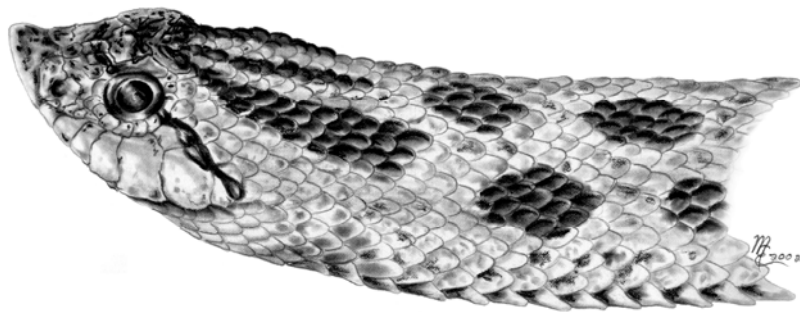


COSEWIC
Assessment and Update Status Report

on the

Eastern Hog-nosed Snake
Heterodon platirhinos

in Canada



THREATENED
2007

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 reports:

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).

Schueler, F.W. 2001. COSEWIC assessment and status report on the Eastern Hog-nosed Snake *Heterodon platirhinos* in Canada, in 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. Pages 1-23 pp.

Schueler, F.W. 1997. COSEWIC status report on the Eastern Hog-nosed Snake *Heterodon platirhinos* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 21 pp.

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COSEWIC Assessment Summary

Assessment Summary – November 2007

Common name

Eastern Hog-nosed Snake

Scientific name

Heterodon platirhinos

Status

Threatened

Reason for designation

This species faces several threats, particularly increased mortality and severe habitat fragmentation caused by an expanding road network and increased traffic. The species is mobile for a snake, but this mobility places it at high risk when it encounters roads. The species also suffers from persecution by humans not only because it is a relatively large snake but also because of its complex defensive threats when confronted. In southwest Ontario and south of the Canadian shield, the species has suffered extensive habitat loss from agriculture and rapid increase in housing development. Poaching for the illegal wildlife trade is a growing threat.

Occurrence

Ontario

Status history

Designated Special Concern in April 1997. Status re-examined and designated Threatened in November 2001 and November 2007. Last assessment based on an update status report.



COSEWIC
Executive Summary

Eastern Hog-nosed Snake
Heterodon platirhinos

Species information

The Eastern Hog-nosed Snake, *Heterodon platirhinos* Latreille 1801, is a medium-sized, stout-bodied, oviparous colubrid. Its apt common name is derived from the upturned scale, unique to hog-nosed snakes, at the tip of its snout. Individuals of this species are highly variable in colour and pattern, with phenotypes ranging from colourful and blotched to melanistic. However, its tendency, when approached by humans, to inflate its neck to a cobra-like hood, hiss, and strike, eventually defecate, roll onto its back with mouth open and tongue extended, and sometimes even exude blood from its mouth and/or cloaca is usually sufficient for its identification. Although this species is harmless, it is often killed by humans perhaps alarmed by its complex defensive behaviour. Slight sexual dimorphism occurs in this species, with males generally smaller than females.

Distribution

The Eastern Hog-nosed Snake occurs in both Canada and the United States, but less than 10% of its global range is in Canada. In Canada, the Eastern Hog-nosed Snake is restricted to southern and south-central Ontario and is found in two geographically distinct areas: the Carolinian Region of southwestern Ontario and the Great Lakes/St. Lawrence Region of central Ontario south of the French River and Lake Nipissing and east of Georgian Bay. This snake is extirpated from the Regional Municipalities of Halton, Peel and York, as well as Pelee Island, Point Pelee National Park and other more local areas. Also, the records from Bruce, Grey, and Prince Edward Counties are considered historic and *H. platirhinos* may be extirpated from these areas.

In the United States, the Eastern Hog-nosed Snake is present in all eastern states from southern New England, west to Minnesota and South Dakota, south to Texas and east to Florida.

Habitat

Six features have been used to define the preferred habitat of *H. platirhinos*: 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. Eastern Hog-nosed Snakes in shoreline areas often rely on driftwood and other ground cover in beach and beach dune habitats, where their prey of choice, toads (*Bufo spp.*), is found. South of Parry Sound, in the Georgian Bay region, Eastern Hog-nosed Snakes prefer open grass, sand, human-impacted and forest habitats over rock, wetland, and aquatic habitats. Because the Eastern Hog-nosed Snake is a prey specialist on toads, it is also important to consider habitat requirements and population trends of toads.

Habitats preferred by Eastern Hog-nosed Snakes have declined or disappeared because, coincidentally, these habitats have soils favourable for agriculture and beach/water-related recreation.

Biology

Eastern Hog-nosed Snakes appear to hunt mainly by olfaction. Snakes in the U.S. feed on toads, frogs and lizards, but they also feed on some insects, other amphibians, molluscs, birds, crustaceans, turtles, earthworms, and spiders. However, adult snakes in Canada appear to feed almost exclusively on toads (*Bufo americanus* and *B. fowleri*).

In Kansas, age at maturity is reached in approximately 2 years; however, in Canada, age at maturity may be delayed to 4-5 years. Captive individuals have lived 11 years. Copulation occurs in spring, and in August and early September; females may copulate with more than one male. The Eastern Hog-nosed Snake is oviparous; females lay between 7 and 37 eggs in nests in sandy soil about 10-20 cm below the surface, but also nest in cavities under rocks as well as under driftwood on beaches. Oviposition begins in late June and continues for 2-3 weeks. In Canada, in the northern portion of the species' range, females may need to excavate nests in locations that provide enough sunlight to ensure appropriate thermal conditions for egg incubation.

Eastern Hog-nosed Snakes hibernate from October to April, do not exhibit communal hibernation, may or may not excavate their hibernation site depending on the availability of an acceptable pre-existing burrow, and may or may not exhibit hibernation site fidelity. The availability of hibernation sites may or may not be a limiting factor, depending on the area.

Eastern Hog-nosed Snakes may experience higher natural mortality by predation than other species of snake found in Ontario because they are active predators and are naturally a highly vagile snake. Predators include mustelids, foxes, other medium-sized mammals, owls and other raptors. Pet and feral cats and dogs are also likely predators. Eastern Hog-nosed Snakes in or near urban areas suffer high rates of added mortality from anthropogenic sources.

Population sizes and trends

It is difficult to estimate the abundance of Eastern Hog-nosed Snakes in Ontario because there are few studies incorporating data on population trends and abundance. However, Eastern Hog-nosed Snakes are found in low densities wherever density has been measured, with values from Canadian studies ranging between 0.04-0.004 snakes per hectare. The NHIC has ranked 8% of known element occurrences of Eastern Hog-nosed Snakes in Ontario as extirpated and another 35% of element occurrences as historic, or unconfirmed in the last 20 years. Based on these densities, the NHIC ranks of Element Occurrences and size of activity ranges, a crude estimate of total number of adults in Canada is less than 10,000. Ultimately, the decline in available habitat, the increase in road construction in south-central Ontario, and the threat of human persecution will result in a continuing decline in number of snakes. The Eastern Hog-nosed Snake is highly mobile, for a snake, which increases its susceptibility to urbanization and habitat fragmentation.

Although *H. platirhinos* is found in the U.S. directly south and west of Ontario, rescue effect from American populations of snakes would be virtually impossible. Canadian populations are separated from the American populations by the Great Lakes and *H. platirhinos* is currently designated as Vulnerable in Michigan, Ohio, and Pennsylvania.

Limiting factors and threats

Limiting factors for this species include the availability of suitable habitat, especially the sandy soils necessary for oviposition and hibernacula, and the availability of prey. Because these snakes are specialists on toads, declines and fluctuations in toad populations may cause declines in Eastern Hog-nosed Snake populations. However, *Heterodon platirhinos* has disappeared from Point Pelee and Pelee Island where Fowler's Toads have also been extirpated, although American Toads remain common. The key threat to this snake is the ongoing proliferation of road networks which increase mortality and habitat fragmentation. Persecution by humans and collection for the pet trade also negatively affect this species' survival.

Special significance of the species

The amazingly intricate defensive behaviour of *H. platirhinos* makes it, perhaps, the most interesting snake in Canada. The occurrence of this behaviour by *H. platirhinos* also provides the opportunity to study the adaptive significance of death-feigning.

Existing protection or other status designations

The Eastern Hog-nosed Snake received status under COSEWIC in 1997 when it was designated as Vulnerable, and was reassessed as Threatened in 2001. It was designated as Threatened by the Ontario Ministry of Natural Resources in 2001. Also, this species is a “Specially Protected Reptile” under the Ontario *Fish and Wildlife Conservation Act*.

Heterodon platirhinos is listed at some level of peril in 11 of the 34 states where it is found. The Global status is G5; in the U.S., the national status is N5 and in Canada the national status is N3.



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 (2007)

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.



Environment Canada
Canadian Wildlife Service

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Canada

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

**Update
COSEWIC Status Report**

on the

Eastern Hog-nosed Snake
Heterodon platirhinos

in Canada

2007

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SPECIES INFORMATION

Name and classification

The Eastern Hog-nosed Snake's common name is derived from the upturned, keeled scale on the tip of its nose. Its scientific name, *Heterodon platirhinos* Latreille 1801 (spelled *H. platyrhinos* until recently, but corrected by Platt (1985)), is derived from physical aspects of the snake as well. The genus name is derived from *hetero* (= different) and *odontos* (= teeth), referring to the varying sizes of the teeth. The species name is derived from *plati* (= flat or broad), and *rhinos* (= nose), referring to – as the common name does – the upturned nose scale, which gives the snake its unique “hog-nosed” appearance (Johnson 1989).

Heterodon platirhinos is a colubrid snake and has traditionally been classified under the Subfamily Xenodontinae, a group of Central and South American snakes. However, some biologists doubt whether the Eastern Hog-nosed Snake and the Ring-necked Snake (*Diadophis punctatus*) – the other North American snake classified in this subfamily – are actually closely related to each other or to the other tropical, xenodontine snakes (Schueler 1997).

Morphological description

The Eastern Hog-nosed Snake is a stout-bodied snake; it has keeled scales, a divided anal plate, and a distinctive upturned, keeled scale at the tip of its nose (Harding 1997).

Adults

Individuals of this species are highly variable in colour and pattern, with phenotypes ranging from colourful and blotched to melanistic. Some individuals have a distinctive pattern of irregular blotches down the back, alternating with dark spots along the side, on a background of grey, brown, tan, olive, orange, yellow, or pinkish colour, whereas others lack all patterning and are typically plain grey, brown, olive, or black. In fact, many individuals are intermediate in pattern (Harding 1997). Dark neck blotches are visible in all but the darkest individuals. The belly is often mottled and can be yellowish, grey, cream, or pinkish (Harding 1997). The chin, throat, and subcaudal scales are usually lighter than the rest of the underside (Harding 1997). Total length of adults ranges from 50 to 115.6 cm (Harding 1997), with males being, on average, smaller than females.

Hatchlings

Hatchlings of this species have dark dorsal and smaller lateral blotches on a light grey or brown background. This pattern is present even in individuals that will be unpatterned and unicoloured as adults. The belly of hatchlings can be dark grey or black and the throat and subcaudal scales white or yellowish (Harding 1997). The total length of hatchlings ranges from 12.5 to 25.4 cm (Harding 1997).

Genetic description

There are no data available on the genetic structure of populations within the Canadian range. However, given that many populations in Ontario are spatially isolated and small, these populations are genetically isolated and therefore could experience inbreeding and/or genetic bottlenecks (Meffe and Carroll 1994; Chek *et al.* 2007). Because this species moves considerable distances, for a snake, populations should be less likely to be isolated in areas with continuous habitat.

There are no subspecies currently recognized. Crother (2001) and Platt (1969) concluded that variants, which are sometimes designated as subspecies, are not sufficiently discrete to warrant their subspecies recognition.

Designatable units

The distribution of the Eastern Hog-nosed Snake in Ontario appears to comprise two disjunct regions corresponding to two Faunal Provinces (Carolinian and Great Lakes/St. Lawrence) of the Terrestrial Amphibian, Reptile and Mollusc Faunal Provinces (Fig. 3 Appendix F 5 COSEWIC Operations and Procedures Manual 2007). Similarly disjunct distributions occur in several other reptile species in Ontario such as the Gray Ratsnake (*Elaphe spiloides*) and the Five-lined Skink (*Eumeces fasciatus*) (Cook 1984). It is not known whether this disjunction in hognose distribution is related to European settlement or whether it predates that time or whether it is an even older pattern based on phylogeographic history. There are no genetic data from the hog-nosed snake to test for differences between the two regions, nor is there good evidence to suggest that the conservation status between the two regions differs, although the Carolinian population is clearly more fragmented and has undergone greater loss of habitat. Given the uncertainties, it seems reasonable at present to consider the Eastern Hog-nosed Snake as a single Designatable Unit.

DISTRIBUTION

Global range

The Eastern Hog-nosed Snake is found in both Canada and the United States (Fig. 1). In the United States, it is present from southern New England through southern Michigan to Minnesota and South Dakota, south to southern Texas, the Gulf Coast, and southern Florida in 34 states plus the District of Columbia (See Table 2).

Canadian range

Although the Eastern Hog-nosed Snake is widespread in eastern North America, less than 10% of its global range is in Ontario. The Eastern Hog-nosed Snake is restricted in Canada to southern and south-central Ontario and is found in two geographically distinct areas: the Carolinian Region of southwestern Ontario and in the Great Lakes/St. Lawrence Region of central Ontario south of the French River and Lake Nipissing and east of Georgian Bay (Fig. 2). It is absent, however, 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 (Schueler 1997) or to areas with greater than 2100 Annual Crop Heat Units (www.OMAFRA.on). They can extend further into slightly cooler areas if there are sandy, exposed, south-facing slopes that have warmer soil conditions for incubation which probably determine northern range limits (Brooks *et al.* 2003). The Eastern Hog-nosed Snake occurs in two National Heritage Protected Areas managed by Parks Canada (Georgian Bay Islands and Trent-Severn Waterway) and occurs (or has occurred since 1984) in several protected areas including: Arrowhead P.P., Awenda P.P., Apps Mills C.A., Backus Woods, Craigleith P.P., Grundy Lake P.P., Ipperwash P.P., Killbear P.P., Komoka P.P., Long Point P.P., Petroglyphs P.P., Pinery P.P., Port Burwell P.P., Rondeau P.P., Six Mile P.P., Skunks Misery, Spooky Hollow Sanctuary, St. William's Forest, Turkey Point P.P., Wasaga Beach P.P., and Wye Marsh (but see Table 1 for a complete list of protected areas within the hognose's range in Ontario, and of those protected areas that have had at least one reported sighting of an Eastern Hog-nosed Snake). According to the NHIC database, since 1990 there have been sightings in the counties and districts of Lambton, Muskoka, Niagara, Simcoe, Haliburton, Kent, Middlesex, Peterborough, Parry Sound, Victoria, Haldimand, Elgin, Hastings, Frontenac, and Northumberland. The Eastern Hog-nosed Snake has been extirpated from the regional municipalities of Halton, Peel and York, as well as Pelee Island and Point Pelee National Park (Oldham and Austen 1998). Also, the records from Bruce, Grey, and Prince Edward Counties are considered historic and *H. platirhinos* may be extirpated from these areas (Oldham and Austen 1998) and from Hastings and Durham counties (Schueler 1997). (See **Fluctuations and Trends** for other more local areas from which the species may be extirpated.)

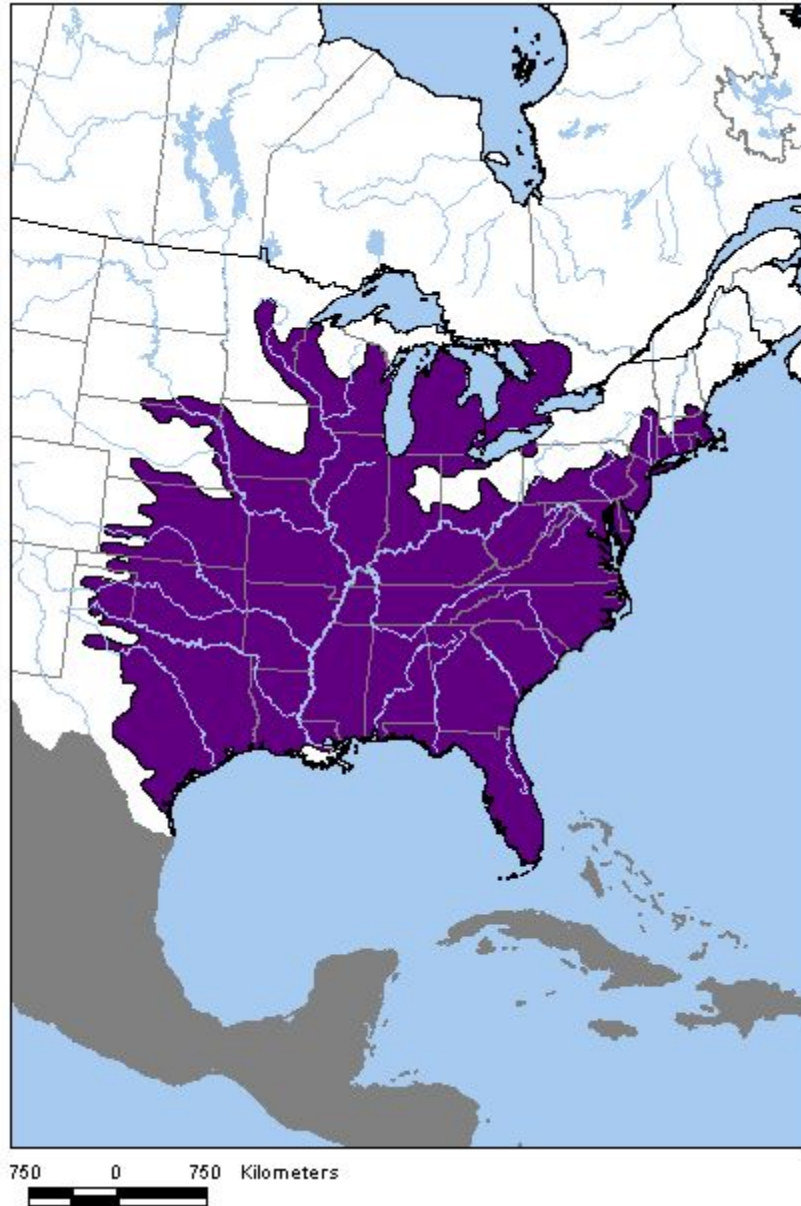


Figure 1. North American range map for the Eastern Hog-nosed Snake (*Heterodon platirhinos*) (NatureServe 2005).

The Extent of Occurrence was calculated by connecting the outermost observations in Fig. 2 to create a Minimum Convex Polygon (MCP), and determining its area which was 107,100 km². The calculation of Area of Occupancy is provided in the section on Abundance in this report.

HABITAT

Habitat requirements

There have been few ecological studies on the Eastern Hog-nosed Snake, particularly in Canada. However, the research that has been done provides us with good insight into the habitat needs of this species. Platt (1969) described six features to define the preferred habitat of *H. platirhinos*: 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. An analysis of habitat use at Wasaga Beach P.P. in Ontario indicated that *H. platirhinos* preferred forested areas as well as wetlands adjacent to conifer plantations, and that meadows and areas currently being used by people (urban, agricultural, etc.) were the least suitable (Cunnington 2004b). Eastern Hog-nosed Snakes in shoreline areas such as Rondeau P.P. and Long Point P.P. often rely on driftwood and other ground cover in beach and beach dune habitats (Seburn 2005), where their prey of choice, *Bufo fowleri*, is found. A telemetry study done south of Parry Sound in Ontario suggests that, at the landscape level, Eastern Hog-nosed Snakes in that area preferred meadow, sand, human-impacted areas (i.e. private dwellings, trailer parks, sand/gravel pits), and forest habitats over rock, wetland, and aquatic habitats (Rouse 2006). In the Parry Sound study, telemetry locations of individual snakes were distributed somewhat evenly across the different habitat types; such distribution reflects this species' vagility and tortuous ("meandering" versus linear) movements Rouse (2006). There are not many data regarding habitat use by juvenile Eastern Hog-nosed Snakes throughout the species' range, but juveniles in Norfolk County appear to use the same habitat, including cover and thermoregulation sites, as adults (S. Gillingwater pers..comm.). Also, hatchlings at Rondeau P.P. use the same cover material as adults soon after hatching (S. Gillingwater pers. comm.).

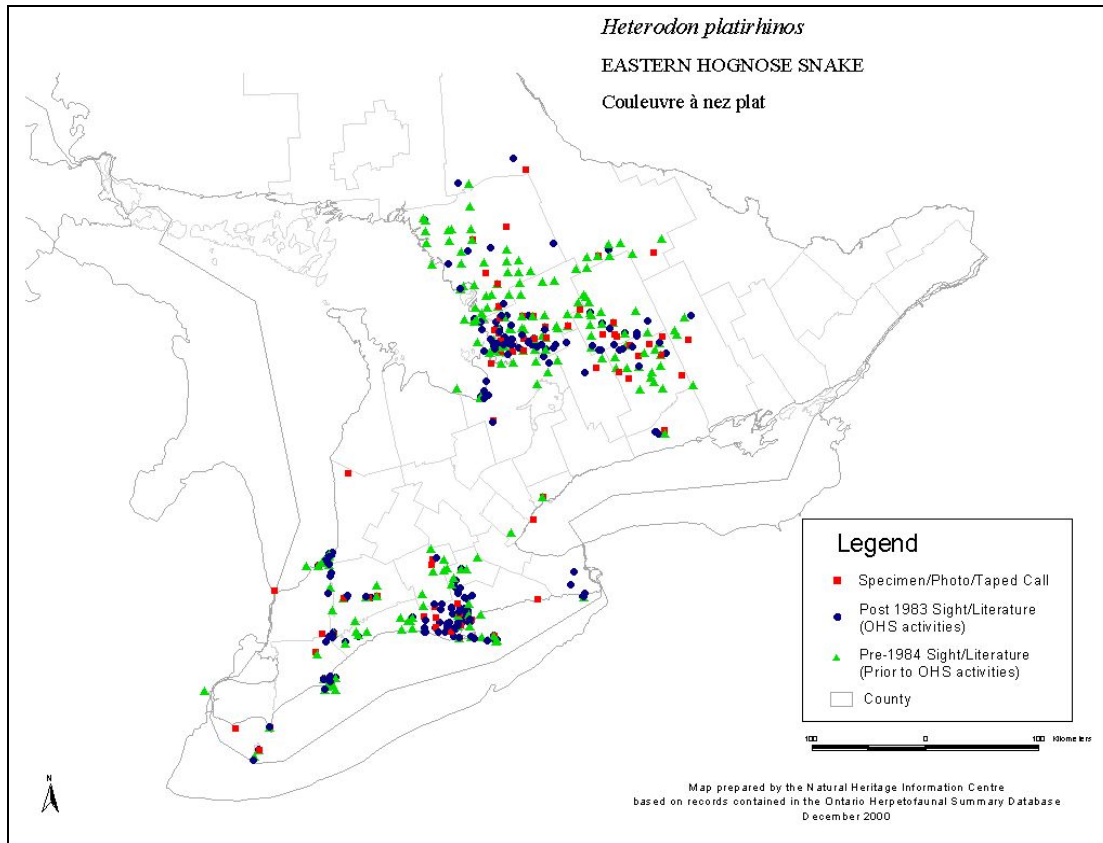


Figure 2. Canadian range map for the Eastern Hog-nosed Snake (*Heterodon platirhinos*).

Adult Eastern Hog-nosed Snakes are very mobile for snakes and have home ranges that can exceed 100 ha (Cunnington 2004b). Daily movements of 100 m occur (Cunnington 2004b) and the maximum straight-line distance moved over an active season approaches 5 km (Rouse 2006). However, actual distances moved can be much greater than these values because the snakes follow a tortuous path in their search for food or mates (Rouse 2006).

As the Eastern Hog-nosed Snake is a prey specialist, it is important to take into consideration the habitat requirements of both American Toads and Fowler's Toads when discussing the snake's survival. According to Harding (1997), if reported local declines in toad populations in parts of the Great Lakes region are sustained over time, Eastern Hog-nosed Snakes would face another challenge to their survival and, combined with other threats, this lack of food could cause a decline in this species' populations as well. A report suggests some Great Lakes basin-wide declines in American Toads (Crewe *et al.* 2005), but the implications of the alleged declines for the Eastern Hog-nosed Snake are unknown.

Habitat trends

Much of the habitat of the Eastern Hog-nosed Snake in southern Ontario has been destroyed by land alterations linked to farming and urban sprawl (Bakowsky and Riley 1992; Snell 1987). The well-drained, sandy soils preferred by *H. platirhinos* in most of its range are, coincidentally, soils which are favourable for farming (Armason 2001; W. Chesworth pers. comm. 2007) and beach/water-related recreation (e.g. Wasaga Beach P.P.). Much of the area surrounding Wasaga Beach P.P. has been urbanized and is no longer suitable habitat for the snake. At the northern portion of its range, on the Canadian Shield (Parry Sound District and surrounding area, near the Muskokas), the terrestrial, upland habitat preferred by the Eastern Hog-nosed Snake is being altered and fragmented as people build cottages and demand the associated network of access roads (see Figs. 3 and 4.).

Natural habitat in Ontario south of the Canadian Shield is more fragmented than any region of comparable size in the Great Lakes Basin (Riley and Mohr 1994; Larson *et al.* 1999). This fragmentation is accentuated by the highest density of roads per capita in the world (Forman *et al.* 2003). The road density in the Shield region occupied by the Eastern Hog-nosed Snake continues to expand (Taylor *et al.* 2001, Fig. 3), recently accelerated by the extension of a 4-lane highway through the heart of the Georgian Bay region north to Parry Sound. This road will be further “four-laned” through the remaining hognose habitat to the species’ northern limit (Ontario Government Notice, of Study Completion and Filing of Design and Construction Report. June 19, 2007.). This expanded highway will bring many more people to the region and stimulate construction of more roads into recreational and forest management areas. Snake abundance within a half km of roads has been shown to be less than half that more than 850 m from roads (Rudolph *et al.* 1999).

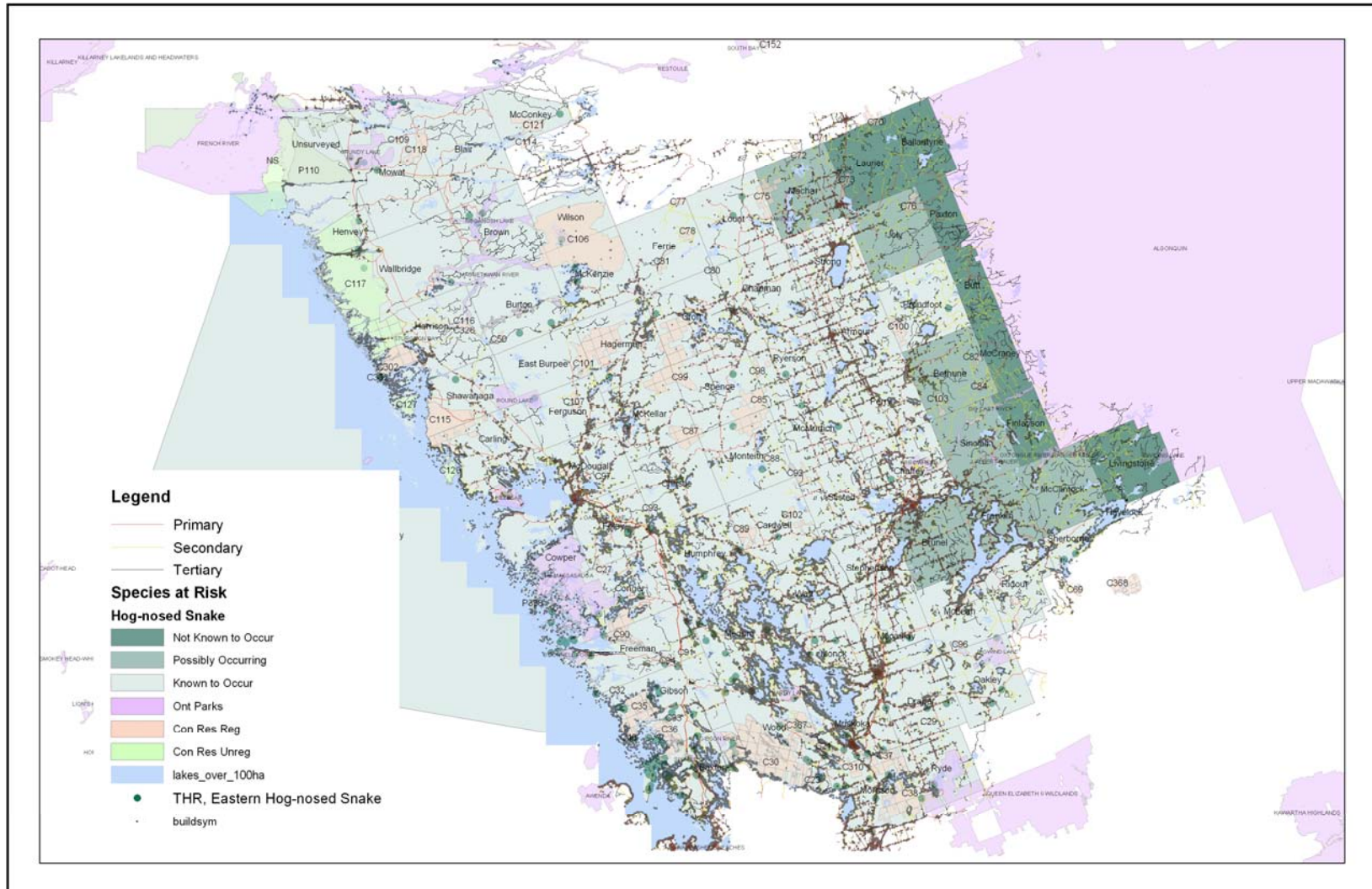


Figure 3. Map of Georgian Bay region showing roads, buildings, Provincial Parks, Conservation Reserves and Element Occurrences of Eastern Hog-nosed Snakes. Expansion of road networks and their associated development is increasingly isolating populations of hog-nosed snakes throughout their Ontario range, but especially in the southern Georgian Bay region (see text).

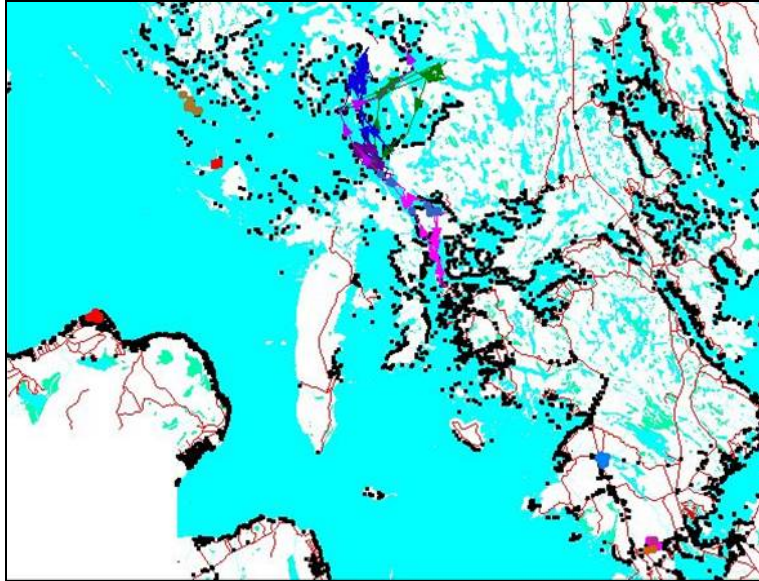


Figure 4. Map of southern coast of Georgian Bay showing roads and buildings (represented by black dots).

Habitat protection/ownership

Some of the known populations are in protected areas such as Pinery PP, Komoka PP, Rondeau PP, and Wasaga Beach PP (Table 1). However, snakes in these parks are still killed by visitors and nearby residents, either deliberately or accidentally by road traffic. For example, while conducting surveys for snakes in Rondeau PP in 2000-2001, Gillingwater interviewed several in-park cottagers who admitted killing hognosed and other snake species and two individuals stated that they would continue to do so (S. Gillingwater pers. comm. email May 2007). In 2001, three Eastern Hog-nosed Snakes were found dead on Rondeau PP roads. Over 23 days of irregular sampling in Sept-Oct 2001, 241 snakes were found dead on just one part of one road in Rondeau PP (Gillingwater and Brooks 2002), although only two of these were hog-nosed snakes, as the species' abundance has greatly declined there (Schueler 1997). In Pinery PP, the Eastern Hog-nosed Snake was the snake species most commonly encountered as roadkill (Brad Steinberg pers. comm. 2007), but since 2003 it seems to have declined markedly and is now rarely encountered (A. MacKenzie, pers. comm. 2007). Similarly, in the northern part of the hognosed snake's range, road mortality has been shown to be a significant factor in loss of Eastern Foxsnakes (*Elaphe gloydii*) in Killbear PP, to the extent that these snakes have higher mortality when in the park than when outside (A. Lawson, pers. comm. 2007). Another study of this species found that 9 of 13 mortalities occurred in protected areas (MacKinnon 2005). In a detailed study modelling factors affecting roadkill inside and adjacent to Point Pelee NP and Rondeau PP, rates of mortality of snakes per km per day were higher inside the parks than outside (Farmer 2006). Likely most of this difference occurred because there were more snakes and snake habitat inside the park, but nevertheless, roads and high park use make these protected areas poor havens for snakes (Lawson, 2004).

Overall, less than 3% of hognose distribution in Canada occurs in Provincial Parks and only 1.7% is in Conservation Reserves (Crowley 2006). Only 3% of Ontario Provincial Parks within the range of the 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, Fig. 5). As Rivard *et al.* (2000) reported in an extensive review of Canada's National Parks, parks may not be able to maintain species that are extirpated from the surrounding region because extinction in these protected areas is more closely related to regional patterns of extinction than to park characteristics. It seems a truism that this principle is most likely to hold for smaller parks as they are more permeable to the development features of the surrounding region (Rivard *et al.* 2000; Crowley 2006).

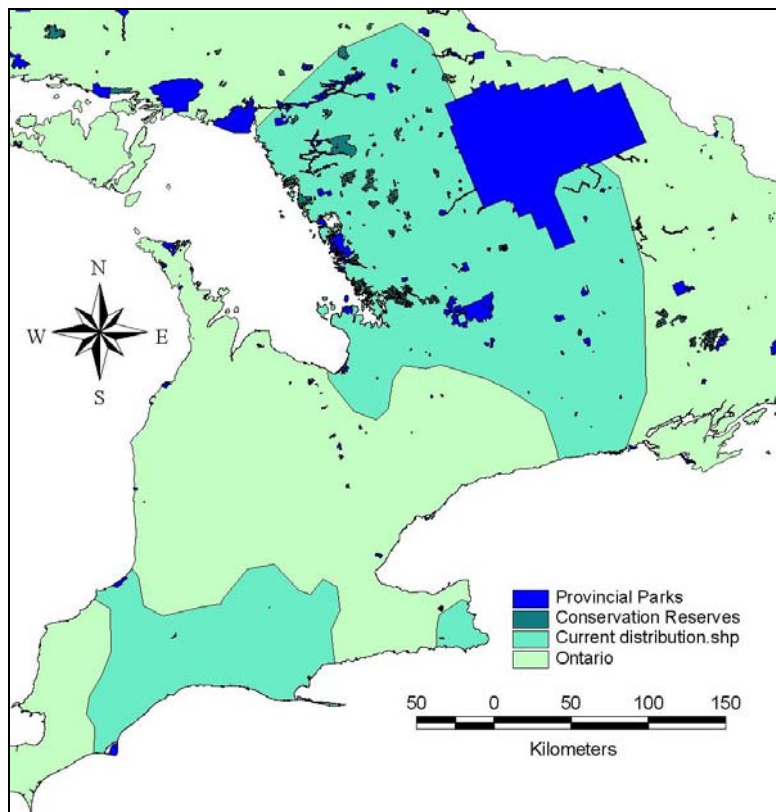


Figure 5. Map showing the Extent of Occurrence of the Eastern Hog-nosed Snake and protected areas within that range. (Note that the species is possibly extirpated from Algonquin Provincial Park, which is by far the largest protected area within the species putative range. Brooks *et al.* 2003). The apparent lack of protected areas, particularly in southwest Ontario is because the areas are too small to readily show up on this scale. (Map prepared by J.F. Crowley).

Although hog-nosed snakes have been found north to the mighty French River (Fig. 2), most recent records in the Great Lakes/St. Lawrence region occur in and east of the southern third of the Georgian Bay region around Wasaga and in Muskoka and east to the Peterborough area (Fig. 2). This region is undergoing rapid development and has perhaps the highest rate and density of recreational development and activity on the

Canadian Shield (Figs. 3 and 4). Indeed, the Wasaga/Port Severn area in Simcoe County (see Figs. 2,3,4) appears to be a stronghold for the Eastern Hog-nosed Snake, so it is noteworthy that the town of Wasaga is currently one of the fastest growing communities in Ontario (Watters 2003). Wasaga Beach PP is surrounded by development, and although the park has no public roads, the small size of the park (it is 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 2004a). As these aforementioned provincial parks are not contiguous they do not provide the opportunity for snakes from these separated areas to interbreed (i.e. little potential for recolonization, and increasing tendency for inbreeding and loss of genetic variation). Although the populations in the most northern portion of the range may sometimes be more or less contiguous, the majority of the habitat is not protected and is currently subject to development and land privatization. Much of the southern coast of Georgian Bay is covered in cottages, and roads to service these structures continue to proliferate (C. MacKinnon, pers. comm. 2007, J. Rouse pers. comm. 2007, Fig. 4).

Table 1. List of Provincial Parks and Conservation Reserves in the Extent of Occurrence of the Eastern Hog-nosed Snake including those which contain an NHIC Element Occurrence (Compiled by J.F. Crowley, 2006)

Provincial Parks within the current distribution of the EHS	Presence confirmed and sent to NHIC
ALGONQUIN PROVINCIAL PARK	x
ARROWHEAD PROVINCIAL PARK	x
AWENDA PROVINCIAL PARK	x
BALSAM LAKE PROVINCIAL PARK	
BASS LAKE PROVINCIAL PARK	
BELL BAY PROVINCIAL PARK	
BIG EAST RIVER PROVINCIAL PARK (WATERWAY CLASS)	
BIGWIND LAKE PROVINCIAL PARK	x
BRONTE CREEK PROVINCIAL PARK	x
CARSON LAKE PROVINCIAL PARK	
DIVIDING LAKE PROVINCIAL PARK (NATURE RESERVE CLASS)	
EGAN CHUTES PROVINCIAL NATURE RESERVE	
EMILY PROVINCIAL PARK	
FERRIS PROVINCIAL PARK	
FISH POINT PROVINCIAL NATURE RESERVE	x
FRENCH RIVER PROVINCIAL PARK	
GIBSON RIVER PROVINCIAL PARK (NATURE RESERVE CLASS)	
GRUNDY LAKE PROVINCIAL PARK (NATURAL ENVIRONMENT CLASS)	x
HARDY LAKE PROVINCIAL PARK	x
INDIAN POINT PROVINCIAL PARK	
IPPERWASH PROVINCIAL PARK	x
J. ALBERT BAUER PROVINCIAL PARK	
JOHN E. PEARCE PROVINCIAL PARK	
KAWARTHA HIGHLANDS PROVINCIAL PARK	
KILLBEAR PROVINCIAL PARK	x
KOMOKA PROVINCIAL PARK	x
LAKE ST. PETER PROVINCIAL PARK	
LONG POINT PROVINCIAL PARK	x

Provincial Parks within the current distribution of the EHS	Presence confirmed and sent to NHIC
MAGNETAWAN RIVER PROVINCIAL PARK (WATERWAY CLASS)	x
MANITOU ISLANDS PROVINCIAL NATURE RESERVE	
MARA PROVINCIAL PARK	
MARK S. BURNHAM PROVINCIAL PARK	
MATTAWA RIVER PROVINCIAL PARK	
MCRAE POINT PROVINCIAL PARK	
MIKISEW PROVINCIAL PARK	
NOGANOSH LAKE PROVINCIAL PARK (WATERWAY CLASS)	x
OASTLER LAKE PROVINCIAL PARK	
O'DONNELL POINT PROVINCIAL NATURE RESERVE	x
OPEONGO RIVER PROVINCIAL PARK	
OXTONGUE RIVER - RAGGED FALLS PROVINCIAL PARK	
PETER'S WOODS PROVINCIAL NATURE RESERVE	
PETROGLYPHS PROVINCIAL PARK	x
PORT BURWELL PROVINCIAL PARK	x
QUACKENBUSH PROVINCIAL PARK	
QUEEN ELIZABETH II WILDLANDS PROVINCIAL PARK (NATURAL ENVIRONMENT CLASS)	x
RESTOULE PROVINCIAL PARK (NATURAL ENVIRONMENT CLASS)	
RONDEAU PROVINCIAL PARK	x
ROUND LAKE PROVINCIAL NATURE RESERVE	x
SANDBANKS PROVINCIAL PARK	x
SERPENT MOUNDS PROVINCIAL PARK	
SILENT LAKE PROVINCIAL PARK	
SILENT LAKE PROVINCIAL PARK ADDITION	x
SIX MILE LAKE PROVINCIAL PARK	x
SOUTH BAY PROVINCIAL PARK	
SPRINGWATER PROVINCIAL PARK	
STURGEON BAY PROVINCIAL PARK	
THE MASSASAUGA PROVINCIAL PARK	x
THE PINERY PROVINCIAL PARK	x
TRILLIUM WOODS PROVINCIAL PARK	
TURKEY POINT PROVINCIAL PARK	x
UPPER MADAWASKA PROVINCIAL PARK	
WASAGA BEACH PROVINCIAL PARK	x
WAUBASHENE BEACHES PROVINCIAL PARK	
WEST SANDY ISLAND PROVINCIAL NATURE RESERVE	
WOLF ISLAND PROVINCIAL PARK	
Conservation Reserves within the current distribution of the EHS	Presence confirmed and sent to NHIC
AHMIC FOREST AND ROCK BARRENS CONSERVATION RESERVE	
AXE LAKE WETLAND CONSERVATION RESERVE	
BEAR CREEK CONSERVATION RESERVE	
BEAR LAKE PEATLAND CONSERVATION RESERVE	
BIG DEER LAKE CONSERVATION RESERVE	
BOULTER-DEPOT CREEK CONSERVATION RESERVE	
BRAY LAKE CONSERVATION RESERVE	
BRIDGE LAKE OUTWASH PLAIN FOREST CONSERVATION RESERVE	
CACHE BAY WETLAND CONSERVATION RESERVE	
CALLANDER BAY WETLAND CONSERVATION RESERVE	
CARDWELL TOWNSHIP OLD GROWTH CONSERVATION RESERVE	
CHAIN LAKES CONSERVATION RESERVE	

Conservation Reserves within the current distribution of the EHS	Presence confirmed and sent to NHIC
CLEAR LAKE CONSERVATION RESERVE	x
COGNASHENE LAKE CONSERVATION RESERVE	
COGNASHENE POINT CONSERVATION RESERVE	
COMMANDA CREEK CONSERVATION RESERVE	
CONROYS MARSH CONSERVATION RESERVE	
CRANE LAKE FOREST CONSERVATION RESERVE	
CROWE RIVER SWAMP CONSERVATION RESERVE	
DRAPER TOWNSHIP CONSERVATION RESERVE	
DUTCHER LAKE CONSERVATION RESERVE	
FERGUSON TOWNSHIP WHITE PINE FOREST CONSERVATION RESERVE	
FERRIE TOWNSHIP FOREST CONSERVATION RESERVE	
FISH BAY CONSERVATION RESERVE	
FREEMAN TOWNSHIP SUGAR MAPLE FOREST CONSERVATION RESERVE	
GIBSON RIVER CONSERVATION RESERVE	x
HORSESHOE LAKE CONSERVATION RESERVE	
ISLAND LAKE FOREST AND BARRENS CONSERVATION RESERVE	x
JEVINS & SILVER LAKE CONSERVATION RESERVE	
JOLY TOWNSHIP HARDWOODS CONSERVATION RESERVE	
LITTLE SPRING LAKE CONSERVATION RESERVE	
LONG LAKE - LANCELOT CREEK CONSERVATION RESERVE	
LOON LAKE WETLAND CONSERVATION RESERVE	
LOUCK LAKE WETLAND CONSERVATION RESERVE	
LOWER MOON RIVER CONSERVATION RESERVE	x
MCCRAE LAKE CONSERVATION RESERVE	x
MONTEITH FOREST CONSERVATION RESERVE	
MOREAU'S BAY CONSERVATION RESERVE	
MORRISON LAKE WETLAND CONSERVATION RESERVE	
MOWAT TOWNSHIP HEMLOCK FOREST CONSERVATION RESERVE	
MULDREW BARRENS CONSERVATION RESERVE	
NAISCOOT FOREST CONSERVATION RESERVE	
NORTHERN MCCONKEY CONSERVATION RESERVE	
OXBOW LAKE FOREST CONSERVATION RESERVE	
PAKESHKAG RIVER FOREST CONSERVATION RESERVE	
PLASTIC LAKE AND DAWSON PONDS CONSERVATION RESERVE	
POINTE AU BARIL FORESTS AND WETLANDS CONSERVATION RESERVE	
RAGANOOTER LAKE CONSERVATION RESERVE	
RYERSON TOWNSHIP FOREST CONSERVATION RESERVE	
SAUSAGE LAKE FOREST CONSERVATION RESERVE	
SEGUIN RIVER CONSERVATION RESERVE	
SEVERN RIVER CONSERVATION RESERVE	x
SHACK CREEK WETLAND CONSERVATION RESERVE	
SHARPE BAY FEN CONSERVATION RESERVE	
SHAWANAGA LAKE CONSERVATION RESERVE	
SOUTH RIVER FOREST CONSERVATION RESERVE	
SWAN LAKE CONSERVATION RESERVE	
TORRANCE BARRENS CONSERVATION RESERVE	x
UPPER RAFT LAKE CONSERVATION RESERVE	
UPPER SHEBESHEKONG WETLAND CONSERVATION RESERVE	
WAHWASHKESH - NAISCOOT CONSERVATION RESERVE	
WAINFLEET BOG CONSERVATION RESERVE	

BIOLOGY

Feeding

Eastern Hog-nosed Snakes appear to hunt mainly by olfaction, and feed on toads, frogs, or lizards (Platt 1969). Although these prey as well as insects, other amphibians, molluscs, birds, crustaceans, turtles, earthworms, and spiders (Hamilton and Pollack 1956, Mills and Yeomans 1993) have been recorded as part of the diet of *H. platirhinos* in the U.S., adult snakes in the wild in Canada are only known to feed on toads (*Bufo americanus* and *B. fowleri*) (J. Rouse and G. Cunnington pers. comms.). Juveniles feed upon smaller prey such as juvenile toads, Redback Salamanders (*Plethodon cinereus*), Spring Peepers (*Pseudacris crucifer*), or invertebrates (Michener and Lazell 1989). It is also unclear as to whether some of the aforementioned invertebrate prey items were secondarily ingested, or whether the difference between the Canadian populations of Eastern Hog-nosed Snakes and the ones from the U.S. is due to differing prey availability or preference. Captive *H. platirhinos* only reluctantly feed on, and usually have to be force-fed, any food other than live toads (Schueler 1997). However, in some cases, a good feeding response to other species (e.g. mice) can be induced by rubbing them with a toad (S. Gillingwater pers. comm.).

Observations of *H. platirhinos* feeding in the wild in Ontario have been recently recorded and described. It has been observed that once the snake has found the scent trail of a toad and has visually located it, it essentially charges at its prey as quickly as it can with a gaping mouth. If the snake successfully catches the toad, it often also has debris in its mouth, such as bits of twigs and leaves (G. Cunnington pers. comm.). If a toad inflates itself during the feeding process the snake can deflate it by piercing it with its rear fangs, which can also deliver mildly venomous secretions from the Duvernoy's glands (Young 1992). The Eastern Hog-nosed Snake has been described as an awkward, slow, clumsy feeder, and therefore may have difficulty catching faster prey such as frogs and small mammals (G. Cunnington pers. comm.). The apparent tolerance of the Eastern Hog-nosed Snake to the toxins in toads has not been investigated, but it may confer protection to the snake from its own predators (Greene, 1997).

Life cycle and reproduction

According to Harding (1997), *H. platirhinos* reaches maturity at 2-3 years of age and has been known to live to 11 years in captivity, although these observations are from specimens in the U.S. Since Ontario represents the northern portion of this species' range, age at maturity for snakes in Canada may be as high as 4-5 years of age (Seburn 2005). Generation time can be estimated as $\text{Gen Time} = \text{age } 50\% \text{ maturity} + 1/M$ where M = natural mortality rate. Thus, $\text{GT} = 4 + 1/0.40 = 6.5$ years.

In a study conducted in 2005 in Wasaga Beach Provincial Park, most sightings of copulation occurred between August 7th and September 17th, although one mating pair was seen copulating as early as May 14th (Cunnington and Cebek 2005). According to the same study, males actively seek out females and follow them for hours while

engaging in courtship behaviour; the males rub themselves along the female's body and if the female is receptive, the mating pair may be linked in copulation for up to 3 days. During September, one female was seen mating with 5 of her 9 suitors with copulations occurring 1-6 days apart. Mating was also observed between August 7th and September 18th in a population located near Parry Sound (Rouse 2006). In this population located on the Canadian Shield, most copulations observed occurred at the end of August and in September, although copulations have also been recorded in the spring in other areas (Harding, 1997; S. Gillingwater pers. comm.), particularly in the U.S.A.

The Eastern Hog-nosed Snake is oviparous; females lay eggs in nests up to 20 cm below the surface in sandy soil (Platt 1969, Cunnington and Cebek 2005), or under driftwood, partially buried in sand (S. Gillingwater pers. obs.). Oviposition can occur anytime during a 2-3 week period beginning in late June (Cunnington and Cebek 2005, J. Rouse pers. comm.). In Canada, at the northern portion of the species' range, females may be required to excavate nests in locations that provide enough sunlight to ensure proper thermal conditions for incubation of the eggs (Cunnington and Cebek 2005). Therefore, females carefully choose oviposition sites by probing the ground with the tip of their rostra and often abandon excavation sites if improper conditions are encountered (Cunnington and Cebek 2005). Communal nesting has been reported only once for this species (in Wasaga Beach P.P., Cunnington and Cebek 2005). As Magnusson and Lima (1984) point out, communal nesting in snakes may be a consequence of a limited number of suitable oviposition sites, and cued by chemical cues produced by conspecifics that indicate a suitable site. Although the number of observed communal nests is small, this seems a likely explanation in the Wasaga region because there is little suitable oviposition habitat found in Wasaga Beach Provincial Park (only 1.3% of the total available area). Hog-nosed Snakes on the Canadian Shield sometimes lay eggs in sandy nests but have also been observed to nest in cavities under rocks (J. Rouse pers. comm.). In addition, the Eastern Hog-nosed Snake shows high nest site fidelity from year to year (observations from Wasaga Beach Provincial Park, G. Cunnington pers. comm.). In one case, however, where an old agricultural field was restored (in south Walsingham), potentially as many as 20 Eastern Hog-nosed Snakes nested over the span of 2 days in June of 2006 (M. Gartshore pers. comm.), apparently attracted by freshly tilled sandy soil.

The clutch size for this species, in all its range except for Ontario, averages 19-23 eggs (Schueler 1997). Data from natural nests in Ontario come from only four nests from Wasaga Beach Provincial Park, numbering 7, 12, 27, and 28 eggs (Cunnington and Cebek 2005), and a small number of nests from Parry Sound, numbering between 17 and 37 eggs (J. Rouse pers. comm.). The average number of eggs from 10 Ontario clutches laid in captivity, however, averaged 35.5 with half the clutches numbering 40 or more eggs (Schueler 1997). Also, the snake from Parry Sound that laid 37 eggs did so prior to release, after spending 3 days in captivity. The large difference between the number of eggs from clutches in natural settings and ones laid in captivity is unexplained and not discussed in the literature. One possible explanation is that these snakes lay more than one clutch in the wild and that the conditions of captivity force or induce them to lay all their eggs in one place (K. Beriault, pers. hypothesis).

There is little information available regarding hatching success of eggs of *H. platirhinos* in Ontario. The only study that measured this found that hatching success of three nests in the wild was 33.3%, 57.1%, and 74.1%, and hatching success of a nest incubated in a laboratory was 85.7% (Cunnington and Cebek 2005). The hatching success of the eggs of the female that laid her clutch in a bag was 100%; these eggs were also incubated in the laboratory. The average number of days to hatching of nests in the wild is 58 (n=3, Cunnington and Cebek 2005), and hatching occurs in late August and early September.

Eastern Hog-nosed Snakes probably don't hibernate communally, may or may not excavate their hibernation site depending on the availability of appropriate pre-made sites such as burrows (Plummer 2002), and may or may not exhibit hibernation site fidelity. Also, hibernation sites may be a natural source of mortality if the ambient temperature falls below the freezing level as snakes had body temperatures approximating the temperature of the hibernaculum (Plummer 2002). In one Ontario study, the species hibernated from October to April (Cunnington 2004a).

Predation

Eastern Hog-nosed Snakes probably experience high mortality from predation presumably because they are active predators and are naturally a highly vagile species. Predation rates have been estimated at 40% of the adult population per year (Cunnington 2006; J. Rouse pers. comm.). The major predators on the nests are mustelids, foxes, and other medium-sized mammals such as raccoons. Raptors and wild turkeys (see Fig. 6) are also predators of juveniles and adults. Pet and feral cats and dogs are also likely predators (S. Gillingwater pers. comm.) although in some locations humans are responsible for many snake deaths.

Eastern Hog-nosed Snakes have developed an unusual adaptation to predation which consists of complex defensive behaviour. When approached by a predator this snake has a tendency to inflate its neck to a cobra-like hood, hiss, and strike, usually with mouth closed, eventually defecate and cover itself with foul-smelling (as opposed to the sweet type) excrement, roll onto its back (see Fig. 6), open its mouth with its tongue flopping out, and possibly even exude blood from its mouth and/or cloaca (Harding 1997). This seems to be a poor strategy, and certainly is if humans are the threat. However, it is possible that the toxins ingested from the snake's diet of toads provides protection either as toxin or by providing olfactory cues that repel predators from toads (R. Brooks pers. comm.). This is a strategy analogous to that used by some molluscs that incorporate the stinging threads (nematocysts) of their cnidarian prey for their own defence.

Physiology

The average incubation temperature of the three nests from Wasaga Beach P.P. was 24.8 °C with one nest having both the lowest and highest recorded temperatures (13.0 °C and 37.8 °C; n=3, Cunnington and Cebek 2005). The female equipped with a temperature-sensitive transmitter had an average body temperature of 30.5 °C (±1.0 °C) throughout oviposition.



Figure 6. Examples of “phases” of the defensive display of the Eastern Hog-nosed Snake. Top – display of ‘hood’; middle – open mouth threat; bottom – death feigning, also showing wounds from attack by Wild Turkey (*Meleagris gallopavo*) (photos courtesy of Scott Gillingwater).

Eastern Hog-nosed Snakes probably use grass habitat and sand pits, more than they do forest and wetlands (Rouse 2006), to regulate their body temperature as well as to find suitable prey.

Interspecific interactions

There is no literature on the interaction of *H. platirhinos* with organisms other than toads, but unidentified parasites have been seen in the mouths of some individuals and they can also be infested by mites (S. Gillingwater pers. obs.). In addition, Eastern Hog-nosed Snakes have been seen under cover material with Five-lined Skinks (*Eumeces fasciatus*) at Rondeau P.P. and will share underground networks of tunnels with mice and foxsnakes (*Elaphe gloydi*) at Long Point P.P. (S. Gillingwater pers. obs.). Eastern Hog-nosed Snakes historically occurred at all sites along Lake Erie in Ontario where Fowler's Toad, *Bufo fowleri*, was found (Schueler 1997). At Point Pelee and Pelee Island, where Fowler's Toad has apparently disappeared (Green 1989), the Eastern Hog-nosed Snake populations have also vanished even though *Bufo americanus* remains common (Schueler 1997).

It has been hypothesized that the snakes' spatial and temporal distribution in the various types of habitats (riparian, forest uplands, etc.) can be explained by the seasonal movement of their only source of food, toads (G. Cunnington pers. comm.). If this interaction exists and if it is further examined, it may provide insight as to the best approach for the conservation of *H. platirhinos*.

Adaptability

Eastern Hog-nosed Snakes survive in a variety of habitats, although these areas are always found near open sand pits (J. Rouse pers. comm.). They also seem to persist in urban areas, although populations in these areas suffer high rates of mortality and have a male-biased sex ratio (G. Cunnington pers. comm.). The data indicate that this species experiences an annual adult mortality rate of 40% (Rouse, 2006, J. Rouse pers. comm.; Cunnington, 2006, G. Cunnington pers. comm.), similar to a rate of 50% reported by Plummer and Mills (2000) for an American population. In Wasaga Beach P.P., 38% of mortality is human-caused (G. Cunnington pers. comm.).

POPULATION SIZES AND TRENDS

Search effort

Only a handful of areas in Ontario have been extensively and actively searched for the presence of Eastern Hog-nosed Snakes. Areas which were thoroughly and regularly checked include Wasaga Beach P.P., an area 30 km south of Parry Sound that has recently been bisected by the Hwy 400 extension, Long Point P.P., Rondeau P.P., St. Williams Forest Station, and the Upper Thames River Watershed. Many areas in Norfolk County are also sporadically, but usually annually, searched by naturalists and

herpetologists for species at risk, including the Eastern Hog-nosed Snake. Over the past couple of decades, Eastern Hog-nosed Snakes have been observed occasionally by people conducting surveys for Spotted Turtles (*Clemmys guttata*) and Massasaugas (*Sistrurus catenatus*) on islands and on the mainland in the area of Twelve Mile Bay, south of MacTier, ON (J. Litzgus pers. comm.).

The most extensive sampling occurred within the town limits of Wasaga where a 5-year capture-mark-recapture study took place (Cunnington, 2004a,b, 2006, G. Cunnington pers. comm.). Search efforts enabled the researcher to estimate the size of the population and the number of snakes per hectare of suitable habitat.

During the summer 2005, a survey near the Trent-Severn Waterway was conducted through Parks Canada. This survey was performed by 4-5 people experienced with searching for *H. platirhinos*; they visited a total of 32 element occurrences from the NHIC database. No Eastern Hog-nosed Snakes were found but 7 of the 32 element occurrences were described as good habitat. The rest of the element occurrences were in habitat which was poor to fair at best (G. Cunnington pers. comm.).

Abundance

It is difficult to estimate the abundance of Eastern Hog-nosed Snakes in Canada because so few studies have been done on this species in Canada, and because there are few data available regarding population trends and abundance. However, it appears that Eastern Hog-nosed Snakes are almost always found in low densities wherever they occur (Schueler 1997). In Ontario, Schueler (1997) cited numerous reports from Georgian Bay region, Peterborough County, "Central Ontario generally" and Oxford County stating that the species was rare. However, it was reported to be common in PPNP and other areas in southwest Ontario in the early 20th century (Schueler 1997). An estimate of density from a 5-year study of a Canadian population in Wasaga Beach PP. has been calculated at approximately 0.04 individuals per hectare (G. Cunnington pers. comm., which is an order of magnitude less than densities reported by Platt (1969) from the central U.S.A. The number of individuals within the Wasaga town limits is approximately 58 adults (95% C.I. = 42-67; G. Cunnington pers. comm.). In a study conducted over three years (2003-2005) south of Parry Sound, approximately 20 Eastern Hog-nosed Snakes were found within an area roughly 10 x 5 km (J. Rouse pers. comm.), which translates to a snake density of 0.004 individuals per hectare, an order of magnitude less than reported by Cunnington. These three estimates may reflect a latitudinal trend but obviously are not strong evidence of such.

An estimate of the number of Canadian adult Eastern Hog-nosed Snakes will unavoidably be crude. There are 126 recently verified element occurrences in Ontario and many of them are based on single observations (Oldham and Ben-Oliel 2001). This suggests that some occurrences represent small populations (Oldham and Ben-Oliel 2001) or remnants of ecologically extinct populations. In the northern part of their extent of occurrence, the average range length (the two points furthest apart within the home range) for *H. platirhinos* was determined to be 2180 m (116-4971; Rouse 2006). So, to

estimate the abundance of Eastern Hog-nosed Snakes, all known observations from the NHIC database (only element occurrences confirmed from 1990 onward were used) were overlain with a 3x3 km grid (based on home range sizes reported by Cunnington 2204b, and Rouse 2006), and all squares that contained observations were compiled and a total area of occupancy (AO) was calculated. The total AO was then multiplied by the density of 0.04 individuals per hectare. According to these calculations there are approximately 7,524 Eastern Hog-nosed Snakes in Ontario. This is clearly a rough estimate, but there are several considerations that suggest it is not unreasonable.

Given that many NHIC element occurrences represent single observations and that some of these observations were of juvenile Eastern Hog-nosed Snakes, it is unlikely that the population exceeds 10,000 adult individuals. Conversely, if all NHIC element occurrences were included (i.e. we assume that there are still snakes at all places where they have not been reported since before 1990), then the estimated population would exceed 10,000 snakes. Most of the element occurrences that are “historic” (i.e. not seen since 1990) are in the northern Georgian Bay region (see Fig. 2) where density (0.004/ha) appears to be much lower than further south. Many of these sites probably still have Eastern Hog-nosed Snakes, but this lower density if incorporated into the abundance estimate would consequently add relatively few snakes to the total. In contrast, most “historic” sites in the Carolinian region probably are truly historic (i.e. the snake has been extirpated), given ongoing habitat loss and decline, the dense network of roads, the small size of protected areas and remaining patches of suitable habitat (see Fig. 5) and a relatively large number of observers and the remarkable display of this species which makes its discovery memorable. The same assessment can be applied to many EOs east of and around the Wasaga/Port Severn/Honey Harbour area on the Shield. This supposition gains support from the failure of a search team to find any Eastern Hog-nosed Snakes in 32 EOs on the Trent-Severn Waterway in 2005, and that many EOs were no longer suitable habitat (G. Cunnington, pers. comm.). Finally, if we ignore these “uncertainties” and look at the NHIC map (Fig. 2), we see that the hog-nosed snake recently seems largely restricted to a 3-4 isolated areas of southwest Ontario and an area around the fast-growing Honey Harbour-Wasaga Beach region of Muskoka, and the heavily used south-west edge of the Shield (see also Schueler 1997). Thus, it seems reasonable to infer that the total Ontario population would be less than 7500 adults (see next section).

Fluctuations and trends

All available information points toward a decline in number of animals based on decline in available habitat and disappearance or drastic decline of Eastern Hog-nosed Snakes from several areas including parts of the Trent-Severn, Algonquin Park (Brooks *et al.* 2003), parts of Long Point (R. Bolton pers. comm.. 2007), Pinery P.P. (A. MacKenzie pers. comm. 2007), Pelee Island and Point Pelee NP. Schueler (1997) cites several other areas in which this snake seems to have gone from being common to being rare or extirpated including Boshkung Lake, Haliburton County, Big Creek, parts of Haldimand–Norfolk County, Essex County and the Toronto area. The NHIC has determined that Eastern Hog-nosed Snakes have been extirpated from a minimum of 8%

of element occurrences in Ontario (Oldham and Austen 1998). Furthermore, 35% of element occurrences are ranked as historic, or unconfirmed in the last 20 years (Oldham and Austen 1998). However, the species undoubtedly persists at many northern sites because searches have been limited and the species is cryptic and uncommon there. Ultimately, however, the decline in available habitat, the increase in road construction and subsequent vehicle traffic in south-central Ontario, and the threat of human persecution can only mean a decline in number of snakes (S. Gillingwater pers. comm.).

In the Carolinian region, it seems likely that the hognose exists in viable numbers only around the Pinery PP area and parts of Haldimand-Norfolk County (Figs. 2, 5). Outside these places, the species exists only in isolated small populations. The Eastern Hog-nosed Snake is never found in high densities and is highly vagile, which when considered together increase its susceptibility to urbanization, habitat fragmentation and mortality when crossing roads. In the latter case, increased mortality is an inevitable consequence of increased vagility, all else being equal (Bonnet *et al.* 1999; Shine *et al.* 2004; Rouse 2006). Roads increase this risk because snakes are small and slow. Thus a vagile snake is not mobile compared to, for example, a vagile canid. For a vagile snake, roads represent linear barriers, either snakes attempt to cross and are killed or they avoid crossing and are confined and isolated by the roads (Gibbs, 1998; Cunnington 2004ab, 2006; Hawbaker *et al.* 2006; Rouse 2006). Vagility and high dispersal capability are traits that have been previously implicated in road mortality of herpetofauna (Gibbs 1998; Bonnet *et al.* 1999; Carr and Fahrig 2001). According to Roe *et al.* (2004, 2006), the notion that animals that regularly migrate or disperse long distances may be at greater risk of decline in fragmented landscapes is in contrast to the widely held belief that such animals may be most resistant to habitat fragmentation. However, if costs (e.g., mortality) incurred during dispersal or migratory movements are considered, what may be a valuable trait for colonizing new habitat patches or utilizing widely dispersed resources may become a handicap in landscapes modified by road networks.

Rescue effect

Although *H. platirhinos* is found in the U.S. directly south and west of Ontario, the populations at the southern part of its Canadian range are separated from the American populations by the Great Lakes. Given that Eastern Hog-nosed Snakes have only rarely been reported to swim (Tynning 1990), there is little evidence that they would cross large water bodies, and any rescue by American snake populations would be unlikely. Also, *H. platirhinos* is currently designated as Vulnerable (S3) in Michigan, Ohio, and Pennsylvania, which further decreases the likelihood of exchange.

Rescue effect from one Ontario population to the next is also highly unlikely because Eastern Hog-nosed Snakes have shown reluctance to cross roads and those that do venture on roads, are likely to be killed (Rouse 2006).

LIMITING FACTORS AND THREATS

Limiting factors for this species include the availability of suitable habitat, especially sandy soils for oviposition (in some areas) and hibernation sites, and the availability of prey. These soils were easiest to clear and preferred for agriculture (Armason 2001; W. Chesworth, pers. comm 2007), and intensive agriculture is the land use with the strongest link to species' endangerment in Ontario (Kerr and Cihlar 2004). Hence, the hog-nosed snake lost much of the habitats that are key to its survival. The lack of available oviposition sites is especially remarkable in Wasaga Beach P.P. where only 1.3% of the total available area is suitable for oviposition (G. Cunnington pers. comm.). There, communal nesting and clustering of oviposition sites have been observed (G. Cunnington pers. comm.).

Eastern Hog-nosed Snakes are prey specialists and in Canada have only been observed to feed on toads, so the disappearance of *Bufo americanus* and/or *Bufo fowleri* would likely cause these snakes to vanish completely from such areas. This effect may have occurred at Pinery PP recently where it appears that both toads and hog-nosed snakes were at one time commonly encountered and reported from the dune habitat but now seem to have declined sharply in this habitat (A. MacKenzie, pers. comm. 2007). Historically, the Eastern Hog-nosed Snake occurred at all sites along Lake Erie in Ontario where Fowler's Toads (*Bufo fowleri*) were found (Schueler 1997). At Point Pelee and on Pelee Island, where these toads have apparently disappeared (Green 1989), so has *H. platirhinus*, even though the American Toad (*Bufo americanus*) remains common (Schueler 1997).

Road mortality, human persecution, nest predation, and other anthropogenic threats all negatively affect this species' survival. Motor vehicles on paved roads, dirt roads, and trails may be second only to habitat loss as a cause of declines and losses of reptile populations (Wright 2007) and especially pose a major threat to vagile snakes like the eastern hog-nose (Gibbs, 1998; Bonnet *et al.* 1999; Rudolph *et al.* 1999; Carr and Fahrig, 2001; Webb *et al.* 2003; Crowley 2006; MacKinnon *et al.* 2005; Rouse 2006). Crowley (2006) demonstrated using NHIC Element Occurrences that road density is significantly higher where Hog-nosed Snakes have become extirpated than where they are still extant. A similar conclusion, albeit somewhat anecdotally based, was drawn by Wright (2007) concerning disappearance of Western Hog-nosed Snakes (*Heterodon nasicus nasicus*) in an area of Alberta bisected by a paved road. Recently, Clark (2007) has reported that in New York roads increase genetic differentiation among populations of Timber Rattlesnakes (*Crotalus horridus*) isolated by these roads. Radiotracking data show that some Eastern Hog-nosed Snakes avoid crossing roads and this avoidance restricts the size of their home range and further isolates/fragments populations (Rouse 2006). Recent studies of Prairie Rattlesnakes (*Crotalus viridus*) and Massasaugas (*Sistrurus catenatus*) suggest that mortality on roads may act as a selective pressure that reduces the mobility of the population by removing those individual snakes that are more vagile (Jorgenson and Gates, 2006, Rouse pers. comm., D. Jorgenson pers. comm.). Reluctance to cross roads might seem beneficial to the survival of this snake but in reality it illustrates a scenario where fragmentation of suitable habitat by expanding road networks will produce a

number of small isolated populations which are unable to disperse and may suffer from inbreeding.

As noted earlier, even protected areas are dangerous to these snakes because most of these areas in the southern parts of the species' Ontario range are small and intensively used by people and their vehicles (Crowley 2006, Kerr and Cihlar 2004). The Carolinian region which holds about half of the Eastern Hog-nosed Snake's distribution in Canada is severely fragmented, has an extremely high density of roads (Taylor *et al.* 2001) and is highly modified into intensive agriculture and urban areas, and the conservation status of the entire region has been termed "critical" (Ricketts *et al.* 1999). Over 94% of upland forests have been cleared and ploughed (Larsen *et al.* 1999) and over 99% of its dry prairie habitat has been converted (Bakowsky and Riley 1994). In the snake's range in the Georgian Bay region the expansion of Highway 69 and the related upgrades of surrounding roads (see **Habitat Trends** section) and the continued frantic development of other areas of the southern Shield will increase anthropogenic threats to hog-nosed snakes as well as increase the snakes' mortality from increased, and higher speed traffic (Aresco 2005; Farmer 2006) and from associated landscape changes (Crowley 2006).

Human persecution is also a major threat because of the hog-nosed's exaggerated and intimidating, although harmless, defensive display and the fact that these displays make it resemble venomous snakes such as "cobras" and "puff adders". This persecution is especially significant in urbanized areas surrounding snake habitat (e.g. Wasaga Beach P.P.), although cottagers still kill snakes even in protected areas (S. Gillingwater pers. comm.). Nest predation by subsidized predators such as raccoons has not been quantified but is potentially a significant threat. Aside from the aforementioned threats, occasionally, human garbage might pose a small threat; there have even been two reported cases of *H. platirhinos* getting stuck in discarded pop cans (S. Gillingwater pers. comm.). Also, there is a growing demand for these snakes in the pet trade (S. Gillingwater, email, Nov. 2007; P. Catling, email, Nov. 2007). (Also, see Google "hognosed snake pets" for a large selection of relevant websites selling/trading/extolling this species as pets.)

SPECIAL SIGNIFICANCE OF THE SPECIES

Heterodon platirhinos is interesting and important for several reasons. First, it feeds almost exclusively on toads which are highly toxic. This feeding strategy thus provides us with an excellent opportunity to study metabolism and digestion. The snake's extravagant death feigning defence also provides a rare opportunity to study the evolution of anti-predator behaviour (e.g. Gregory, 2007). Also, this species' extensive movements, solitary hibernation behaviour, unusual oviposition behaviour and large clutch size provide potential for interesting future studies in evolutionary ecology.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

The Eastern Hog-nosed Snake received status under COSEWIC in 1997 when it was designated as Vulnerable. It was subsequently reassessed as Threatened in 2001. It was also designated as Threatened by the Ontario Ministry of Natural Resources (Ontario Ministry of Natural Resources 2005). *Heterodon platirhinos* is listed at some level of peril in 11 of the 34 states where it is found (Table 2). The Global status is G5; in the U.S., the national status is N5, and in Canada the national status is N3 (02NOV98).

Table 2. NatureServe Rank for the Eastern Hog-nosed Snake (*Heterodon platirhinos*) for all jurisdictions within its global range.

State/Province	S2 Imperiled	S3 Vulnerable	S4 Apparently Secure	S5 Secure	SNR/SNA Not Ranked/ Not Applicable
Rhode Island	X				
South Dakota	X				
Ontario		X			
Indiana		X			
Kansas		X			
New Hampshire		X			
Ohio		X			
West Virginia		X			
Connecticut		X	X		
Michigan		X	X		
New York		X	X		
Pennsylvania		X	X		
Delaware			X		
Iowa			X		
Massachusetts			X		
Minnesota			X		
Nebraska			X		
Tennessee			X		
Wisconsin			X		
North Carolina			X	X	
Alabama				X	
Arkansas				X	
Georgia				X	
Illinois				X	
Kentucky				X	
Louisiana				X	
Maryland				X	
Mississippi				X	
New Jersey				X	
Oklahoma				X	
Texas				X	
Virginia				X	
District of Columbia					SNA
Missouri					SNR
South Carolina					SNR

TECHNICAL SUMMARY

Heterodon platirhinos

Eastern Hog-nosed Snake

Couleuvre à nez plat

Range of Occurrence in Canada: Southern Ontario

Extent and Area Information

<ul style="list-style-type: none"> • <i>Extent of occurrence (EO)(km²)</i> [A MCP was calculated using all element occurrences from the NHIC database] see p. 4 	107,100 km ²
<ul style="list-style-type: none"> • <i>Specify trend in EO</i> 	Declining
<ul style="list-style-type: none"> • <i>Are there extreme fluctuations in EO?</i> 	No
<ul style="list-style-type: none"> • <i>Area of occupancy (AO) (km²)</i> [NHIC observations from 1990 onward were overlaid with a 3x3 km grid and all squares that contained at least one observation were compiled. The total “occupied” grid area was then calculated.] See section on Abundance 	1,881 km ²
<ul style="list-style-type: none"> • <i>Specify trend in AO</i> 	Declining
<ul style="list-style-type: none"> • <i>Are there extreme fluctuations in AO?</i> 	No
<ul style="list-style-type: none"> • <i>Number of known or inferred current locations</i> 	More than 126
<ul style="list-style-type: none"> • <i>Specify trend in #</i> 	Declining
<ul style="list-style-type: none"> • <i>Are there extreme fluctuations in number of locations?</i> 	No
<ul style="list-style-type: none"> • <i>Specify trend in area, extent or quality of habitat</i> 	Declining

Population Information

<ul style="list-style-type: none"> • <i>Generation time (average age of parents in the population)</i> See section on Life Cycle and Reproduction 	~ 6-7 years
<ul style="list-style-type: none"> • <i>Number of mature individuals</i> See section on Abundance 	(~7,524) Less than 10,000 adults
<ul style="list-style-type: none"> • <i>Total population trend:</i> 	Declining
<ul style="list-style-type: none"> • <i>% decline over the last/next 10 years or 3 generations.</i> 	Unknown
<ul style="list-style-type: none"> • <i>Are there extreme fluctuations in number of mature individuals?</i> 	No
<ul style="list-style-type: none"> • <i>Is the total population severely fragmented?</i> 	Yes, and becoming increasingly so because of increase in roads and development (see sections on Habitat, Habitat Protection, Abundance, and Limiting Factors and Threats)
<ul style="list-style-type: none"> • <i>Specify trend in number of populations</i> 	Unknown
<ul style="list-style-type: none"> • <i>Are there extreme fluctuations in number of populations?</i> 	No
<ul style="list-style-type: none"> • List populations with number of mature individuals in each: 	

Threats (actual or imminent threats to populations or habitats)

Mortality on roads, persecution by humans, habitat fragmentation, urbanization, collection for the pet trade, and possibly, declines in specialized food source (toads).
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Rescue Effect (immigration from an outside source)

<ul style="list-style-type: none"> • <i>Status of outside population(s)?</i> USA: N5 Global: G5 	
<ul style="list-style-type: none"> • <i>Is immigration known or possible?</i> 	Not possible
<ul style="list-style-type: none"> • <i>Would immigrants be adapted to survive in Canada?</i> 	Probably
<ul style="list-style-type: none"> • <i>Is there sufficient habitat for immigrants in Canada?</i> 	Possibly

• <i>Is rescue from outside populations likely?</i>	Very unlikely
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Quantitative Analysis

Insufficient data.

Current Status

COSEWIC: Threatened (November 2007) COSEWIC: Threatened (2001)

Status and Reasons for Designation

Status: Threatened	Alpha-numeric code: B2ab(iii)
<p>Reasons for Designation: This species faces several threats, particularly increased mortality and severe habitat fragmentation caused by an expanding road network and increased traffic. The species is mobile for a snake, but this mobility places it at high risk when it encounters roads. The species also suffers from persecution by humans not only because it is a relatively large snake, but also because of its complex defensive threats when confronted. In southwest Ontario and south of the Canadian Shield, the species has suffered extensive habitat loss from agriculture and rapid increase in housing development. Poaching for the illegal wildlife trade is a growing threat.</p>	

Applicability of Criteria

Criterion A: (Declining Total Population): not applicable
Criterion B: (Small Distribution, and Decline or Fluctuation): Meets Threatened, 2) AO<2000 km ² ; a) severely fragmented by roads; b(iii) loss of habitat.
Criterion C: (Small Total Population Size and Decline): Could meet C2a(i) <10,000 adults, likely to decline, no population greater than 1000 adults.
Criterion D: (Very Small Population or Restricted Distribution): Population exceeds criteria
Criterion E: (Quantitative Analysis): Not applicable

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