection of Species at Risk in Canada* and the *Canada–British Columbia Agreement on Species at Risk*.

What is recovery?

Species at risk recovery 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 provincial recovery document?

Recovery documents summarize the best available scientific and traditional information of a species or ecosystem to identify goals, objectives, and strategic approaches that provide a coordinated direction for recovery. These documents outline what is and what is not known about a species or ecosystem, identify threats to the species or ecosystem, and explain what should be done to mitigate those threats, as well as provide information on habitat needed for survival and recovery of the species. The provincial approach is to summarize this information along with information to guide implementation within a recovery plan. For federally led recovery planning processes, information is most often summarized in two or more documents that together make up a recovery plan: a strategic recovery strategy followed by one or more action plans used to guide implementation.

Information in provincial recovery documents may be adopted by Environment and Climate Change Canada for inclusion in federal recovery documents that federal agencies prepare to meet their commitments to recover species at risk under the *Species at Risk Act*.

What's next?

The Province of British Columbia accepts the information in these documents as advice to inform implementation of recovery measures, including decisions regarding measures to protect habitat for the species.

Success in the recovery of a species depends on the commitment and cooperation of many different constituencies that may be involved in implementing the directions set out in this document. All British Columbians are encouraged to participate in these efforts.

For more information

To learn more about species at risk recovery in British Columbia, please visit the B.C. Recovery Planning webpage at:
<http://www2.gov.bc.ca/gov/content/environment/plants-animals-ecosystems/species-ecosystems-at-risk/recovery-planning>

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Additional copies

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Disclaimer

This recovery plan has been prepared by the British Columbia Ministry of Environment and Climate Change Strategy, as advice to the responsible jurisdictions and organizations that may be involved in recovering the species. The B.C. Ministry of Environment and Climate Change Strategy has received this advice as part of fulfilling its commitments under the *Accord for the Protection of Species at Risk in Canada* and the *Canada–British Columbia Agreement on Species at Risk*.

This document identifies the recovery strategies and actions that are deemed necessary, based on the best available scientific and traditional information, to recover Island Tiger Moth populations in British Columbia. Recovery actions to achieve the goals and objectives identified herein are subject to the priorities and budgetary constraints of participatory agencies and organizations. These goals, objectives, and recovery approaches may be modified in the future to accommodate new findings.

The responsible jurisdictions have had an opportunity to review this document. However, this document does not necessarily represent the official positions of the agencies or the personal views of all individuals who reviewed this document.

Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that may be involved in implementing the directions set out in this plan. The B.C. Ministry of Environment and Climate Change Strategy encourages all British Columbians to participate in the recovery of Island Tiger Moth.

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EXECUTIVE SUMMARY

Island Tiger Moth (*Grammia complicata*) is a medium-sized (wingspan 32-40 mm) moth that is primarily active during the day. The dorsal forewings resemble the species wing venation but are variable in their colour and pattern. Specimens vary from dark brown-black interlaced with light orange-peach patterns, whereas others are the converse, with orange-peach patterns interlaced with dark brown-black patterns. The dorsal hindwings are typically lighter than the forewings, and are an overall orange-yellow-peach colour, with brown wing margins and brown dots towards the outer wing margins. Both sexes have similar wing markings and the head, thorax, and sides of the abdomen (both sexes) are also dark brown-black with peach-orange markings. Larvae have been captive-reared in British Columbia, although no associated morphological or descriptive information accompanies the adult museum specimens.

The flight period for Island Tiger Moth is from early May to late July with one generation per year. *Grammia* adults (in general) are short lived (3 weeks), have non-functional mouthparts, and do not eat. Studies on the related tiger moth species, *G. geneura*, document 100 to1 000 eggs laid in non-specific areas amongst ground litter and dead vegetation. Island Tiger Moth eggs likely hatch shortly after oviposition and larvae continue to grow until late August and early September. Most temperate tiger moths overwinter as larvae and resume feeding the following spring. Larvae likely pass through six or seven instars before pupation, which likely occurs in late April to mid-May.

Island Tiger Moth was designated as Threatened in 2013by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). This near-endemic moth has a small global distribution, with most of the global records from British Columbia and restricted to the Garry Oak and coastal sand ecosystems of the southern Georgia Basin. The species is known from a total of 18 sites: four extant sites, five historical sites with potential suitable habitat remaining, and an additional nine sites with vague collection locality information, unlikely to have habitat remaining. Much of its habitat has been destroyed and the quality of what remains is in decline because of ongoing residential and commercial development, recreational activities, invasive or non-native species, and plant and tree succession, which has accelerated owing to disruption of historical fire regimes. Island Tiger Moth is not listed in Canada on Schedule 1 of the *Species at Risk Act* (SARA).[1] In British Columbia, Island Tiger Moth is ranked S1 (imperiled) and Red-listed by the B.C. Conservation Data Centre. Recovery is biologically and technically feasible.

The primary threat to Island Tiger Moth is the potential spray of a commercial pesticide containing the bacteria *Bacillus thuringiensis kurstaki* (Btk) to control the introduction and spread of non-native Gypsy Moth. This pesticide also affects most non-target butterfly and moth larvae and is applied during the Island Tiger Moth larval activity period. Other high impact threats include: the potential for a tsunami to destroy three of the four extant Island Tiger Moth populations; recreational activities that trample host plants (e.g., off-leash dog walking and off-trail hiking); and ecosystem modifications related to the natural succession of both invasive non-

[1] The COSEWIC assessment will be reviewed by the Governor in Council who may, on the recommendation of the Minister, amend the List to include this species on Schedule 1 of SARA.

native/alien species and of problematic native species resulting from ongoing fire suppression programs. The impacts of climate change, including habitat shifting, droughts, and an increase in the scope and severity of winter storms and flooding, are also threats.

The recovery (population and distribution) goal is to maintain populations of Island Tiger Moth at all extant sites within the province, including any additional populations that may be identified in the future, and to maintain or increase population connectivity.

The recovery objectives for Island Tiger Moth are:

1. to secure protection[2] for the extant populations of Island Tiger Moth with no loss or degradation of occupied habitat;
2. to confirm the distribution of Island Tiger Moth within its range in British Columbia;
3. to assess the levels of real and potential threats to this species and its habitat and to mitigate their impacts; and
4. to address knowledge gaps (e.g., habitat requirements, life history, dispersal) for the successful maintenance of populations, including habitat restoration if necessary.

[2] Protection can be achieved through various mechanisms, including voluntary stewardship agreements, conservation covenants, sale of private lands by willing vendors, land use designations, and protected areas.

RECOVERY FEASIBILITY SUMMARY

Based on the four criteria that Environment and Climate Change Canada uses to establish recovery feasibility, the technical and biological feasibility of Island Tiger Moth recovery is unknown. Following a precautionary principle, a recovery plan has been prepared that addresses the recovery feasibility unknowns.

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. Island Tiger Moth is difficult to detect and population trends, natural fluctuations or abundance, dispersal, and reproductive capability are unknown. Based on a lack of sight and collection records for this bright, day-active and showy moth, the species appears to maintain itself in low populations within a habitat patch. Recent (since 2000) records of the moth suggest four extant Canadian populations[3] exist and, although the reproductive capabilities of the moth are unknown, it is assumed the quality and quantity of habitat is sufficient to sustain these populations. It is unknown whether the populations are stable; however, it is inferred that if the habitat does not change in area, extent, or quality, these populations are likely to remain extant. Detrimental changes in the quality of habitat include natural plant succession related to fire suppression, invasive species, or recreational activities that degrade the habitat.

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

   Yes. Island Tiger Moth populations occur in open and grassy Garry oak plant communities, open moist to dry meadows, grassy shoreline sandy areas, and in stabilized, sparsely vegetated areas in coastal sand dunes. Recent records of the moth (since 2000) suggest four separate and extant populations exist within habitats that are natural and appear suitable to sustain populations. It is assumed the species can maintain its population given sufficient habitat and host plant availability. Habitat management and restoration is likely necessary to maintain the open habitats at all extant populations.

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

Unknown. The primary threats to Island Tiger Moth are the potential spray of the commercial pesticide Btk to control the introduction and spread of non-native Gypsy Moth. The pesticide also affects most non-target butterfly and moth larvae and is applied during the Island Tiger Moth larval activity period.

Other high impact threats include: the potential for a tsunami to destroy three of the four extant Island Tiger Moth populations; recreational activities that trample host plants (e.g.,

[3] The COSEWIC (2013) status report suggested that five extant populations of the Island Tiger Moth exist; however, the population on Thetis Island has not been recorded since 1975 and is now considered "historical" according to NatureServe (2016) guidelines, which suggest a 20-year period without records to classify a population as historical, whereas the COSEWIC (2016) guidelines suggest a 50-year period for the "historical" classification.

off-leash dog walking and off-trail hiking); and natural succession from invasive non-native/alien species and encroachment of problematic native species related to ongoing fire suppression programs. Habitat degradation caused by the spread of invasive plants can be prevented by ongoing removal and restoration activities; however, it is unknown whether these mitigation options are viable in the long-term, such that continued, active human intervention is not required. It is unknown to what extent habitat degradation caused by climate change can be mitigated or avoided.

Secondary threats include residential and commercial development, transportation and service corridors, recreational activities, and problematic native species. Populations of Island Tiger Moth coincide with a densely populated part of British Columbia, and threats to its habitat from land developments will continue. Nevertheless, it may be possible to mitigate these threats by habitat protection, stewardship, and development of best practices. Lower-level cumulative threats applicable to Island Tiger Moth are similar to other species living within sparsely vegetated sand ecosystems and Garry oak habitats. Threat mitigation approaches can be combined with approaches used with other species that have similar threats.

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

Yes. Existing techniques to achieve population and distribution objectives include developing inventory techniques for the moth (e.g., life stage observed, dates, abundance, activity patterns including oviposition sites and larval host plants), and site-specific threat information that allows informed decisions about habitat protection or management. Captive breeding to supplement the wild populations is not thought necessary for the recovery of Island Tiger Moth. The species appears to occur at low abundance within suitable habitats, and further inventory, dispersal ability and abundance at extant sites needs to be completed before supplementing wild populations with captive bred individuals. Captive breeding may take place to gain knowledge regarding this species' life history and reproductive capabilities. Habitat management or restoration actions include: removing invasive shrub plants that shade and out-compete potential host grasses for the moth; managing recreational activities (e.g., extensive foot traffic, dog walking, or illegal camping) to minimize soil compaction; and informing land owners and managers of stewardship options for the moth and its associated habitat. Development of additional recovery techniques to achieve the population and distribution objectives is expected within a reasonable time frame.

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1 COSEWIC* SPECIES ASSESSMENT INFORMATION

Assessment Summary: May 2013
Common Name: Island Tiger Moth
Scientific Name: *Grammia complicata*
Status: Threatened
Reason for Designation:[a] This near endemic moth has a small distribution and is restricted to only five[b] locations in the Georgia Basin in British Columbia. Much of its habitat has been destroyed and the quality of what remains is declining due to ongoing residential and commercial development, recreational activities, invasive or non-native species, and vegetation succession that has changed due to disruption of former fire regimes.
Occurrence: British Columbia
Status History: Designated Threatened in May 2013.

* Committee on the Status of Endangered Wildlife in Canada.
[a] Criteria provided: B1ab(iii)+2ab(iii). See COSEWIC quantitative criteria and guidelines for the status assessment of wildlife species (Table 2 of the COSEWIC assessment process guidelines http://www.cosewic.gc.ca/default.asp?lang=En&n=ED199D3B-1&offset=5&toc=show)).
[b] The B.C. Conservation Data Centre uses a 20-year time frame and so identifies only four extant locations.

2 SPECIES STATUS INFORMATION

Island Tiger Moth[a]			
Legal Designation:			
FRPA:[b] No	OGAA:[b] No	B.C. *Wildlife Act*:[c] No	SARA:[d] No
Conservation Status[e]			
B.C. List: Red	B.C. Rank: S2 (2016)	National Rank: N1N2 (2002)	Global Rank: G1 (2002)
Other Subnational Ranks:[f] Washington State: SNR			

B.C. = British Columbia; CF = Conservation framework; FRPA = *Forest Range and Protection Act*; OGAA = *Oil and Gas Activities Act*; SARA = *Species at Risk Act*;
Data source: B.C. CDC (2016) unless otherwise noted.
[b] No = not listed in one of the categories of wildlife that requires special management attention to address the impacts of forestry and range activities on Crown land under the FRPA (Province of British Columbia 2002) and/or the impacts of oil and gas activities on Crown land under the OGAA (Province of British Columbia 2008).
[c] No = not designated as wildlife under the B.C. *Wildlife Act* (Province of British Columbia 1982).
[d] No = not on any Schedules under the SARA (Government of Canada 2002). The COSEWIC assessment will be reviewed by the Governor in Council who may, on the recommendation of the Minister, amend the List to include this species on Schedule 1 of SARA.
[e] Red: Includes any indigenous species or subspecies that have, or are candidates for, Extirpated, Endangered, or Threatened status in British Columbia. S = subnational; N = national; G = global; T = refers to the subspecies level; X = presumed extirpated; H = possibly extirpated; 1 = critically imperilled; 2 = imperilled; 3 = special concern, vulnerable to extirpation or extinction; 4 = apparently secure; 5 = demonstrably widespread, abundant, and secure; NA = not applicable; NR = unranked; U = unrankable.
[f] Data source: NatureServe (2015).
[g] Data source: B.C. Ministry of Environment (2009).
[h] Six-level scale: Priority 1 (highest priority) through to Priority 6 (lowest priority).

3 SPECIES INFORMATION

3.1 Species Description

Island Tiger Moth (*Grammia complicata*) is within the Family Erebidae (tussock moths, tiger moths, underwings, and relatives). Globally, 37 species exist in the genus *Grammia*, with 36 occurring in North America (Schmidt 2009) and 12 in British Columbia (B.C.) (Pohl *et al*. 2015). The life history of the species has not been studied.

3.1.1 Adults

Island Tiger Moth is medium sized (wingspan 32–40 mm). The wing pattern and colouration is variable and without sexual dimorphism (Figure 1). The dorsal forewing colour is dark brown-black interlaced with light orange-peach patterns resembling the species' wing venation. Conversely, some specimens are orange-peach interlaced with dark brown-black patterns. The dorsal hind wings are orange-yellow-peach, with brown wing margins and brown dots towards the margins, and typically lighter than the forewings. The head, thorax, and abdomen are also dark brown-black with peach-orange markings.

Figure 1. Island Tiger Moth specimens deposited at the Royal B.C. Museum, showing wing diversity and patterns[4]

[4] Photograph by Jennifer Heron

Museum specimens suggest an adult flight period in B.C. from early May to late July (Appendix A, Table A-1). Island Tiger Moth is not migratory and the maximum dispersal distance is unknown; however, females are not likely to fly far because of their small wing area and heavy egg-filled abdomen (Schmidt, pers. comm., 2016). *Grammia* adults, particularly females, are often observed crawling within the ground vegetation. The most recent record of the moth was found in low-lying grassy vegetation (Yip, pers. comm., 2015). Adults do not feed; their focus is to mate and lay eggs; thus, energy is not likely to be spent on dispersal. *Grammia* adults in general are short lived (less than 3 weeks). Information on the dispersal distances of other tiger moths suggests flight capabilities of "a few hundred yards" (e.g., *Cycnia inopinatus*; Bess 2005).

3.1.2 Eggs

Island Tiger Moth eggs have not been observed or described. The eggs of other *Grammia* species are typically circular, flattened at the base, and with shallow dimples or geometrical reticulations (Wagner 2009). The tiger moth species *G. geneura* lays 100–1 000 eggs (Singer 2000) in non-specific areas amongst ground litter and dead vegetation (Singer 2000; Schmidt 2009; Wagner 2009). The duration from oviposition to egg-hatch for Island Tiger Moth is unknown. Eggs likely hatch shortly after oviposition and larvae continue to grow by successive moults until early September.

3.1.3 Larvae

Island Tiger Moth larvae have not been described. Ten adult specimens deposited at the Royal B.C. Museum were originally collected as larvae in the wild, from late March to mid-June, and reared to adults. No accompanying specimen information is available regarding the larval instar collected, duration to pupation, or duration to adult moth emergence (Royal B.C. Museum records; Appendix A, Table A-1); field notes do not provide additional information on morphological description of larvae or pupae (C. Copley, pers. comm., 2016).

Grammia larvae, in general, are large and conspicuous, up to 6 cm long, hairy, and have black integument with lateral stripes of variable orange-brown-yellow (Wagner 2009). Most temperate tiger moths overwinter as larvae and resume feeding the following spring (Byers 1988; Schmidt 2009; Wagner 2009). Island Tiger Moth larvae have been collected as early as March 25th. Pupation likely occurs in late April to mid-May. Larvae likely pass through six or seven instars before pupation (Byers 1988).

3.1.4 Pupae

Pupae associated with the larval specimens noted above are deposited at the Royal B.C. Museum (C. Copley, pers. comm., 2016). *Grammia* pupae tend to be smooth, shiny with a waxy bloom, and are somewhat bullet-shaped (Wagner 2009). Studies of Blake's Tiger Moth (*G. blakei*) showed that before pupation, larvae form fragile cocoons covered with plant matter and situated within clumps of grass and loose soil, under cattle dung, or within loose soil in shallow depressions (Byers 1988). Some tiger moth species weave their setae (hairs on the larva, sometimes with sequestered toxic compounds) (Hartmann et al. 2005) into the pupal cocoon; however, *Grammia* species (in general) form silken cocoons free of setae (Conner 2009). *Grammia* cocoons have sticky oil-like beads that are retained in the tip of the pupa. Although

their characteristics have not been researched, the chemicals in these beads likely provide a defence mechanism (Conner 2009).

Tiger moth eggs, larvae, and adults are all known to contain pyrrolizidine alkaloids sequestered through feeding on plants containing these chemicals (Hartmann et al. 2005; Hartmann 2009). The result is a chemical defence system against predators.

3.2 Populations and Distribution

The global range of Island Tiger Moth is small and restricted to the southeastern side of Vancouver Island in B.C. and San Juan Island in Washington State. More specifically, the northernmost range extent is Comox and Savary Island in B.C., the southernmost Canadian range extent is the greater Victoria area, and only one record exists for San Juan Island in Washington State (Figure 2). One record exists for Thetis Island (population #2; Table 1) within the Strait of Georgia. This range extent coincides with that of the Garry oak (*Quercus garryana*) and associated ecosystems (Garry Oak Ecosystem Recovery Team 2016), although no records of the moth exist within the two isolated pockets of habitat in the lower Fraser Valley (i.e., Sumas Mountain or near Yale).

The global range of Island Tiger Moth is approximately 3 600 km^2. The species is near-endemic, with approximately 85% of the species' global range in Canada (COSEWIC 2013).

Island Tiger Moth records in the province date from 1895 to 2012 (Appendix A). Several of these records are from previous collections, have unknown specific collection sites (geographic name). The remaining Records, with site information, are grouped into 19 populations (Table 1). A population is based on some evidence of historical or current presence of breeding, which includes oviposition, the presence of immature life stages, the shed pupal exoskeleton (remaining after adult moth emergence), or adults, and potential habitat availability at the time of the collection or sight record (Section 3.3). Island Tiger Moth populations separated by more than 1 km of unsuitable habitat are considered as separate and presumed to not mix (B.C. CDC 2016).

Four populations are considered extant. These populations have been recorded within the past 20 years and are in areas where natural habitat is considered suitable for the moth (Section 3.3):

- #1 HMCS Quadra 19 Wing Comox Goose Spit (2003; referred to as Goose Spit, throughout this document);
- #3 Savary Island (2002);
- #4 Jáji7em and Kw'ulh Marine Provincial Park, also known as Sandy Island Marine Park (2000; referred to as Sandy Island throughout this document); and
- #9 Nanoose Hill, also known as Notch Hill (2012).

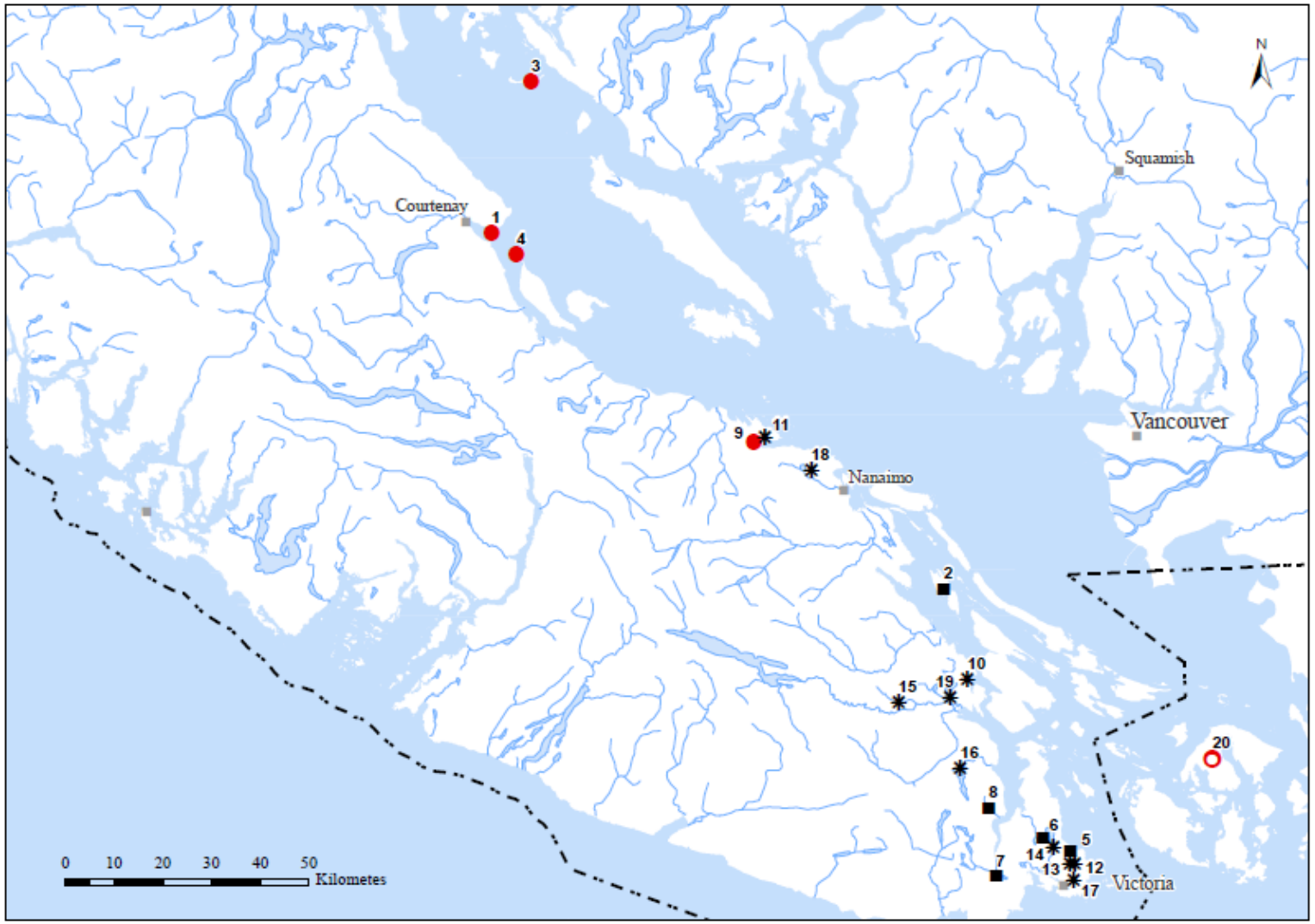

Figure 2. Island Tiger Moth populations and distribution in British Columbia, Canada, and North America (COSEWIC 2013)

Note: Extant populations indicated with a (red) dot (including #20, Orcas Island, WA, USA); historical populations within areas of suitable habitat are indicated by a square (collection sites are approximate), and possibly extirpated historical populations are indicated with an asterisk. Map numbers correspond to population locations in Table 1.

Fifteen populations are considered historical as there have been no confirmed records within the last 40 years.[5] The five populations listed below still have patches of suitable habitat remaining. Because Island Tiger Moth is detected at low abundance, the species could persist within fragmented patches of this habitat at these locations:

- #2 Thetis Island (1975)[6];
- #5 Mount Douglas Park (1954);
- #6 Observatory Hill (Herzberg Institute of Astrophysics) (1958);
- #7 Goldstream Provincial Park (1903); and
- #8 Spectacle Lake Provincial Park (1964).

Ten additional historical populations (#10–19) are possibly extirpated.[7] Records for these populations have vague collection information and it is unlikely that suitable habitat persists in the general geographic area. Nevertheless, field verification and/or reconnaissance have not confirmed this presumption. As such, until the B.C. Conservation Data Centre (CDC) has assigned status to these populations, they are considered historical populations.

[5] Historical rank includes occurrences based only on historical collection data, or occurrences that previously were considered viable, but that are now, without field survey work, considered to be possibly extirpated owing to general habitat loss or degradation of the environment in the area. In the absence of known disturbance and with the habitat still extant, "historical" is generally recommended for occurrences that have not been reconfirmed for 20 or more years. With very few exceptions, occurrences are to be regarded as historical after 40 years without confirmation, even with no effort to locate the species NatureServe (2016b). Field studies have occurred in some of these areas more recently; however, this field information needs to be sorted and verified for records.

[6] This population has been categorized as per NatureServe (2016b) definition. The COSEWIC (2013) status report defined this population as recent (extant), as it allows for up to 50 years without confirmation of the species if the habitat remains.

[7] Extirpated means that adequate surveys by one or more experienced observers at times and under conditions appropriate for the species at the occurrence location, or other persuasive evidence, indicate that the species no longer exists there or that the habitat or environment of the occurrence has been destroyed to such an extent that it can no longer support the species (Hammerson *et al.* 2016).

Table 1. Status and description of Island Tiger Moth populations in British Columbia.

Population number (Figure 2)	Population name	Population Status (first record[a]/most recent record), and habitat description	Land tenure
1	Goose Spit, Comox	• Extant (2003). One specimen. • The habitat is considered suitable for the moth. • The specific habitat where the moth was trapped is managed by HMCS Quadra. Adjacent to this collection site, comparable habitat is available and continuous throughout the three land jurisdictions at Goose Spit. It is assumed the moth occupies the whole habitat patch.	Three landowners/managers: 1. Comox First Nation 2. Goose Spit Park, Comox Regional District (Parks Department) 3. Federal Department of National Defence (DND) HMCS Quadra, 19 Wing Comox
2	Thetis Gulf Island, Strait of Georgia	• Historical (1975). One specimen. Precise collection site unknown. • Thetis Island is largely undeveloped and suitable moth habitat is likely available.	Private (likely private land, actual status unknown)
3	Savary Island	• Extant (2002). One specimen. • The habitat is considered suitable for the moth. • The collection site is known and habitat presumed suitable.	Fifty percent undivided interest held by two landowners: 1. Private conservation organization The Nature Trust of B.C. 2. Private citizen
4	Sandy Island	• Extant (2000). One specimen. • The habitat is considered suitable for the moth. • The island is often visited by boaters and recreational users. A large sandy beach is present and hiking trails traverse the island. The island has designated camp sites (directly on the ground), although camping often occurs outside of these areas.	Provincial government (provincial park)
5	Mount Douglas Saanich Park	• Historical (1935/1954). • The habitat is considered suitable for the moth. • Popular municipal park close to urban areas and with a variety of habitats and recreational facilities. Over time, the open Garry oak and associated meadow ecosystems have experienced natural succession by both native and non-native plants (e.g., Scotch broom). Several additional species at risk have been recorded from the park and parks staff is aware of these and manage the Garry oak habitats for conservation values.	Private (local government, District of Saanich, Saanich Parks)

Population number (Figure 2)	Population name	Population Status (first record[a]/most recent record), and habitat description	Land tenure
6	Observatory Hill, Saanich	• Historical (1957/1958). • The habitat is considered suitable for the moth. • Popular federally managed facility/park close to urban areas and with a variety of habitats and recreational facilities. Over time, the open Garry Oak and associated meadow ecosystems have experienced the threat of natural succession by both native and non-native plants (e.g., Scotch Broom). Numerous additional species at risk have been recorded from the park, and lands managers manage for these conservation values.	Federal (Herzberg Institute of Astrophysics)
7	Goldstream Provincial Park	• Historical (1903). • The habitat is considered suitable for the moth. • Popular provincial park close to urban areas and with a variety of habitats and recreational facilities. Over time, the open Garry oak and associated meadow ecosystems have experienced the threat of natural succession, and in many cases the specific location of these habitats is unknown.	Provincial government (provincial park)
8	Spectacle Lake Provincial Park, Cowichan	• Historical (1964). • The habitat is considered suitable for the moth. • Provincial park close to urban areas and with a variety of habitats and recreational facilities. Over time, the open Garry oak and associated meadow ecosystems have experienced natural succession, and the historical distribution of these habitats within the park is now unknown. The park is surrounded by private land parcels that provide some suitable habitat.	Provincial government (provincial park)
9	Nanoose Hill (Notch Hill)	• Extant (1977;collection site is vague and unknown / 2012; photographic record). • DND owns a portion of this extensive area of habitat and the Nanaimo Regional District owns adjacent portions. Several hiking trails are located within the regional district lands.	Two landowners/managers: 1. Federal (Canadian Forces Maritime Experimental and Testing Ranges) under the administration of Canadian Forces Base Esquimalt 2. Local government (Regional District of Nanaimo)
10	Maple Bay	• Historical (1896 / 1910) unknown collection site. • Possibly extirpated because habitat likely not suitable owing to urban or agricultural development.	Unknown; likely private

Population number (Figure 2)	Population name	Population Status (first record[a]/most recent record), and habitat description	Land tenure
11	Royal Oak	• Historical (1917; unknown collection site). • Possibly extirpated because habitat likely not suitable owing to urban or agricultural development.	Unknown; likely private
12	Saanich Dist.	• Historical (1921; unknown collection site). • Possibly extirpated because habitat likely not suitable owing to urban or agricultural development.	Unknown; likely private
13	Saanich, Braefoot	• Historical (1954; unknown collection site). • Possibly extirpated because habitat likely not suitable owing to urban or agricultural development.	Unknown; likely private
14	Saanich, Royal Oak	• Historical (1958 / 1962; unknown collection site). • Possibly extirpated because habitat likely not suitable owing to urban or agricultural development.	Unknown; likely private
15	Sahtlam Dist.	• Historical (1935; unknown collection site). • Possibly extirpated because habitat likely not suitable owing to urban or agricultural development.	Unknown; likely private
16	Shawnigan Dist.	• Historical (1933; unknown collection site). • Possibly extirpated because habitat likely not suitable owing to urban or agricultural development.	Unknown; likely private
17	Victoria	• Historical (1900 / 1933[?]; six unknown collection sites labeled "Victoria"). • Possibly extirpated because habitat likely not suitable owing to urban or agricultural development.	Unknown; likely private
18	Wellington	• Historical (1949 / 1953; unknown collection site.). • Possibly extirpated due to habitat likely not suitable due to urban or agricultural development.	Unknown; likely private
19	Duncan; Quamichan Lake	• Historical (1920; unknown collection site). • Possibly extirpated because habitat likely not suitable owing to urban or agricultural development.	Unknown; mostly residential (private) land; any semi-natural land is likely private

B.C. = British Columbia; DND = Department of National Defense; HMCS = Her Majesty's Canadian Ship
[a] As applicable

3.3 Habitat and Biological Needs of the Island Tiger Moth

3.3.1 General Habitat

The general habitat in which Island Tiger Moth has been recorded includes xeric and sparsely vegetated coastal sand ecosystems, open maritime meadows, and dry Garry oak ecosystems. Most western North American *Grammia* species occur at low to mid-elevations in areas of poor or shallow soils, sand hills, beaches, and other similar habitats (Schmidt 2009). *Grammia* species typically do not inhabit closed-canopy forests (Schmidt, pers. comm., 2016) and Island Tiger Moth has not been recorded within these habitats.

In British Columbia, Island Tiger Moth populations have been recorded from habitat that is characterized as either Garry oak and associated ecosystem habitats or sparsely vegetated coastal sand ecosystem habitats.

Garry oak and associated ecosystem habitats
Garry oak and associated ecosystem habitats are part of the Coastal Douglas-fir biogeoclimatic zone (B.C. Ministry of Forests, Lands and Natural Resource Operations 2012) and have been described in more detail by Roemer (1962) and Erickson (1993, 1995). In general, Garry oak and associated ecosystems are open meadow habitats that are sparsely treed with Garry oak, arbutus (*Arbutus menziesii*), Douglas-fir (*Pseudotsuga menziesii*), and other species (Fuchs 2000). Understory vegetation includes native and introduced grasses with a high diversity of forbs, and various shrubs. For further descriptions and lists of the plants in this ecosystem refer to Fuchs (2000). Garry oak ecosystems are further classified into two major ecosystem types: parkland Garry oak ecosystems and scrub Garry oak ecosystems (Pojar 1980a, 1980b).

The most recent record from Nanoose Hill (#9) is within a Garry oak ecosystem habitat. The specimen was photographed within low-lying dry grassy vegetation in an open mossy meadow adjacent to a patch of small conifers and arbutus trees (Yip, pers. comm., 2016). Four historical populations (#5, 6, 7, 8) are where Garry oak and associated ecosystem habitats remain. Although portions of Savary Island are considered Garry oak ecosystems (Garry Oak Ecosystem Recovery Team 2011), the collection site on Savary Island (#3) is from sparsely vegetated sand ecosystem habitats (explanation is provided below). The collection site and habitat description for the Thetis Island (#2) specimen is unknown, but both Garry oak and associated ecosystems and sparsely vegetated coastal sand ecosystem habitats occur on Thetis Island.

Sparsely vegetated coastal sand ecosystem habitats
Three of the four extant populations of Island Tiger Moth are from lowland (< 10 m elevation) sparsely vegetated grassy habitats within the taller and more established (e.g., above the high tide) vegetation adjacent to sandy beach and dune habitats (B.C. CDC 2016). These populations are: Goose Spit, Savary Island, and Sandy Island (#1, 3, and 4, respectively).

Plants at these sparsely vegetated coastal sand dune habitats include American dunegrass (*Leymus mollis*), silver burweed (*Ambrosia chamissonis*), large-headed sedge (*Carex macrocephala*), beach pea (*Lathyrus japonicus*), and American searocket (*Cakile edentula*) (Page, pers. comm., 2016).

3.3.2 Specific Habitat Functions

Island Tiger Moth has four life stages which include the egg, larva, pupa and adult stages, each requiring specific habitat features (Table 2). The previous years' and current years' weather and habitat quality available to one life stage greatly influences the population demographics of the subsequent life stages. Limited information is available to describe the habitat requirements for each life stage.

The following provides an overview of each essential function of the Island Tiger Moths' life stage and required habitat features and is summarized in Table 2.

Oviposition and egg development habitat
Island Tiger Moth has one generation per year. The host plant(s) for Island Tiger Moth are unknown, although the species is likely a generalist herbivore and therefore oviposition site selection may not be based entirely on host plant(s). Island Tiger Moth eggs may not have an adhesive, based on knowledge of related *Grammia* species. For example, although the closely related *G. parthenice* also lives in grassland habitats, females oviposit eggs without adhesive and within a concealed grassy area (Peterson 1963 as read in Conner 2009).

Larval habitat
Larvae require sufficient host plant(s) to progress through a series of moults (egg-hatch to adult emergence). The host plants are associated with dry and sparsely treed habitats, including meadows, grasslands, open forest, rocky slopes, dunes, sparsely vegetated habitats, and gravely or rocky substrates (Schmidt 2009). *Grammia* species are generalist herbivores, consuming a wide range of low-growing plant species (Ferguson 1985; Byers 1988; Schmidt 2009). For example, *G. incorrupta* has been recorded feeding on 80 plant species in 50 families (Conner 2009) and studies of G. *blakei* document larvae feeding on both mono-and dicotyledonous plants (Byers 1988). Island Tiger Moth likely has similar generalist feeding preferences. One record exists of an Island Tiger Moth larva in British Columbia that fed on non-native English plantain (*Plantago lanceolata*) (Royal B.C. Museum records from May 24, 1958; C. Copley, pers. comm., 2016). According to the associated field notes with this collected specimen (George Hardy's field notes housed at the Royal B.C. Museum; C. Copley, pers. comm., 2016), it is unclear whether the specimen was fed this plant in captivity, or observed feeding on this plant in the natural environment and subsequently collected and reared.

Emergence habitat
Exuvia (the cast larval exoskeleton left after moulting) have not been collected in the province; this evidence of pupation is difficult to find given its cryptic colouration. *Grammia* larvae generally find a suitable and safe substrate under which to pupate. Cover items include boards (e.g., artificial cover objects such as lumber), litter, bark, and loose vegetation, although sometimes pupation is above ground (Conner 2009).

Foraging habitat
Island Tiger Moth adults have non-functional mouthparts and do not eat (Schmidt 2009); therefore, foraging habitat is not applicable or described.

Perching, roosting, resting, and mating habitat
Island Tiger Moth mating habitat is most likely defined by the spatial extent of the female's pheromone odour plume (chemical signal), which is released into the moth's habitat to attract

males. The release of pheromones is termed "calling" and the odour plume is wind-dispersed throughout the moth's habitat. Mating habitat includes the aerial areas above the oviposition habitat (Section 3.3.1), which are used by males patrolling for calling females. In general, female tiger moths are heavy with eggs, not likely to move far, and are most often observed crawling amongst ground vegetation. Males typically fly upwind, and follow the odour plume to its source; however, if the plume is lost, males will zig-zag across the wind line until they detect the scent (Conner 2009). Acoustic cues and ultrasonic calling are also used in mate finding of moths (Conner 2009). The spatial area of habitat includes the aerial height to which the moths will fly and the horizontal area that moths patrol, which is difficult to quantify and requires further study.

Island Tiger Moth requires perching and roosting habitat for cover and rest, and low-lying herbaceous vegetation within which to hide and take cover. The most recent sighting of an Island Tiger Moth adult was amongst grassy, low-lying ground vegetation at Nanoose Hill (#9) (Yip, pers. comm., 2016).

The spatial extent of perching, roosting, resting and mating habitat is not well studied. The delineation of a moth population includes a 500 m distance surrounding habitat where breeding and/or oviposition has been observed and/or larva/exuviae have been found. This distance is based on the possible detection threshold of a male tiger moth when searching for the females' pheromone odour plume.

Table 2. Summary of essential functions and features of Island Tiger Moth habitat in British Columbia.

Life stage	Function[a]	Feature(s)[b]
Egg	Egg development	Based on oviposition sites of other *Grammia* species, egg incubation likely occurs in non-specific areas amongst ground litter, thick herbaceous and dead vegetation, grasses, and forbs.
Larva	Feeding, foraging	Larval host plants are unknown but other *Grammia* species are generalist herbivores, feeding on both mono-and dicotyledonous plants.
Pupa	Pupation and emergence	Cover items at pupation sites include leaf litter, bark, thick dead grass, and loose vegetation; sometimes pupation occurs above ground.
Adult	Mating, oviposition (females), cover, perching, and roosting	Females use dense, low-lying herbaceous vegetation, thick grassy clumps, and leaf litter. Males use similar habitat to females in addition to aerial habitat to patrol for calling females.

[a] **Function:** a life-cycle process of the species (e.g., breeding, feeding/foraging).
[b] **Feature:** the essential structural components of the habitat required by the species. The specific thresholds (measurements and qualifiers; i.e., attributes) to each of the features listed are unknown.

3.4 Ecological Role

Island Tiger Moth does not feed as an adult, females are poor fliers and likely do not fly far, and the species is therefore not likely a significant pollinator. The larvae of a few *Grammia* species (e.g., *G. blakei*) are considered occasional vegetation pests (Byers 1988; 1989).

3.5 Limiting Factors

Limiting factors are generally not human-induced and include characteristics that make the species less likely to respond to recovery and conservation efforts. The main limiting factors for Island Tiger Moth are speculative but are likely a combination of the following.

- *Small population size*. Island Tiger Moth likely occurs as small or localized populations. Since 2000, only four specimens have been documented, albeit with limited search effort.

- *Poor dispersal ability*. Historically, Garry oak and associated ecosystems were connected and more widespread; however, present-day ecosystems are isolated and fragmented. Island Tiger Moth is likely not able to disperse long distances through unsuitable habitat. Female moths are not highly mobile and are unlikely to disperse far owing to their heavy, egg-filled bodies. Population structure and spatially isolated habitats likely limit dispersal capabilities and population intermixing.

- *Natural parasitic enemies.* Parasites are known to attack tiger moths during all life stages (Wagner 2009) however no species-specific information is available for Island Tiger Moth. Ichneumonoid wasps and tachinid flies are the most commonly encountered parasitoids of tiger moths (Conner 2009). Studies on the related *G. geneura* documented more than 14 parasitoid species, mostly polyphagous tachinid flies (Stireman and Singer 2002). Further information on parasitism in *Grammia* species is summarized in Conner (2009) and Schmidt (2009).

- *Direct mortality.* Although likely a minor factor, the eggs and larvae of Island Tiger Moth may be subject to direct mortality or damage by browsing animals. Columbian Black-tailed Deer (*Odocoileus hemionus columbianus*) and Roosevelt Elk (*Cervus canadensis roosevelti*) have been observed browsing on vegetation throughout the open habitats where Island Tiger Moth occurs, and may trample larvae or host plants. Eggs may also be prey items for smaller vertebrates such as predatory birds, reptiles, and some arthropods.

- *Genetic isolation*. Island Tiger Moth populations are within small, isolated, and limited habitat patches. Likely little or no interbreeding or genetic mixing occurs between populations, leading to inbreeding depression and local extinctions.

- *Vulnerability to weather patterns.* The overall seasonal weather patterns affect the abundance and distribution of tiger moths at all life stages. For example, the previous year's weather (e.g., average temperature, average rainfall, frost) affects the timing of host plant growth, senescence, and abundance and directly impacts the larval health and abundance of the next generation. Humidity and extreme winter temperatures affect larval survival (Leather *et al.* 1993); as well as the ability for the female pheromone to distribute throughout the landscape. Temperature and rainfall impact the species' growth and adult movement. Adults do not feed, and if the temperature is low and rainfall high, these factors limit the species activity patterns. All these factors contribute to the degree days and subsequent emergence of the next year's generation.

4 THREATS

Threats are defined as the proximate activities or processes that have caused, are causing, or may cause in the future the destruction, degradation, and/or impairment of the entity being assessed (population, species, community, or ecosystem) in the area of interest (global, national, or subnational) (adapted from Salafsky *et al.* 2008). For purposes of this threat assessment, only present and future threats are considered.[8] Threats were assessed for extant and historical populations where remaining suitable habitat is within the area (#1,3,4,9 [extant] and #2,5,6,7,8 [historical]). Note, this threats assessment differs from the COSEWIC (2013) assessment, which included only threats to extant populations, plus Thetis Island (#2), which was considered extant for the purposes of the status assessment). Threats presented here do not include limiting factors,[9] which are outlined in Section 3.5.

For the most part, threats are related to human activities, but they can also be natural. The impact of human activity may be direct (e.g., destruction of habitat) or indirect (e.g., introduction of invasive species). Effects of natural phenomena (e.g., fire, flooding) may be especially important when the species is concentrated in one location or has few occurrences, which may be a result of human activity (Master *et al.* 2012). As such, natural phenomena are included in the definition of a threat, though they should be considered cautiously. These stochastic events should only be considered a threat if a species or habitat is damaged from other threats and has lost its ability to recover. In such cases, the effect on the population would be disproportionately large compared to the effect experienced historically (Salafsky *et al.* 2008).

4.1 Threat Assessment

The threat classification below is based on the International Union for Conservation of Nature–Conservation Measures Partnership (IUCN–CMP) unified threats classification system and is consistent with methods used by the B.C. CDC. For a detailed description of the threat classification system, see the Open Standards website (Open Standards 2014). Threats may be observed, inferred, or projected to occur in the near term. Threats are characterized here in terms of scope, severity, and timing. Threat "impact" is calculated from scope and severity. For information on how the values are assigned, see Master *et al.* (2012) and table footnotes for details. Threats for the Island Tiger Moth were assessed for the entire province including extant and historical populations that continue to have suitable moth habitat (Table 3).

[8] Past threats may be recorded but are not used in the calculation of threat impact. Effects of past threats (if not continuing) are taken into consideration when determining long-term and/or short-term trend factors (Master *et al.* 2012).
[9] It is important to distinguish between limiting factors and threats. Limiting factors are generally not human-induced and include characteristics that make the species or ecosystem less likely to respond to recovery/conservation efforts (e.g., inbreeding depression, small population size, and genetic isolation).

Table 3. Threat classification table for Island Tiger Moth in British Columbia

Threat #[a]	Threat description	Impact[b]	Scope[c]	Severity[d]	Timing[e]	Populations
1	Residential & commercial development	Medium	Restricted	Serious	Moderate	-
1.1	Housing & urban areas	Medium	Restricted	Serious	Moderate	Applicable to one of four extant populations. Savary Island (#3), and private property adjacent to Nanoose Hill (#9).
1.2	Commercial & industrial areas	Medium	Restricted	Serious	Moderate	Applicable to one of four extant populations: Portion of Goose Spit (#1) managed by Comox First Nation.
1.3	Tourism & recreation areas	Low	Restricted	Moderate	High	Applicable to two of four extant populations: Portion of Goose Spit (#1) managed by Comox Regional District and Sandy island (#4). May be applicable to the five historical populations within areas of suitable habitat.
4	Transportation & service corridors	Low	Restricted	Moderate	Moderate	-
4.1	Roads & railroads	Low	Restricted	Moderate	Moderate	Applicable to two of four extant populations: Goose Spit (#1), all three landowners, and Savary Island (#3).
4.2	Utility & service lines	Low	Restricted	Moderate	Moderate	Applicable to two of four extant populations.: Goose Spit (#1) - all three landowners, and Savary Island (#3).
5	Biological resource use	Not a threat	-	-	Insignificant/Negligible or past	
5.2	Gathering terrestrial plants	Not a threat (in the assessed time frame)			Insignificant/ Negligible or past	Applicable to one of four extant population: Goose Spit (#1).
6	Human intrusions & disturbance	Low	Pervasive	Slight	High	-
6.1	Recreational activities	Low	Pervasive	Slight	High	Applicable to the four extant populations. Applicable to at least four of the five historical populations within areas of suitable habitat (#5,6,7,8).

Threat #[a]	Threat description	Impact[b]	Scope[c]	Severity[d]	Timing[e]	Populations
7	Natural system modifications	Low	Pervasive	Slight	High	-
7.1	Fire & fire suppression	Low	Pervasive	Slight	High	Highly applicable to extant populations at Nanoose (#9); less applicable at Goose Spit (#1), Savary Island (#3), and Sandy Island (#4). Applicable to the five historical populations within areas of suitable habitat.
7.3	Other ecosystem modifications	Low	Pervasive	Slight	High	Applicable to the four extant populations. Applicable to at least four of the five historical populations within areas of suitable habitat (#5,6,7,8)..
8	Invasive & other problematic species, genes & diseases	Medium	Pervasive	Moderate	Moderate	-
8.1	Invasive non-native/alien species/diseases	Medium	Pervasive	Moderate	Moderate	Applicable to the five historical populations within areas of suitable habitat.
9	Pollution	High	Large	Serious	Moderate	-
9.3	Agricultural & forestry effluents	High	Large	Serious	Moderate	Applicable to the four extant populations. Less applicable to Sandy Island (#4). Applicable to the five historical populations within areas of suitable habitat.
10	Geological events	Unknown	Pervasive	Serious	Unknown	-
10.2	Earthquakes/ tsunamis	Unknown	Pervasive	Serious	Unknown	Applicable at three of four extant populations: Goose Spit (#1), Savary Island (#3), and Sandy Island (#4). May be applicable to Thetis Island (#2).

Threat #[a]	Threat description	Impact[b]	Scope[c]	Severity[d]	Timing[e]	Populations
11	Climate change & severe weather	Medium	Large	Moderate	Moderate	-
11.1	Habitat shifting & alteration	Unknown	Pervasive	Moderate	Unknown	Applicable to the extant populations. Applicable to the five historical populations within areas of suitable habitat.
11.2	Droughts	Unknown	Pervasive	Unknown	Unknown	Applicable to the extant populations. Applicable to the historical populations within areas of suitable habitat.
11.4	Storms & flooding	Medium	Large	Moderate	Moderate	Applicable to the extant populations. Potentially applicable to Thetis Island (#2), within areas of suitable habitat.

Note: A description of the threats included in this table is found in Section 4.2.

[a] Threat numbers are provided for Level 1 threats (i.e., whole numbers) and Level 2 threats (i.e., numbers with decimals).

[b] **Impact** – The degree to which a species is observed, inferred, or suspected to be directly or indirectly threatened in the area of interest. The impact of each threat is based on severity and scope rating and considers only present and future threats. Threat impact reflects a reduction of a species population. The median rate of population reduction for each combination of scope and severity corresponds to the following classes of threat impact: Very High (75% declines), High (40%), Medium (15%), and Low (3%). Unknown: used when impact cannot be determined (e.g., if values for either scope or severity are unknown); Not Calculated: impact not calculated as threat is outside the assessment time (e.g., timing is insignificant/negligible [past threat] or low [possible threat in long term]); Negligible: when scope or severity is negligible; Not a Threat: when severity is scored as neutral or potential benefit.

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

[d] **Severity** – Within the scope, the level of damage to the species from the threat that can reasonably be expected to be affected by the threat within a 10-year or three-generation time frame. For this species, a 10-year time frame was used was used, resulting in severity being scored over a 10-year time frame. Usually measured as the degree of reduction of the species' population. (Extreme = 71–100%; Serious = 31–70%; Moderate = 11–30%; Slight = 1–10%; Negligible < 1%; Neutral or Potential Benefit ≥ 0%).

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

4.2 Description of Threats

The overall province-wide Threat Impact for this species is Very High.[10] The overall threat considers the cumulative impacts of multiple threats. Threats were assessed for the four extant populations as well as the five historical populations with remaining suitable habitat.

The primary threat to Island Tiger Moth is the potential spray of a commercial pesticide containing Btk, a bacterium used to control the introduction and spread of non-native Gypsy Moth. Other High impact threats include the potential for a tsunami to destroy three of the four extant Island Tiger Moth populations (#1, 3 and 4) and potentially applicable to historical population #2.

Other threats include recreational activities that trample host plants (e.g., off-leash dog walking and off-trail hiking), succession from invasive non-native/alien species and encroachment of problematic native species related to ongoing fire suppression programs. An increase in the scope and severity of winter storms and flooding is also prominent at some populations (#1, 3, and 4, and potentially #2) (Table 3). Other lower impact threats and details are discussed below under the Threat Level 1 headings. The text is summarized from the Island Tiger Moth status report (COSEWIC 2013), with supplemental information that has become available since the status report.

Threat 1. Residential & commercial development (Medium impact)

1.1 Housing & urban areas (Medium impact)

This threat is applicable to the Savary Island extant population (#3). Savary Island is a popular summer tourist destination, and has numerous summer homes and recreational properties. The property where Island Tiger Moth was recorded is owned with 50% undivided interest between two landowners: one landowner wants to subdivide the property into smaller lots and offer these for sale for cottage/housing development and the second landowner is a private conservation organization wanting to conserve the land with no further housing development. Savary Island (in general) has been subject to ongoing development pressure for many years (see the Savary Island Land Trust Society [n.d.] website < https://savaryislandlandtrust.org/>)and ongoing incremental housing development is occurring on small habitat parcels throughout the island. This development will remove Island Tiger Moth habitat, including oviposition, resting, and mating sites, and fragment the habitat. Repeated soil compaction from, for example, machinery or foot traffic during construction, development, and access to the site, will slow host plant and vegetative cover regrowth.

1.2 Commercial & industrial areas (Medium impact)

This threat is applicable to part of the Goose Spit extant population (#1). There are unconfirmed plans to develop a portion of Goose Spit by one landowner, including a marina, although the timing, possibility, and extent of this development is unknown. Road infrastructure would be required to access the marina through a portion of the spit belonging to the other two landowners (Threat 4.1). This potential development will remove Island Tiger Moth habitat, including

[10] The overall threat impact was calculated following Master *et al.* (2012) using the number of Level 1 Threats assigned to this species where timing = High or Moderate, which included no Very High, no High, 2 Medium, and 3 Low threats. The overall threat impact considers the cumulative impacts of multiple threats.

oviposition, resting, and mating sites; fragment the habitat; and slow host plant and vegetative cover growth through soil compaction related to road and vehicle traffic, as well as increased foot traffic. Although the Island Tiger Moth has not been captured on the portion of the property under potential development, it is likely the moth inhabits the entire sparsely vegetated sand ecosystem habitat at Goose Spit. The other two land jurisdictions are not at risk of commercial or industrial development.

1.3 Tourism & recreational areas (Low impact)

This threat is applicable to three extant populations: the portion of Goose Spit managed by Comox Regional District, Savary Island, and Sandy Island (#1, 3 and 4, respectively). The threat is also applicable to the historical populations: Mount Douglas Park, Observatory Hill Herzberg Institute of Astrophysics, and Goldstream and Spectacle Lake provincial parks (#5, 6, 7, and 8, respectively).

The scope, severity, and timing of this threat vary at the habitat for each population. The threat includes trail, washroom facility, parking lot, and other similar forms of infrastructure expansion. Sandy Island (#4) has designated tenting camp sites and public pressure to increase the number of camping spots available. The portion of Goose Spit (#1) within the Goose Spit Comox Regional District Park has recently experienced limited (less than 100 m^2) habitat loss from expansion of washroom facilities and parking areas. This type of recreational development will remove Island Tiger Moth habitat such as oviposition, resting, and mating sites; fragment the habitat; and slow host plant and vegetative cover growth through soil compaction from increased public foot and/or vehicle traffic.

Threat 4. Transportation & service corridors (Low impact)

4.1 Roads & railroads (Low impact)

The construction of new roads is possible at Goose Spit and Savary Island (#1, 3). In general, new road construction is likely to destroy Island Tiger Moth habitat, increase the rate of spread of introduced plants to these habitats, as well as compact the soil and prevent host plant growth.

Towards the tip of Goose Spit (#1), the main road is narrow and travels first through a portion of habitat within Goose Spit Comox District Regional Park. This roadway is periodically flooded by ocean tides during large storms. There is ongoing pressure from park users to rip-rap the road sides and expand the width of the roadway to provide pull-outs for vehicles and increase the park area. The road is then gated where it enters the portion of the property managed by HMCS Quadra 19 Wing Comox. The road travels through this military property towards the tip of the spit and end of the road, which is governed by Comox First Nation. If potential commercial development proposals were to go forward (Threat 1.2), this road would be paved, the current single-lane portions would become two-lane, with further public access permitted. This development would decrease the amount of potential Island Tiger Moth habitat and available host-plant sites.

At Savary Island (#3), any further housing development would increase the possibility of concurrent road construction (Threat 1.1).

4.2 Utility & service lines (Low impact)

The construction of new utility and service lines is possible at Goose Spit and Savary Island (#1 and 3); however, this infrastructure would likely follow the same routes as the roads developed within these properties (Threat 4.1) and therefore is considered a low threat.

Threat 5. Biological resource use (Not in time frame)

5.2 Gathering terrestrial plants (Not in time frame)

This threat was considered negligible on Goose Spit (#1). The sparsely vegetated ecosystems at Goose Spit are of significance to First Nations and culturally significant plants grow throughout the habitat. Impacts from gathering (e.g., picking plants, walking on plants, or digging plants) are not considered a threat because the plants gathered would not likely be the same ones consumed by Island Tiger Moth larvae.

Threat 6. Human intrusions & disturbance (Medium impact)

6.1 Recreational activities (Medium impact)

Recreational activities are ongoing at the four Island Tiger Moth extant populations. Goose Spit (#1), Sandy Island (#4), and Nanoose Hill (#9) are popular hiking, dog walking, and picnic areas. Ongoing damage to the habitat includes trampling of plants, garbage deposition, and adverse impacts from pets (e.g., host-plant trampling, digging, urination, and defecation). Sandy Island is a popular boating and tourist destination, and although it has designated tenting camp sites, illegal camping within the natural sand habitat occurs. Illegal camping leads to compacted host plants and potential destruction of larvae or eggs when tents and/or people trample these sites. Savary Island (#3) is a popular summer tourist destination where the above-mentioned recreational activities are ongoing. The landowners at Savary Island do not want people using the property for recreational purposes; however, monitoring and enforcing this request is difficult (Webster, pers. comm., 2016).

Threat 7. Natural system modifications (Low impact)

7.1 Fire & fire suppression (Low impact)

Island Tiger Moth range is subject to significant wildfire risk, particularly within natural tracts of land, areas adjacent to roadways and rights-of-way (e.g., where someone could potentially discard a lit cigarette), and recreational areas where unattended campfires may smolder. Brush clearing, piling, and periodic burning of vegetation and woody debris occur on private and public lands throughout the Island Tiger Moth's range. Although burning would only affect small areas, this may overlap with unknown occurrences of the moth. The smoke generated from periodic brush burning, and the resultant char and burned debris are also detrimental to habitat quality: smoke will cause larval mortality. At present, prescribed burning is not considered a potential threat; it is not planned for any of the extant or historical Island Tiger Moth population habitats. The threat of wildfire is applicable to all Island Tiger Moth populations and potential habitat, with variable scope and severity at each moth habitat.

Fire suppression has led to natural vegetation succession, resulting in the ecosystem modifications discussed below under Threat 7.3.

7.3 Other ecosystem modifications (Low impact)

The habitats of both extant and historical Island Tiger Moth populations have experienced substantial ecosystem modification from fire-suppression programs, which has led to an increase in native plant succession. Historically, low-intensity, frequent fire played an important role in the maintenance of Garry oak ecosystems (Daubenmire 1968; Agee 1993; McPherson 1997; Fuchs 2000) and kept native trees and shrubs from encroaching into these open habitats. Fire suppression and exclusion has resulted (and continues to result) in gradual changes to the plant community composition within Garry oak ecosystems (McCoy 2006). Potential larval host plants, adult nectar sources, and adult activity require open habitat with abundant light and moisture[11]

Natural forest succession will eventually decrease the size and quality of Island Tiger Moth habitats. Like other species confined to patchy habitats, populations of Island Tiger Moth are isolated and as natural forest succession continues at variable rates in surrounding habitats, those populations will become more isolated and fragmented. In some areas, natural succession may be delayed and/or forest harvesting may create open habitat for the expansion of Island Tiger Moth populations. Natural forest and shrub succession occurs rapidly within open habitats where the Island Tiger Moth has been captured. Natural succession from native plants, such as roadside rock moss (*Racomitrium canescens*), Douglas-fir, and lodgepole pine (*Pinus contorta*), occur in scattered patches throughout three extant Island Tiger Moth populations (#1, 3, 4). Goose Spit (#1) has some Douglas-fir and lodgepole pine natural succession at the westernmost tip (in the portions owned by 19 Wing Comox and Comox First Nation). Both Savary and Sandy islands (#3, 4) have tree, shrub, and moss ingrowth in the inner island open sand areas, as well as along the foreshore-beach interface.

Threat 8. Invasive & other problematic species, genes & diseases (Medium impact)

8.1 Invasive non-native/alien species (Medium impact)

Widespread and abundant non-native invasive plants (e.g., Scotch broom [*Cytisus scoparius*], cheatgrass [*Bromus tectorum*], European beachgrass [*Ammophila arenaria*], orchard grass [*Dactylis glomerata*], common velvet-grass [*Holcus lanatus*], soft brome [*Bromus hordeaceus*], and rattail fescue [*Vulpia myuros*]) threaten habitat quality at the four extant populations (# 1, 3, 4, 9). Numerous non-native plants occur throughout Island Tiger Moth habitats and out-compete the lower-growing herbaceous plants that are potential host plants for Island Tiger Moth.

Insect parasitoids, such as tachinid flies (Family Tachinidae) have been introduced as biological control agents for various pests (Tothill 1913). For example, *Cyzenis albicans* was introduced to southwestern British Columbia to control Winter Moth (*Operophtera brumata*), which is a pest of Garry oak trees, fruit trees, and many other plants (Cannings and Scudder 2005). *Compsilura concinnata* is considered the most polyphagous of all tachinids, with over 200 recorded host species. This species was introduced from Europe, mainly to control Gypsy Moth (*Lymantria dispar*) in eastern North America but has spread west to the Pacific coast. This tachinid attacks many insects, including *Pissodes* weevils, *Cimbex* sawflies, *Limenitis* butterflies,

[11] Refer to Pojar and McKinnon [1994] for associated habitat information on potential host plants; and Section 3.3 Habitat and Biological Needs of the Island Tiger Moth

and *Smerinthus* sphinx moths (Cannings and Scudder 2005) but is thought to be primarily a forest-inhabiting species and thus may not attack Island Tiger Moth extensively. This species, other introduced tachinids, and other parasitoids (e.g., ichneumonid and braconid wasps, Family Hymenoptera) may have some effect on Island Tiger Moth populations. Numerous invertebrate predators have been introduced to British Columbia as biological control agents (targeting invasive plant species) and have unknown impacts to Island Tiger Moth populations.

Threat 9. Pollution (High impact)

9.3 Agricultural & forestry effluents (High impact)

The Canadian range of Island Tiger Moth coincides with the potential range of introduction of European Gypsy Moth (*Lymantria dispar dispar*) and Asian Gypsy Moth (*L. dispar asiatica*). Pheromone traps are set up in systematic grids throughout this potential range to detect the presence of these invasive moths. Should Gypsy Moth be found in significant numbers, ground and aerial spraying of a pesticide containing Btk may occur. This commercial pesticide uses the spores of this naturally occurring pathogenic bacterium to control defoliating caterpillars. The bacterium also affects most non-target butterfly and moth larvae. Typical applications for Gypsy Moth occur in early April to early May, coinciding with the Island Tiger Moth larval activity period (see Appendix A, Table A-1, for larval collection dates).

In the last 5 years, aerial spray for Gypsy Moth has occurred close to Island Tiger Moth populations. All extant and historical populations are within the pheromone trapping and detection grid that is overlaid with the potential future spray zones and monitored by the B.C. Ministry of Forests, Lands and Natural Resource Operations and the federal Canadian Food Inspection Agency. Gypsy Moth trap results are compiled for at least the previous 2 years. If spraying with Btk is necessary within or adjacent to Island Tiger Moth populations, alternate treatment options include ground spray from truck tanks or backpack sprayers operated by individual personnel. It is unlikely that Gypsy Moth control would be required simultaneously throughout all Island Tiger Moth population habitats.

The most recent aerial spray (May/June 2017) to control Gypsy Moth was not within the immediate vicinity to any of the extant or historical populations of Island Tiger Moth.

Threat 10. Geological events (Unknown impact)

10.2 Earthquakes & tsunamis (Unknown impact)
The possibility of an earthquake and/or tsunami is applicable at three extant Island Tiger Moth populations (#1, 3, 4). Portions of these habitats are slightly above sea level (less than 10 m elevation) and would be affected by flooding. Potential destruction of this seaside habitat would occur during a tsunami event.

Threat 11. Climate change & severe weather (Medium impact)

11.1 Habitat shifting & alteration (Unknown impact)
Within the Pacific Maritime Ecozone (where Garry oak ecosystems, coastal sparsely vegetated sand dune ecosystems, and Island Tiger Moth occurs in Canada) mean annual temperatures increased by 1.71°C from 1960 to 2006 (Coristine and Kerr 2011). By 2050, mean annual temperatures are expected to increase by approximately 2–3°C (Hebda 1997). This projected

climate change may allow for the expansion of Garry oak trees on southern Vancouver Island (Hebda 2004), although it is unlikely that understory plant communities will be able to concurrently expand their ranges (Lea 2006). The specific understory communities that are needed for Island Tiger Moth are unknown, and the ecosystem changes would likely occur at a timescale outside the scope of the threats assessment.

11.2 Droughts (Unknown impact)

The threat of drought potentially applies to all extant Island Tiger Moth populations (#1, 3, 4, 9). Increased summer droughts (Mote and Salathe 2010) may affect Island Tiger Moth habitat and will decrease the available site moisture that allows for suitable host-plant growth. Conversely, an anticipated increase in winter precipitation is projected for coastal areas such as east Vancouver Island. A recent analysis of global observations from 1925 to 1999 showed that precipitation increased by 6.2 mm per decade in the latitude band of 50–70° north, which includes almost all of British Columbia (Zhang *et al*. 2007). More specifically, on southeastern Vancouver Island, the projected change in precipitation by the middle of the 21st century (2041–2071) relative to historical records (1961–1990), models a 10–25% increase for average winter conditions (December, January, February) and a 0–10% decrease for average summer conditions (June, July, August) (Rodenhuis 2009). Increased precipitation may benefit the host-plant growth, allowing for plants to grow for a longer period and senesce later in the season, and for larva to feed and grow longer into the season. Overall the threat is unknown.

11.4 Storms & flooding (Medium impact)

Shoreline erosion and related stochastic events are threats to coastal sand ecosystems. These events could also affect Island Tiger Moth habitat along the more stabilized sand areas. This threat applies to three of the extant Island Tiger Moth populations (#1, 3, 4) and to the suitable habitat that remains at the historical population on Thetis Island (#2). This same is applicable to habitats within 25 to 100 m of the shoreline of the Sand-verbena Moth (*Copablepharon fuscum*) (SARA; Endangered) (British Columbia Invertebrates Recovery Team 2008).

5 RECOVERY GOAL AND OBJECTIVES

5.1 Recovery (Population and Distribution) Goal

The recovery (population and distribution) goal is to maintain populations of Island Tiger Moth at all known extant sites within the province, including any additional populations that may be identified in the future and to maintain or increase population connectivity.

5.2 Rationale for the Recovery (Population and Distribution) Goal

Island Tiger Moth is a Canadian near-endemic species, with a small restricted global range. Globally, the species is known from 20 collection sites, 19 of which are in Canada. The moth is a day-flyer, does not feed as an adult, has a short (under 3 weeks) lifespan and is, therefore, difficult to survey and detect. Thus, most records are the result of incidental collections (i.e., random-chance collections when surveying for other species) over many years.

Existing habitat information suggests the moth is associated with open, sparsely vegetated areas including Garry oak and associated ecosystems and coastal sand ecosystems, both of which are

highly threatened. Among other considerations, its small distribution and decline in habitat led to its assessment as Threatened[12] in Canada. The threshold criteria for the "Threatened" classification include:

1. an estimated extent of occurrence of less than 20 000 km^2 and an estimated index of area of occupancy of less than 2000 km^2; and
2. a continued decline in the area, extent, and/or quality of habitat, combined with severe fragmentation,[13] with fewer or equal to 10 locations.[14]

Island Tiger Moth has a small extent of occurrence (3600 km^2 for all known extant populations; 1881 km^2 for populations since 1975) and a small index of area of occupancy (76 km^2 for all known populations; 20 km^2 for extant populations). Approximately 5 to8 locations are known to exist,[14] with inferred continuing habitat loss and fragmentation. There is no evidence to suggest that this species was more widely distributed in the past.

Because of knowledge gaps (e.g., status confirmation of historical populations with suitable habitat remaining, extant population abundance, habitat requirements, life history, dispersal and re-colonization capabilities, and threats to the species), the recovery goal for Island Tiger Moth cannot be quantified at this time. Population information on Island Tiger Moth is limited to incidental collections and observations (four observations since 2000), and thus information that could provide an understanding of lifespan, dispersal distance, and other factors is not yet available. Addressing these knowledge gaps will provide important information to help maintain the population abundance for extant populations/habitats, and allow the recovery goal to be quantified in the future. In the interim, conserving and increasing (where feasible) habitat quantity and quality will serve as a surrogate for maintaining population abundance. Where biologically and technically feasible and appropriate (to be determined; Section 6.2), increasing connectivity within and/or among populations by restoring or protecting habitat in the intervening areas could be used to reduce fragmentation and maintain a "rescue effect" between populations.

[12] COSEWIC assessed as Threatened **Criteria:** [a] B1ab(iii)+2ab(iii)

[13] The term 'severely fragmented' as defined by COSEWIC: A taxon can be considered to be severely fragmented if most (>50%) of its total area of occupancy is in habitat patches that are (1) smaller than would be required to support a viable population, and (2) separated from other habitat patches by a large distance. Fragmentation must be assessed at a scale that is appropriate to biological isolation in the taxon under consideration. (Source: IUCN 2016).

[14] The term 'location' as defined by COSEWIC: The term 'location' defines a geographically or ecologically distinct area in which a single threatening event can rapidly affect all individuals of the taxon present. The size of the location depends on the area covered by the threatening event and may include part of one or many subpopulations. Where a taxon is affected by more than one threatening event, location should be defined by considering the most serious plausible threat. Where the most serious plausible threat does not affect all of the taxon's distribution, other threats can be used to define and count locations in those areas not affected by the most serious plausible threat. (Source: IUCN 2010, 2011). In the absence of any plausible threat for the taxon, the term "location" cannot be used and the subcriteria that refer to the number of locations will not be met. (Source: IUCN 2016).

5.3 Recovery Objectives

The recovery objectives for the Island Tiger Moth are:
1. to secure protection[15] for the known extant populations of Island Tiger Moth with no loss or degradation of occupied habitat;
2. to confirm the distribution of Island Tiger Moth within its range in British Columbia;
3. to assess the levels of real and potential threats to this species and its habitat and to mitigate their impacts; and
4. to address knowledge gaps (e.g., habitat requirements, life history, dispersal) for the successful maintenance of populations, including habitat restoration if necessary.

6 APPROACHES TO MEET OBJECTIVES

6.1 Actions Already Completed or Underway

Although this species has not been assessed by the B.C. Conservation Framework (B.C. Ministry of Environment 2009), the following actions have been categorized by the action groups of the assessment process. Status of the action group for this species is given in parentheses.

Compile Status Report (complete)
- COSEWIC report completed (COSEWIC 2013).

Send to COSEWIC (complete)
- Island Tiger Moth assessed as Threatened (COSEWIC 2013). Re-assessment due 2023.

Planning (in progress)
- B.C. Recovery Plan completed (this document, 2017).

Inventory (in progress)
- The most recent inventory was completed in preparation of the COSEWIC (2013) status report.
- Parks Canada completed a light-trapping (nocturnal) inventory for sand ecosystem moths over 9 nights from late June to late July 2014 at Sidney and Hook Spits, Gulf Islands National Park Reserve. No tiger moths were recorded (Kroeker, pers. comm., 2016). Although Island Tiger Moth is day-flying, it has been recorded from black/ultraviolet light traps (Page, pers. comm., 2016).

Habitat Protection and Private Land Stewardship (in progress)
- Population #1 Goose Spit: The portion of Goose Spit managed by HMCS Quadra 19 Wing Comox (federal) holds a Sea Cadet Summer Training Camp each summer, and uses an obstacle course permanently situated within the natural sand dune habitat. Additional species at risk are present on the property, and the environmental management staff at 19 Wing Comox has developed site-specific plans that minimize trampling and protect both these species at risk and their habitats (Table 4).

[15] Protection can be achieved through various mechanisms, including: voluntary stewardship agreements, conservation covenants, sale of private lands by willing vendors, land use designations, and protected areas.

- Population #4 Sandy Island (Jáji7em and Kw'ulh Marine Provincial Park, also known as Sandy Island Marine Park; known locally as Tree Island and the nearby Seal Islets).
    - As recent as 2013, some areas within the park were used by HMCS Quadra 19 Wing Comox (DND) for sea cadet training during July and August. Until this time, the department followed a site management plan meant to minimize impacts to sand dunes and other fragile ecosystem values within the park. Beginning in 2014, BC Parks revoked the department's access and the site is no longer used for sea cadet training.
    - Jáji7em and Kw'ulh Marine Provincial Park has an approved park master plan that also includes Fillongley, Tribune Bay, and Helliwell provincial parks. Within this park plan are provisions for the conservation, management, and protection of sensitive species and ecosystems on Sandy Island (Province of British Columbia 1987).

Table 4. Existing mechanisms that afford habitat protection for Island Tiger Moth.

Existing mechanisms that afford habitat protection	Threat[a] or concern addressed	Population
British Columbia *Park Act* (Province of British Columbia 1996b)	All, but primarily 1.1, 1.2, 1.3, 4.1, 6.1	Sandy Island (#4)
Federal *Species at Risk Act* (Government of Canada 2002)	All, but primarily 1.1, 1.2, 1.3, 4.1, 6.1	Goose Spit (#1) portion managed by HMCS Quadra 19 Wing Comox and portion governed by Comox First Nation
	All, but primarily 1.1, 1.2, 1.3, 4.1, 6.1	Nanoose Hill (#9) portion managed by Canadian Forces Maritime Experimental and Testing Ranges under the administration of Canadian Forces Base Esquimalt
British Columbia *Land Act* (Province of British Columbia 1996a), Section 16 Reserve; Section 17 Reserve or Notation of Interest	1.1, 1.2, 1.3, 2.3, 4.1	All
Comox Regional District; Goose Spit Park	All, but primarily 1.1, 1.2, 1.3, 4.1, 6.1	Goose Spit (#1) portion managed by Comox Regional District

HMCS = Her Majesty's Canadian Ship
[a] Threat numbers according to the IUCN–CMP classification (see Table 3 for details).

6.2 Recovery Action Table

Recovery planning for Island Tiger Moth is consistent with recovery planning approaches for similar species under the Garry Oak Ecosystems Recovery Team (2016), the South Coast Conservation Program (SCCP 2016), and initiatives led by other conservation organizations that are more site specific (e.g., Savary Island Land Trust, The Nature Trust, DND, BC Parks, Comox Regional District). Because of the extensive knowledge gaps for this moth, most of the recovery planning activities listed in Table 5 centre on inventory, natural history, habitat information gathering, and threat clarification. These activities will help prioritize areas for future surveys and inform habitat stewardship and protection efforts. A combined approach to recovery also includes engaging the academic, naturalist, and stewardship communities in recovery projects for the species.

Table 5. Recovery actions for Island Tiger Moth.

Objective	Conservation Framework action group	Actions to meet objectives	Performance measure	Threat or concern addressed	Priority
		Protect populations			
1, 2	Habitat Protection, Restoration and Private Land Stewardship	1. Using geographic information system applications, complete habitat mapping and spatial delineation of potential suitable habitat at the locations of the populations (extant #1, 3, 4, 9; historical #2, 5, 6, 7, 8)	Mapping with polygons that spatially delineate potential habitat completed by 2021.	All threats	Essential
		2. Once habitat mapping has been completed for populations (as above), determine whether suitable connective habitat exists among these populations, and whether it is biologically and technically feasible and appropriate to restore and/or protect suitable connective habitat via acquisition or stewardship.	Mapping with potential habitat linkages competed by 2021.		Necessary
		3. Confirm land ownership within the habitat polygons delineated in Action 1. This action coincides with the landowner contact strategy outlined in Action 13 (below).	List of landowners of possible suitable habitat (at extant and historical populations) drafted by 2021.	All threats	Essential
		4. Work with landowners/managers to determine appropriate stewardship measures to protect habitat of extant populations (#1, 3, 4, 9) and at historical population sites (#2, 5, 6, 7, 8), if the moth's presence is confirmed, and any new populations.	Stewardship agreements and/or covenants for known (and any new) populations on private conservation lands, regional district and municipal lands initiated by 2021. Approaches will differ, depending on the landowner.	All threats	Necessary
		5. Work with landowners/managers to determine appropriate stewardship measures and guidelines to protect extant populations and mitigate site-specific threats to the habitats (portions of habitat for population #1, 3, and 9, as well as for population # 2, 5, 6, 7, and 8).	From the list of landowners of possible suitable habitat (at extant and historical populations) (Action 3 above), draft appropriate stewardship measures by 2021.	1, 6.1, 8.1, 9	Necessary

Objective	Conservation Framework action group	Actions to meet objectives	Performance measure	Threat or concern addressed	Priority
		6. On undesignated provincial Crown land with populations, initiate the process to establish a Section 16 Reserve; or Section 17 Reserve or Notation of Interest under the British Columbia *Land Act*, such that future development interests know species-at-risk habitat occurs on the site.	Habitat polygon maps for populations on provincial Crown land and applications drafted for a Section 16 Reserve and/or Section 17 Reserve or notation of interest under the provincial *Land Act* at these habitats by 2021.	All threats	Essential
		7. Work with BC Parks to update the park Master Plan for Sandy Island Provincial Park (#4) to include management actions for this moth. Update park Master Plans for historical populations (Goldstream and Spectacle Lake Provincial Parks, #7, 8). If no master plans are available, draft a separate management recommendation plan for the moth within the park.	If inventory in BC Parks confirms populations, update park Master Plans (if written) with appropriate management information; if no Master Plan is available, draft a separate management recommendation plan for the park specifically for the Island Tiger Moth by 2021.	1.3, 6.1	Necessary
		8. Work with the DND (Canadian Forces Base Esquimalt) to determine the appropriate stewardship measures to protect habitat at associated populations (#1 and 9, #6)	Work towards land management plans that include protection of the moth and its habitat by 2021.	All threats but primarily 1.1, 1.2, 1.3, 6.1	Essential
		Confirm distribution and address knowledge gaps, such as habitat requirements for each life stage			
2, 4	Monitor Trends	9. Develop standardized inventory protocol, including habitat attributes, plant community information, life stage surveys (e.g., months to survey for specific life stages), immediate threats, and other natural history information.	Inventory protocols developed and tested by 2021.	Knowledge gaps; all threats	Essential
		10. Using standard inventory protocol developed above, complete fieldwork at populations (extant #1, 3, 4, and 9; historical #2, 5, 6, 7, and 8) and additional habitats.	Completed habitat descriptions for each population by 2021.	Knowledge gaps; all threats	Necessary

Objective	Conservation Framework action group	Actions to meet objectives	Performance measure	Threat or concern addressed	Priority
		11. Using the habitat information obtained (above), develop inputs to a habitat suitability model that can be mapped using geographic information systems.	Completed habitat model to guide and prioritize future inventory work by 2021.	Knowledge gaps; all threats	Necessary
		12. Use the outputs from this habitat suitability model to prioritize survey sites in unchecked potential habitat.	Identify and continue to inventory additional potential habitat within the species' range and refine habitat model (ongoing).	Knowledge gaps; all threats	Essential
		13. Develop a 10-year inventory and monitoring schedule and landowner contact strategy for priority sites.	Landowner contact, inventory, and monitoring schedule drafted by 2021.	Knowledge gaps; all threats	Essential
		14. Work with landowners/managers to identify and inventory priority sites (from habitat model) and refine habitat model as fieldwork is completed.	Completed habitat model to guide and prioritize future inventory work by 2021.	Knowledge gaps; all threats	Essential
		15. Explore the feasibility of monitoring these sites to obtain information on the life history, movements, habitat use, and population biology of the species. This will enable a better understanding of habitat requirements for each life stage, and the potential dispersal to adjacent habitats.	Completed habitat model to guide and prioritize future inventory work by 2021.	Knowledge gaps; all threats	Essential
		Develop threats assessment and monitor known and potentially extant populations and habitats			
3	Monitor Trends	16. Develop threats assessment methods (e.g., determine scope, severity, and timing of threat) and habitat monitoring protocols (e.g., photographic) for populations (extant #1, 3, 4, and 9; historical #2, 5, 6, 7, and 8). This information to be gathered concurrently with standard inventory protocols developed in Action 9 and improved during Actions #10–12.	Protocols to compare and measure site-specific threats completed by 2021. Site-specific assessments at extant and historical habitats completed by 2021.	All threats	Essential

Objective	Conservation Framework action group	Actions to meet objectives	Performance measure	Threat or concern addressed	Priority
		17. Continue to work with respective agencies (B.C. Ministry of Forests, Lands and Natural Resource Operations and federal Canadian Food Inspection Agency) to reduce risks from potential pesticide spraying with Btk (outreach with appropriate authorities that monitor Gypsy Moth, research alternate treatment solutions).	Maintain an active presence on the Provincial Gypsy Moth Committee led by the Ministry of Forests, Lands and Natural Resource Operations.	6.1	Essential
		18. Investigate shoreline erosion/flood potential and possible mitigation strategies (e.g., soft shoreline protection actions/strategies) at populations adjacent to marine areas.	Protocols to compare and measure site-specific threats completed by 2021. Site-specific assessments at extant and historical habitats completed by 2021.		Beneficial
		19. Investigate a program that addresses fire risk and implements strategies to reduce fuel build-up in areas adjacent to and within Island Tiger Moth habitats.	Protocols to compare and measure site-specific threats completed by 2021. Site-specific assessments at extant and historical habitats completed by 2021.		Beneficial
		Increase the profile of Island Tiger Moth			
1, 2, 3, 4	Private Land Stewardship and Habitat Protection	20. Engage regional conservation organizations and integrate this species into the biodiversity planning and engagement actions currently led by these conservation organizations (South Coast Conservation Program, Garry Oak Ecosystems Recovery Team, Savary Island Land Trust, The Nature Trust, Coastal Douglas-fir and Associated Ecosystems Conservation Partnership, Comox Valley Land Trust, and other local organizations).	Information sheets for landowners/ managers developed that are specific to the populations, outlining stewardship actions to mitigate the threats; and/or integrate this information into an ecosystem approach information sheet (i.e., combining all ecosystem information), by 2021.	All	Beneficial

Objective	Conservation Framework action group	Actions to meet objectives	Performance measure	Threat or concern addressed	Priority
		21. Develop public outreach and communications materials that focus on the natural history and habitat needs for this species, threats at known populations (e.g., from recreational activities, invasive species), and how to minimize threats.	Information sheets for landowners/ managers developed that are specific to the populations, outlining stewardship actions to mitigate the threats; and/or integrate this information into an ecosystem approach information sheet (i.e., combining all ecosystem information), by 2021.	All	Beneficial
		22. Develop a list of co-occurring species at risk within each habitat of the four extant and the five historical populations. Use this list to develop concurrent restoration, mitigation, and threat reduction actions.	List of co-occurring species at risk within each of the extant and historical populations completed by 2021. Population-specific list of threat reduction actions developed by 2021.		Beneficial

[a] Threat numbers according to the IUCN–CMP classification (see Table 3 for details).
[b] Essential (urgent and important, needs to start immediately); Necessary (important but not urgent, action can start in 2–5 years); or Beneficial (action is beneficial and could start at any time that was feasible).

7 SPECIES SURVIVAL AND RECOVERY HABITAT

Survival and recovery habitat is defined as the habitat that is necessary for the survival or recovery of the species. This is the spatial area where the species naturally occurs or depends on directly or indirectly to carry out its life-cycle processes, or where it formerly occurred and has the potential to be reintroduced.

7.1 Biophysical Description of the Species' Survival/Recovery Habitat

A description of the known biophysical features of the species' habitat required to support these life-cycle processes (functions) is provided in Section 3.3. Additional work required to fulfill habitat knowledge gaps are included in the Recovery Action Table (Table 5).

7.2 Spatial Description of the Species' Survival/Recovery Habitat

The area of survival/recovery habitat required for a species is guided by the amount of habitat needed to meet the recovery goal. Although no maps that spatially define this habitat are included with this document, it is recommended that locations of survival/recovery habitat be described on the landscape to mitigate habitat threats and to facilitate the actions for meeting the recovery (population and distribution) goals.

8 MEASURING PROGRESS

Performance measures toward meeting each of the four recovery objectives have been integrated into the Recovery Action Table in Section 6.2 (Table 5). This recovery plan will be reviewed in ten years to assess progress and to identify additional approaches or changes that may be required to achieve recovery.

The performance indicators presented below provide a way to define and measure progress toward achieving the recovery (population and distribution) goal:

- All extant populations of Island Tiger Moth in B.C. are maintained; and
- Habitat quality and connectivity is maintained or increased for Island Tiger Moth populations all populations, where suitable habitat exists, in B.C.

9 EFFECTS ON OTHER SPECIES

Recovery planning activities for Island Tiger Moth will be implemented with consideration for all co-occurring species at risk, such that no negative impacts occur to these species or their habitats. Efforts to restore and protect Garry oak and associated ecosystems, as well as sparsely vegetated coastal sand ecosystems, will be beneficial to many species that rely on both these rare ecosystems. Numerous species at risk co-occur within the same habitats as Island Tiger Moth, including: Sand-verbena Moth (*Copablepharon fuscum*; Endangered), Horned Lark (*Eremophila alpestris strigata*; Endangered), contorted-pod evening-primrose (*Camissonia contorta*; Endangered), and black knotweed (*Polygonum paronychia*; provincial Blue-List). On a broader scale, at least 79 at-risk species occur in the Garry oak and associated ecosystem habitats and 12 species at risk occur in the coastal sand ecosystem habitats.

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APPENDIX A. ISLAND TIGER MOTH MUSEUM SPECIMENS

Table A-1. Island Tiger Moth museum specimens

Year	Month	Day	Collection site name	Pop[n] #[a]	Museum or collection	Life stage
1895	June	18	unknown site		UBC; E.H. Blackmore collection no. 978	adult
1896	March	18	Maple Bay	10	RBCM	adult
1896	September	16	unknown site		UBC; E.H. Blackmore collection no. 978	adult
1900	July	17	Victoria		RBCM	adult
1903	June	7	Goldstream Provincial Park	7	RBCM	adult
1910	July	10	Maple Bay	10	RBCM	adult
1917	August	7	Royal Oak	11	UBC; Ex. W. Downes collection donated 1958	adult
1917	July	11	Victoria	17	UBC; E.H. Blackmore collection no. 978	adult
1918	June	16	Victoria	17	UBC; E.H. Blackmore collection no. 978	adult
1918	March	2	Victoria	17	UBC; E.H. Blackmore collection no. 978	adult
1920	July	7	Duncan; Quamichan Lake	19	RBCM	adult
1921	May	6	Saanich Dist.	12	UBC; Ex. W. Downes collection donated 1958	adult
1924	July	9	unknown site		RBCM	adult
1929	June	26	unknown site		RBCM	adult
1933	July	17	Shawnigan Dist.	16	UBC; Llewellyn Jones collection no. 1039	adult
1934	March	25	unknown site		RBCM	ex larva
1934	March	25	unknown site		RBCM	ex larva
1935	May	27	Sahtlam Dist.	15	UBC; Llewellyn Jones collection no. 1039	adult
1949	June	14	unknown site		RBCM	adult
1951	May	21	Wellington	18	UBC	adult
1953	June	9	Wellington	18	RBCM	adult
1954	July	31	Saanich, Mt. Douglas	5	RBCM	ex larva
1954	June	29	Saanich, Braefoot	13	RBCM	light trapped; adult
1956	June	2	Saanich; Royal Oak	14	RBCM	light trapped; adult
1956	June	21	Saanich; Royal	14	RBCM	adult

Year	Month	Day	Collection site name	Pop[n] #[a]	Museum or collection	Life stage
			Oak			
1956	May	31	Saanich; Royal Oak	14	RBCM	ex larva
1957	June	19	Saanich; Observatory Hill	6	RBCM	adult
1957	May	19	Saanich, Observatory Hill	6	RBCM	ex larva
1957	May	28	Saanich; Observatory Hill	6	RBCM	adult
1957	May	29	Saanich; Observatory Hill	6	RBCM	adult
1957	May	30	Saanich; Observatory Hill	6	RBCM	ex larva
1958	June	15	Saanich; Observatory Hill	6	RBCM	ex larva
1958	May	20	Saanich, Observatory Hill	6	RBCM	ex larva
1958	May	24	Saanich, Observatory Hill	6	RBCM	ex larva; *Plantago lanceolata*
1958	May	24	Saanich, Royal Oak	14	RBCM	light trapped; adult
1958	May	26	Saanich; Observatory Hill	6	RBCM	adult
1958	May	26	Saanich; Observatory Hill	6	RBCM	adult
1958	May	25	Saanich; Royal Oak	14	RBCM	adult
1961	June	21	Saanich; Royal Oak	14	RBCM	adult
1961	May	29	Saanich; Observatory Hill	6	RBCM	adult
1962	June	30	Saanich, Royal Oak	14	RBCM	ex larva
1962	June	30	Saanich; Royal Oak	14	RBCM	adult
1964	July	4	Spectacle Lake Park	8	RBCM	adult
1975	July	6	Thetis Island	2	RBCM	adult
1977	May	3	Nanoose Hill	9	RBCM	adult
1977	May	3	Nanoose Hill	9	RBCM	adult
2000	June	8	Sandy Island	4	J. Troubridge	adult
2002	June	11	Savary Island	3	J. Troubridge	adult
2003	June	4	Goose Spit	1	J. Troubridge	adult
2012	June	15?	Nanoose Hill	9	Mike Yip; photographic record	adult

Year	Month	Day	Collection site name	Pop[n] #[a]	Museum or collection	Life stage
1933?	August	unknown	Victoria	17	UBC; Ex. W. Downes collection donated 1958	adult
Unknown	unknown	unknown	unknown site		CNC	adult
Unknown	unknown	unknown	unknown site		RBCM	adult
Unknown	unknown	unknown	Victoria		UBC; E.H. Blackmore collection no. 978	adult

CNC = Canadian National Collection of Insects, Arachnids and Nematodes, Ottawa, ON; RBCM = Royal British Columbia Museum; UBC = Beaty Biodiversity Museum Spencer Entomological Collection, University of British Columbia.
See Figure 2 for population numbers.
[a] Pop[n] # = Population Number