

COSEWIC **Assessment and Status Report**

on the

Lake Huron Grasshopper *Trimerotropis huroniana*

in Canada



THREATENED
2015

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada



COSEPAC
Comité sur la situation
des espèces en péril
au Canada

COSEWIC status reports are working documents used in assigning the status of wildlife species suspected of being at risk. This report may be cited as follows:

COSEWIC. 2015. COSEWIC assessment and status report on the Lake Huron Grasshopper *Trimerotropis huroniana* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. ix + 32 pp. (http://www.registrelep-sararegistry.gc.ca/default_e.cfm).

Production note:

COSEWIC would like to acknowledge Allan Harris and Rob Foster for writing the status report on the Lake Huron Grasshopper (*Trimerotropis huroniana*), in Canada, prepared under contract with Environment Canada. This status report was overseen and edited by Jennifer Heron and Paul Grant, Co-chairs of the COSEWIC Arthropods Specialist Subcommittee.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le Criquet du lac Huron (*Trimerotropis huroniana*) au Canada.

Cover illustration/photo:

Lake Huron Grasshopper — Photo provided by author.

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Catalogue No. CW69-14/724-2016E-PDF

ISBN 978-0-660-04612-9



COSEWIC Assessment Summary

Assessment Summary – November 2015

Common name

Lake Huron Grasshopper

Scientific name

Trimerotropis huroniana

Status

Threatened

Reason for designation

This globally rare grasshopper is endemic to the Great Lakes region of Ontario, Michigan, and Wisconsin where it is restricted to dunes along the shores of lakes Huron, Michigan, and Superior. In Canada, it is known from 11 dune sites: one location on the east shore of Lake Superior, and seven on Lake Huron at the south shore of Manitoulin Island and Great Duck Island. Formerly, it occurred at three additional sites on Lake Huron but these subpopulations appear to have become extirpated in the 1990s, likely as a result of residential and commercial development combined with intensive recreational use which damaged much of the dune habitat. While recreational use by pedestrians and off-road vehicles continue to threaten some dunes, other sites have undergone recent improvements under dune stewardship programs. Additional threats to dune environments include invasive plants and changes in lake levels related to climate change, natural cycles, or lake level management.

Occurrence

Ontario

Status history

Designated Threatened in November 2015.



COSEWIC Executive Summary

Lake Huron Grasshopper *Trimerotropis huroniana*

Wildlife Species Description and Significance

Lake Huron Grasshopper is silver-grey to brownish with variable speckles and colours to blend in with its sandy habitat. In flight, the hind wings are exposed to show clear or pale yellow areas at the base, a black band across the middle, and clear or smoky tips. The females (29 to 40 mm) are larger than the males (24 to 30 mm). It is one of a few species endemic to the Laurentian Great Lakes area.

Distribution

Lake Huron Grasshopper is endemic to the Great Lakes region of Ontario, Wisconsin and Michigan. The species is found exclusively on dunes along the shores of lakes Huron, Michigan and Superior. In Canada, it occurs at 11 dune sites: one location on the east shore of Lake Superior, and seven locations on Lake Huron at the south shore of Manitoulin Island and Great Duck Island. Historically it was also found at Giant's Tomb Island and Wasaga Beach in Georgian Bay, and at Sauble Beach (Southampton) on the east shore of Lake Huron. The species is now considered extirpated from these sites.

Habitat

Great Lakes dunes cover a total area of less than 1800 ha in Canada including 492 ha on Lake Huron and 100 ha on Lake Superior. Dunes occur on shorelines where there is plentiful sand in glacial deposits and at river mouths. Exposure to wind and waves is essential to maintain erosion and deposition of sand, and to prevent forest succession. Preferred habitat of Lake Huron Grasshopper is the foredune, a low ridge closest to the lake with open bare sand and scattered grasses.

Biology

In late summer, male Lake Huron Grasshoppers attract females by stridulating (producing trills by rubbing the hind leg on the forewing) and conducting display flights while flashing their wings and producing a crackling sound. After mating, females lay clusters of eggs in the sand and the nymphs emerge the following spring. Nymphs pass through five instars before maturing into adults in late July or August. Marram Grass, Tall Wormwood, and Long-leaved Reed Grass are the preferred foods of nymphs and adults.

Population Sizes and Trends

Population sizes and trends are unknown. All known extant Canadian subpopulations were discovered since 2002 and no subpopulation estimates or monitoring data are available. Lake Huron Grasshoppers appear to have become extirpated from three historical sites in Canada (Giant's Tomb Island, Wasaga Beach, and Sauble Beach) between the early 1990s and the mid-1990s.

Threats and Limiting Factors

Residential and commercial development and intensive recreational use destroyed or damaged much of the dune habitat, likely causing the extirpation of Lake Huron Grasshopper at historical sites. Recreational use by pedestrians and off-road vehicles significantly reduces subpopulations and continues to threaten some dunes by damaging vegetation and causing dune blowouts (depressions caused by erosion of sand by wind). Invasive plants, especially Common Reed and Spotted Knapweed can replace preferred food plants and alter dune processes. Changes in lake levels related to climate change, natural cycles, or lake level management have the potential to reduce the amount of dune habitat. Some sites have undergone recent improvements under dune stewardship programs.

Protection, Status and Ranks

Lake Huron Grasshopper is not protected under any legislation or regulations in Canada. It listed as Threatened in Michigan and Endangered in Wisconsin but is not listed under the US *Endangered Species Act*. It is not listed under the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES). Pancake Bay on Lake Superior is a provincial park, but other habitat is under municipal and private ownership. Lake Huron Grasshopper occurs at 10 sites with Pitcher's Thistle (Threatened in Ontario and Special Concern nationally) where dunes receive some protection under Ontario's *Endangered Species Act*.

The Global Rank is G2G3 (Imperilled to Vulnerable). The Subnational Rank in Ontario was adjusted to S2 (Imperilled) from S1 following the discovery of new subpopulations in 2014. It is ranked as S1 (Critically Imperilled) in Wisconsin and S2S3 (Vulnerable) in Michigan.

TECHNICAL SUMMARY

Trimerotropis huroniana

Lake Huron Grasshopper

Criquet du lac Huron

Range of occurrence in Canada (province/territory/ocean): Ontario

Demographic Information

Generation time	1 year
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Inferred decline
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future. <i>Three subpopulations (Giant's Tomb Island, Sauble Beach, and Wasaga Beach) were extirpated between the early 1990s and the mid-1990s but the subpopulation sizes are unknown.</i>	Unknown
Are the causes of the decline a. clearly reversible and b. understood and c. ceased? <i>Historical declines in habitat are probably due to shoreline development and intensive recreation use and not clearly reversible. Shoreline development has largely ceased at extant sites but recreational use continues to damage habitat and impact subpopulations. Invasive species are also a potential threat.</i>	a. No b. Yes c. No
Are there extreme fluctuations in number of mature individuals? <i>No data for Canadian subpopulations. Monitoring data for a Michigan subpopulation (the only data available) showed less than an order of magnitude fluctuation over eight years and therefore did not satisfy the definition of "extreme fluctuation".</i>	Unlikely

Extent and Occupancy Information

Estimated extent of occurrence	3900 km ²
Index of area of occupancy (IAO)(2x2 grid value).	48 km ²
Is the population "severely fragmented" i.e. is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No

Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	8-11
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Unknown
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Unknown
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Unknown
Is there an [observed, inferred, or projected] decline in number of "locations"*?	No
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, inferred
Are there extreme fluctuations in number of subpopulations?	Unknown
Are there extreme fluctuations in number of "locations"*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	Unknown

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	N Mature Individuals
	Unknown
Total	

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Quantitative analysis was not done
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Threats (actual or imminent, to populations or habitats, from highest impact to least)

Human intrusions and disturbance; Invasive and other problematic species; Residential and commercial development; Habitat loss.

Rescue Effect (immigration from outside Canada)

Status of outside population(s)	
S2S3 (Vulnerable) in Michigan, US	
Is immigration known or possible?	Possible
Would immigrants be adapted to survive in Canada?	Yes.
Is there sufficient habitat for immigrants in Canada?	Unknown.
Are conditions deteriorating in Canada? ⁺	Yes.
Are conditions for the source population deteriorating? ⁺	Unknown.
Is the Canadian population considered to be a sink? ⁺	Unknown.

* See Definitions and Abbreviations on [COSEWIC website](#) and [IUCN](#) (Feb 2014) for more information on this term

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

Is rescue from outside populations likely?	Possible
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Data Sensitive Species

Is this a data sensitive species?	No.
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Status History

COSEWIC: Designated Threatened in November 2015.
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Status and Reasons for Designation:

Status: Threatened	Alpha-numeric code: B1ab(iii)+2ab(iii)
Reasons for designation: <p>This globally rare grasshopper is endemic to the Great Lakes region of Ontario, Michigan, and Wisconsin where it is restricted to dunes along the shores of lakes Huron, Michigan, and Superior. In Canada, it is known from 11 dune sites: one location on the east shore of Lake Superior, and seven on Lake Huron at the south shore of Manitoulin Island and Great Duck Island. Formerly, it occurred at three additional sites on Lake Huron but these subpopulations appear to have become extirpated in the 1990s, likely as a result of residential and commercial development combined with intensive recreational use which damaged much of the dune habitat. While recreational use by pedestrians and off-road vehicles continue to threaten some dunes, other sites have undergone recent improvements under dune stewardship programs. Additional threats to dune environments include invasive plants and changes in lake levels related to climate change, natural cycles, or lake level management.</p>	

Applicability of Criteria

<p>Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Subpopulation trends unknown.</p>
<p>Criterion B: (Small Distribution Range and Decline or Fluctuation): Meets Threatened B1ab(iii)+2ab(iii) since the EOO and IAO are both below the threshold (3900 km² and 48 km² respectively), there are currently 8-11 locations and there is a continuing decline in the area, extent and quality of habitat.</p>
<p>Criterion C: (Small and Declining Number of Mature Individuals): Not applicable. Number of mature individuals not known.</p>
<p>Criterion D: (Very Small or Restricted Total Population): Does not meet criterion. Number of mature individuals not known and IAO and number of locations exceed threshold.</p>
<p>Criterion E: (Quantitative Analysis): Not applicable. No quantitative analysis was performed.</p>



COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS (2015)

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

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

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

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



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

COSEWIC Status Report

on the

Lake Huron Grasshopper *Trimerotropis huroniana*

in Canada

2015

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Phylum: Arthropoda – arthropods

Class: Insecta - insects

Order: Orthoptera – Grasshoppers, crickets, and katydids

Superfamily: Acridoidea MacLeay, 1819

Family: Acrididae MacLeay, 1819 - short-horned grasshoppers

Genus: *Trimerotropis* Stål, 1873

Species: *Trimerotropis huroniana* E. M. Walker, 1902

Type locality: Southampton, Ontario, Canada

Taxonomic background and similarities: *Trimerotropis huroniana* (Lake Huron Grasshopper) was described by E.M. Walker in 1902 from specimens collected at Southampton, Ontario (Walker 1902). Lake Huron Grasshopper has been treated as a full species since its description and no subspecies have been described (Otte 1984). Lake Huron Grasshopper was named after the type locality on the east shore of Lake Huron.

The genus *Trimerotropis* is distributed from Canada to Argentina and includes 43 North American species (Otte 1984). The range of Lake Huron Grasshopper overlaps with Seaside Grasshopper (*T. maritima*) and Cracker Grasshopper (*T. verruculata*) but morphological characteristics and courtship behaviour suggest it is more closely related to Pallid-winged Grasshopper (*T. pallidipennis*) of western North America (Otte 1984). Lake Huron Grasshopper was presumably isolated from Pallid-winged Grasshopper by a glacial advance about 10,000 years ago (Scholtens *et al.* 2005).

English common name(s): Lake Huron Grasshopper. The species is sometimes referred to as Lake Huron Locust (e.g., Rabe 1999) but “locust” more accurately applies to grasshoppers that aggregate into migratory swarms under crowded conditions (Marshall 2006). This behaviour is apparently unknown in *Trimerotropis*.

French common name: Criquet du lac Huron

Morphological Description

Lake Huron Grasshopper is a cryptically coloured, band-winged grasshopper. The forewings (tegmina) cover the top of the abdomen at rest but in flight, the black and clear or yellowish hindwings are exposed. The overall colour of the body and forewings ranges from silver-grey to brownish with variable speckles and banding on the forewing (Figure 1). Males are typically more strongly mottled than females. Several females with a distinct orange body colour were observed at Manitoulin Island in 2014 and have also been noted in Michigan and Wisconsin (Ballard 1989). Several individuals with straw-yellow forewings and body were observed on Manitoulin Island in 2014. The females (29 to 40 mm) are larger than the males (24 to 30 mm) (Otte 1984). The hindwing is clear or pale yellow at the base, with a black band across the middle, and clear or smoky tips.



Figure 1. Female Lake Huron Grasshopper at Carter Bay Sep 3 2014 (A.G. Harris).

Other band-winged grasshoppers within the range of Lake Huron Grasshopper and inhabiting similar dune habitats include Clear-winged Grasshopper (*Camnula pellucida*), Mottled Sand Grasshopper (*Spharagemon collare*), Carolina Grasshopper (*Dissosteira carolina*), Cracker Grasshopper, and Seaside Grasshopper. The first three of these species have a single notch (sulcus) in the ridge along the top of the thorax (pronotum) in contrast with two notches in the genus *Trimerotropis* (Vickery and Kevan 1985). Cracker Grasshopper has a darker body and hindwing tip than Lake Huron Grasshopper and is usually associated with rocky or clay substrates rather than sand (although occasionally present at the edge of dunes). Seaside Grasshopper can be distinguished from Lake Huron Grasshopper by the pale, rather than black inner surface of the hind femur (Vickery and Kevan 1985) (Figure 2).



Figure 2. Lake Huron Grasshopper showing the dark blotch at the base of the inside face of the femur. Carter Bay Sep 3 2014 (A.G. Harris).

Population Spatial Structure and Variability

No genetic or subpopulation structure studies have been completed for Lake Huron Grasshopper in Canada or the United States. There are no known morphological differences between subpopulations. The species has a disjunct distribution due to the discontinuous nature of dunes but adults are capable of flight and have colonized islands > 10 km offshore, suggesting that dispersal over significant distances is possible. The Pancake Bay occurrence is separated by about 200 km from the next closest Canadian occurrence, but is only about 30 km from the nearest Michigan occurrence and genetic connectivity between Canadian occurrences and the larger United States subpopulation is possible.

Designatable Units

Lake Huron Grasshopper has one designatable unit in Canada. There are no data on discreteness, genetic structure, or evolutionary significance among subpopulations and no subspecies are recognized. The species occurs on the border between the Great Lakes Plains and Boreal National Ecological Areas (COSEWIC 2011).

Special Significance

Lake Huron Grasshopper is of significance to Canadians because it is endemic to the Great Lakes area in Ontario, Michigan and Wisconsin, and Canada therefore has a high global conservation responsibility for this species. Along with Pitcher's Thistle (*Cirsium pitcheri*) it is a quintessential Great Lakes dune species. The type locality is at Southampton Ontario, where it was first collected by the eminent Canadian entomologist E.M. Walker of the Royal Ontario Museum. There is no Aboriginal Traditional Knowledge (ATK) for this species.

DISTRIBUTION

Global Range

The global range of Lake Huron Grasshopper is restricted to the shores of Lake Huron, Lake Michigan, and southern Lake Superior in Michigan, Wisconsin, and Ontario (Figures 3 and 4). The species is extant at over 70 dune complexes in Michigan, two in Wisconsin, and 11 in Ontario (Sjogren 2001; Bland 2003; Cuthrell pers. comm. 2014).



Figure 3. Lake Huron Grasshopper habitat at Shrigley Bay, Manitoulin Island Sep 1 2014 (R.F. Foster).

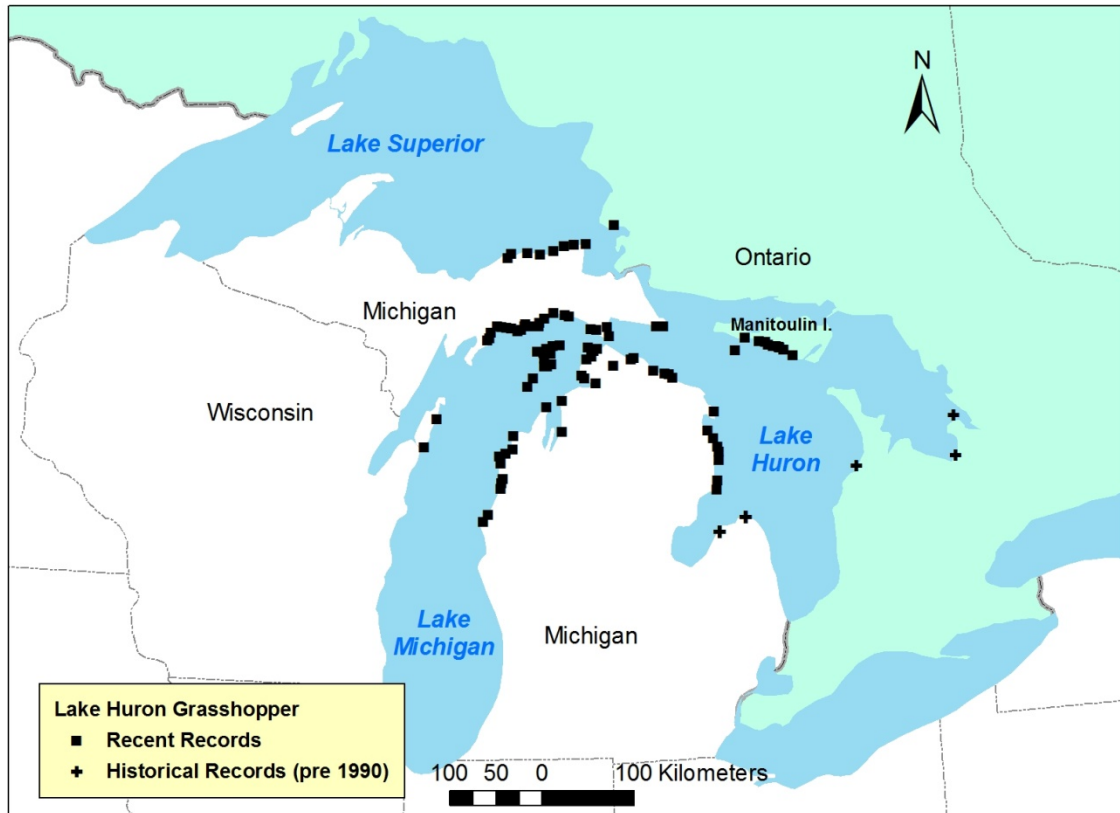


Figure 4. Global range of Lake Huron Grasshopper. US records from the Michigan Biotics database (Cuthrell pers. comm. 2014) and Kirk and Bomar (2005). Canadian records from COSEWIC (unpublished report) and Marshall (2003).

Canadian Range

The Canadian range of Lake Huron Grasshopper includes Pancake Bay on southern Lake Superior and ten dune complexes on the south shore of Manitoulin Island, and Great Duck Island in Lake Huron (Figures 5 and 6).

Historically the range extended farther south in both Ontario and Michigan. Subpopulations at Giant's Tomb Island, Wasaga Beach, and Sauble Beach (Southampton) in Ontario and Saginaw Bay in Michigan are apparently extirpated (Figure 4 and 5). Surveys at these historical sites have failed to find this species since the 1990s. About 11% of the species' current global range is in Canada.



Figure 5. Canadian range of Lake Huron Grasshopper showing 2014 search effort. The Pic River and Pinery sites surveyed in 2014 are north and south respectively of the area shown on the map. Unsurveyed dunes are dunes not surveyed in 2014 (Bakowsky and Henson 2014). Surveys at historical sites at Wasaga Beach, Sauble Beach and Giant's Tomb Island since the 1940s failed to find the species and these sites were not surveyed in 2014. However, surveys of these sites and surrounding area have been conducted prior to 2014, after the discovery of new subpopulations in 2003. However, while the Lake Huron Grasshopper was not detected, these surveys did not specify exact dates or locations.

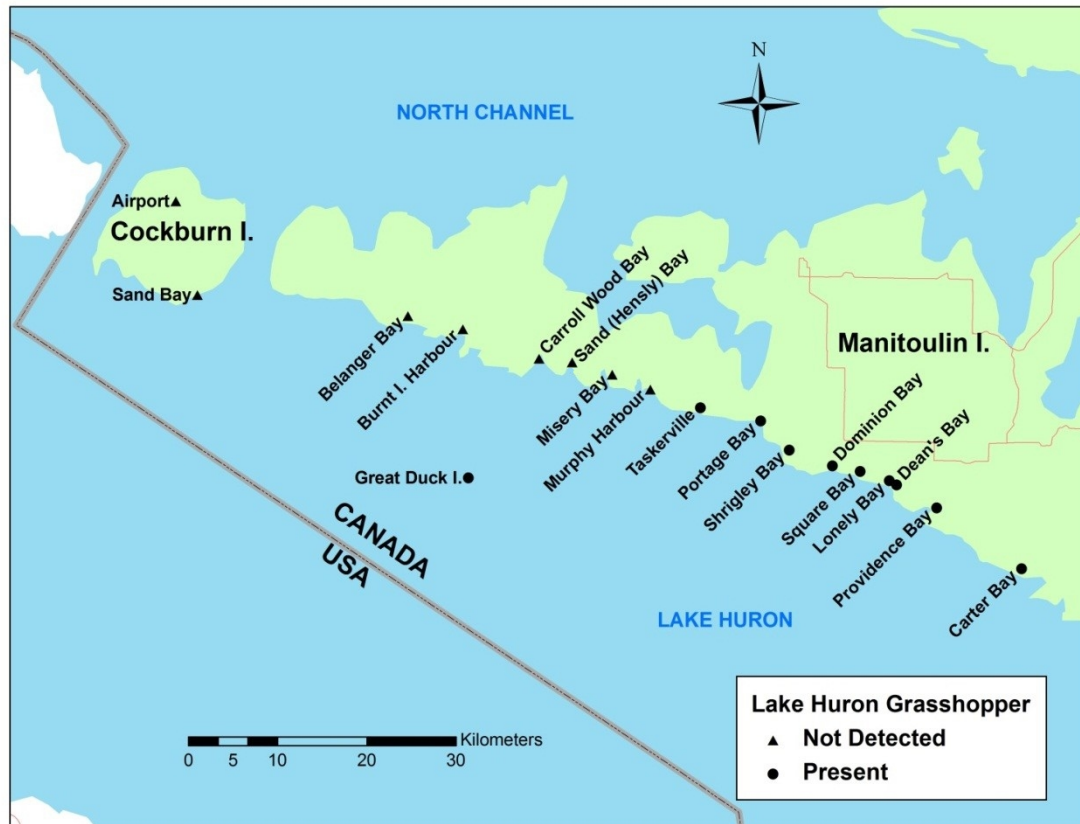


Figure 6. Detailed map of the Manitoulin Island area showing 2014 survey sites.

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EOO), with a minimum convex polygon, in Canada is 3900 km². The index of area of occupancy (IAO) (2 km x 2 km grid) is 48 km² (11 grid squares).

Search Effort

Lake Huron Grasshopper was discovered and first described as a species in 1901 at Sauble Beach near Southampton, Ontario by E.M. Walker (1902). Walker subsequently found the species at Giant's Tomb Island in 1908, and Wasaga Beach in 1936 (Figure 5, Table 1). No additional Canadian occurrences were known until 2002 when Marshall (2003) surveyed potential habitat at five dune complexes on the east shore of Lake Huron from Goderich to Manitoulin Island. Marshall (2003) discovered a new subpopulation at Carter Bay, but found that Lake Huron Grasshopper had apparently been replaced by Seaside Grasshopper at Sauble Beach. With a few exceptions (Table 2) other surveys in the region of the extirpated sites did occur prior to 2014, after the discovery of sites in 2003. These surveys did not specific exact locations or dates, yet the Lake Huron Grasshopper was not detected.

Table 1. Canadian specimens of Lake Huron Grasshopper from Royal Ontario Museum (ROM), Canadian National Collection (CNC), and the University of Guelph Insect Collection (DEBU).

Collection	Collector	Date	Location	Notes
CNC91615		21-Jul-1901	"Southampton, Ont."	Presumably Sauble Beach
CNC91616	E.M. Walker	30-Jul-1908	Giant's Tomb Island	
ROM	E.M. Walker	30-Jul-1908	Giant's Tomb Island	
DEBU01037498		30-Jul-1908	Georgian Bay	
DEBU01037499		30-Jul-1908	Georgian Bay	Presumably Giant's Tomb Island. No dune habitat at label coordinates (43.978 N, - 79.838 W), about 25 km northeast of Giant's Tomb Island
ROM		20-Jul-1915	Giant's Tomb Island	
DEBU00008971	R.H. Ozburn	12-Jul-1930	"Guelph"	Apparently mislabelled
ROM	E.M. Walker	11-Aug-1936	Wasaga Beach	
ROM	E.M. Walker	30-Jul-1937	Wasaga Beach	
ROM	F.A. Urquhart	14-Aug-1940	Wasaga Beach	
ROM	F.A. Urquhart	20-Aug-1941	Wasaga Beach	
DEBU00192524	S.A. Marshall	01-Aug-2002	Manitoulin I., Carter Bay	
DEBU00192512	S.A. Marshall	01-Aug-2002	Manitoulin I., Carter Bay	
DEBU00192525	S.A. Marshall	01-Aug-2002	Manitoulin I., Carter Bay	
DEBU00192508	S.A. Marshall	01-Aug-2002	Manitoulin I., Carter Bay	
DEBU00192526	S.A. Marshall	01-Aug-2002	Manitoulin I., Carter Bay	
DEBU00192527	S.A. Marshall	01-Aug-2002	Manitoulin I., Carter Bay	
DEBU01132352	S.M. Paiero	01-Aug-2003	Manitoulin I., Carter Bay	
DEBU01132351	S.M. Paiero	01-Aug-2003	Manitoulin I., Carter Bay	
DEBU01131640	S.A. Marshall	8-Aug-2003	Manitoulin I., Carter Bay	
DEBU01132347	S.A. Marshall	28-Aug-2003	Manitoulin I., Carter Bay	

Table 2. Lake Huron Grasshopper surveys 1990 to 2008.

Location	Observer	Date	Notes
Giant's Tomb Island	D. Sutherland	Mid-1990s	No Lake Huron Grasshoppers.
Inverhuron Provincial Park	S. Marshall	Summer 2002	No Lake Huron Grasshoppers. Seaside Grasshopper common.

Location	Observer	Date	Notes
Sauble Beach	S. Marshall	Summer 2002	No Lake Huron Grasshoppers. Seaside Grasshopper common.
Dorcas Bay	S. Marshall	Summer 2002	No Lake Huron Grasshoppers.
Carter Bay	S. Marshall	Summer 2002	Lake Huron Grasshopper and Seaside Grasshopper present
Providence Bay	S. Marshall	Summer 2002	No Lake Huron Grasshoppers. Seaside Grasshopper common.
Providence Bay	S. Paiero	August 2003	Lake Huron Grasshopper present.
Pukaskwa National Park	S. Paiero	July 2003	No Lake Huron Grasshoppers.
Giant's Tomb Island	J. Kamstra	Aug 28 2008	No Lake Huron Grasshoppers. About 12 Seaside Grasshoppers on the east shore of the island where there is substantial dune habitat.

Fieldwork conducted in support of the present status report included surveys of 26 dunes from the Pinery on Lake Huron to Pic River on Lake Superior (Figure 5). Survey effort in 2014 totalled approximately 65 person-hours.

About 76% of the dune complexes within or adjacent to the extent of occurrence have been surveyed. Unsurveyed dunes include North Sandy Island, Goulais Bay, and Oiseau Bay on Lake Superior, Mississagi Island, Wagosh Bay on Cockburn Island, Horseshoe Bay on Great Duck Island, Western Duck Island, and Michael's Bay on Manitoulin Island (Bakowsky and Henson 2014; Judith Jones pers. comm. 2014) (Figure 5). Habitat conditions and threats at these dunes are unknown.

HABITAT

Habitat Requirements

Lake Huron Grasshopper exclusively inhabits open dunes on lakes Huron, Michigan and Superior. Great Lakes dunes cover a total area of less than 1800 ha in Canada including 492 ha on Lake Huron and 100 ha on Lake Superior (Bakowsky and Henson 2014). Dunes occur on shorelines where there is a source of sand, especially at glaciofluvial outwash plains, glaciolacustrine deposits, or where sand is being actively deposited at river mouths. Exposure to wind and waves is essential to maintain sand movement and deposition and prevent succession to forest (Maun 2009). The intervening habitat between dunes on the south side of Manitoulin Island and southern Lake Superior consists mainly of rocky shore.

Lake Huron Grasshopper occurs most commonly on the foredune, a sand ridge predominantly covered with Marram Grass (*Ammophila breviligulata*) and Long-leaved Reed Grass (*Calamovilfa longifolia*) (Figure 3) (Rabe 1999; Foster pers. obs. 2014; Harris pers. obs. 2014). The vegetation type is described as *Little Bluestem – Long-leaved Reed Grass – Great Lakes Wheat Grass Dune Grassland* (Lee *et al.* 1998). The species is usually found on dry sand among scattered grasses and herbs (Hubbell 1929; Rabe 1999) but will move to heavier dune grass cover during windy or overcast weather, apparently seeking shelter (Rabe 1999). Lake Huron Grasshopper occurs almost exclusively on the ground and rarely climbs on vegetation. On cool mornings during 2014 fieldwork, Lake Huron Grasshoppers were most common on east-facing dune slopes, probably warming in the sun (Foster pers. obs. 2014; Harris pers. obs. 2014).

Lake Huron Grasshopper presence was not correlated with the size of the dune system in over 100 dunes surveyed in Michigan (Scholtens *et al.* 2005). However, the largest subpopulations in Michigan are associated with extensive, wide dunes. Shorelines that are at least 1.5 km long with at least two sets of dunes containing blowout areas are ideal (Rabe 1999). In Ontario, dune systems occupied by Lake Huron Grasshopper ranged from about 1.2 ha (Dominion Bay) to 30 ha (Great Duck Island) (Table 3) and from approximately 3 m to 400 m wide.

Preferred food plants include Marram Grass, Tall Wormwood (*Artemisia campestris*) and Long-leaved Reed Grass (Rabe 1999; Scholtens *et al.* 2005). Botanical surveys on Manitoulin Island, the Duck Islands, and Cockburn Island found at least one of these plant species at all 20 dunes surveyed (Judith Jones pers. comm. 2014). The occurrence of Lake Huron Grasshoppers in the Sable Dunes in Michigan was positively correlated with percent cover of Tall Wormwood (Marshall and Storer 2005).

Table 3. Summary of habitat threats at extant Lake Huron Grasshopper sites in Canada. Adapted from Pitcher's Thistle recovery strategy by Parks Canada Agency (2011). "X" indicates that the threat is present. A blank box indicates that no evidence of that threat was detectable at the site. Areas of open dune habitat were estimated from GoogleEarth imagery.

Location	Site	Open Dune Area (ha)	Off-road Vehicle	Vegetation Trampling	Succession	Human Structures	Erosion / Blowouts	Invasive Plants
1	Great Duck Island	25						
2	Carter Bay, Manitoulin I.	20	X		X	X	X	
3	Providence Bay, Manitoulin I.	6			X	X		
4	Dean's Bay, Manitoulin I.	1	X	X	X	X		
4	Lonely Bay, Manitoulin I.	1	X	X	X	X	X	
4	Square Bay, Manitoulin I.	1	X	X	X	X		X
5	Dominion Bay, Manitoulin I.	1		X	X	X	X	X
6	Shrigley Bay, Manitoulin I.	5	X		X	X	X	

Location	Site	Open Dune Area (ha)	Off-road Vehicle	Vegetation Trampling	Succession	Human Structures	Erosion / Blowouts	Invasive Plants
6	Portage Bay, Manitoulin I.	4	X	X	X	X		
7	Taskerville, Manitoulin I.	18						
8	Pancake Bay	10		X				X

Habitat Trends

Historical declines in habitat are due to shoreline development and intensive recreational use. Shoreline development has largely ceased at extant sites but recreational use continues to damage habitat and impact subpopulations. Intensive human use (beach grooming, heavy trampling, and shoreline development) at Wasaga Beach apparently caused the loss of 17.5 ha of Lake Huron Grasshopper habitat in the 1900s. Other historical sites at Sauble Beach (23.9 ha) and Giant's Tomb Island (approximately 5 ha) are also heavily used by recreationalists, which probably contributed to the loss of those subpopulations (Sutherland pers. comm. 2014). In contrast, most Manitoulin sites have had lower levels of disturbance and development and still support intact dune flora and processes. The damage caused by human disturbance at two large sites (Carter Bay and Providence Bay on Manitoulin Island) has improved as a result of restricting foot traffic at both localities, and preventing off-road vehicle use at Providence Bay, which have reduced the occurrence of dune blowouts (COSEWIC 2010).

The amount of Lake Huron Grasshopper habitat at Manitoulin Island and Great Duck Island has remained more or less stable for the last 15 years, although habitat quality continues to decline at many sites (Table 3) (COSEWIC 2010). Habitat for Lake Huron Grasshopper also varies with natural processes. Dune ecosystems require wind, waves, ice-scour, and occasional storms to maintain open, sparsely vegetated sand (Parks Canada Agency 2011). In the absence of disturbance, shrubs and trees displace dune grasses. Dune habitat also fluctuates due to natural lake level cycles. Lake Huron water levels fluctuate over a short-term cycle of about 30 years superimposed on a 120 to 200 year cycle (Wilcox *et al.* 2007). Monitoring data in Michigan suggest that subpopulations of Lake Huron Grasshopper are greatest during low lake levels when dunes are at their greatest extent (Scholtens *et al.* 2005). However, periods of high water are also important for the long-term health of the dunes. Greater dune growth occurs when high water increases erosion and replenishes the supply of sand (Albert 2000). Low water levels cause reduced sand deposition in the foredune, allowing vegetation growth to increase (Parks Canada Agency 2011). The dunes at Pancake Bay on Lake Superior have not been monitored but are apparently stable (Morris pers. comm. 2014).

BIOLOGY

Most information about Lake Huron Grasshopper biology originates from unpublished Michigan studies by Scholtens (1996; 1997), Ballard (1991) and a summary of these and other unpublished data by Sjogren (2001). A monograph by Otte (1970) describes breeding behavior. Scholtens *et al.* (2005) describe threats and interspecific relationships between Lake Huron Grasshopper and other grasshoppers in Michigan. Where species-specific information is unavailable, general information on grasshopper behaviour and ecology is provided from Otte (1981; 1984) and Capinera *et al.* (2004).

Life Cycle and Reproduction

Lake Huron Grasshopper undergoes a single generation per year. Courtship takes place in late summer on open sand with scattered grasses. Males stridulate by producing two to eight short trills by rubbing the hind femur on the edge of the forewing as they approach a female (Figure 2) (Otte 1970). On warm days (~27°C) males perform flight displays by hovering, flashing their wings, and producing a crackling sound (crepitating) (Sjogren 2001). Aggressive displays between males consist of tipping and shaking their femurs (Vickery and Kevan 1985). Males tend to be evenly distributed throughout suitable habitat with territories of about 1 m in diameter (Rabe 1999). The male mounts the female and transfers a sperm sac (spermatophore) to the female's genitalia (Otte 1981).

After mating, females lay eggs in sandy soil (Vickery and Kevan 1985). Details of egg laying are apparently not documented for Lake Huron Grasshopper, but other grasshoppers lay clusters of 3 to nearly 200 eggs held together by a frothy secretion that dries to form a rigid case (Capinera *et al.* 2004; Kirk and Bomar 2005). Several egg clusters are typically produced by each female. The eggs of Lake Huron Grasshopper overwinter in the sand substrate and the nymphs hatch in late spring and go through five instars before reaching maturity in June or July (Sjogren 2001). Adults survive until the first hard frosts, typically in late September or October.

Hybridization between Lake Huron Grasshopper and other species has not been described and its range does not overlap with its most closely related congeners (*T. pallidipennis*, *T. saxitilis*, *T. colusa*, and *T. schaefferi*) (Otte 1984). However, Hubbell (1929) found a male Lake Huron Grasshopper copulating with a female Cracker Grasshopper.

Physiology and Adaptability

Little is known about physiological and behavioural adaptations of Lake Huron Grasshopper. The species is adapted to dune habitats, which are subject to daily and seasonal extremes in moisture and temperature, low nutrient availability, and continually changing substrate (Maun 2009). As a result of the extreme conditions, dunes have sparse vegetation and little cover from predators. Changing lake levels and vegetation succession alter dune habitats over longer time spans. Lake Huron Grasshopper feeds on a range of common dune plants (Scholtens *et al.* 2005), but apparently avoids dense stands of the invasive Spotted Knapweed (*Centaurea biebersteinii* = *C. maculosa* or *C. stoebe*) (Marshall

and Storer 2007). In addition to live and dead plant material, nymphs feed on dead invertebrates, apparently to supplement their diet with nitrogen (Sjogren 2001). The cryptic coloration presumably reduces predation.

Dispersal and Migration

Dispersal capability of Lake Huron Grasshopper has not been studied, but the occurrence of a subpopulation on Great Duck Island in Lake Huron suggests dispersal of several kilometres over unsuitable habitat is possible. Lower lake levels about 9000 years ago meant that there may have been greater connectivity between Great Duck Island and Manitoulin Island, but subsequent water level increases during the Nipissing phase (about 5000 years ago) probably submerged the islands (Larsen 1987; National Geophysical Data Center 1999). By using other islands as stepping stones, Lake Huron Grasshoppers could have dispersed a minimum distance of about 4 km over open water to colonize the island. Similarly, the presence of Lake Huron Grasshopper on North Fox, South Fox and other islands in Lake Michigan suggest adults are able to fly a minimum of about 15 km over open water. Lake Huron Grasshopper does not migrate.

The Lake Huron Grasshopper population is not severely fragmented. Dune complexes occur in isolated patches separated by 2 to 36 km from the nearest neighbouring subpopulation, but adults are capable of flight and apparently able to disperse at least several kilometres given the occurrences on small islands in Lakes Huron and Michigan.

Interspecific Interactions

Seaside Grasshopper and Lake Huron Grasshopper occupy similar habitat but rarely occur together, suggesting that the two species may compete for food or other limiting resources (Otte 1970). Seaside Grasshopper replaces Lake Huron Grasshopper on the beaches of southern Lake Huron and southern Lake Michigan (Otte 1970; Marshall 2003; Scholtens *et al.* 2005). Sauble Beach and Giant's Tomb Island were inhabited by Lake Huron Grasshopper in the early 1900s, but only Seaside Grasshopper was found there in the most recent surveys (Marshall 2003; Kamstra pers. comm. 2014). In Michigan, the boundary between the ranges of the two species shifted northward about 80 km between the 1940s and 1960s (Otte 1970). In contrast, Seaside Grasshopper was collected at Providence Bay and Carter Bay (where Lake Huron Grasshopper was also present) in 2002 (Marshall 2003), but only Lake Huron Grasshopper was found at these dunes in 2014.

Mottled Sand Grasshopper inhabits disturbed parts of beaches in Michigan where Lake Huron Grasshopper is typically absent (Kirk and Bomar 2005; Scholtens *et al.* 2005). Cracker Grasshoppers were observed in 2014 surveys in Ontario at the edges of some of the beaches supporting Lake Huron Grasshopper. Cracker Grasshoppers were also found in the Pic River dunes on the north shore of Lake Superior where Lake Huron Grasshopper was absent. Other grasshoppers inhabiting the same beaches as Lake Huron Grasshopper during 2014 surveys included Carolina Grasshopper, Clear-winged Grasshopper, Two-striped Grasshopper (*Melanoplus bivittatus*), and Migratory Grasshopper (*M. sanguinipes*).

Predators on grasshoppers include robber flies (Diptera: Asilidae) and spiders (Araneae) among many other arthropods (Capinera *et al.* 2004). Larvae of some species of blister beetle (Coleoptera: Meloidae) and bee flies (Diptera: Bombyliidae) feed on grasshopper eggs (Capinera *et al.* 2004). Many species of vertebrates, including Raccoons (*Procyon lotor*), Red Fox (*Vulpes vulpes*), American Toads (*Bufo americanus*), American Kestrels (*Falco sparverius*), and Common Grackles (*Quiscalus quiscula*), probably feed opportunistically on Lake Huron Grasshopper. All of these species were seen at Lake Huron Grasshopper habitat in 2014. Flocks of gulls (Laridae) are frequently found on the beaches and as opportunistic predators likely feed on some Lake Huron Grasshoppers. Smaller birds probably feed on nymphs.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

The 2014 survey included 26 dune complexes on and near Manitoulin Island, on eastern Lake Superior, and on the east shore of Lake Huron (Figure 5). Effort focused on Manitoulin Island due to the large amount of potential habitat that had not been previously surveyed. Surveys at historical sites at Wasaga Beach, Sauble Beach and Giant's Tomb Island since the 1940s failed to find the species and these sites were not surveyed in 2014. Searches were conducted by walking slowly through open dune habitat and watching for adult grasshoppers, which typically jumped or flew when approached to within about 1.0 to 1.5 m. Total survey effort was approximately 65 person-hours.

Abundance

No subpopulation estimates of Lake Huron Grasshopper are available. The 2014 survey counted over 500 individuals but no systematic subpopulation estimate was completed. The species appeared to be most common at Carter Bay and Shrigley Bay where over 100 individuals were counted at each. Only six individuals were counted at Pancake Bay. Previous reports (Walker 1902; Marshall 2003) did not provide subpopulation estimates.

Fluctuations and Trends

No subpopulation monitoring data are available for Canadian occurrences, most of which were discovered in 2014. Lake Huron Grasshopper is apparently extirpated at historical sites at Sauble Beach, Wasaga Beach, and Giant's Tomb Island (Marshall 2003; Sutherland pers. comm. 2014) and was believed to be extirpated from Ontario until Marshall (2003) discovered a previously unknown subpopulation at Carter Bay on Manitoulin Island. Lake Huron Grasshopper was not collected at Providence Bay in 2002 (Marshall 2003), but was present in 2014, suggesting that Lake Huron Grasshopper may have colonized the site between 2002 and 2013.

Extreme fluctuations are changes in distribution or in the total number of mature individuals of a wildlife species that occur rapidly and frequently, and are typically of more than one order of magnitude. Subpopulations of some grasshopper species (e.g., *Melanoplus* spp.) fluctuate greatly in terms of distribution and numbers from year to year in response to food, weather, and other factors (Vickery and Kevan 1985). However, it's unknown if Lake Huron Grasshopper subpopulations undergo extreme fluctuations. The only available subpopulation monitoring data showed that a Michigan subpopulation ranged from a low of about 750 to a high of 4000-6000 individuals over eight years (Scholtens *et al.* 2005). This range is less than an order of magnitude and therefore does not meet the definition of extreme fluctuation (IUCN 2010).

Rescue Effect

Rescue effect is possible. Pancake Bay is 35 km across Lake Superior from a Lake Huron Grasshopper subpopulation at Whitefish Point, Michigan, but Ile Parisienne and the Sandy Islands occur between these sites and reduce the expanse of open water. Both have dune habitat. Similarly, a Lake Huron Grasshopper subpopulation in Chippewa County, Michigan is about 60 km from the west end of Manitoulin Island or 80 km from Great Duck Island. Beaches on Cockburn and Drummond islands could act as stepping stones between Michigan and Canadian habitat. Given the apparently stable or growing subpopulation in Michigan (Cuthrell pers. comm. 2014) and apparent dispersal capability of the species, movement of Lake Huron Grasshoppers from Michigan to Canada is plausible.

THREATS AND LIMITING FACTORS

Many of the threats facing Lake Huron Grasshopper also apply to Pitcher's Thistle, another Great Lakes dune endemic species that is present at most extant Lake Huron Grasshopper habitat in Canada. Threats to Pitcher's Thistle were assessed for the recovery strategy (Parks Canada Agency 2011) and are discussed below. The International Union of Conservation-Conservation Measures Partnership (2006) (IUCN-CMP) threats calculator was used to classify and list threats to Lake Huron Grasshopper (Salafsky *et al.* 2008; Master *et al.* 2009) (Table 4). A summary of the threats acting at each dune system inhabited by Lake Huron Grasshopper is presented in Table 3. Overall threat impact was medium.

Table 4. IUCN Threats calculator.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development	CD	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	
1.1	Housing & urban areas	D	Low	Small (1-10%)	Serious - Moderate (11-70%)	Moderate (Possibly in the short term, < 10 yrs)	Housing development was an historical threat at Wasaga Beach and Sauble Beach where Lake Huron Grasshopper is extirpated. Extant sites are in municipally owned shoreline, parks, and protected area. Parts of the dunes at Carter Bay and Great Duck I. may be eligible for housing development.
1.2	Commercial & industrial areas			Unknown	Serious - Moderate (11-70%)	Moderate (Possibly in the short term, < 10 yrs)	Potential for development - uncertainty around Carter Bay - depends on the landowners' plans.
1.3	Tourism & recreation areas	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Commercial tourism development was an historical threat at Wasaga Beach and Sauble Beach where Lake Huron Grasshopper is extirpated. Nine of 11 extant sites have at least low level of threat from volleyball courts, fire pits, boat storage associated with nearby cottages; volleyball courts are unregulated by the community;
2	Agriculture & aquaculture						
2.1	Annual & perennial non-timber crops						N/A
2.2	Wood & pulp plantations						N/A
2.3	Livestock farming & ranching						N/A
2.4	Marine & freshwater aquaculture						N/A
3	Energy production & mining						
3.1	Oil & gas drilling						N/A
3.2	Mining & quarrying						N/A
3.3	Renewable energy						N/A
4	Transportation & service corridors		Negligible	Restricted (11-30%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs)	
4.1	Roads & railroads		Negligible	Restricted (11-30%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs)	Road are within 25 m of two sites, but probably negligible threat because the grasshopper rarely leaves dune habitat.
4.2	Utility & service lines						Not applicable. Unlikely for line development because this is usually associated with housing development.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.3	Shipping lanes						There is shipping on the north part of Lake Huron, but the impacts from freighters is likely insignificant.
4.4	Flight paths						N/A
5	Biological resource use						
5.1	Hunting & collecting terrestrial animals						N/A
5.2	Gathering terrestrial plants						Not considered a threat; the grasshopper feeds upon a number of common dune plants but none are collected for human use.
5.3	Logging & wood harvesting						N/A
5.4	Fishing & harvesting aquatic resources						N/A
6	Human intrusions & disturbance	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	
6.1	Recreational activities	C	Medium	Pervasive (71-100%)	Moderate (11-30%)	High (Continuing)	Trampling vegetation and dune blowouts caused by pedestrians and off-road vehicles are a threat at 8/11 sites. However, Lake Huron Grasshopper is tolerant of moderate levels of recreational use in MI. Severity of trampling has been recently reduced at two Manitoulin sites through boardwalks and signage.
6.2	War, civil unrest & military exercises						N/A
6.3	Work & other activities						Beach cleaning at Providence Bay and other sites accounted for under 6.1.
7	Natural system modifications			Unknown	Unknown	Moderate (Possibly in the short term, < 10 yrs)	
7.1	Fire & fire suppression						Not considered a threat. Dune ecosystems have not evolved with fire.
7.2	Dams & water management/use		Not a Threat (in the assessed timeframe)	Unknown	Unknown	Low (Possibly in the long term, >10 yrs)	Altered discharge from Lake Superior into Lake Huron and diversion of water from lakes Huron and Michigan is possible but impacts on dunes unknown.
7.3	Other ecosystem modifications			Unknown	Unknown	Moderate (Possibly in the short term, < 10 yrs)	Erosion control structures are not present at extant sites but are a potential threat.
8	Invasive & other problematic species & genes	C	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	Moderate (Possibly in the short term, < 10 yrs)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.1	Invasive non-native/alien species	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	Moderate (Possibly in the short term, < 10 yrs)	Common Reed and Spotted Knapweed can form dense stands and stabilize blowing sand, altering dune succession. Replacement of preferred food plants by Knapweed has been documented in MI. Common Reed is present at low levels at two sites and Spotted Knapweed at one, but both species are highly invasive.
8.2	Problematic native species	CD	Medium - Low	Large (31-70%)	Moderate - Slight (1-30%)	High (Continuing)	Apparent competitive interactions with Seaside Grasshopper. Some evidence that woody vegetation is growing in at a faster rate than new dunes are developing.
8.3	Introduced genetic material						N/A
9	Pollution						None of the inhabited dunes are in close proximity to major highways, agricultural land, or industrial development where significant spills are possible.
9.1	Household sewage & urban waste water						N/A
9.2	Industrial & military effluents						N/A
9.3	Agricultural & forestry effluents						Most of the agricultural is pasture and hayfields; mostly several km from beaches. Not applicable.
9.4	Garbage & solid waste						N/A
9.5	Air-borne pollutants						N/A
9.6	Excess energy						N/A
10	Geological events						
10.1	Volcanoes						N/A
10.2	Earthquakes/tsunamis						N/A
10.3	Avalanches/landslides						N/A
11	Climate change & severe weather			Unknown	Unknown	High (Continuing)	Isostatic rebound of Lake Huron could also be a threat. The species is not host specific but given a severe climatic change, could be particularly susceptible given its phenology and timing of nymph emergence.
11.1	Habitat shifting & alteration			Unknown	Unknown	High (Continuing)	Climate models predict declining Great Lakes water levels and may increase the amount of Lake Huron Grasshopper habitat in the short-term, but habitat may decrease over the longer term if dune vegetation succession occurs at a faster pace than dune building processes. Low water since the late 1990s is believed to have altered successional processes and threatened dune habitat at eight of the 11 dunes.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.2	Droughts						Not considered a threat. Because the dunes are close to Lake Huron/Superior, they may be less vulnerable than ecosystems perched higher than the water table.
11.3	Temperature extremes			Unknown	Unknown	High (Continuing)	Subpopulations occur in a limited geographical range and could be vulnerable to severe weather conditions such as harsh winters, late frosts, unusually cool and wet growing seasons.
11.4	Storms & flooding			Unknown	Unknown	High (Continuing)	Subpopulations occur in a limited geographical range and could be vulnerable to severe weather conditions such as harsh winters, late frosts, unusually cool and wet growing seasons, or drought.

Human Intrusions and Disturbance (IUCN 6)

Dune vegetation can be damaged by pedestrians, leading to increased erosion and receding shorelines (Peach 2005; Parks Canada Agency 2011). Intensive use by bathers and pedestrians at Giant's Tomb Island, Wasaga Beach, and Sauble Beach apparently contributed to damage to dune vegetation and the loss of Lake Huron Grasshopper at those sites (Sutherland pers. comm. 2014). High foot traffic damages vegetation and removes stabilizing grasses and shrubs (Parks Canada Agency 2011). Repeated foot traffic creates paths through dunes that can lead to blowouts, with unstable sand supporting little vegetation. Publically accessible protected areas are more often more vulnerable than private or isolated areas. Habitat damage by pedestrians is a threat at six of 11 Lake Huron Grasshopper sites (Table 3). The severity of trampling has been a concern at Providence Bay and Carter Bay, but has recently been somewhat reduced by constructing boardwalks, stairways, and designated pathways to keep pedestrians off the vegetation (Parks Canada Agency 2011). Although recreational use of beaches has apparently contributed to the extirpation at Wasaga and Sable beaches, Lake Huron Grasshopper coexists with moderate levels of human use at other beaches.

Off-road recreational vehicles are a significant threat to dune vegetation and significantly reduce Lake Huron Grasshopper subpopulations (Scholtens *et al.* 2005). They are capable of moving off trails or roads throughout the dune habitat (Parks Canada Agency 2011) and cause erosion and blowouts by damaging grasses and shrubs that stabilize sand. They are also vectors for invasive plants. Although quantitative data are unavailable, Michigan dunes used by off-road vehicles appeared to have smaller subpopulations of Lake Huron Grasshoppers than those with no vehicles (Scholtens *et al.* 2005). Off-road vehicle use is prevalent on Manitoulin Island especially where shoreline areas contain a public right-of-way (Parks Canada Agency 2011). Off-road vehicles are a threat at six of 11 dunes where Lake Huron Grasshopper occurs (Table 3).

Lake Huron Grasshoppers are present at Pancake Bay, Carter Bay and Providence Bay, where there is a moderate level of recreational use by walkers and bathers (user numbers are apparently unavailable), suggesting that the present level of use is conducive to maintaining suitable habitat. A similar situation exists in Michigan where healthy Lake Huron Grasshopper subpopulations have coexisted with human recreational use if dune vegetation and processes are intact (Sjogren 2001).

Modification of dunes and beaches to remove vegetation and re-create more open, sandy conditions for recreational use is a threat at some privately owned sites on Manitoulin Island. Two dune sites (one with Lake Huron Grasshopper, one without) had been tilled using a tractor and disk trencher to remove beach vegetation in 2014.

Invasive and Other Problematic Species and Genes (IUCN 8)

Invasive plant species can displace preferred food plants or alter dune processes and are potential threats to Lake Huron Grasshopper. Invasive plants are a potential threat at all Lake Huron Grasshopper sites regardless of land tenure or protection status, but dunes with the greater risk include those with existing subpopulations of invasive plants and those with a high degree of public access (Table 3). Although invasive plants are not yet pervasive at Manitoulin dunes, several species have aggressively invaded other Lake Huron dunes (Peach 2005) and there is no significant barrier to their dispersal to the island.

Two of the most significant threats are Common Reed (*Phragmites australis*) and Spotted Knapweed. Dense stands of both species can stabilize blowing sand and thereby alter dune succession (Michigan Natural Features Inventory 2010). The invasive Common Reed is present at several dunes with Lake Huron Grasshopper at Manitoulin Island (Parks Canada Agency 2011). Although not yet highly invasive at these sites, Common Reed has the potential to take over large areas of shoreline, as has occurred on southern Lake Huron (Parks Canada Agency 2011). Spotted Knapweed has invaded parts of Grand Sable Dunes in Michigan where it has apparently displaced Tall Wormwood (a preferred food plant) (Marshall and Storer 2007). Lake Huron Grasshoppers were more likely to be found where Spotted Knapweed was absent. Spotted Knapweed is apparently absent at Manitoulin and Great Duck Island dunes (Jones pers. comm. 2014), but present at Pancake Bay, Ontario.

Northward expansion of Seaside Grasshopper and invasion of disturbed dunes by Mottled Sand Grasshopper may be threats to Lake Huron Grasshopper. Mottled Sand Grasshopper seems to increase when dunes are disturbed by recreational activities and Lake Huron Grasshopper is rarely found in the same dunes as Mottled Sand Grasshopper (one of over 100 sites). Disturbance from recreational activity may cause changes in dune vegetation allowing Mottled Sand Grasshopper to invade and displace Lake Huron Grasshopper. Lake Huron Grasshopper is able to tolerate some human activity when Mottled Sand Grasshopper is absent (Scholten *et al.* 2005).

Lake Huron Grasshopper was present at Sauble Beach and Giant's Tomb Island in the early 1900s (Table 1), but surveys since the mid-1990s have found only Seaside Grasshopper (Marshall 2003; Kamstra pers. comm. 2014; Sutherland pers. comm.

2014). Similarly, Michigan surveys found only Seaside Grasshopper at dunes formerly occupied by Lake Huron Grasshopper, suggesting a northward shift of about 80 km in the range boundary between about 1941 and 1966 (Otte 1970; 1984; Scholtens *et al.* 2005). Further research is required to determine if the range shift can be attributed to competitive displacement.

Residential and Commercial Development (IUCN 1)

Residential and commercial development was probably the primary cause of the loss of the Lake Huron Grasshopper subpopulations at Wasaga Beach and Sauble Beach. These beaches are lined with retail operations, homes, and cottages. Such development encourages heavy recreational use and consequent damage to dune vegetation (discussed under *Human intrusions and disturbance*).

Most sandy bays on Manitoulin Island are subdivided with cottages on the back dune or adjacent forest (Parks Canada Agency 2011). Although the cottages may be outside Lake Huron Grasshopper habitat, structures such as volleyball courts, fire pits, and boat storage are often present on the dunes themselves. Eight of the 11 dune sites inhabited by Lake Huron Grasshopper face at least a low level of threat from residential development and associated structures (Table 3), but there have been no major changes since 1999 (COSEWIC 2010). In contrast, some cottage owners are actively involved in dune stewardship and prevent damaging activities from taking place in front of their lots (COSEWIC 2010).

Transportation and Service Corridors (IUCN 4)

No transportation or service corridors cross Lake Huron Grasshopper habitat. Roads parallel the back of the dunes at Pancake Bay and Providence Bay within about 25 m of suitable habitat, but probably have little direct impact on the species because it is not known to enter wooded habitat (Rabe 1999). Further road development is not likely to be a significant threat.

Natural System Modifications (IUCN 7)

Water level regulations include altering the discharge from Lake Superior into Lake Huron and potential diversion of water from Lakes Huron and Michigan (COSEWIC 2010) is a possible influence, but the impacts on dunes and the Lake Huron Grasshopper is unknown.

Climate Change and Severe Weather (IUCN 11)

Climate models predict declining Great Lakes water levels over the next century, largely due to increased evaporation (Mortsch *et al.* 2006) (although above average precipitation in 2013 and 2014 caused increases in levels of Lake Superior and Lake Huron; NOAA 2014). As discussed under Habitat Trends, declining lake levels may increase the amount of Lake Huron Grasshopper habitat in the short-term, but habitat may decrease over the longer term if dune vegetation succession occurs at a faster pace than dune building processes. Low water since the late 1990s is believed to have altered successional processes and threatened dune habitat at eight of the 11 dunes supporting Lake Huron Grasshopper (Table 3) (COSEWIC 2010).

Lake Huron Grasshopper subpopulations in Canada occur in a limited geographical range and could be vulnerable to severe weather conditions such as harsh winters, late frosts, unusually cool and wet growing seasons, or drought. Climate related changes in lake levels could also affect dune habitats. However, the impact of climate change and severe weather are unknown.

Number of Locations

The Lake Huron Grasshopper occurs at 11 dune sites in Canada and is considered to occur at 8-11 locations. At the high end of the scale all 11 dune sites were considered locations. At the low end of the scale sites which were geographically distinct (adjacent along coastal habitat) and were subject to the same most serious plausible threat were grouped into locations, resulting in eight locations (Table 3). At most sites, off-road vehicle use was considered the most serious plausible threat which could rapidly affect individuals.

Great Duck Island had one site and was considered a single location as it is privately owned and isolated, with very little human use and no apparent threats. On Manitoulin Island, Carter Bay and Providence Bay both have heavy recreational use, but boardwalks have been put in place to control erosion. Unlike Providence Bay, which is a municipal park, Carter Bay is privately owned and is subject to off-road vehicle use. Therefore both Carter Bay and Providence Bay sites were considered separate locations. Dean's Bay, Lonely Bay and Square Bay sites are municipally owned shoreline subject to off-road vehicle use, and were grouped as a single location. Dominion Bay was not subject to off-road vehicle use but invasive plants were a threat, and therefore considered a separate location. Adjacent Shrigley and Portage Bay sites were also municipally owned shoreline subject to off-road vehicle and considered as one location. The Taskerville Bay site was considered a separate location as it is owned by the Nature Conservancy of Canada and therefore more protected and less subject to human disturbance. Pancake Bay on Lake Superior was also considered a separate location as it was geographically distinct and a provincial park where spotted knapweed is present.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Lake Huron Grasshopper is not protected under Canada's *Species at Risk Act* or Ontario's *Endangered Species Act*. The species is listed as Threatened in Michigan (Michigan Natural Features Inventory 2007) and Endangered in Wisconsin (Wisconsin Department of Natural Resources 2014) but is not listed under the US *Endangered Species Act*. It is not listed under the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES).

Non-Legal Status and Ranks

Nature Serve (2014) provides the following ranks:

- Global Rank: G2G3 (last reviewed 14 October 2015; Dale Schweitzer pers. comm. 2015)
- National Rank (Canada): N2 (last reviewed 14 October 2015; Colin Jones pers. comm. 2015)
- National Rank (US): N2N3 (last reviewed 14 October 2015; Dale Schweitzer pers. comm. 2015)

Subnational Ranks (S-ranks) are as follows:

- S1 (Critically Imperilled): WI (WI DNR 2015)
- S2 (Imperilled): ON (Colin Jones, pers. comm. 2015)
- S2S3 (Vulnerable): MI (Cuthrell pers. comm. 2014).

The Ontario rank was previously S1 but has been re-ranked to S2 to reflect discovery of new sites in 2014. The Michigan rank was changed from S2 to S2S3 in 2014 to reflect the recent discovery of new subpopulations (Cuthrell pers. comm. 2014).

Habitat Protection and Ownership

Habitat at Pancake Bay is in a provincial park and protected from shoreline development and off-road vehicles, but vulnerable to other recreational use and invasive plants. The Nature Conservancy of Canada owns one site at Manitoulin Island (Taskerville). Carter Bay is privately owned but development has previously been proposed at the site. Great Duck Island is also privately owned and is somewhat protected by its remote locality. The remaining Lake Huron Grasshopper habitat consists of an approximately 20 m wide strip of municipally owned shoreline, backed by privately owned lots. A beach and dune stewardship initiative on Manitoulin Island provides landowners and others with information on dune ecology and protection (Peach 2005).

Pitcher's Thistle habitat is covered by "general habitat protection" under Ontario's *Endangered Species Act* and may offer some umbrella protection to Lake Huron Grasshopper as these species share habitat at ten sites. The Great Duck Island occurrence is designated as critical habitat for Pitcher's Thistle (Parks Canada Agency 2011).

ACKNOWLEDGEMENTS

Judith Jones was invaluable in identifying dune habitats, contacting landowners, and providing local knowledge of the Manitoulin Island sites. Her help is greatly appreciated. Colin Jones (Natural Heritage Information Centre, Ontario Ministry of Natural Resources and Forestry) participated in the Manitoulin Island area surveys and conducted the Pinery, Point Farms, and Point Black surveys. Mike Jones participated in the Manitoulin Island area surveys and conducted the St. Joseph Island survey.

Ed Morris at Ontario Parks and Cara Copeland and John Grant at the Nature Conservancy of Canada granted us permission to survey lands under their jurisdiction and provided advice and other support. Wasyl Bakowsky (Natural Heritage Information Centre, Ontario Ministry of Natural Resources and Forestry) provided information on Ontario coastal dunes.

We thank Point Farms Park Superintendent Jim Peck for logistical support and Park Warden Dave Griffin for assisting with surveys. Alistair Mackenzie at Pinery Provincial Park assisted with surveys and provided logistical support. Peter Burke assisted Colin Jones with the southern Lake Huron surveys.

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Allan Harris is a biologist with over 25 years' experience in northern Ontario. He has a B.Sc. in Wildlife Biology from the University of Guelph and an M.Sc. in Biology from Lakehead University. After spending seven years as a biologist with the Ontario Ministry of Natural Resources, he co-founded Northern Bioscience, an ecological consulting company based in Thunder Bay, Ontario. Al has authored or coauthored dozens of scientific papers, technical reports, and popular articles, including COSEWIC status reports for Riverine Clubtail, Laura's Clubtail, Rapids Clubtail, Gibson's Big Sand Tiger Beetle, Northern Barrens Tiger Beetle, Powesheik Skipperling, Mormon Metalmark, Weidemeyer's Admiral, Bogbean Buckmoth, Hop-tree Borer, Georgia Basin Bog Spider, Broad-banded Forestsnail, Nahanni Aster, Crooked-stem Aster, Bluehearts, Drooping Trillium and Small-flowered Lipocarpha. Al also authored the Ontario provincial status report for woodland caribou, and has authored or coauthored national and provincial recovery strategies for vascular plants and birds.

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COLLECTIONS EXAMINED

Canadian specimens of Lake Huron Grasshopper were compiled from the Royal Ontario Museum (ROM) by Brad Hubley (collections manager) and from the Canadian National Collection (CNC) by Owen Lonsdale (collections manager). Collections from the University of Guelph were accessed through Canadensys database (University of Guelph Department of Environmental Biology 2014) (Table 1).