

COSEWIC
Assessment and Status Report

on the

Eastern Hog-nosed Snake
Heterodon platirhinos

in Canada



THREATENED
2021

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada



COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

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Previous report(s):

COSEWIC. 2007. COSEWIC assessment and update status report on the Eastern Hog-nosed Snake *Heterodon platirhinos* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. viii + 36 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC. 2001. COSEWIC assessment and status report on the Eastern Hog-nosed Snake *Heterodon platirhinos* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 23 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

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COSEWIC Assessment Summary

Assessment Summary – April 2021

Common name

Eastern Hog-nosed Snake

Scientific name

Heterodon platirhinos

Status

Threatened

Reason for designation

This large, mobile snake has a patchy distribution in southern and south-central Ontario, where it relies on habitats with sandy soils for oviposition and hibernation, and feeds mainly on toads. The population faces a suspected continuing decline in abundance, based on ongoing threats. These include road traffic mortality, road construction and expansion, urban expansion, agricultural intensification, introduced and abnormally abundant predators, and persecution. Based on recent extirpation of five subpopulations, there appear to be significant range contractions in landscapes highly modified by agriculture and urbanization in the south, as well as in more intact landscapes in the northeast, including protected areas. The magnitude of decline is uncertain because this species is more challenging to monitor than other, similarly sized snakes. However, declines are suspected to exceed 30% over the next 20 years.

Occurrence

Ontario

Status history

Designated Special Concern in April 1997. Status re-examined and designated Threatened in November 2001, November 2007 and May 2021.



COSEWIC
Executive Summary

Eastern Hog-nosed Snake
Heterodon platirhinos

Wildlife Species Description and Significance

Eastern Hog-nosed Snake is a large, stout-bodied, egg-laying snake. Its common name is derived from the upturned scale at the tip of its snout, a feature unique to hog-nosed snakes. Individuals are highly variable in colour and pattern, ranging from colourful and blotched to melanistic (very dark). When approached, this snake may flare its neck, similar to a cobra, hiss, mock strike, gape its mouth, release a strong-smelling musk, roll onto its back with mouth open and tongue extended, and sometimes even exude blood from its mouth and/or cloaca. The snake's extravagant death feigning defence provides educational value for the public and a rare opportunity to study the evolution of anti-predator behaviour.

Distribution

Eastern Hog-nosed Snake ranges from south-central Ontario southward across much of eastern United States. In Ontario, it occurs in two geographically distinct areas: the Carolinian Region in the southwest and the Great Lakes/St. Lawrence Region in the central part of the province, south of the French River and Lake Nipissing and east of Georgian Bay on the Canadian Shield.

Habitat

The preferred habitat of Eastern Hog-nosed Snake includes well-drained, loose or sandy soil, open woods, brushland, and forest edge, often in proximity to water. Climatic conditions in these habitats are typical of the eastern deciduous forest. South of Parry Sound in the Shield region to the east of Georgian Bay, it prefers open grass, sand, human-altered habitats and forest over rock, wetland, and aquatic habitats. Habitat decline and loss have occurred due to residential and urban development, agricultural practices, and recreation.

Biology

In Canada, adult snakes appear to feed almost exclusively on American and Fowler's toads. Age at maturity is estimated at 4-5 years and generation time at 6-7 years. In late June and July females excavate nests in sandy soil and lay between seven and 37 eggs; they may also nest in cavities beneath rocks or wood. Nest site fidelity is high from year to

year. In the northern portion of the species' range, females are restricted to nesting sites that provide sufficient sunlight to ensure appropriate thermal conditions for egg incubation. Eastern Hog-nosed Snake hibernates from October to April, does not exhibit communal hibernation, and either excavates its hibernation site or uses pre-existing burrows. Predators include mustelids, foxes, Raccoon, cats, Wild Turkey, owls, and other raptors.

Population Sizes and Trends

Eastern Hog-nosed Snake occurs in low densities, with recorded values in Canada ranging from 0.004 to 0.04 adults per hectare. The crude upper limit estimate of adult population size is approximately 15,000. The Ontario Natural Heritage Information Centre has ranked 24% of element occurrences (EO) of Eastern Hog-nosed Snakes in the province as extirpated and another 28% as historical or unconfirmed over the past 20 years. Since 2008, eight EOs previously designated as extant were re-classed as historical, and five EOs previously designated as historical were re-classed as extirpated. Data from two repeatedly searched sites suggest declines in abundance of more than 30% and more than 80% at those sites over the past decade. The Canadian population has likely declined in the past 20 years (3 generations) and a continuing decline is expected based on threats. Particularly notable are disappearances from the Golden Horseshoe region, extensive areas of southwestern Ontario including Point Pelee, as well as Algonquin Provincial Park. Although Eastern Hog-nosed Snake is found in the United States directly south and west of Ontario, rescue from the American population would be unlikely due to barriers to movements.

Threats and Limiting Factors

Major threats to this species include an increase in road networks and subsequent road mortality, and habitat loss and fragmentation from intensive agriculture and residential development. Other threats include collection and persecution by humans, nest predation by subsidized predators (resource availability altered by humans leading to increased predator population), and recreational activities. Limiting factors include specific dependence on sandy soils during nesting and overwintering, and preference for specific prey. Because of a reliance on toads for the bulk of the diet, declines and fluctuations in toad populations may cause a decline in the Eastern Hog-nosed Snake population. Low reproductive potential limits the ability of this species to rebound from perturbations.

Protection, Status and Ranks

Eastern Hog-nosed Snake is listed as Threatened under Schedule 1 of the *Species at Risk Act*, following COSEWIC assessment in 2007. It was also designated as Threatened by the Ontario Ministry of Natural Resources and Forestry in 2001. This species is a "Specially Protected Reptile" under the Ontario *Fish and Wildlife Conservation Act*. Eastern Hog-nosed Snake is listed at some level of peril in 14 of the 36 American states where it is found. The global status is Secure (G5); in the United States the national status is Secure (N5) and in Canada the national status is Vulnerable (N3). The IUCN Red List category for Eastern Hog-nosed Snake is Least Concern (LC).

TECHNICAL SUMMARY

Heterodon platirhinos

Eastern Hog-nosed Snake

Couleuvre à groin de l'Est

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

Demographic Information

| | |
|--|--|
| Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used) | ~6-7 yrs |
| Is there an [observed, inferred, or projected] continuing decline in number of mature individuals? | Yes, inferred and projected continuing decline based on ongoing threats (primarily road mortality) and ongoing habitat loss. |
| 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]. | Suspected reduction of >30% due to road mortality, habitat loss and other threats. |
| [Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations]. | Suspected reduction of >30% due to road mortality, habitat loss and other threats. Threats Calculator projects a 10-70% decline (Overall threat impact: High). |
| [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. | Suspected reduction of >30% due to ongoing road mortality, habitat loss and other threats. Threats Calculator projects a 10-70% decline (Overall threat impact: High). |
| Are the causes of the decline a. clearly reversible and b. understood and c. ceased? | a. No b. Yes c. No |
| Are there extreme fluctuations in number of mature individuals? | No |

Extent and Occupancy Information

| | |
|---|--|
| Estimated extent of occurrence (EEO) | 120,627 km ² |
| Index of area of occupancy (IAO) (Always report 2x2 grid value). | 3,780 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. Probably not, but the landscape is fragmented, primarily due to roads. |

| | |
|---|--|
| Number of "locations"* (use plausible range to reflect uncertainty if appropriate) | Unknown but presumed to be large (>10). Road mortality and habitat loss from human developments are probably the greatest threats, but these vary in scope and intensity throughout the range. |
| Is there an [observed, inferred, or projected] decline in extent of occurrence? | Observed decline based on comparisons of current and historical records. |
| Is there an [observed, inferred, or projected] decline in index of area of occupancy? | Observed and inferred decline based on comparisons of current and historical records. |
| Is there an [observed, inferred, or projected] decline in number of subpopulations? | Observed decline based on extirpation of 5 NHIC element occurrences (=subpopulations); timing of extirpation is uncertain. |
| Is there an [observed, inferred, or projected] decline in number of "locations"*? | Unknown |
| Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat? | Yes, observed and inferred decline in area and quality of habitat due to urban and residential expansion including new roads, expansion of existing roads, increases in traffic volumes, and agricultural expansion in some areas. |
| Are there extreme fluctuations in number of subpopulations? | No |
| Are there extreme fluctuations in number of "locations"*? | No |
| Are there extreme fluctuations in extent of occurrence? | No |
| Are there extreme fluctuations in index of area of occupancy? | No |

Number of Mature Individuals (in each subpopulation)

| Subpopulations (give plausible ranges) | N Mature Individuals |
|--|---|
| | Unknown |
| Total | Number of adults unknown, but crude estimate probably fewer than 15,000 |

Quantitative Analysis

| | |
|--|---|
| Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]? | No PVA conducted; Probability of extinction in the wild is unknown. |
|--|---|

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

Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species?

Yes. Threats call completed 2020.01.07.

Assigned Overall Threat Impact: High

Level 1 Threat impact counts: 1 med, 7 low (no range)

Key threats were identified as:

- i. Transportation and Service Corridors (4.1 – roads and railroads) – Medium threat impact
- ii. Residential and commercial development (1.1 – housing and urban areas) – Low threat impact
- iii. Agriculture and aquaculture (2.1 – annual and perennial non-timber crops; 2.2 – wood and pulp plantations) – Low threat impact
- iv. Biological resource use (5.1 – hunting and collecting terrestrial animals) - Low threat impact
- v. Human intrusions and disturbances (6.1 – recreational activities) – Low threat impact
- vi. Natural system modifications (7.1 – fire and fire suppression; 7.3 – other ecosystem modifications) - Low threat impact
- vii. Invasive and other problematic species and genes (8.1 – invasive non-native/alien species) – Low threat impact
- viii. Climate change and severe weather (11.3 – storms and flooding) – Low threat impact

What additional limiting factors are relevant?

This is a prey specialist (toads) with particular reliance on sandy soils for prey availability, hibernation, and oviposition. Low reproductive potential limits its ability to rebound from perturbations.

Rescue Effect (immigration from outside Canada)

| | |
|--|---|
| Status of outside population(s) most likely to provide immigrants to Canada. | Vulnerable (S3) in Michigan, New York, and Pennsylvania; Apparently Secure (S4) in Ohio. |
| Is immigration known or possible? | Unknown, but unlikely due to separation of Canadian range from American range by the Great Lakes and large areas of unsuitable habitat. |
| Would immigrants be adapted to survive in Canada? | Probably |
| Is there sufficient habitat for immigrants in Canada? | Unknown |
| Are conditions deteriorating in Canada?+ | Yes |
| Are conditions for the source (i.e., outside) population deteriorating?+ | Unknown |
| Is the Canadian population considered to be a sink?+ | No |
| Is rescue from outside populations likely? | No, rescue is unlikely due to separation of Canadian range from American range by the Great Lakes. |

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

Data Sensitive Species

| | |
|-----------------------------------|--|
| Is this a data sensitive species? | Yes, this species is targeted for collection by hobbyists (including illegal wildlife trade) and for intentional killing out of fear or disdain; therefore, specific location information, including hibernacula, should not be shared. [also data-restricted in ON] |
|-----------------------------------|--|

Status History:

COSEWIC:

Designated Special Concern in April 1997. Status re-examined and designated Threatened in November 2001, November 2007 and May 2021.

Status and Reasons for Designation:

| | |
|--|--|
| Status: Threatened | Alpha-numeric codes: A2cde+3cde+4cde |
| Reasons for designation: This large, mobile snake has a patchy distribution in southern and south-central Ontario, where it relies on habitats with sandy soils for oviposition and hibernation, and feeds mainly on toads. The population faces a suspected continuing decline in abundance, based on ongoing threats. These include road traffic mortality, road construction and expansion, urban expansion, agricultural intensification, introduced and abnormally abundant predators, and persecution. Based on recent extirpation of five subpopulations, there appear to be significant range contractions in landscapes highly modified by agriculture and urbanization in the south, as well as in more intact landscapes in the northeast, including protected areas. The magnitude of decline is uncertain because this species is more challenging to monitor than other, similarly sized snakes. However, declines are suspected to exceed 30% over the next 20 years. | |

Applicability of Criteria

| |
|---|
| Criterion A (Decline in Total Number of Mature Individuals): Meets Threatened, A2cde, A3cde, A4cde. A suspected >30% decline in number of mature individuals over the past (A2), within the next (A3), and over three generations (20 years) spanning the past and future (A4), based on a decline in index of area of occupancy, extent of occurrence, and quality of habitat (subcriterion c), exploitation (subcriterion d), and the effects of introduced and subsidized predators (subcriterion e). |
| Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. EOO of 120,627 km ² and IAO of 3,780 km ² both exceed thresholds. |
| Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Number of mature individuals is over 10,000, exceeding thresholds. |
| Criterion D (Very Small or Restricted Population): Not applicable. The population is neither small nor restricted. |
| Criterion E (Quantitative Analysis): Not applicable. Analysis not conducted. |

PREFACE

Since the previous status report (COSEWIC 2007), additional information is available on habitat use and movements of Eastern Hog-nosed Snake related to roads from radio-tracking studies in Canada (Robson 2011; Rouse *et al.* 2011; Peet-Paré and Blouin-Demers 2012; Robson and Blouin-Demers 2013) and the U.S. (Lagory *et al.* 2009; Goulet *et al.* 2015; Akresh *et al.* 2017; Buchanan *et al.* 2017; Vanek and Wasko 2017). Additional long-term data on abundance of Eastern Hog-nosed Snake from multi-year studies are available from two repeatedly searched sites. New information is available on population genetic structure based on microsatellite analyses (Xuereb *et al.* 2014, 2015). Expanded search effort and engagement of citizen science have yielded additional occurrences, resulting in an apparent increase in index area of occupancy, but not extent of occurrence, since the last report.



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 (2021)

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

* Formerly described as "Vulnerable" from 1990 to 1999, or "Rare" prior to 1990.
 ** Formerly described as "Not In Any Category", or "No Designation Required."
 *** Formerly described as "Indeterminate" from 1994 to 1999 or "ISIBD" (insufficient scientific information on which to base a designation) prior to 1994. Definition of the (DD) category revised in 2006.



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

COSEWIC Status Report

on the

Eastern Hog-nosed Snake *Heterodon platirhinos*

in Canada

2021

TABLE OF CONTENTS

| | |
|---|----|
| WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE | 4 |
| Name and Classification | 4 |
| Morphological Description | 4 |
| Designatable Units | 5 |
| Special Significance | 6 |
| DISTRIBUTION | 6 |
| Global Range..... | 6 |
| Canadian Range..... | 8 |
| Extent of Occurrence and Area of Occupancy..... | 9 |
| Search Effort..... | 10 |
| HABITAT..... | 11 |
| Habitat Requirements | 11 |
| Habitat Trends | 13 |
| BIOLOGY | 18 |
| Life Cycle and Reproduction..... | 18 |
| Physiology and Adaptability..... | 18 |
| Dispersal and Migration | 18 |
| Interspecific Interactions | 19 |
| POPULATION SIZES AND TRENDS | 19 |
| Sampling Effort and Methods | 19 |
| Abundance | 20 |
| Fluctuations and Trends | 21 |
| Population Fragmentation..... | 22 |
| Rescue Effect | 22 |
| THREATS AND LIMITING FACTORS | 23 |
| Threats | 23 |
| Limiting Factors | 27 |
| Number of Locations | 27 |
| PROTECTION, STATUS AND RANKS | 28 |
| Legal Protection and Status..... | 28 |
| Non-Legal Status and Ranks..... | 28 |
| Habitat Protection and Ownership | 29 |
| ACKNOWLEDGEMENTS AND AUTHORITIES CONTACTED | 31 |
| Acknowledgements | 31 |
| Authorities Contacted | 31 |

| | |
|---|----|
| INFORMATION SOURCES..... | 32 |
| BIOGRAPHICAL SUMMARY OF REPORT WRITER(S)..... | 39 |

List of Figures

| | |
|---|----|
| Figure 1. Eastern Hog-nosed Snake (<i>Heterodon platirhinos</i>) distribution in Canada. Current occurrence records are from 1998 to 2018, historical records are from prior to 1998. Occurrence records are courtesy of Ontario Reptile and Amphibian Atlas (Ontario Nature), Natural Heritage Information Centre, and the Nature Conservancy of Canada. Map prepared by Sydney Allen (COSEWIC Secretariat)..... | 5 |
| Figure 2. Global distribution of Eastern Hog-nosed Snake (<i>Heterodon platirhinos</i>). Map from IUCN based on NatureServe data from 2007. | 7 |
| Figure 3. Eastern Hog-nosed Snake (<i>Heterodon platirhinos</i>) index of area of occupancy (IAO) squares containing current (1998-2018) occurrence records only (red), historical (pre-1998) records only (black), and both current and historical records (yellow). IAO is calculated by overlaying a 2 km x 2 km grid over all occurrence records and calculating area occupied based on the number of grid cells with an occurrence record. Map prepared by Sydney Allen (COSEWIC Secretariat). . | 8 |
| Figure 4. Distribution of roads and 2 km x 2 km occupancy squares for Eastern Hog-nosed Snake (<i>Heterodon platirhinos</i>) in northern (a) and southern halves (b) of the Canadian species range. Map prepared by Sydney Allen (COSEWIC Secretariat)..... | 16 |
| Figure 5. Human footprint analysis of Georgian Bay region showing cumulative impacts of human influence (i.e., threats) on the landscape (from ECCC 2017; permission granted to reproduce)..... | 17 |

List of Tables

| | |
|--|----|
| Table 1. Comparison of Extent of Occurrence and Index Area of Occupancy for Eastern Hog-nosed Snakes in Canada..... | 9 |
| Table 2. Summary of targeted search effort for Eastern Hog-nosed Snakes in Canada | 10 |
| Table 3. List of protected areas with occurrence records of Eastern Hog-nosed Snake. Historical records are prior to 1998, current records are 1998-2018; if 'Current' is in bold, there were no records prior to 1998. | 29 |

List of Appendices

| | |
|--|----|
| Appendix 1. Threats Calculator results for Eastern Hog-nosed Snake (<i>Heterodon platirhinos</i>)..... | 40 |
|--|----|

WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Eastern Hog-nosed Snake (*Heterodon platirhinos* Latreille 1801; family Colubridae) is one of five North American Hog-nosed Snakes in the genus *Heterodon* (Crother *et al.* 2017). Its common name is derived from the upturned, keeled scale on the tip of its snout, which gives the snake its unique “hog-nosed” appearance (Johnson 1989). The French common name is Couleuvre à groin de l’Est (Green 2012).

Morphological Description

Eastern Hog-nosed Snake (see Cover photo) is stout-bodied, with keeled scales, a divided anal plate, and a distinctive upturned keeled scale at the tip of its snout (Harding 1997). Diagnostic dark neck blotches are present and visible in all but the darkest individuals, most notably when the neck is flared.

Adults are highly variable in colour and pattern, ranging from colourful and blotched to melanistic. Individuals from Parry Sound District have been described as duller and not as well marked as individuals in more southern parts of Ontario (Rowell 2012). Some individuals have a distinctive pattern of 20 to 30 irregular blotches dorsally, alternating with dark spots along the side, on a background of grey, brown, tan, olive, red, orange, yellow, or pink; others lack all patterning and are typically plain grey, brown, olive, or black, whereas many individuals are intermediate in pattern (Harding 1997; Rowell 2012). The underside is often mottled and can be yellowish, grey, cream, or pinkish (Harding 1997). Total length of adults ranges from 40 to 116 cm (Harding 1997; Rowell 2012).

Juveniles have dark dorsal and smaller lateral blotches on a light grey or brown background. This pattern is present even in individuals that become unpatterned and unicoloured as adults. The belly of juveniles is dark grey or black and the throat and subcaudal scales are white or yellowish (Harding 1997). Length of young at hatching ranges from 16 to 25 cm (Conant 1978).

Population Spatial Structure and Variability

No subspecies of Eastern Hog-nosed Snake are currently recognized (Crother *et al.* 2017). Habitat areas of Eastern Hog-nosed Snakes in Ontario are small and fragmented, and they could harbour genetically isolated populations susceptible to inbreeding and/or genetic bottlenecks (COSEWIC 2007). Xuereb *et al.* (2014) developed microsatellite markers for Eastern Hog-nosed Snake to assess genetic diversity and quantify spatial structuring of the species in Ontario. Distinct genetic clusters were found in Wasaga Beach, Georgian Bay/Shield, and Long Point/Norfolk county, with a fourth cluster comprising individuals from Pinery and Rondeau provincial parks (Xuereb *et al.* 2015). Snakes distributed over a large area of relatively continuous habitat in the Shield region east of Georgian Bay were genetically similar (Xuereb *et al.* 2015). Genetic data from each of these four Ontario subpopulations revealed evidence of inbreeding and population declines

over time. In addition, using an Approximate Bayesian Computation approach, it was estimated that a bottleneck occurred in the Wasaga Beach subpopulation approximately 117 years ago (95% CI 32.5-162.6 years) (Xuereb *et al.* 2015).

Designatable Units

COSEWIC guidelines state that populations must be both discrete and evolutionarily significant in order to be considered separate designatable units. The distribution of Eastern Hog-nosed Snake in Ontario comprises two ecologically distinct regions (see **DISTRIBUTION**) located in separate Terrestrial Amphibians and Reptiles Faunal Provinces (Carolinian and Hurontario) (Figure 3 in Appendix F5 of COSEWIC Operations and Procedures Manual 2019). Disjunct distributions corresponding to the two faunal provinces occur in several other reptile species in Ontario, including Gray Ratsnake (*Elaphe spiloides*) and Five-lined Skink (*Plestiodon fasciatus*) (Cook 1984), but the distribution of Eastern Hog-nosed Snake is less disjunct than those of other species, particularly when historical records are incorporated (Figure 1).

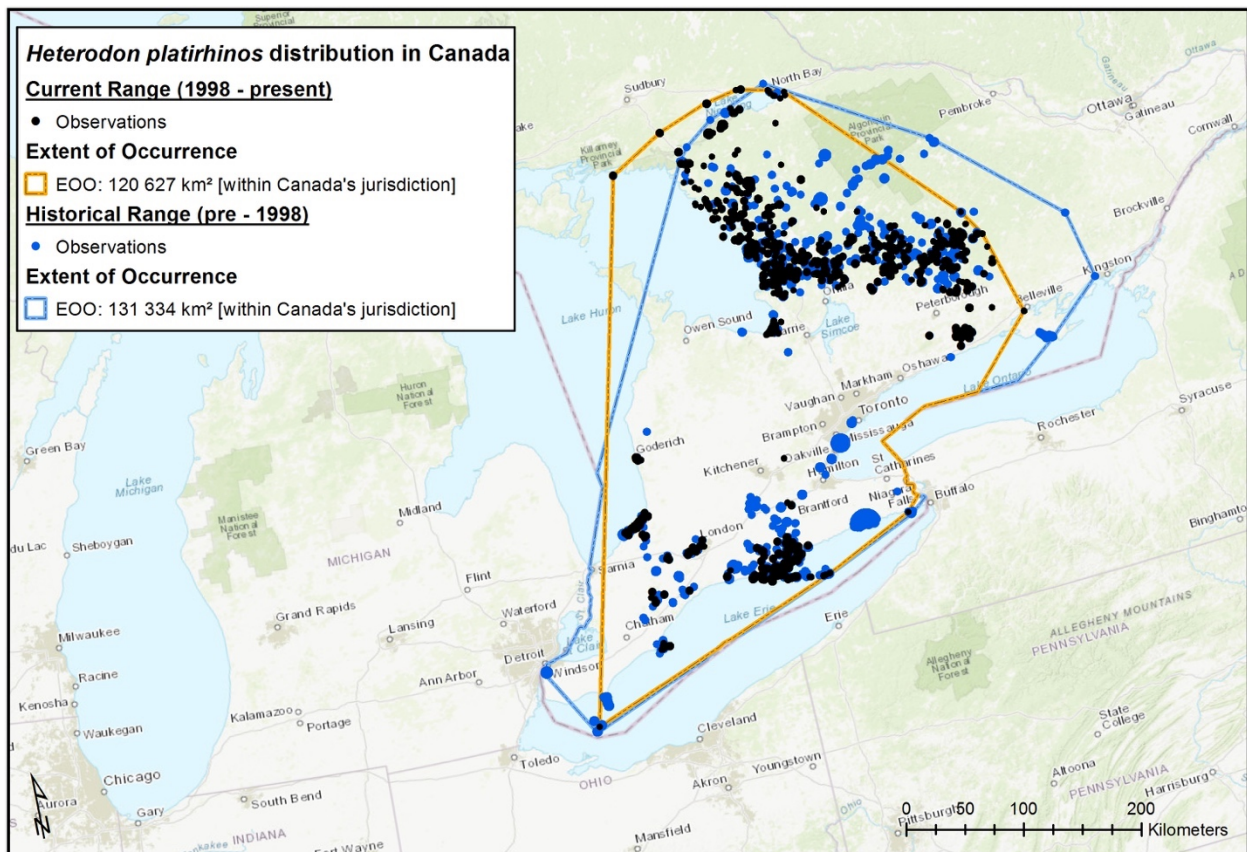


Figure 1. Eastern Hog-nosed Snake (*Heterodon platirhinos*) distribution in Canada. Current occurrence records are from 1998 to 2018, historical records are from prior to 1998. Occurrence records are courtesy of Ontario Reptile and Amphibian Atlas (Ontario Nature), Natural Heritage Information Centre, and the Nature Conservancy of Canada. Map prepared by Sydney Allen (COSEWIC Secretariat).

Genetic data from 12 microsatellite DNA markers support distinction of the Hurontario (Shield) region but also contain evidence for three additional genetically distinct clusters in Ontario (Wasaga Beach, Long Point/Norfolk county, and Pinery and Rondeau Provincial Parks) (Xuereb *et al.* 2015; see **Population Spatial Structure and Variability**). These genetic clusters provide evidence of population fragmentation and discreteness but do not provide sufficient evidence of evolutionary significance between the two regions. It is unknown whether this disjunction in Eastern Hog-nosed Snake distribution is related to European settlement or whether it predates that time and reflects deeper phylogeographic history. There is some evidence of slight differences in colouration between regions, but no other evidence of differences in morphology. There is also limited evidence for differences in habitat use between regions (see **HABITAT**), although at the landscape level the species is a habitat generalist and will use a wide variety of open and semi-open habitats. There have been few studies in the Shield region, and additional work is needed to assess differences in morphology, habitat use, or life history characteristics between the two regions.

At present, more than one designatable unit is not defensible: historical records do not show a disjunction in distribution; microsatellite DNA data do not support a two-designatable unit approach based on eco-geographic regions (as applied to other Ontario reptiles) nor do they provide sufficient evidence for evolutionary significance among distinct clusters. Thus, it seems reasonable at present to continue to consider Eastern Hog-nosed Snake as a single designatable unit, though this may change in future.

Special Significance

Eastern Hog-nosed Snake is of scientific interest and ecologically important. It feeds almost exclusively on toads, which are toxic to most predators. This feeding strategy thus provides an excellent opportunity to study metabolism and digestion. The snake's elaborate defence displays, including death feigning, also provide a rare opportunity to study evolution of anti-predator behaviour and make the species of educational value to the public.

DISTRIBUTION

Global Range

Eastern Hog-nosed Snake occurs in eastern Canada and United States (Figure 2). Its range extends from Ontario to the Gulf Coast and southern Florida, and from the Atlantic Coast west to parts of Texas, Oklahoma, Kansas, and Nebraska. In the United States, it is found in 34 states and the District of Columbia.



Figure 2. Global distribution of Eastern Hog-nosed Snake (*Heterodon platirhinos*). Map from IUCN based on NatureServe data from 2007.

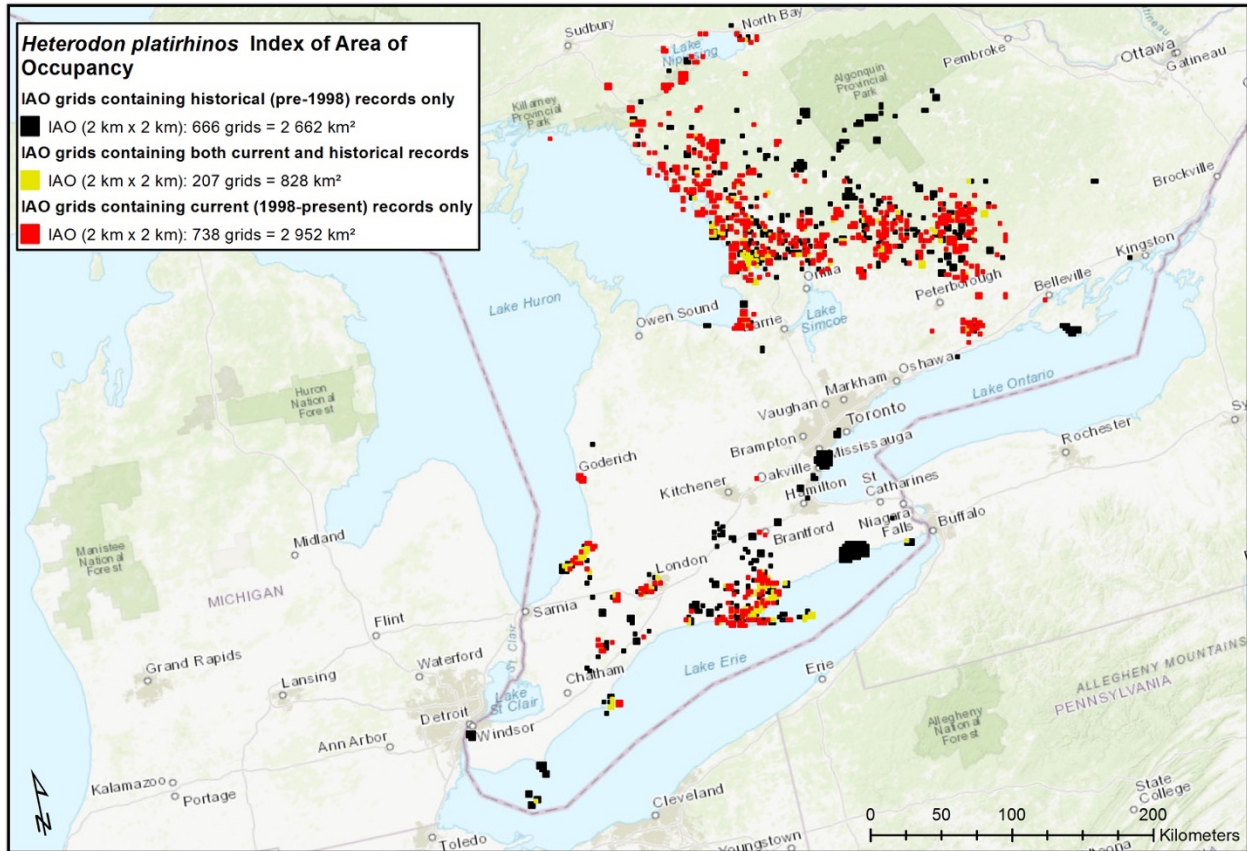


Figure 3. Eastern Hog-nosed Snake (*Heterodon platirhinos*) index of area of occupancy (IAO) squares containing current (1998-2018) occurrence records only (red), historical (pre-1998) records only (black), and both current and historical records (yellow). IAO is calculated by overlaying a 2 km x 2 km grid over all occurrence records and calculating area occupied based on the number of grid cells with an occurrence record. Map prepared by Sydney Allen (COSEWIC Secretariat).

Canadian Range

Less than 10% of the global range of Eastern Hog-nosed Snake is in Canada, where it is presently restricted to two geographically distinct areas: the Carolinian Region of southwestern Ontario and the Shield region of central Ontario south of the French River and Lake Nipissing and east of Georgian Bay (Figure 1). It is absent from the St. Lawrence drainage (eastern Ontario and most of New York State). The northern limit of its range corresponds approximately to a 120-day frost-free period or to areas with greater than 2100 Annual Crop Heat Units. The species extends farther north into slightly cooler areas where there are sandy, exposed, south-facing slopes with warmer soil conditions for incubation, which probably determine northern range limits (Brooks *et al.* 2003).

Occurrence records for Eastern Hog-nosed Snake indicate areas where the species has not been recorded within the past 20 years. There are no current records (from 1998 to the present) in the Golden Horseshoe region around the west end of Lake Ontario, or in extensive areas of southwestern Ontario including Point Pelee (Figures 1, 3). On Pelee

Island, despite multiple historical records, there is only a single current (2001) record of a road-killed snake. It is likely extirpated from Algonquin Provincial Park, where it has not been recorded since 1984. The occurrence records also indicate areas where Eastern Hog-nosed Snake was either not found historically or was infrequently recorded. For example, there are multiple current occurrence records around Lake Nipissing near the northern limit of the range, and north of Goderich, where this species was first reported in 2011 (Figure 1). These occurrences most likely reflect increased search effort rather than an expanding range in Canada.

Extent of Occurrence and Area of Occupancy

The current extent of occurrence (EOO) for Eastern Hog-nosed Snake within Canada’s jurisdiction is 120,627 km². This was calculated from a minimum convex polygon around all current occurrence records from 1998 to 2018, eliminating any areas outside of Canada’s jurisdiction (Figure 1). The comparable calculation of EOO from historical records (pre-1998) is 131,334 km² (Figure 1). However, it is likely that current locations that lack historical records were occupied historically, due to dramatic increases in current sampling effort and relative proximity of all new current records to historical ones. In light of this, calculation of historical EOO based on all records (current and historical) is probably more accurate; such a measurement yields a probable historical EOO of 142,798 km². Based on that estimate, the present EOO represents a 15.5% decrease in size from the historical EOO (Table 1).

Table 1. Comparison of extent of occurrence and index of area of occupancy for Eastern Hog-nosed Snakes in Canada.

| Metric | Historical (pre-1998) | Current (1998-2018) | All records (up to 2018) | Difference between all records and current ** |
|-------------------------------|-------------------------------------|-------------------------------------|-------------------------------------|---|
| Extent of Occurrence (EOO) | 131,334 km ² | 120,627 km ² | 142,798 km ² | -15.5% |
| Index Area of Occupancy (IAO) | 3,492 km ² (873 grids) * | 3,780 km ² (945 grids) * | 6,444 km ² (1,611 grids) | -41% |

* Includes 207 grid squares in which snakes were recorded both historically and currently. These are shown separately in Figure 3.

** It is assumed that current locations that lack historical records were occupied historically, due to dramatic increases in current sampling effort and proximity of all new current records to historical ones; therefore, ‘all records’ better define actual historical IAO and EOO.

The current index of area of occupancy (IAO) for Eastern Hog-nosed Snake is 3,780 km², calculated as the area covered by 2 x 2 km grid cells overlaid onto all current (1998-2018) occurrence records. The historical index of area of occupancy (IAO), based only on pre-1998 records, was 3,492 km², suggesting an 8% increase from historical to current IAO. However, as outlined above for EOO, a more accurate calculation of historical IAO, which presumes that all squares presently inhabited were also historically inhabited, should be based on all records (current and historical). Such a measurement yields a probable historical IAO of 6,444 km², based on a total of 1,611 grid cells with occurrence records

(666 cells with historical records only, 207 cells with both current and historical records, and 738 cells with current records only (Figure 3)). From that estimate, the present IAO represents a putative 41% decrease in size from the historical IAO (Table 1). However, it is likely that many historical sites have not been re-sampled recently (i.e., in the past 20 years), especially in the Shield. In addition, even when sites are resampled, the species can remain undetected, given its low detectability. As such, while a decline has most likely occurred, the magnitude of the decline remains uncertain. Additionally, an estimate of actual IAO should be based on the most limiting habitat (such as hibernacula), but this information is unavailable; hence all of the above IAO values are likely overestimates of the true value.

Search Effort

Search effort for Eastern Hog-nosed Snakes in Canada has been sporadic, and many occurrence records are the result of opportunistic encounters. Reporting of all herpetofauna, including Eastern Hog-nosed Snake, has increased dramatically in recent years with citizen science atlas initiatives (e.g., Ontario Reptile and Amphibian Atlas (<https://ontarionature.org/tag/atlas/>)). For example, there have been 3,400 occurrence records of Eastern Hog-nosed Snake submitted to the Natural Heritage Information Centre (NHIC) since 2008 (Government of Ontario 2017), comprising over 60% of all records for the species in the NHIC database. However, Eastern Hog-nosed Snake is cryptic, and several researchers working on this species have commented that it is especially difficult to find compared to other snake species (Cunnington, Maddalena, Rouse pers. comms. 2019).

Areas that have been checked for Eastern Hog-nosed Snakes (in some cases on an annual basis) include Long Point Provincial Park and National Wildlife Area, an area 30 km south of Parry Sound bisected by the Hwy 400 extension, Rondeau Provincial Park, St. Williams Conservation Reserve, Trent-Severn Waterway, Wasaga Beach Provincial Park, Beausoleil Island and Georgian Bay Islands National Park, the Upper Thames River Watershed including Komoka Provincial Park, and an area north of Goderich (Table 2). Two multi-year mark-recapture studies have occurred in Wasaga Beach Provincial Park, in 2001-2005 and in 2015-2017 (Cunnington pers. comm. 2019), enabling an estimate of subpopulation size in Wasaga Beach Provincial Park.

Table 2. Summary of targeted search effort for Eastern Hog-nosed Snakes in Canada.

| Year range | Locality | Methods | Source |
|-------------------------|--|---|-------------------------------|
| 1996-1999; 2003-2004 | Long Point Provincial Park and National Wildlife Area | Annual visual search | Gillingwater pers. comm. 2019 |
| 1996-1999; 2000-2001 | Rondeau Provincial Park | Annual visual search | Gillingwater pers. comm. 2019 |
| 1996-2020 | St. Williams Conservation Reserve | Annual visual search, and mark-recapture using passive integrated tags (PIT) | Gillingwater pers. comm. 2019 |
| 2001-2005; 2015-2017 | Wasaga Beach Provincial Park | Mark-recapture studies | Cunnington pers. comm. 2019 |

| Year range | Locality | Methods | Source |
|------------|---|--|---|
| 2003-2005 | 30 km south of Parry Sound on either side of Hwy 400 extension | Radio-telemetry tracking study | Rouse 2006; Rouse <i>et al.</i> 2011 |
| 2005 | Trent-Severn Waterway | Visual search of 32 NHIC element occurrences | Cunnington pers. comm. 2019; surveys conducted through Parks Canada |
| 2009-2019 | Beausoleil Island and Georgian Bay Islands National Park | Annual visual search on May long weekend | Crowley pers. comm. 2018 |
| 2018-2019 | Area north of Goderich | Radio-telemetry tracking study | Maddalena 2019; Maddalena pers. comm. 2019 |
| 2019 | Upper Thames River Watershed (including Komoka Provincial Park) | Mark-recapture using passive integrated tags (PIT) | Gillingwater pers. comm. 2019 |

During summer 2005, a dedicated survey near the Trent-Severn Waterway was conducted by Parks Canada using 4-5 people experienced with searching for Eastern Hog-nosed Snakes; they visited a total of 32 previously identified sites (element occurrences) from the NHIC database (Table 2). No Eastern Hog-nosed Snakes were found but seven of the 32 element occurrences were described as good habitat. The remaining were in habitat deemed poor to fair (Cunnington pers. comm. 2019). Annual surveys during the May long weekend have been conducted on Beausoleil Island in Georgian Bay Islands National Park since 2009 (Crowley pers. comm. 2018). The species appears to be widely distributed and relatively abundant across the northern half of Beausoleil Island where surveys have occurred. Occurrence of Eastern Hog-nosed Snake north of Goderich was first reported in 2011. In 2017, researchers surveyed local residents in Goderich and collected 50 new observations of this species, and in 2018 a radio-telemetry tracking study tracked 10 individuals (Maddalena 2019), with tracking continuing in this area in 2019 (Maddalena pers. comm. 2019). Over the past two decades, Eastern Hog-nosed Snakes have occasionally been observed during surveys for turtles and snakes on islands and on the mainland in the area of Twelve Mile Bay, south of MacTier (COSEWIC 2007). Many areas in Norfolk County are also sporadically, but usually annually, searched by naturalists and herpetologists for species at risk, including Eastern Hog-nosed Snake.

HABITAT

Habitat Requirements

Eastern Hog-nosed Snakes use a variety of forested and open habitats. At a landscape level, early descriptions of Eastern Hog-nosed Snake habitat in the eastern United States describe six features that define their preferred habitat: well-drained soil, loose or sandy soil, open vegetative cover such as open woods, brushland or forest edge, proximity to water, and climatic conditions typical of the eastern deciduous forest biome (Platt 1969). More recent telemetry studies in New York (Vanek and Wasko 2017), Massachusetts (Buchanan *et al.* 2017) and New Hampshire (Lagory *et al.* 2009) have generally confirmed these xeric habitat preferences, identifying the importance of open old field and edge habitat with densely vegetated microhabitats, and sandy loam soil. A follow-up study at the New Hampshire study site found that snake activity sites were associated

with higher ground-surface temperatures, closer proximity to wetlands, less canopy closure, and more abundant shrubs, ground debris and rock cover (Goulet *et al.* 2015).

In Canada, habitat preferences of Eastern Hog-nosed Snakes at a landscape level include open canopy habitats with sandy soils. Habitat suitability modelling at the landscape scale indicated a positive relationship with forest density and a negative relationship with crop density (Thomasson and Blouin-Demers 2015). In two areas in the Long Point area in southern Ontario, sand dunes, tree plantation, and human altered habitat (i.e., roads, edges of agricultural fields, and residential areas) were used more frequently than denser canopy forests (Robson 2011). At Wasaga Beach Provincial Park in Ontario Eastern Hog-nosed Snake preferred forested habitat as well as wetlands adjacent to conifer plantations; meadows and areas currently used by people (e.g., urban, agricultural) were the least suitable (Cunnington 2004b). Eastern Hog-nosed Snake on the Canadian Shield south of Parry Sound in Ontario preferred meadow, sand, and forest habitats over rock, wetland, human-impacted areas (i.e., private dwellings, trailer parks, sand/gravel pits), and aquatic habitats (Rouse 2006). At Long Point National Wildlife Area and Rondeau Provincial Park, Eastern Hog-nosed Snakes were most commonly encountered in barrier dune and beach habitat with dune grasses and driftwood; this coincided with habitat most commonly used by Fowler's Toad (*Anaxyrus fowleri*), one of their primary prey species (Gillingwater pers. comm. 2019). Within Komoka Provincial Park, both meadow and open woodland habitat were used, with a number of juveniles found within an adjacent private property along the edge of south facing buildings (Gillingwater pers. comm. 2019). Juveniles in Norfolk and Middlesex Counties appear to consistently use the same habitat as adults, including cover and thermoregulation sites (Gillingwater pers. comm. 2019). Also, juveniles at Rondeau Provincial Park use the same cover material as adults soon after hatching (Gillingwater pers. comm. 2020).

Microhabitat preferences by Eastern Hog-nosed Snake appear to be primarily explained by thermoregulation. For example, on Beausoleil Island, Eastern Hog-nosed Snake is regularly encountered basking in rock outcrops, forest clearings and edges, and along shorelines of lakes and wetlands. (Crowley pers. comm. 2019). Sand dunes, tree plantations, and human altered habitat provide areas for basking within edge habitat in the Long Point Area (Robson 2011). Within St. William's Conservation Reserve, the species was found most commonly along grass-covered dune edges, sparsely and heavily vegetated sandy meadow and forest edge habitat, and a large number of animals have been found along exposed tree stumps and fallen trees in meadow habitat (Gillingwater pers. comm. 2019).

As Eastern Hog-nosed Snake is a prey specialist on toads (see **BIOLOGY**), it is important to consider the habitat requirements of both American Toad (*Anaxyrus americanus*) and Fowler's Toad. American Toad is found in a wide variety of terrestrial habitats from mown grass to dense forests, and breeds in shallow ponds, streams and along river margins (Ontario Nature 2019). The most recent report from the Great Lakes Marsh Monitoring program indicates a stable trend of occurrence of American Toad within the Great Lakes basin (Tozer 2013).

Fowler's Toad is listed as Endangered in Canada, and is now restricted to Rondeau Provincial Park, Long Point National Wildlife Area, and the north shore of Lake Erie from Long Point to Fort Erie (Niagara) (COSEWIC 2010). Fowler's Toad occurs along the Lake Erie shoreline in areas with sandy soils or sand dunes, sandy beaches, sandy deciduous woodland and rocky areas with little vegetation (COSEWIC 2010). Eastern Hog-nosed Snake in shoreline areas such as Rondeau Provincial Park and Long Point National Wildlife Area uses beach and dune habitat, and often relies on driftwood and other ground cover in these habitat types, where Fowler's Toad is also found (Gillingwater and Piraino 2004).

Eastern Hog-nosed Snakes probably do not hibernate communally. They may excavate their hibernation site or use pre-made sites such as burrows (Plummer 2002). It is unclear whether they exhibit hibernation site fidelity. In one Ontario study within the Blueberry Plains of Wasaga Beach Provincial Park, the species hibernated from October to April (Cunnington 2004a). Near Goderich, three snakes were tracked to their hibernacula in beach and bluff habitat (Maddalena 2019). Hibernacula are difficult to locate because, unlike other snake species, individuals often do not remain near their hibernation site after emerging in spring (Rouse pers. comm. 2019).

Female Eastern Hog-nosed Snake excavates and lays eggs in nests 7-20 cm below the surface in sandy soil (Platt 1969; Cunnington and Cebek 2005; Peet-Paré and Blouin-Demers 2012), or under driftwood that is partially buried in sand (Gillingwater pers. comm. 2020). Eastern Hog-nosed Snake on the Canadian Shield sometimes lays eggs in sandy nests but has also been observed nesting in cavities under rocks (Rouse pers. comm. 2019). Nest site fidelity is high, with females frequently returning to the same nest site used in previous years (Cunnington and Cebek 2005; Robson 2011). Communal nesting has been reported in Wasaga Beach Provincial Park (Cunnington and Cebek 2005) and Norfolk County (Crowley pers. comm. 2019), Komoka Provincial Park, and close proximity of nests found near Goderich suggests a communal nesting site (Maddalena 2019). Sites were generally on a south-facing hill in relatively small, open, sandy areas (approximately 1 m x 1 m), in an otherwise grass-covered area (Gillingwater 2018). Communal nesting in snakes may result from limited availability of suitable sites and be cued by conspecific scents (Magnusson and Lima 1984). In Wasaga Beach Provincial Park only 1.3% of the total available area was deemed suitable oviposition habitat (Cunnington pers. comm. 2019). In another case, in which an old agricultural field in South Walsingham was re-tilled, potentially as many as 20 Eastern Hog-nosed Snakes nested over the span of two days in June 2006 (COSEWIC 2007), apparently attracted by freshly tilled sandy soil.

Habitat Trends

Much of the habitat of Eastern Hog-nosed Snake in southern Ontario has been lost, damaged or fragmented by land alteration linked to farming and urban sprawl (Snell 1987; Bakowsky and Riley 1992). The well-drained, sandy soils preferred by Eastern Hog-nosed Snake in most of its range are also favourable for farming (Armason 2001; COSEWIC 2007) and beach/water-related recreation (e.g., Wasaga Beach Provincial Park). Sandy loam soils were easiest to clear and preferred for agriculture (Armason 2001; COSEWIC 2007); intensive agriculture is the land use with the strongest link to species' endangerment

in Ontario (Kerr and Cihlar 2004). Hence, Eastern Hog-nosed Snake has lost many of the habitats that are key to its survival.

In Point Pelee National Park where Eastern Hog-nosed Snake formerly occurred, there has been a loss of open terrestrial habitats, such as savannahs and meadows, and an increase in forests with closed canopies, as well as an expansion of invasive Common Reed (*Phragmites australis*) (Markle *et al.* 2018). The loss of open terrestrial habitats may have reduced important thermoregulation habitats (Markle *et al.* 2018) for Eastern Hog-nosed Snake. Availability of cover objects also decreased due to the decline in treed and shrubby sand dunes (Hecnar and Hecnar 2011).

Along Long Point, a 38 km long sandspit that extends into Lake Erie, the landscape has been altered by fluctuating lake levels and strong storm events, as well as by the dramatic increase in *P. australis* since the mid-1990s (Wilcox *et al.* 2003; Gillingwater pers. comm. 2019; Long Point Phragmites Action Alliance n.d.). These changes have altered the landscape such that former snake foraging grounds are no longer available, thermoregulation habitat has been lost, movement corridors have been altered, and breeding habitat for Fowler's Toads has been substantially reduced. Additionally, increasingly high water-levels in Lake Erie between 2014 and 2020 have flooded out areas previously used by Eastern Hog-nosed Snake, American Toad, and Fowler's Toad. High water levels along Long Point also further extend the reach of *P. australis*, as new shallow water areas are created within interior portions of the point. Between ongoing beach erosion, increasing lake water levels and large-scale invasion of *P. australis*, the Long Point National Wildlife Area and adjacent properties (Long Point Company property, Ontario Ministry of Natural Resources and Forestry (OMNRF) property, Ministry of Transportation property and Long Point Provincial Park) have increasingly been impacted by habitat alteration, fragmentation, and loss. No formal studies have targeted Eastern Hog-nosed Snakes at Long Point, although based on life history, known habitat availability and changes to the landscape, it is likely that snakes are being negatively impacted. Similar changes due to lake levels and expansion of *P. australis* are occurring along the south shore of Lake Huron between Grand Bend and Sarnia (Gillingwater pers. comm. 2019).

Continuing disturbance/destruction of habitat is occurring within the St. William's Conservation Reserve in Norfolk County due to non-native plant species and off-road vehicle use. The most frequently used areas of habitat are consistently disturbed from ATV and dirt bikes. Conservation officers have been trying to limit off-road vehicle use in protected areas, although the problem is difficult to enforce. Natural succession is also causing a reduction in open habitat, with trees and shrubs encroaching over open meadow and dune habitat, and canopy cover within the forested areas is increasing. Ongoing efforts to manage the reserve are helping, with non-native plant removal, and tree removal being conducted to open up the site (Gillingwater 2018).

Within the southern portion of the Upper Thames River Conservation Authority, increased residential development in rural areas and rapid urban expansion between the City of London, Komoka, and Delaware have resulted in a decline in Eastern Hog-nosed Snake habitat availability and quality. Increased development has also resulted in an

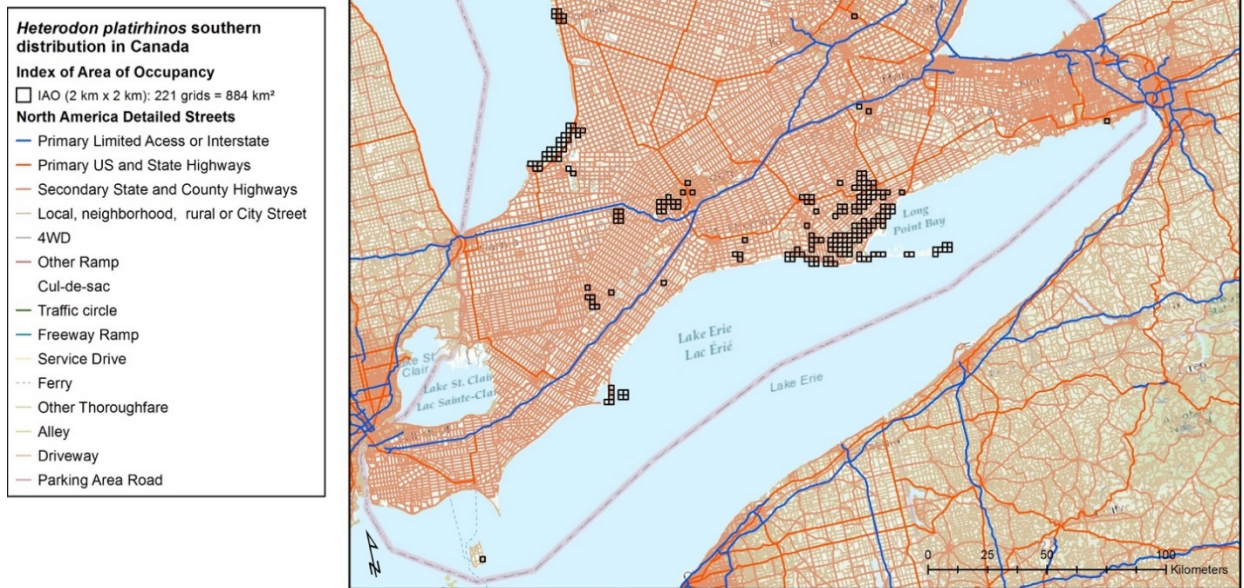
increase in human presence in natural areas, and an increase of roads and vehicles in current and former snake habitat (Gillingwater pers. comm. 2020).

In the northern portion of its range, on the Canadian Shield (Parry Sound District and surrounding area, near the Muskokas), the upland habitat preferred by Eastern Hog-nosed Snake is being altered and fragmented as cottages and the associated network of access roads are built, although available habitat has not changed significantly in the last 10 years (Rouse pers. comm. 2019). Much of the southern coast of Georgian Bay is covered in cottages, and roads to service these structures continue to proliferate (COSEWIC 2007; Rouse pers. comm. 2019; Figure 4a). Much of the area surrounding Wasaga Beach Provincial Park has been urbanized and is no longer suitable habitat for the snake. Although the park contains only a single road, much of the park is bounded by roads; the small size of the park (smaller than the home range of individual snakes), and intensive use of the surrounding area, means that snakes are either killed on roads or are confined to the park (Cunnington 2003). The extent of habitat available in the park has changed little in the last 10 years; however, a study from 2015-2017 found that snakes were only occupying 340 ha, an 80% reduction in area occupied in the park compared to the previous study from 2001 to 2005 (Cunnington pers. comm. 2019).

Although Eastern Hog-nosed Snake has been found north to French River (Figure 1), most current occurrence records in the Shield region occur across the southern third of the area (Figure 1). This region is undergoing rapid development and has perhaps the highest rate and density of recreational development and activity on the Canadian Shield (Figure 5). Indeed, the Wasaga/Port Severn area in Simcoe County appears to be a stronghold for Eastern Hog-nosed Snake, so it is noteworthy that the town of Wasaga is currently one of the fastest growing communities in Ontario and witnessed a 13% growth between 2015-2019 (McSweeney 2020).

Natural habitat in southern Ontario is more fragmented than any region of comparable size in the Great Lakes Basin (Riley and Mohr 1994; Larson *et al.* 1999), and this fragmentation is accentuated by the high density of roads (Forman *et al.* 2003; Figure 4b). Road density in the Canadian Shield region occupied by the Eastern Hog-nosed Snake is lower than in more southern regions of Ontario (Taylor *et al.* 2001; Figure 4) but has been accelerated by the expansion of Highway 69 from a 2-lane highway to a divided 4-lane highway through the Shield region north to Parry Sound. Different segments of Highway 69 opened to four lanes of traffic between 2012 and 2017. While some sections of this highway are still two lanes, the divided highway now extends through to the species' northern limit (Ontario Government Notice of Study Completion and Filing of Design and Construction Report, June 19, 2007). Road mortality mitigation strategies are becoming standard for large transportation infrastructure projects in Ontario; however, a before-after-control-impact study (BACI design) on Highway 69 found that reptile abundance on the road was higher after mitigation measures were implemented and there was limited use of the ecopassages (Baxter-Gilbert *et al.* 2015).

a.



b.

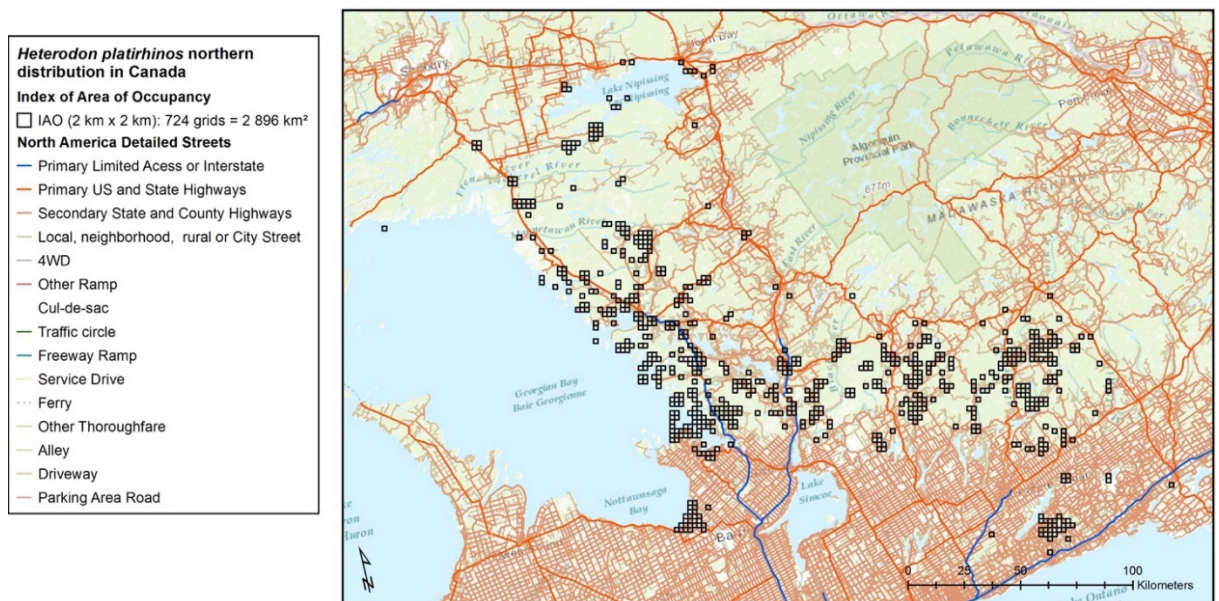


Figure 4. Distribution of roads and 2 km x 2 km occupancy squares for Eastern Hog-nosed Snake (*Heterodon platirhinos*) in northern (a) and southern halves (b) of the Canadian species range. Map prepared by Sydney Allen (COSEWIC Secretariat).

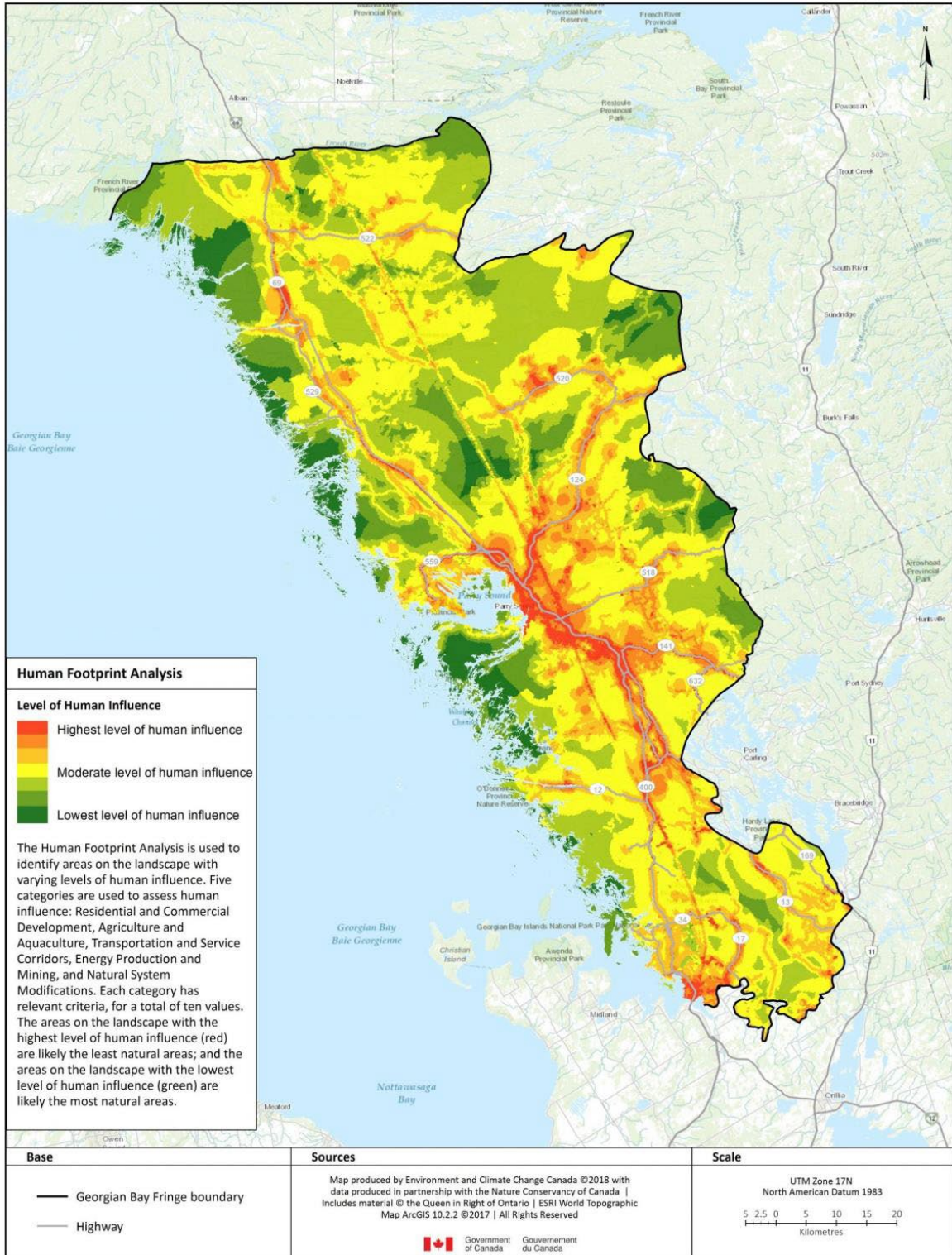


Figure 5. Human footprint analysis of Georgian Bay region showing cumulative impacts of human influence (i.e., threats) on the landscape (from ECCC 2017; permission granted to reproduce).

BIOLOGY

Life Cycle and Reproduction

Age at maturity for Eastern Hog-nosed Snake is 2-3 years of age in the United States, and snakes can live to 11 years in captivity (Harding 1997). In the northern portion of this species' range, age at maturity for snakes may be as high as 4-5 years (Seburn 2008). Adult survival in Arkansas has been estimated at ~50% (Plummer and Mills 2000). Generation time (GT) can be estimated as $GT = \text{age 50\% maturity} + 1/M$ where $M = \text{natural mortality rate}$. Thus, $GT = 4.5 + 1/0.50 = 6.5$ years.

Eastern Hog-nosed Snake is oviparous; oviposition can occur anytime during a 2-3 week period beginning in late June-early July, with young snakes emerging from nests in August-September (Cunnington and Cebek 2005; Buchanan 2012; Rouse pers. comm. 2019). In one study (Cunnington and Cebek 2005) incubation periods varied from 49 to 63 days, with highly variable temperatures within some individual nests.

Clutch size in the wild in Ontario averages around 27 eggs per nest, ranging between 7 and 40 eggs (Cunnington and Cebek 2005; Peet-Paré and Blouin-Demers 2012; Gillingwater pers. comm. 2019; Rouse pers. comm. 2019). In Ontario, the only study published to date reported hatching success of 33.3%, 57.1%, and 74.1% in three nests in the wild (Cunnington and Cebek 2005). Average number of days to hatching of nests in the wild is 58 (n=3); hatching occurs in late August and early September (Cunnington and Cebek 2005). No data are available on post-hatching and juvenile survival, but limited data on adult survival suggest an annualized rate of ~50% (Plummer and Mills 2000).

Physiology and Adaptability

In an early-successional sand-dune ecosystem on the Cape Cod National Seashore of southeastern Massachusetts, average snake body temperature was 27.9°C with a range of 5.5-39.5°C (Buchanan *et al.* 2016). At the northern range limit, access to microsites with sufficient heat for thermoregulation and incubation is critical. Anatomical and physiological features, including large gape and enlarged adrenal glands, likely reflect the degree to which Eastern Hog-nosed Snake has become relatively specialized and reliant on toads as prey (Spaur and Smith 1971). This specialization may limit its adaptability to environmental changes that impact either it or its prey, particularly at the edge of the species' range.

Dispersal and Migration

Eastern Hog-nosed Snake is highly vagile and moves relatively long distances, albeit slowly, when compared to other large snakes. Average daily distance moved by adult Eastern Hog-nosed Snake was estimated at 30 m/day in Massachusetts (Buchanan *et al.* 2017) and 51 m/day in New Hampshire (Lagory *et al.* 2009), and daily movements of 100 m are known to occur (Cunnington 2004b). The maximum straight-line distance moved over an active season approaches 5 km (Rouse 2006). Adult males have been found to be more vagile than adult females during the mating season (Rouse *et al.* 2011). However,

reproductive females make substantial movements as they seek appropriate conditions for nesting, and make large movements (as large as 250 m) immediately following oviposition (Cunnington and Cebek 2005; Robson 2011; Buchanan *et al.* 2017).

Adult Eastern Hog-nosed Snake has home ranges of approximately 35 ha in Massachusetts (Buchanan *et al.* 2017), 39 ha in the Long Point area in southern Ontario (Robson 2011), 50 ha in New Hampshire (Lagory *et al.* 2009) and can exceed 100 ha in Wasaga Beach Provincial Park in Ontario (Cunnington 2004). Home ranges were significantly larger when they included some closed-canopy forested habitat than when they contained only managed early successional habitat (Akresh *et al.* 2017); this supports the theory that habitat quality may affect home range size. In the northern part of their Canadian range, the average range length (the two points furthest apart within the home range) for Eastern Hog-nosed Snake was 2180 m (range of 116-4971 m; Rouse 2006). Most of the above studies are not explicit about including or excluding movements to hibernacula in range estimates; differences in such movements among studies may increase heterogeneity among those estimates.

Interspecific Interactions

Across the species' range, Eastern Hog-nosed Snake appears to hunt mainly by olfaction, and feeds primarily on toads, frogs, and lizards (Platt 1969). Insects, other amphibians, molluscs, birds, crustaceans, turtles, earthworms, and spiders have also been recorded as part of the diet, as documented in the United States (Hamilton and Pollack 1956; Mills and Yeomans 1993). In Canada, wild adult snakes have only been documented feeding on American and Fowler's toads (Rouse and Cunnington pers. comms. 2019). It seems reasonable to assume they also feed on lizards and a variety of invertebrates as secondary prey. At Rondeau Provincial Park Eastern Hog-nosed Snake has been found under cover material with Five-lined Skink (*Plestiodon fasciatus*); at Long Point National Wildlife Area it has shared underground networks of tunnels with mice and Eastern Foxsnake (*Pantherophis vulpinus*) (Gillingwater pers. comm. 2020).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Most available data on abundance and density of Eastern Hog-nosed Snake come from radio-telemetry tracking studies in Wasaga Beach Provincial Park from 2001 to 2005 (Cunnington and Cebek 2005; Cunnington 2006) and 2015-2017 (Cunnington pers. comm. 2019), near Goderich from 2018 to 2019 (Maddalena pers. comm. 2019), Long Point area from 2009 to 2010 (Robson 2011), and Parry Sound area from 2003 to 2005 (Rouse 2006). Visual searches were conducted in these study areas, and snakes encountered were captured and marked, and some individuals were implanted with radio-transmitters. Ongoing mark-recapture (PIT [passive integrated transponder] tagging) studies have been in place at Komoka Provincial Park and surrounding area and in St. Williams Conservation Reserve from 2017 to 2020. These PIT tagging efforts were preceded by 20 years of

surveys and photographing specimens for individual identification at St. Williams Conservation Reserve (Gillingwater 2018, pers. comm. 2020).

Abundance

Few studies have estimated abundance or density of Eastern Hog-nosed Snake in Canada. This is compounded by the species' low detectability (Cunnington, Maddalena, Rouse pers. comms. 2019). As such, the densities presented herein should be interpreted with caution as they are likely not representative of the population as a whole. However, it appears that Eastern Hog-nosed Snake in Canada is usually found in low densities where it occurs.

A density estimate from a 5-year study (2001-2005) in Wasaga Beach Provincial Park has been calculated at approximately 0.04 adults per ha (Cunnington pers. comm. 2019). This is an order of magnitude lower than densities reported (3.7- 6.2 individuals per ha) from central United States (Platt 1969). These differences in density may reflect a latitudinal trend. In 2005, the number of individuals within the Wasaga town limits was estimated at 58 adults (95% CI: 42-67 adults; Cunnington pers. comm. 2019). This is very similar to an independent estimate of 54 for the same population, based on Approximate Bayesian Computation from an assessment of microsatellite markers (Xuereb *et al.* 2015). A follow-up study ending in 2017 estimated this same population as 39 adults (95% CI: 26-63 adults), suggesting a decline (Cunnington pers. comm. 2019).

In a three-year study (2003-2005) south of Parry Sound, approximately 100 km north of Wasaga, 20 Eastern Hog-nosed Snakes were found within an area roughly 50 km² (Rouse pers. comm. 2019). This translates to a minimum snake density of 0.004 individuals per hectare, an order of magnitude lower than that reported by Cunnington in the Wasaga study; however, it is unlikely that all individuals present were detected.

The previous COSEWIC report estimated 7,524 Eastern Hog-nosed Snakes in Ontario (COSEWIC 2007) using a density of 0.04/ha estimated from the Wasaga Beach Provincial Park study (Cunnington pers. comm. 2019). A total area of occupancy was calculated using element occurrences confirmed from 1990 onward from the NHIC database overlain with a 3 x 3 km grid (based on home range sizes (Cunnington 2004; Rouse 2006) and then multiplied by a density of 0.04 individuals/ha (COSEWIC). The IAO calculated in this status update was based on 945 squares (2 x 2 km) that contained occurrence records from 1998 to 2018. If this calculation is repeated using the same density estimate of 0.04 individuals/ha and the IAO calculated here (3,780 km²), it yields an estimate of 15,120 adults. However, this value is likely high because most individual IAO squares contain some inappropriate habitat, and among squares densities are likely lower in more northern areas (Rouse pers. comm. 2019). Further, the density estimate is derived from a single study within a small area, and on that basis alone extrapolation to the entire Ontario range of the species is problematic.

Fluctuations and Trends

All available information points toward a decline in number of animals based on decline in available habitat and disappearance or decline of Eastern Hog-nosed Snake from several areas, including parts of the Trent-Severn Waterway, Algonquin Provincial Park, parts of Norfolk County (Gillingwater pers. comm. 2019), Pinery Provincial Park (COSEWIC 2007), Wasaga Beach Provincial Park (Cunnington pers. comm. 2019), Pelee Island and Point Pelee National Park (Markle *et al.* 2018), and Essex County (Choquette and Jolin 2018) (Figures 1, 3). Genetic diversity data (see **Population Spatial Structure and Variability**) provide additional evidence that there have been recent population declines in the southwestern Ontario region and the Shield region, and a more severe decline (~two orders of magnitude) in Wasaga Beach, where it was estimated that a bottleneck event occurred approximately 117 years ago (Xuereb *et al.* 2015). Eastern Hog-nosed Snake historically occurred at all sites along Lake Erie in Ontario where Fowler's Toad was found (Schueler 1997). It is possible that declines in Eastern Hog-nosed Snake may be related, in part, to disappearance of Fowler's Toad; for example, at Point Pelee National Park, Fowler's Toad has disappeared (Green 1989), and Eastern Hog-nosed Snake has also disappeared (Markle *et al.* 2018). American Toad remains common in the Great Lakes basin, and the population trend for this species has been stable from 1995 to 2012 (Tozer 2013), although it appears less common along some beach/dune habitats formerly inhabited by Fowler's Toad.

Data on abundance of Eastern Hog-nosed Snake from multi-year studies are available from two repeatedly searched sites. In Wasaga Beach Provincial Park, where Eastern Hog-nosed Snake has been surveyed during two multi-year studies, abundance has declined approximately 33%, from a mean of 58 to 39 adults, over the last 10 years (Cunnington pers. comm. 2019). At St. William's Conservation Reserve in Norfolk County annual surveys began in 1996; at the time this was the most productive known site for the species in southwestern Ontario (Gillingwater pers. comm. 2019). Surveys at this site have continued to date, yielding 78 snakes in total over 25 years. From 1995 to 2008 annual average search time per snake ranged from 0.63 to 3.42 hrs (mean = 1.84, SD = 0.79). In 2009, search time per snake increased sharply, with annual averages from 2009 to 2020 ranging from 4.38 to 39.1 hrs (mean = 23.3, SD = 12.4), indicating a substantial decline (ca. 89%) in abundance from the previous decade (Gillingwater 2018, pers. comm. 2019, 2021).

The Ontario government reports 67 NHIC element occurrences (EOs) of Eastern Hog-nosed Snake documented in Ontario (Government of Ontario 2017). Element occurrences consist of aggregations of observation localities that are separated from each other by barriers to movement or dispersal, or (in the case of Eastern Hog-nosed Snake) by a 1 km buffer across unsuitable habitat, or 10 km buffer across suitable but apparently unoccupied habitat (NatureServe 2002; NatureServe 2020); they are functionally equivalent to subpopulations. Element occurrences are classified as extant, historical, or extinct. Although there are often time lags in incorporating occurrences, these NHIC rankings were updated in May 2017 and indicate that Eastern Hog-nosed Snake has been extirpated from 16 EOs (24%); most of these extirpations are in southwestern Ontario but also include Algonquin Provincial Park. In addition, 19 NHIC EOs (28%) are ranked as historical (i.e.,

unconfirmed in the last 20 years) (Government of Ontario 2017). There are 32 NHIC EOs ranked as extant, but 14% of these are based on observations of a single snake.

Since 2008, eight EOs previously designated as extant have been re-classed as historical and five EOs previously designated as historical as extirpated. In southwestern Ontario, the species exists mainly in isolated small pockets; it seems likely that it exists in larger numbers only around the Pinery Provincial Park area, parts of Haldimand-Norfolk County and possibly Komoka Provincial Park; however, the area surrounding Komoka Provincial Park is increasingly under threat of ongoing development and road use, limiting habitat use outside of the park's borders.

The species may persist at northern sites on the Shield that are ranked as historical because searches have been limited and the species is cryptic and uncommon there. In the Parry Sound region, the number of sightings has remained stable since a telemetry study from 2003 to 2005 (Rouse pers. comm. 2019).

Population Fragmentation

Previously (COSEWIC 2007), the population was considered “severely fragmented” because of habitat fragmentation caused primarily by roads and development. However, ‘severe fragmentation’ no longer applies under current interpretation of the term, i.e., more than 50% of the population must be in habitat fragments smaller than expected to support a viable subpopulation. While the habitat is fragmented, data on subpopulation sizes and viability are largely lacking. Furthermore, the species is relatively vagile with individuals capable of moving relatively long distances (up to 5 km). Subpopulation structure is poorly known, apart from areas occupied by four distinct genetic clusters described by Xuereb *et al.* (2015): Wasaga Beach, Georgian Bay/Shield, Long Point/Norfolk county, and a genetic cluster that included individuals from Pinery Provincial Park and Rondeau Provincial Park.

The population is especially fragmented in southern Ontario where several areas with snake occurrences exist that are 100 km or more from the next closest area with occurrences (e.g., near Goderich, Wasaga Beach Provincial Park, Rondeau Provincial Park, Norfolk and Middlesex counties). In the area east of Georgian Bay on the Canadian Shield (Figure 1), where there are large tracts of land and where the landscape is less fragmented than in southern Ontario, individuals have been noted to range extensively, and subpopulation structure is less clear (Rouse pers. comm. 2019).

Rescue Effect

Although Eastern Hog-nosed Snake occurs in the United States directly south and west of Ontario, the southern part of its Canadian range is separated from the American population by the Great Lakes and large rivers. Given that Eastern Hog-nosed Snake has only rarely been reported to swim (Tyning 1990), there is little evidence that it would cross large water bodies, and any rescue is unlikely. Additionally, in areas bordered by rivers, habitat is generally unsuitable due to extensive agriculture, urban development, and a high density of road networks.

THREATS AND LIMITING FACTORS

Threats

Habitat loss from intensive agriculture and residential development, increase in road networks and subsequent road mortality and habitat fragmentation are major threats to this species' survival. Other threats include human-caused persecution, nest predation by subsidized predators (resource availability altered by humans leading to increased predator population), and other anthropogenic threats. Eastern Hog-nosed Snake occurs in low densities and is highly vagile, factors which when considered together increase its susceptibility to urbanization, habitat fragmentation and mortality when crossing roads. The Carolinian and Shield regions in many cases have different threat levels in terms of scope and severity, with the Carolinian region often having the higher threat level. Direct threats to Eastern Hog-nosed Snakes in Canada are categorized below using the classification scheme developed by IUCN (2012) and are presented in order of highest to lowest impact as determined by a panel of experts using the IUCN threats calculator (Appendix 1). The overall threat impact was rated as "high" (implying 10–70% decline over the next three generation period from threats operating over the next 10 years), based on the threats calculator results.

Transportation & Service Corridors (IUCN threat 4.0)

Roads constitute a medium-impact threat that is pervasive in scope (70-100% of the population exposed) and moderate in severity (11-30% population decline predicted based on impacts over a 10-year period within the scope). The threat is from accidental mortality and habitat destruction from newly built roads, and ongoing mortality from traffic on existing roads. An assessment of road density across the range of several reptile species at risk in Ontario found that road density was significantly higher in areas where Eastern Hog-nosed Snake has been extirpated compared to areas where the species persists (Crowley 2006), suggesting that roads and associated impacts are a driver of local extirpation. Motor vehicles on paved roads, unpaved roads, and trails may be second only to habitat loss as a cause of declines and losses of reptile populations (Wright 2007), and vagility and high dispersal capability have been previously implicated in increasing road mortality of herpetofauna (Gibbs 1998; Bonnet *et al.* 1999; Carr and Fahrig 2001).

Although data on population-level effects of road mortality are not available for Eastern Hog-nosed Snakes, population models for several other Canadian snake species with similar life-histories have demonstrated that even small increases in annual adult mortality can result in significant declines and increases in local extinction risk (Middleton and Chu 2004; Row *et al.* 2007; COSEWIC 2013, 2018). For example, Row *et al.* (2007) demonstrated that observed rates of Gray Ratsnake mortality along a local gravel road increased the probability of extinction of the local population from 7.3% to 99% over 500 years. A population viability model developed by Winton *et al.* (2020) for a Western Rattlesnake (*Crotalus oreganus*) population predicted a 97% decline over a period of 100

years based on observed rates of road mortality, despite this population occurring in a protected area with low road density. A stage-based population model of the Great Basin Gophersnake (*Pituophis catenifer deserticola*) predicted that excess mortality from roadkill would result in a 40–50% reduction in population size over 3 generations (COSEWIC 2013). Similarly, a stage-based population model for the Gray Ratsnake in Canada predicted that 1% additional mortality would result in declines of 34% (CI 18-50%) over the next 3 generations and that 3% additional mortality would result in a decline of 57.5% (CI 38-77%) (COSWIC 2018). Based on observed rates of road mortality and road density across the range of the Gray Ratsnake, COSEWIC (2018) inferred that additional mortality due to roads would likely fall within the range of these thresholds. Road densities over much of the range of Eastern Hog-nosed Snake are comparable to those experienced by Gray Ratsnake and Great Basin Gophersnake, suggesting that the Eastern Hog-nosed Snake is likely experiencing declines of similar magnitude.

Of the 945 IAO grids with current records of Eastern Hog-nosed Snake, 747 have roads for a total length of 3447 km (Allen pers. comm. 2020). The Carolinian region has a high density of roads (Taylor *et al.* 2001; Figure 4b), whereas in the Shield region, road densities are lower (Figure 4a); however, the expansion of Highway 69 and the related upgrades of surrounding roads has likely resulted in an increase of mortality from more vehicles and higher speed traffic. Radiotracking data show that Eastern Hog-nosed Snakes in some cases avoid crossing paved, but not unpaved roads (Robson and Blouin-Demers 2013), although in other cases that avoidance appears to be dependent on traffic rather than substrate (Rouse *et al.* 2011).

For a vagile snake, roads represent linear barriers; snakes may attempt to cross and be killed or avoid crossing (Cunnington 2006; Hawbaker *et al.* 2006; Rouse 2006; Robson and Blouin-Demers 2013). Reluctance to cross roads might seem beneficial to survival; in reality it exacerbates the fragmentation of suitable habitat as road networks expand, producing small isolated pockets of Eastern Hog-nosed Snakes that are unable to disperse and may suffer from inbreeding. There are convincing data that this isolation is occurring in Eastern Foxsnake (*Pantherophis vulpinus*) (Row *et al.* 2010). If snakes are attempting to cross roads, they may also be spending more time along roadsides and this itself could lead to mortality. For example, radio-tracked snakes have been found moving along the edges of roads in Wasaga Beach Provincial Park without crossing (Cunnington pers. comm. 2019), and one of the snakes tracked in Goderich in 2018 was killed by a roadside mower (Maddalena pers. comm. 2019). Species that move longer distances may be at greater risk of decline in fragmented landscapes due to increased energetic costs and mortality rates (Roe *et al.* 2004, 2006). This contrasts with the widely held belief that species that are more vagile may be most resistant to habitat fragmentation.

Roadkill has been documented across the species' Canadian range. In Rondeau Provincial Park over 23 days of irregular sampling in Sept-Oct 2001, 241 snakes, including two Eastern Hog-nosed Snakes, were found dead on a part of one road (Gillingwater and Brooks 2002). An additional Eastern Hog-nosed Snake was found dead on the park road in June 2001. In Pinery Provincial Park, Eastern Hog-nosed Snake was the snake species most commonly encountered as roadkill (COSEWIC 2007); since 2003 its abundance

seems to have declined markedly, and the species is now rarely encountered (COSEWIC 2007).

In Eastern Foxsnake road mortality in the northern part of the species' range has been a significant source of loss in Killbear Provincial Park, apparently exceeding mortality outside the park (COSEWIC 2007). Another study of this species found that nine of 13 known mortalities in the Georgian Bay area occurred in protected areas (MacKinnon 2005). In a detailed study modelling factors affecting roadkill inside and adjacent to Point Pelee National Park and Rondeau Provincial Park, rates of mortality of snakes per km per day were higher inside the parks than outside (Farmer 2007). Likely most of this difference occurred because there were more snakes and snake habitat inside the park, but nevertheless, this highlights the risk of roads to snakes even in protected areas.

Residential and Commercial Development (IUCN threat 1.0)

Housing and urban area development constitute a low-impact threat, small in scope (1-10% of population exposed) but serious in severity (30-70% population decline within the scope), from direct mortality during development, loss of habitat, and habitat fragmentation. The Carolinian region, especially around the City of London, is affected by new housing and urban developments, notably new retirement communities. Similarly, there are proposals for new retirement communities on Lake Huron. Cottage and seasonal home development is continuing on the Shield. The town of Wasaga Beach witnessed 13% growth between 2015 and 2019 (McSweeney 2020).

Agriculture and Aquaculture (IUCN threat 2.0)

Agriculture poses a low-impact threat, small in scope (1-10% of population exposed) but moderate in severity (11-30% population decline within the scope), with more land being more intensively farmed, particularly in southwestern Ontario in the Carolinian region, than occurred in past. This includes new clearing of woodland habitat not previously farmed, and conversion of small farms to larger farms and the removal of hedgerows. This is not an issue on the Shield, as there is very limited agriculture in that region.

Invasive & Other Problematic Species & Genes (IUCN threat 8.0)

Invasive and other problematic species pose a low-impact threat, restricted in scope (11-30% of population exposed) but slight in severity (1-10% population decline within the scope). Predation on reptiles by feral and domestic animals, particularly cats, is well documented (Loss *et al.* 2013). Nest predation by subsidized predators such as Raccoon (*Procyon lotor*) has not been quantified but is potentially a significant threat. Range expansion of Wild Turkey (*Meleagris gallopavo*) also increases predation risk.

Natural System Modifications (IUCN threat 7.0)

Natural system modifications pose a low-impact threat, small in scope (1-10% of population exposed) and slight in severity (1-10% population decline within the scope). Fire suppression may decrease suitable habitat for Eastern Hog-nosed-Snakes due to loss of open canopy habitat, which is important for thermoregulation. Expansion of the invasive Common Reed (*Phragmites australis*) presents a low-impact threat, as it overtakes wetlands and adjacent habitat in the Carolinian region, where it will likely impact breeding, foraging, and thermoregulation habitat of Eastern Hog-nosed Snake; this is currently not an issue on the Shield.

Biological Resource Use (IUCN threat 5.0)

Eastern Hog-nosed Snake is protected; however, human persecution is still a low-impact threat because of the species' exaggerated and intimidating, although harmless, defensive display and the fact that these displays make it resemble venomous snakes such as "cobras" and "puff adders". During the threats calculator meeting, experts noted that they continue to receive calls about people killing snakes. Collection is also part of the threat of persecution, as there is demand for these snakes in the pet trade (COSEWIC 2007; Gillingwater, pers. comm. 2019). Nova Scotia receives 3-4 requests annually to import pet hog-nosed snakes, usually of unknown origin (Hurlburt, pers. comm. 2021).

Logging and wood harvesting may also pose a threat, primarily from accidental mortality during logging activities and from habitat degradation. Currently, Ontario CFSA (stand and site guide) requires little consideration of Eastern Hog-nosed Snake or its habitat during forestry operations. Although hibernacula and nesting sites are protected under this legislation, these are rarely identified for this species on the landscape, resulting in virtually no protections/conditions during forestry activities. Forestry operations and crown forest activities extensively overlap with Eastern Hog-nosed Snake distribution in the Shield region. Severity of this threat is considered 'unknown' because of lack of data.

Human Intrusions & Disturbance IUCN threat 6.0

Recreational activities pose a low-impact threat, small in scope and slight in severity. Pedestrian and off-road vehicle use of beach or dune habitat may disturb or destroy nests due to erosion, soil compaction, or direct crushing; as well, off-road vehicle use can result in direct mortality on juvenile and adult snakes throughout their range. As noted earlier, threats from human activity occur even in protected areas; this is a particular concern for Eastern Hog-nosed Snake in the Carolinian region where many of the parks and conservation reserves with snake occurrences are small and intensively used by people and vehicles (Kerr and Cihlar 2004; Crowley 2006).

Climate Change & Severe Weather (IUCN threat 11.0)

Increased frequency and intensity of storms and flooding associated with climate change pose a low-impact threat, small in scope but moderate-slight in severity (1-30% population decline within the scope), particularly along shorelines of the Great Lakes, where suitable habitat has declined in recent years. Terrestrial habitat along Lake Erie at Long Point has decreased, and along Lake Huron more frequent and severe winter storms have resulted in slumping of sand dunes along the shore. These changes threaten both nesting success and overwinter survival.

Pollution (9.0)

Discarded waste in natural settings may pose a threat to Eastern Hog-nosed Snakes. Human garbage for example can pose a threat; there have even been two reported cases of Eastern Hog-nosed Snake getting stuck in discarded pop cans (Gillingwater pers. comm. 2019). Plastic mesh netting may also pose a threat; this material is used for gardening, erosion control, and vegetation establishment (Kapfer and Paloski 2011). Other snake species, including Eastern Foxsnake, have become lethally entangled in this material. The scope of this threat is likely limited to urban areas and road construction projects. Eastern Hog-nosed Snake may also be threatened by herbicide and pesticide runoff from agricultural crops in the Carolinian region.

Limiting Factors

Limiting factors for this species include availability of suitable habitat, especially sandy soils for oviposition (in some areas) and hibernation sites, availability of prey, and climate. Concentration of nests and high nest site fidelity have been noted in several locations and lend support to the argument that nesting sites are limiting (see **Biology** – Life cycle and reproduction). Eastern Hog-nosed Snake is a prey specialist and in Canada has been observed to feed almost exclusively on toads, so any decline in numbers of American Toad or Fowler's Toad could limit the Eastern Hog-nosed Snake population. Such coincident declines have recently occurred at Pinery Provincial Park (COSEWIC 2007), as well as Point Pelee National Park (Markle *et al.* 2018) and other sites along Lake Erie in Ontario where Fowler's Toads were once abundant (Schueler 1997). Climate limits the northern range of the population and likely impacts nest success, reproductive capacity (e.g., number of clutches each year, or overall hatch success) and suitable hibernation habitat, especially in the northern portion of its distribution.

Number of Locations

The number of threat-based locations for Eastern Hog-nosed Snake is unknown, but it is probably in the hundreds. Road mortality, followed by habitat loss from agriculture and residential development are probably the greatest threats, but the intensity and timing of individual disturbance events vary across the species' range. The effects of threats are cumulative and not due to single events, such as individual developments or roads, which could be viewed as threat locations.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

Eastern Hog-nosed Snake was reassessed by COSEWIC as Threatened in 2007 and is currently listed as Threatened on Schedule 1 of the federal *Species at Risk Act* (SARA). SARA contains provisions that allow for the protection of certain listed species at risk individuals, their residences as well as their critical habitat. In addition, the Canadian *National Parks Act* helps protect species listed under SARA by supervising recovery efforts and protecting species and their habitats found in national parks and other areas managed by Parks Canada. A federal Recovery Strategy has been prepared for Eastern Hog-nosed Snake in Canada (Seburn 2009).

Eastern Hog-nosed Snake was listed as Threatened in Ontario when the provincial *Endangered Species Act (ESA)* took effect in 2008; the ESA is currently administered by the Ministry of the Environment, Conservation and Parks (MECP). The Ontario recovery strategy for Eastern Hog-nosed Snake was published in 2011 (Kraus 2011). The ESA provides protection to species designated at risk and their habitats (prohibits killing, harm, and harassment of the species; and prohibits damage to their habitat), and promotes the recovery of species at risk. Eastern Hog-nosed Snake is listed under Schedule 9 of the Ontario *Fish and Wildlife Conservation Act (FWCA)*, 1997, as a “Specially Protected Reptile”; the FWCA is administered through the OMNRF. The FWCA prohibits hunting or trapping for specially protected wildlife.

Non-Legal Status and Ranks

The global status according to NatureServe (2020) is G5 - Secure (last reviewed Feb 2, 2016). The national status in the United States is N5 - Secure (last reviewed on Oct 5, 1996); in Canada the national status is N3 - Vulnerable (last reviewed on Feb 2, 2016). The IUCN Red List category for Eastern Hog-nosed Snake is LC - Least concern (last assessed on March 1, 2007) (Hammerson 2007).

Eastern Hog-nosed Snake is listed at some level of peril in 14 of the 36 states in the United States where it is found, in addition to the province of Ontario (NatureServe 2020). According to NatureServe (2020), Eastern Hog-nosed Snake was up-listed in eight states since the last COSEWIC report in 2007. It is now listed as Possibly Extirpated (SH) in the District of Columbia, and Critically Imperilled (S1) in New Hampshire. The species is now listed as Imperilled (S2) in five states, in only two of which it was previously listed at that rank (NatureServe 2020). Eastern Hog-nosed Snake was down-listed in one state since 2007; in Ohio it was previously listed as Vulnerable (S3) and is now listed as Apparently Secure (S4).

Habitat Protection and Ownership

There are occurrence records for Eastern Hog-nosed snake in 62 protected areas in Ontario including conservation reserves, provincial parks, national parks, and national wildlife areas (Table 3). However, in 38.7% of these protected areas Eastern Hog-nosed snake is considered either extirpated or historical (i.e., not found since 1998) (Table 3). Across all protected areas with current and/or historical records of Eastern Hog-nosed Snake, a maximum of 252,152 ha (2,522 km²) of habitat is under some form of protection, representing approximately 2% of current EOO. However, not all habitat contained in each protected area is suitable for Eastern Hog-nosed Snake.

Table 3. List of protected areas with occurrence records of Eastern Hog-nosed Snake. Historical records are prior to 1998, current records are 1998-2018; if ‘Current’ is in bold, there were no records prior to 1998.

| Protected Area | Size (ha) | Record history |
|--|-----------|----------------|
| Algonquin Provincial Park (Natural Environment Class) | 264,674 | Historical |
| Arrowhead Provincial Park (Natural Environment Class) | 1,237 | Historical |
| Awenda Provincial Park (Natural Environment Class) | 2,915 | Current |
| Bear Lake Peatland Conservation Reserve | 3,845 | Historical |
| Big Creek National Wildlife Area-Big Creek Unit | 615 | Current |
| Big East River Provincial Park (Waterway Class) | 1,050 | Historical |
| Bigwind Lake Provincial Park (Natural Environment Class) | 1,967 | Historical |
| Bronte Creek Provincial Park (Recreational Class) | 682 | Historical |
| Cognashene Lake Conservation Reserve | 2,945 | Current |
| Cognashene Point Conservation Reserve | 42 | Historical |
| Craighleith Provincial Park (Recreational Class) | 66 | Historical |
| Crowe River Swamp Conservation Reserve | 190 | Current |
| Fish Point Provincial Park (Nature Reserve Class) | 110 | Historical |
| French River Provincial Park (Waterway Class) | 73,530 | Current |
| Georgian Bay Islands National Park of Canada | 1,400 | Current |
| Gibson River Conservation Reserve | 172 | Current |
| Gibson River Provincial Park (Nature Reserve Class) | 333 | Current |
| Grundy Lake Provincial Park (Natural Environment Class) | 3,614 | Current |
| Hardy Lake Provincial Park (Natural Environment Class) | 808 | Historical |
| Island Lake Forest and Barrens Conservation Reserve | 15,473 | Current |
| James N. Allan Provincial Park (Recreational Class) | 117 | Historical |
| Jevins & Silver Lake Conservation Reserve | 2,144 | Historical |
| Kahshe Lake Barrens Conservation Reserve | 3,169 | Current |
| Kawartha Highlands Signature Site Park (Natural Environment Class) | 37,587 | Current |
| Killbear Provincial Park (Natural Environment Class) | 1,760 | Current |
| Komoka Provincial Park (Natural Environment Class) | 321 | Current |
| Long Point National Wildlife Area-Long Point Unit | 2,855 | Current |
| Long Point National Wildlife Area-Thoroughfare Unit | 429 | Historical |

| Protected Area | Size (ha) | Record history |
|--|-----------|----------------|
| Long Point Provincial Park (Recreational Class) | 150 | Current |
| Lower Moon River Conservation Reserve | 2,723 | Current |
| Magnetawan River Provincial Park (Waterway Class) | 3,424 | Historical |
| McCrae Lake Conservation Reserve | 2,039 | Historical |
| Moon River Conservation Reserve | 455 | Historical |
| Noganosh Lake Provincial Park (Waterway Class) | 3,082 | Historical |
| North Georgian Bay Shoreline and Islands Conservation Reserve | 17,107 | Current |
| O'Donnell Point Provincial Park (Nature Reserve Class) | 882 | Historical |
| Ojibway Prairie Provincial Park (Nature Reserve Class) | 64 | Historical |
| Peter's Woods Provincial Park (Nature Reserve Class) | 349 | Current |
| Petroglyphs Provincial Park (Cultural Heritage Class) | 1,643 | Current |
| Pinery Provincial Park (Natural Environment Class) | 2,532 | Current |
| Point Pelee National Park of Canada | 1,520 | Historical |
| Pointe Au Baril Forests and Wetlands Conservation Reserve | 2,366 | Current |
| Port Burwell Provincial Park (Recreational Class) | 239 | Current |
| Queen Elizabeth II Wildlands Provincial Park (Natural Environment Class) | 33,505 | Current |
| Rock Point Provincial Park (Recreational Class) | 187 | Historical |
| Rondeau Provincial Park (Natural Environment Class) | 3,254 | Current |
| Round Lake Provincial Park (Nature Reserve Class) | 2,585 | Historical |
| Sandbanks Provincial Park (Natural Environment Class) | 1,551 | Historical |
| Severn River Conservation Reserve | 9,912 | Current |
| Sharpe Bay Fen Conservation Reserve | 636 | Current |
| Shawanaga Lake Conservation Reserve | 4,932 | Current |
| Silent Lake Provincial Park (Natural Environment Class) | 1,610 | Historical |
| Six Mile Lake Provincial Park (Recreational Class) | 212 | Current |
| St. Williams Conservation Reserve | 1,033 | Current |
| The Massasauga Provincial Park (Natural Environment Class) | 13,264 | Current |
| Torrance Barrens Conservation Reserve | 1,906 | Current |
| Turkey Point Provincial Park (Recreational Class) | 316 | Current |
| Upper Shebeshekong Wetland Conservation Reserve | 5,304 | Current |
| Wahwashkesh - Naiscoot Conservation Reserve | 1,734 | Current |
| Wasaga Beach Provincial Park (Recreational Class) | 1,844 | Current |
| West Sandy Island Provincial Park (Nature Reserve Class) | 266 | Current |
| Wye Marsh National Wildlife Area | 47 | Current |

Snakes in protected areas are still killed by visitors and nearby residents, either deliberately or accidentally by road traffic. For example, while conducting surveys for snakes in Rondeau Provincial Park in 2000-2001, several in-park cottagers admitted killing Eastern Hog-nosed and other snake species and two individuals stated that they would continue to do so (Gillingwater pers. comm. 2019). Road mortality also continues to pose a potential threat in protected areas, and directly adjacent to them (see **Threats**).

Very few Ontario Provincial Parks within the range of Eastern Hog-nosed Snake have no roads (Crowley 2006). Less than 1% of southern Ontario is protected and virtually all of these areas are small and isolated (Kerr and Cihlar 2004). Smaller parks in particular are more permeable to development features of the surrounding region and may be unable to retain species extirpated from those working landscapes (Rivard *et al.* 2000; Crowley 2006). As these small provincial parks are not contiguous, there is little potential for gene flow among them and they are more susceptible to inbreeding, genetic, and stochastic extinction events.

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David Smith is a fish and wildlife technician with LGL Limited in King City, Ontario. David has a wide range of knowledge of herpetofauna in Ontario and has been involved in both radio-telemetry and population studies of numerous Ontario Species at Risk herpetofauna. David is also an MNRF-approved wildlife custodian and has been responsible for over-wintering species at risk snakes in captivity.

Appendix 1. Threats Calculator results for Eastern Hog-nosed Snake (*Heterodon platirhinos*).

| THREATS ASSESSMENT WORKSHEET | | | | |
|---|-----------|--|------------------------------|-----------|
| Species or Ecosystem Scientific Name | | <i>Heterodon platirhinos</i> (Eastern Hog-nosed Snake) | | |
| Element ID | | Elcode | | |
| Date (Ctrl + ";" for today's date): | | 2020-01-07 | | |
| Assessor(s): | | Julia Shonfield (report writer), Dave Smith (report writer), Tom Herman, Kristiina Ovaska, Rosana Soares, Christina Davy, Christopher Edge, Joe Crowley, Nicholas Cairns, Scott Gillingwater, Karolyne Pickett, Glenn Cunnington, Tammy Dobbie, Marcus Maddalena, Prabir Roy | | |
| References: | | Draft COSEWIC status update report (2019) | | |
| Overall Threat Impact Calculation Help: | | | Level 1 Threat Impact Counts | |
| Threat Impact | | | high range | low range |
| A | Very High | | 0 | 0 |
| B | High | | 0 | 0 |
| C | Medium | | 1 | 1 |
| D | Low | | 7 | 7 |
| Calculated Overall Threat Impact: | | | High | High |
| Assigned Overall Threat Impact: | | B = High | | |
| Impact Adjustment Reasons: | | | | |
| Overall Threat Comments | | <i>As explained in the comments for the threats listed below, it is acknowledged that the Carolinian and Shield regions in many cases have different threat levels in terms of scope and severity, with the Carolinian region often having the higher threat level.</i> | | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|--------|--------------------------------------|---------------------|-----|---------------------|-----------------------------|-------------------|---|
| 1 | Residential & commercial development | D | Low | Small (1-10%) | Serious (31-70%) | High (Continuing) | |
| 1.1 | Housing & urban areas | D | Low | Small (1-10%) | Serious (31-70%) | High (Continuing) | Threats are from direct mortality during development, loss of habitat causing reductions in population extent, and isolation of local populations. Does not account for threats from new traffic. The Carolinian area of the population, especially around London is more affected by new housing and urban developments, notably new retirement communities. Similarly in Huron County, there are proposals for retirement communities along the lake. Mitigation proposed for these new developments is not adequate to eliminate impacts. Cottage/seasonal (second) home development continuing on the Shield. |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|--------|-------------------------------------|---------------------|------------|---------------------|-----------------------------|-------------------|---|
| 1.2 | Commercial & industrial areas | | Negligible | Negligible (<1%) | Moderate (11-30%) | High (Continuing) | There is little new infrastructure within the species area of occupancy not already included within urban areas (see 1.1). |
| 1.3 | Tourism & recreation areas | | Negligible | Negligible (<1%) | Moderate (11-30%) | High (Continuing) | Note this does not include human activities within recreation areas (see 6.1), but relates only to new infrastructure (e.g. new buildings in parks). |
| 2 | Agriculture & aquaculture | D | Low | Small (1-10%) | Moderate (11-30%) | High (Continuing) | |
| 2.1 | Annual & perennial non-timber crops | D | Low | Small (1-10%) | Moderate (11-30%) | High (Continuing) | More land is being more intensively farmed particularly in SW Ontario in the Carolinian area than it was in the past. This includes new clearing of woodland habitat not previously farmed. Also includes the conversion of small farms to larger farms. On the Shield this is not an issue for this part of the population, as there is very limited agriculture in this region. |
| 2.2 | Wood & pulp plantations | D | Low | Small (1-10%) | Slight (1-10%) | High (Continuing) | |
| 2.3 | Livestock farming & ranching | | Negligible | Negligible (<1%) | Slight (1-10%) | High (Continuing) | |
| 2.4 | Marine & freshwater aquaculture | | | | | | |
| 3 | Energy production & mining | | Negligible | Negligible (<1%) | Extreme - Serious (31-100%) | High (Continuing) | |
| 3.1 | Oil & gas drilling | | Negligible | Negligible (<1%) | Unknown | High (Continuing) | |
| 3.2 | Mining & quarrying | | Negligible | Negligible (<1%) | Extreme - Serious (31-100%) | High (Continuing) | Refers to new mining and quarrying operations. Rock quarries and gravel pits occur in the distribution of Eastern Hog-nosed Snakes in Canada and there have been new applications for quarries in the area around London. Threat is from direct mortality during earthworks and from destruction of habitat. There may be some suitable habitat when the area is reclaimed. |
| 3.3 | Renewable energy | | Negligible | Negligible (<1%) | Unknown | High (Continuing) | Impact of renewable energy (e.g. wind, solar) currently unknown. |
| 4 | Transportation & service corridors | C | Medium | Pervasive (71-100%) | Moderate (11-30%) | High (Continuing) | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|--------|--|---------------------|------------|---------------------|-----------------------------|--|---|
| 4.1 | Roads & railroads | C | Medium | Pervasive (71-100%) | Moderate (11-30%) | High (Continuing) | Threat is from accidental mortality and habitat destruction from new roads, and ongoing mortality from traffic on existing roads. This reduces population size and isolates populations. Radiotracking data have shown Eastern Hog-nosed Snake avoid crossing roads, paved roads in particular, so roads can cause habitat fragmentation. Extensive road networks and high traffic volumes overlap with the species occurrence in SW Ontario. In the Shield region the road densities are lower as is traffic volume. However, given the size of home ranges, a large proportion of the population is interacting with roads, and very few patches of habitat do not have roads through them. |
| 4.2 | Utility & service lines | | Negligible | Negligible (<1%) | Negligible (<1%) | High (Continuing) | Includes new oil and gas pipelines, hydro towers, and maintenance of these facilities (e.g. mowing along hydro corridors). Trenching for pipelines destroys habitat, there are accidental mortalities, and individuals can become trapped while the ditch is open. |
| 4.3 | Shipping lanes | | | | | | |
| 4.4 | Flight paths | | | | | | |
| 5 | Biological resource use | D | Low | Small (1-10%) | Slight (1-10%) | High (Continuing) | |
| 5.1 | Hunting & collecting terrestrial animals | D | Low | Small (1-10%) | Slight (1-10%) | High (Continuing) | Snakes are protected from capture and killing, however, human persecution is a threat because of the species' exaggerated and intimidating, although harmless, defensive display and the fact that these displays make it resemble venomous snakes such as "cobras" and "puff adders". It was noted during the call that snake experts are still receiving calls about people killing snakes, often Eastern Hog-nosed Snakes get mistaken for cobras. It is estimated that most of this mortality is occurring on private land, but also in protected areas, though to a lesser extent. |
| 5.2 | Gathering terrestrial plants | | Negligible | Negligible (<1%) | Negligible (<1%) | Insignificant/ Negligible (Past or no direct effect) | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|--------|--|---------------------|---------|---------------------|-----------------------------|---|--|
| 5.3 | Logging & wood harvesting | | Unknown | Small (1-10%) | Unknown | High (Continuing) | Threat is from accidental mortality during logging activities and from habitat degradation. Forestry operations and crown forest activities are primarily occurring on the Shield. Severity is considered 'unknown' because we have no data on how forestry impacts the species (some effects could be negative and some positive). |
| 5.4 | Fishing & harvesting aquatic resources | | | | | | |
| 6 | Human intrusions & disturbance | D | Low | Small (1-10%) | Slight (1-10%) | High (Continuing) | |
| 6.1 | Recreational activities | D | Low | Small (1-10%) | Slight (1-10%) | High (Continuing) | Human use of beach habitat may lead to disturbance of nests and loss due to erosion/soil compaction; off-road vehicle use is a source of mortality and nest destruction. |
| 6.2 | War, civil unrest & military exercises | | | | | | |
| 6.3 | Work & other activities | | | | | | |
| 7 | Natural system modifications | D | Low | Small (1-10%) | Slight (1-10%) | High (Continuing) | |
| 7.1 | Fire & fire suppression | D | Low | Small (1-10%) | Slight (1-10%) | Moderate (Possibly in the short term, < 10 yrs) | Fire suppression in both the Shield region and SW Ontario may decrease suitable habitat (loss of open canopy habitat, important for thermoregulation). Prescribed burns in SW Ontario in Long Point area can be an issue if the prescribed burns get out of control (can lead to direct mortality); accidental fires may also be an issue. |
| 7.2 | Dams & water management/use | | | | | | |
| 7.3 | Other ecosystem modifications | D | Low | Small (1-10%) | Slight (1-10%) | High (Continuing) | Expansion of invasive Common Reed (<i>Phragmites australis australis</i>), which overtakes wetlands as well as edges and can impact breeding habitat of Eastern Hog-nosed Snakes. Primarily an issue in SW Ontario but not an issue on the Shield. |
| 8 | Invasive & other problematic species & genes | D | Low | Restricted (11-30%) | Slight (1-10%) | High (Continuing) | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|--------|--------------------------------------|---------------------|---------|---------------------|-----------------------------|---|--|
| 8.1 | Invasive non-native/alien species | D | Low | Restricted (11-30%) | Slight (1-10%) | High (Continuing) | Threat from predation by domestic animals (primarily cats, but also dogs). Loss <i>et al.</i> (2013) highlights the impacts of feral and domestic cats on wildlife, including reptiles, in United States. Presence of snake fungal disease is also noted here, although this potential threat had no influence on the assessment of this threat category because the severity is unknown, even though the disease is likely pervasive. |
| 8.2 | Problematic native species | | Unknown | Restricted (11-30%) | Unknown | High (Continuing) | Nest predation by subsidized predators (e.g. Raccoons). Some examples of Eastern Hog-nosed Snake nests predated by Raccoons, but it is unknown how much greater it is above baseline rates of predation. Predation by Wild Turkey is also considered here. Limited evidence of direct predation by Wild Turkey, so the severity is unknown; however, Wild Turkey populations have been expanding in southern Ontario. |
| 8.3 | Introduced genetic material | | | | | | |
| 9 | Pollution | | | | | | |
| 9.1 | Household sewage & urban waste water | | | | | | |
| 9.2 | Industrial & military effluents | | | | | | |
| 9.3 | Agricultural & forestry effluents | | | | | | |
| 9.4 | Garbage & solid waste | | | | | | |
| 9.5 | Air-borne pollutants | | | | | | |
| 9.6 | Excess energy | | | | | | |
| 10 | Geological events | | | | | | |
| 10.1 | Volcanoes | | | | | | |
| 10.2 | Earthquakes/tsunamis | | | | | | |
| 10.3 | Avalanches/landslides | | | | | | |
| 11 | Climate change & severe weather | D | Low | Small (1-10%) | Moderate - Slight (1-30%) | Moderate (Possibly in the short term, < 10 yrs) | |
| 11.1 | Habitat shifting & alteration | | | | | | |

| Threat | | Impact (calculated) | | Scope (next 10 Yrs) | Severity (10 Yrs or 3 Gen.) | Timing | Comments |
|--------|----------------------|---------------------|---------|---------------------|-----------------------------|---|--|
| 11.2 | Droughts | | Unknown | Small (1-10%) | Unknown | Moderate (Possibly in the short term, < 10 yrs) | Effects of drought not well studied, but could potentially affect populations of toads (the main prey of Eastern Hog-nosed Snakes) relying on small pools to breed. |
| 11.3 | Temperature extremes | | Unknown | Small (1-10%) | Unknown | High (Continuing) | Temperature extremes could lead to lower overwinter survival |
| 11.4 | Storms & flooding | D | Low | Small (1-10%) | Moderate - Slight (1-30%) | Moderate (Possibly in the short term, < 10 yrs) | Water levels in the Great Lakes have been high in recent years. Overall decline in amount of suitable habitat along shorelines. Terrestrial habitat along Lake Erie at Long Point has decreased because of storms and flooding. Along Lake Huron, more frequent and severe winter storms have resulted in slumping of sand dunes along the shore. Storms and flooding could affect nesting success, and overwinter survival. |

Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008).