COSEWIC
Assessment and Status Report

on the

Plains Hog-nosed Snake
Heterodon nasicus

in Canada

SPECIAL CONCERN
2019

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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Production note:
COSEWIC would like to acknowledge Rob Willson and Pamela Rutherford for writing the status report on Plains Hog-nosed Snake (*Heterodon nasicus*) in Canada, prepared under contract with Environment and Climate Change Canada. This report was overseen and edited by Kristiina Ovaska, Co-chair of the COSEWIC Amphibians and Reptiles Specialist Subcommittee.

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Plains Hog-nosed Snake from Spruce Woods Provincial Park, Manitoba (September 2017); photo by Kristiina Ovaska.

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COSEWIC
Assessment Summary

Assessment Summary – November 2019

Common name
Plains Hog-nosed Snake

Scientific name
Heterodon nasicus

Status
Special Concern

Reason for designation
This large prairie snake, distinguished by its prominent upturned snout, belongs to a suite of grassland species restricted to the arid interior of North America. It has a widespread but patchy distribution in southern Alberta, Saskatchewan and Manitoba. Habitat loss is mostly historical, but conversion of grasslands to more intensive agricultural uses continues. The current population size is probably under 10,000 mature individuals, but robust estimates are lacking. Recent population trends are unknown, but continuing decline is suspected based on threats. These include ongoing habitat loss, fragmentation and degradation from agriculture, fire suppression, energy development, and road mortality. The species is near to meeting criteria for Threatened status and could continue to decline if threats are not effectively managed.

Occurrence
Alberta, Saskatchewan, Manitoba

Status history
Designated Special Concern in November 2019.

COSEWIC
Executive Summary

Plains Hog-nosed Snake
Heterodon nasicus

Wildlife Species Description and Significance

Plains Hog-nosed Snake (*Heterodon nasicus*) is one of two species of hog-nosed snakes in Canada, the other being Eastern Hog-nosed Snake (*Heterodon platirhinos*) in Ontario. Adults range from 45 cm to 75 cm snout-to-vent length and are stout bodied. Distinguishing features include an upturned scale at the tip of the snout, giving the snake its hog-nosed appearance. The defensive behaviours exhibited by Plains Hog-nosed Snake, such as flaring of the neck, hissing, and death feigning (playing dead), are some of the most interesting and bizarre behaviours documented for snakes. Although the species is mildly venomous, it poses negligible risk to humans.

Distribution

In Canada, Plains Hog-nosed Snake occurs in southern portions of Alberta, Saskatchewan, and Manitoba. The global range extends south to New Mexico and Texas. The distribution of the species in Canada is poorly understood; this is partially because characteristics of the species' ecology make it difficult to observe. Recent and historical records suggest that the distribution of the Plains Hog-nosed Snake in Canada is not continuous; instead, there are clusters of records that may demarcate isolated subpopulations.

Habitat

In Canada, Plains Hog-nosed Snake occurs in grasslands on soils with higher than average sand content. Within these grasslands, the snakes can be found in a variety of open-canopy communities, ranging from drier habitats to damp lowlands; the snakes are often found in close proximity to water. Plains Hog-nosed Snake is usually a solitary hibernator, unlike most other large snakes found in the southern prairie region of Canada that hibernate communally. It seems likely that the majority of hibernation sites are burrows, either excavated by the snakes or initially created by small mammals. Similarly, constructed burrows are also used for nesting and shelter.

Biology

Females lay a single clutch of 4 to 23 eggs, typically in an abandoned rodent burrow, and hatchlings emerge from nests from late July to mid-September. Females can reproduce annually, but biennial cycles also occur. The age at which the species reaches sexual maturity may be as early as two years, but some individuals may not reach sexual maturity until 3-4 years of age. Their lifespan is between 8 and 14 years, and generation time is deemed to be 5–8 years. Plains Hog-nosed Snake is primarily active during daytime. It feeds mainly on amphibians but also preys on small mammals, ground-nesting birds, turtle eggs, and lizards.

Population Sizes and Trends

The size of the Canadian population of Plains Hog-nosed Snake is unknown. There are insufficient data to document trends or fluctuations in population sizes, and while survey effort has increased in recent years, no systematic surveys across the range of the species have been conducted. The population may be declining due to habitat degradation and other threats.

Threats and Limiting Factors

Habitat degradation from agriculture and fire suppression, energy production, and road mortality are all considered low impact threats. Subpopulations in Alberta, primarily around Medicine Hat, experience the most significant impact from road mortality and from human intrusion and disturbance. All subpopulations may experience negative impacts of road mortality on gravel roads because of the high density of roads (0.74 km/km^2) throughout the species' range. Sites in Saskatchewan and Manitoba are mostly impacted by agriculture, croplands in particular.

Protection, Status and Ranks

COSEWIC assessed Plains Hog-nosed Snake as Special Concern in November 2019. It currently has no status under the *Species at Risk Act*. In national parks, the species is protected under the *National Parks Act*. Provincially, Plains Hog-nosed Snake and its hibernacula are protected under the wildlife acts of Alberta, Saskatchewan, and Manitoba. It is listed as Threatened under Manitoba's *Endangered Species and Ecosystems Act*. Within provincial park boundaries, Plains Hog-nosed Snake is afforded protection through the Alberta, Saskatchewan, and Manitoba provincial parks acts. There is variable protection within the Suffield National Wildlife Area in Alberta, the Manitoba Wildlife Management Areas, and the National Prairie Farm Rehabilitation Administration pastures in Saskatchewan. Approximately 13% of all occurrences and 10% of the Canadian distribution are in protected areas.

TECHNICAL SUMMARY

Heterodon nasicus

Plains Hog-nosed Snake

Couleuvre à groin des plaines

Range of occurrence in Canada: Alberta, Saskatchewan, Manitoba

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)	~5–8 years
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes, inferred decline
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Suspected decline of 3–30% based on a "Medium" threat impact from threats calculator
[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.	Unknown
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. no b. partially understood c. no
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence	142,428–164,188 km² (calculated values for 1991 – 2015 and for 1927 – 2015, respectively)
Index of area of occupancy (IAO) (Always report 2x2 grid value).	428–640 km² (calculated values for 1991 – 2015 and for 1927 – 2015, respectively)

Is the population “severely fragmented” ie. 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. unknown b. unknown
Number of “locations”* (use plausible range to reflect uncertainty if appropriate)	Probably 100s with road mortality as the most plausible threat
Is there an [observed, inferred, or projected] decline in extent of occurrence?	No
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes, inferred
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Yes, inferred decline, based on possible loss of Big Muddy River drainage subpopulation
Is there an [observed, inferred, or projected] decline in number of “locations”*?	Yes, inferred decline, based on lack of recent records from Big Muddy southern Milk River drainages,
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes, inferred decline in area, based on lack of recent records from Big Muddy southern Milk River drainages, and projected decline from threats,
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of “locations”[1*]?	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 (see Abundance)**
	Subpopulation sizes unknown
Total	Unknown but likely <10,000 mature individuals (see **Abundance**)

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Insufficient data for analysis

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

Threats (actual or imminent, to populations or habitats, from highest impact to least)

Was a threats calculator completed for this species? Yes (22 June 2018)

Overall threat impact “Medium” with 4 Low-impact threats:

i. Agriculture (threat impact Low)
ii. Transportation & Service Corridors (threat impact Low) Energy Production & Mining (threat impact Low)
iii. Natural System Modifications (threat impact Low)

What additional limiting factors are relevant?

Relatively low reproductive rate and a life history that is dependent on high adult survivorship; therefore, the species is particularly vulnerable to any factors that increase adult mortality.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Status of outside population(s)? USA: Montana—S2 (Imperilled) North Dakota—SNR (Unranked)
Is immigration known or possible?	Unknown, but possible
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Unknown
Are conditions deteriorating in Canada?*	Yes
Are conditions for the source population deteriorating? *	Unknown
Is the Canadian population considered to be a sink? *	No
Is rescue from outside populations likely?	Yes, but restricted to areas near the border and of limited importance to the Canadian population

Data Sensitive Species

Is this a data sensitive species? No

Status History

COSEWIC: Designated Special Concern in November 2019.

Status and Reasons for Designation:

Status: Special Concern	**Alpha-numeric codes:** Not applicable

* See Table 3 (Guidelines for modifying status assessment based on rescue effect)

Reasons for designation:
This large prairie snake, distinguished by its prominent upturned snout, belongs to a suite of grassland species restricted to the arid interior of North America. It has a widespread but patchy distribution in southern Alberta, Saskatchewan and Manitoba. Habitat loss is mostly historical, but conversion of grasslands to more intensive agricultural uses continues. The current population size is probably under 10,000 mature individuals, but robust estimates are lacking. Recent population trends are unknown, but continuing decline is suspected based on threats. These include ongoing habitat loss, fragmentation and degradation from agriculture, fire suppression, energy development, and road mortality. The species is near to meeting criteria for Threatened status and could continue to decline if threats are not effectively managed.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Insufficient data to reliably infer, project, or suspect a population reduction.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. IAO of 428–640 km² is below the threshold for Threatened, but the population is not severely fragmented, occurs at >10 locations, and does not experience extreme fluctuations.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Number of mature individuals is within threshold for Threatened and there is a continuous decline, but subpopulation sizes are unknown.
Criterion D (Very Small or Restricted Population): Not applicable. The population is not very small or restricted.
Criterion E (Quantitative Analysis): Not applicable.

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 (2019)

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 and Climate Change Canada
Canadian Wildlife Service
Environnement et Changement climatique Canada
Service canadien de la faune
Canada

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

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2019

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Plains Hog-nosed Snake (Couleuvre à groin des plaines), *Heterodon nasicus* (Baird and Girard 1852), is one of five species of North American hog-nosed snakes (Crother 2012). The taxon was formerly considered to be a subspecies, i.e., *Heterodon nasicus nasicus* (the nominate form), of Western Hog-nosed Snake (Crother 2017). The three subspecies of Western Hog-nosed Snake have each been elevated to full species but have retained their former standard English names (Crother 2017). Accordingly, there is no longer a recognized Western Hog-nosed Snake. Plains Hog-nosed Snake is the only one of the three western species that occurs in Canada.

The classification of the species is as follows:

Class: Reptilia
Order: Squamata
Suborder: Serpentes
Family: Dipsadidae
Genus: *Heterodon*
Species: *H. nasicus*

Morphological Description

Plains Hog-nosed Snake is a medium-sized snake with average adult size ranging from 45 cm to 75 cm snout-to-vent length (SVL) (Platt 1969; Pendlebury 1976; Leavesley 1987). In southern Manitoba, individuals with SVL less than 26 cm were classified as hatchlings, and the smallest hatchling documented was 17 cm (Leavesley 1987).

The dorsal background colouration varies from light brown and brownish-grey to buff or reddish-brown (Platt 1969). There is a row of dark brown blotches dorsally and 2 to 4 rows of smaller blotches along the sides. A dark band extends across the eyes to the angles of the jaw. The ventral scales are usually black with yellowish-white or orange blotches, and the subcaudal scales are black (Platt 1969). The body scales are keeled, that is, each scale has a ridge down the middle; the anal plate is divided, and the rostral scale is upturned (Platt 1969; see cover photo).

Population Spatial Structure and Variability

Plains Hog-nosed Snake has a widespread but patchy distribution in Canada. This may indicate that there are numerous potentially isolated subpopulations (see **Canadian Range**) but may also be an artifact of limited search effort. The naturally patchy habitat of the species is further fragmented by roads and other anthropogenic features and activities, potentially enhancing habitat patchiness and isolation of subpopulations (see **Transportation and Service Corridors**). However, no genetic analyses have been conducted to assess gene flow between subpopulations.

The discontinuous nature of Plains Hog-nosed Snake records from Alberta and Saskatchewan suggests that several of the subpopulations could be isolated. Typical movements of the snakes in Manitoba were up to 500 m (Leavesley 1987), while some long-distance movements (up to 1600 m) were recorded for snakes from a Kansas population (Platt 1969).

In Alberta, the distance between the northern and southern subpopulations is 60 km. In Saskatchewan, the western Saskatchewan subpopulation is separated from the Grasslands National Park subpopulation by 190 km (with a handful of localities in between that are 35 km apart). It is 88 km from the Grasslands National Park subpopulation to the sites in central Saskatchewan and a further 200 km from central Saskatchewan to the southwestern Manitoba subpopulation. Finally, the southwestern Manitoba subpopulation is separated from the CFB Shilo/Spruce Woods Provincial Park subpopulation by 70 km. All of these distances are substantially larger than any dispersal movements reported for this species; therefore, there is unlikely to be gene flow among these subpopulations in Alberta, Saskatchewan, and Manitoba.

Designatable Units

The full extent of the geographic range of Plains Hog-nosed Snake in Canada occurs within the Prairie faunal province, as per the boundaries developed for COSEWIC in 2016 for terrestrial amphibians and reptiles (O'Connor and Green 2016). There is no information available that would suggest the presence of any genetic, morphological, or behavioural differences within the Plains Hog-nosed Snake's Canadian range and hence significant local adaptations. Thus, a single designatable unit is warranted.

Special Significance

The defensive display and death feigning performance that hog-nosed snakes exhibit is one of the most interesting and bizarre behaviours documented for snakes. Descriptions of these behaviours never fail to astound the public, and as such Plains Hog-nosed Snake contributes to education efforts about snakes.

DISTRIBUTION

Global Range

Plains Hog-nosed Snake's range in North America extends from Alberta, Saskatchewan, and Manitoba in the north, southward through Montana, North Dakota, Minnesota, Wyoming, South Dakota, Iowa, Illinois, Missouri, Nebraska, Colorado, Kansas, Oklahoma, New Mexico, and Texas (Figure 1). Approximately 8% of the global distribution is in Canada.

Figure 1. North American range of Plains Hog-nosed Snake (*Heterodon nasicus*). NatureServe and IUCN (International Union for Conservation of Nature) 2007. The IUCN Red List of Threatened Species. Version 2014.1. Downloaded on 24 January 2019.

Canadian Range

In Canada, Plains Hog-nosed Snake occurs in southern portions of Alberta, Saskatchewan, and Manitoba (Figure 2). Within its Canadian range, historical and recent observation records indicate that the distribution is discontinuous; there are clusters of records that may demarcate isolated subpopulations. Within Alberta there are two distinct clusters: 1) northern cluster from Medicine Hat to just south of the Red Deer River, and 2) southern cluster from the Manyberries area to the Canada-United States border with Montana (Figure 2). Within Saskatchewan, there are few records, all from three areas: 1) east of Medicine Hat near Maple Creek, 2) Grasslands National Park, and 3) near Big Muddy Lake. There are no records east of Weyburn. Within Manitoba, there are records from two areas: 1) southwestern region near Oak Lake, 2) Canadian Forces Base Shilo, and Spruce Woods Provincial Park.

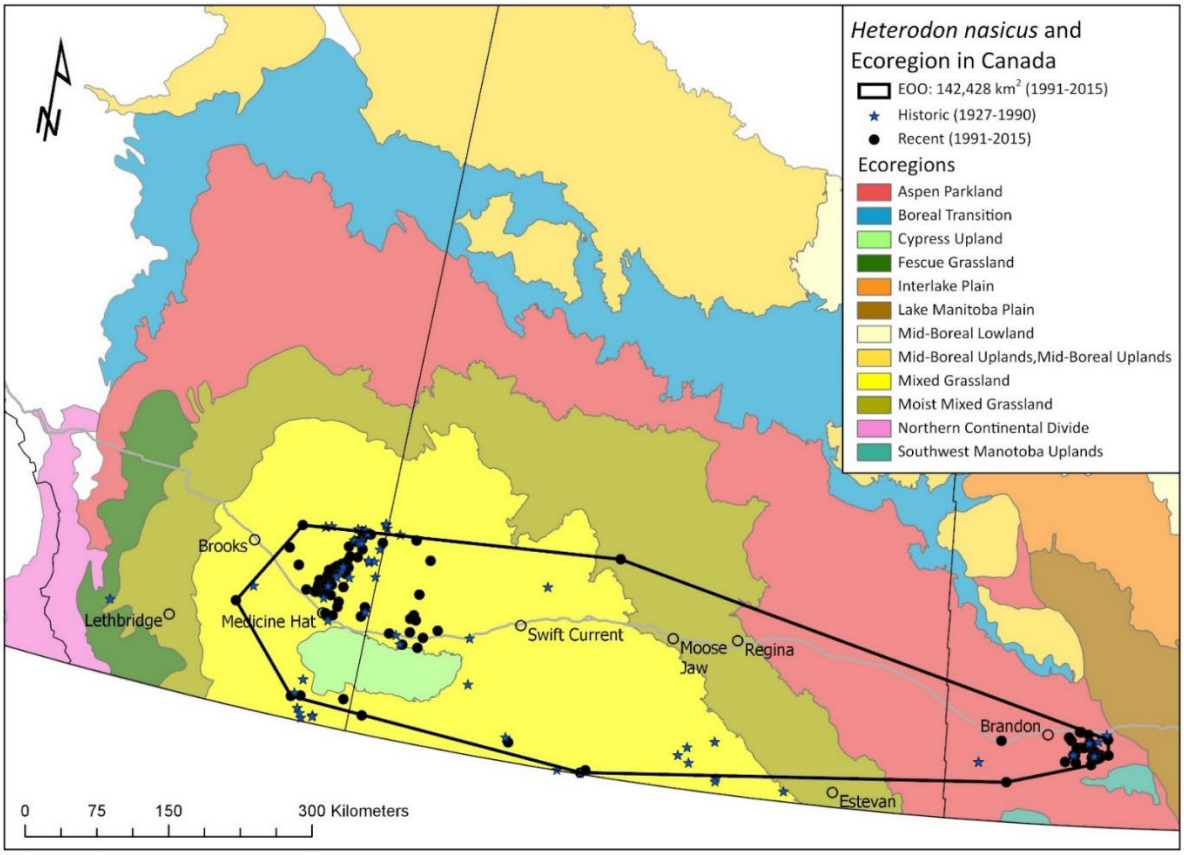

Figure 2. Plains Hog-nosed Snake distribution in Canada in relation to ecoregions within the Prairies ecozone. The species occurs in the following ecoregions: Mixed Grassland in Alberta, Mixed Grassland, Moist Mixed Grassland, Cypress Upland, and Aspen Parkland in Saskatchewan, and Aspen Parkland in Manitoba (Ecological Stratification Working Group 1996). EOO (minimum convex polygon, 1991–2015 records: 142,428 km^2; IAO: 107 grid cells = 428 km^2). Map and calculations by Pam Rutherford.

Extent of Occurrence and Area of Occupancy

The extent of occurrence (EOO) of Plains Hog-nosed Snake in Canada using all records is 164,188 km^2. One record from the Stoney Penitentiary, Manitoba, was considered an extralimital introduction (as per COSEWIC 2010 guidelines) and was excluded. The locality was 130 km east of all other records, and the individual was found in atypical habitat. One record from western Alberta (65 km west of Lethbridge) was retained in the analyses. Although this record was also 130 km west of all other records, this individual was located in grassland habitat along a river in typical habitat for this species. The EOO for historical records (1927–1990) and for recent records (1991–2015) is similar (141,487 km^2 and 142,428 km^2, respectively) (Figure 3). Because of the age of many of the older records and habitat change that has occurred since then, using the value derived from records since 1991 may more accurately represent the true EOO than using all records. However, this value may be an underestimate due to lack of systematic survey efforts and incomplete survey coverage of the sites with historical records.

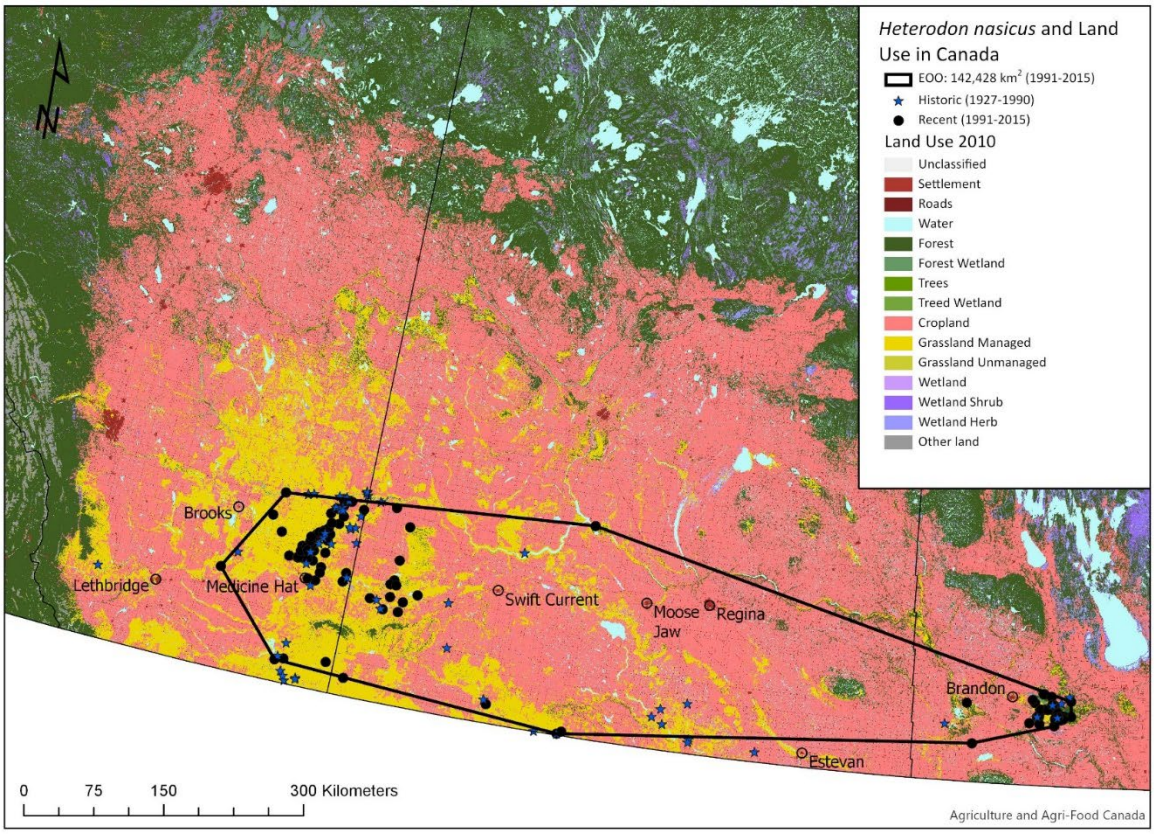

Figure 3. Land use (2010) across the range of Plains Hog-nosed Snake in Alberta, Saskatchewan, and Manitoba (Agriculture and Agri-Food Canada 2010). Most land use is cropland, with areas of grassland (managed and unmanaged) interspersed. There are a small number of areas with trees. Map by Pam Rutherford.

The index of area of occupancy (IAO) of Plains Hog-nosed Snake in Canada, calculated by placing a grid of 2 x 2 km cells over the distribution and using all records, is 640 km^2. For records from 1927–1990, the IAO is 216 km^2, and for records from 1991–2015 the IAO is 428 km^2. The IAO for recent records is twice the size of the IAO for historical records, reflecting increased search effort in all three provinces. There is a possible reduction of the IAO in the Big Muddy River drainage in southeastern Saskatchewan from where there is a cluster of historical records and no recent records (see **Population Trends and Fluctuations**).

Search Effort

Efforts to document occurrences of Plains Hog-nosed Snake have increased in recent years. In Alberta, occurrences have been reported as part of environmental impact assessments and intensive inventories at Suffield National Wildlife Area. In Saskatchewan, several studies of snake species co-occurring with Plains Hog-nosed Snake have been conducted within and adjacent to Grasslands National Park (Martino *et al.* 2012; Fortney *et al.* 2013; Gardiner *et al.* 2013). In Manitoba, efforts to document occurrences of Plains Hog-

nosed Snake have benefited from the Manitoba Herps Atlas (2016), surveys conducted by N. Gushulak (2018), and studies conducted on mixed-grass prairie reptiles in southwestern Manitoba (Rutherford *et al.* 2010; Krause Danielsen *et al.* 2014; Rutherford and Cairns 2018). Nonetheless, search efforts have not been equal across the EOO.

To estimate search effort within Manitoba, observations of any amphibian or reptile within the Manitoba Herps Atlas (MHA) were used. In Manitoba, there have been reports of either an amphibian or reptile species within 282 of the 3044 IAO squares (9%). Plains Hog-nosed Snake was recorded in only 38 IAO squares (1%). There was a significant relationship between the number of MHA records reported per square and the probability of reporting a Plains Hog-nosed Snake (logit model; P = 0.003), with the probability of finding a Plains Hog-nosed Snake increasing to 40% when there are at least 20 MHA records within a square. Most of the 282 IAO squares had fewer than 20 MHA records (N = 262, 93%); the remainder of the squares (N = 20, 7%) ranged from 22 to 189 records per square. Therefore, only a small percentage of IAO squares (N = 20; 0.7%) have received sufficient search effort to detect Plains Hog-nosed Snake. This indicates that within Manitoba the lack of observations may be related to search effort; a similar pattern is expected within Saskatchewan and Alberta. In particular, additional search effort is needed across Saskatchewan, particularly outside Grasslands National Park in eastern Saskatchewan. There is potential habitat across southern Saskatchewan, but no data are available on null observations for the species, making it difficult to determine if and where unsuccessful searches have occurred.

HABITAT

Habitat Requirements

At the landscape scale, Plains Hog-nosed Snake in Canada is found in the Prairies ecozone in the following ecoregions: Fescue Grassland and Mixed Grassland in Alberta, Mixed Grassland and Moist Mixed Grassland in Saskatchewan, and Aspen Parkland in Manitoba (Figure 2; Ecological Stratification Working Group 1996). Within these areas, the snakes occur from drier habitats (Pendlebury 1976) to damp lowlands (Moore 1953), and some suggest that they are typically found in proximity to water (Platt 1969).

The one consistent descriptor mentioned in almost all accounts of Plains Hog-nosed Snake's habitat in Canada is sandy soils (Stanley 1941; Pendlebury 1976; Leavesley 1987; Wright and Didiuk 1998). Given the penchant of hog-nosed snakes to burrow to varying depths for the purposes of nesting, foraging, sheltering, thermoregulating, and hibernating (see below), it seems reasonable to conclude that the presence of sandy substrates dictates, at least in part, the species' distribution in Canada.

The snakes are found most commonly in Chernozemic soils but also occur in Regosolic and Solonetzic soils (P. Rutherford unpubl. data). Chernozemic soils are the dominant soil type in the grassland region of the Canadian prairies. Both Chernozemic and Solonetzic soils are formed from glacial re-working of sedimentary rocks. Regosolic soils

are associated with unstable land surfaces and are commonly associated with river floodplains (Canadian Agricultural Services Coordinating Committee. Soil Classification Working Group 1998).

Hibernation Habitat

For snakes at the northern limits of their geographic distribution, hibernation habitat is critically important (Gregory 2009). Plains Hog-nosed Snake is usually a solitary hibernator (Manitoba: Leavesley 1987; Alberta: Wright and Didiuk 1998; Kansas: Platt 1969) but also uses communal hibernation sites, as reported in Minnesota (Hoaglund *et al.* 2012). The snakes create their own burrows and prefer to burrow in fine sand (Platt 1969), but they have also been located in rodent burrows (Pendlebury 1976; Leavesley 1987).

Nesting Habitat

Locating natural nests of Plains Hog-nosed Snake in Canada is challenging, and most data on nesting habitat come from eggs laid in captivity or sites where hatchlings were found in the wild (Moore 1953; Platt 1969; Leavesley 1987). A spatial ecology study using VHF transmitters in 2010 (N =14) and harmonic radar in 2011 (N = 13) reported that most ovipositing occurred in early July in Minnesota (Hoaglund *et al.* 2012), but this study did not provide detailed information on their nesting habitat.

In Manitoba, hatchlings were located in lowland sites along the edges of trails that intersected dense forest stands (Leavesley 1987). Females of Plains Hog-nosed Snake may lay their eggs by excavating in sparsely vegetated, sandy soils with high levels of sun penetration, similar to Eastern Hog-nosed Snake (Cunnington and Cebek 2005; Peet-Pare and Blouin-Demers 2012).

Other Habitats (Shelter, Mating, Movement)

Plains Hog-nosed Snakes spend considerable time in shelter/retreat sites. Individuals preferred to use burrows or subterranean cavities for shelter and/or thermoregulation rather than cover objects at the surface (e.g., rocks, logs, cover boards) (Platt 1969). Individuals typically had an activity centre that included one or more burrows that were used repeatedly over a period of time lasting from 2–29 days (Platt 1969; Leavesley 1987). These burrows were used for shelter during the night and for daytime retreat from predators or high ground temperatures (Leavesley 1987). Temperatures within the burrows are less extreme than temperatures at the soil surface (Huey *et al.* 1989). Burrows are also used for other purposes, including locating prey and shelter during periods of ecdysis (shedding of skin) (Platt 1969).

In Manitoba, hibernation and mating likely occur in the same habitat, given that mating commenced soon after emergence from hibernation (Leavesley 1987). In Kansas, there was no evidence of long-range movements between summer and hibernation habitats (Platt 1969); this has not been confirmed for Canadian populations.

Habitat Trends

Plains Hog-nosed Snake occurs in grasslands throughout the Canadian prairies. Grasslands are one of the most threatened ecosystems worldwide, with the highest risk of biome-wide biodiversity loss (Heidenreich 2009). In the Canadian prairies, there was extensive loss of grasslands as land was settled and converted to agriculture (late 1800s). It is estimated that approximately 70% of mixed grasslands were lost between settlement and the 1990s (Figure 3; Riley *et al.* 2007; Watmough and Schmoll 2007).

Currently, there are multiple threats that contribute to the further degradation of grasslands, including overgrazing, extraction of oil, natural gas, coal and potash, urbanization, and road construction (Riley *et al.* 2007). There is a high abundance of oil and gas wells throughout Alberta, Saskatchewan, and Manitoba, with the highest density of wells in Alberta. Almost all of these wells are in the prairie and parkland region, and almost all are associated with seismic and other exploration work (Riley *et al.* 2007). The construction of wells, seismic activity, and continued vehicle access to extraction sites may degrade the quality of grassland habitat for Plains Hog-nosed Snake.

BIOLOGY

Life Cycle and Reproduction

Plains Hog-nosed Snake is an egg-laying snake with clutch size ranging from 4–23 eggs, based mainly on data from US populations (Platt 1969). In Canada, palpation of 11 females from a site in southern Manitoba indicated that they contained 5–12 eggs (8.0 ± 2.6; Leavesley 1987). In Alberta, an adult female laid four eggs in captivity from July 19-23; she had an additional seven unlaid eggs that were found during a dissection (Moore 1953).

The smallest gravid females are from the southern portion of the species' range: 361 mm SVL in Arizona, New Mexico, and Mexico (Goldberg 2004), 369 mm in Kansas (Platt 1969). Body size of the smallest reproductively active females was larger in Canadian populations (505 mm SVL; Leavesley 1987). In the US populations studied, reproductively active males were smaller than females (< 300 mm; Platt 1969; Goldberg 2004). Size at first reproduction for males in Canadian populations is unknown, but may be similar or smaller than size of first reproduction in southern populations (Ashton and Feldman 2003; Hileman *et al.* 2017).

Age of first reproduction has been inferred from the presence of spermatozoa or eggs and from growth rates. In Kansas, males of Plains Hog-nosed Snake initiate spermatogenesis in their first spring, when they are nine months old, and have mature spermatozoa when they are one year old (Platt 1969). Some individuals may not initiate reproduction until they are two years old, if they have grown slowly and/or are injured (Platt 1969). Based on growth rates and size at maturity, females likely initiate reproduction in their second spring at approximately 21 months of age (Platt 1969), although some may not mature until the following season or later. In Manitoba, growth rates of male and female

snakes suggest that females first breed in their second spring, which is comparable to Kansas populations (Leavesley 1987).

Platt (1969) found that the maximum age of Plains Hog-nosed Snake in this Kansas population was 8 years, although life expectancy in Colorado is reported to be 14 years (Animal Diversity Web 2018). Annual survivorship is unknown, and hence the generation time cannot be calculated with accuracy. The generation time is deemed to be 5–8 years, based on reproductive maturity at 2 years of age, life expectancy of 8 years in the wild in other areas, and potential lifespan of up to 14 years. The generation time is probably slightly lower than the 8 years estimated for other large grassland snakes (Great Basin Gopher Snake, *Pituophis catenifer deserticola*; Bullsnake, *P. catenifer sayi*), which mature later at ~ 4 years.

Annual reproduction by females has been documented in Canadian populations, but biennial cycles also occur (Leavesley 1987). Up to one half of mature females were not gravid in any one season in Kansas (Platt 1969). Biennial reproduction is particularly common in northern reptiles due to limitations imposed by the short active season (Gregory 2009). Body condition appears to be the primary determinant of whether a female is reproductive in any given year as non-gravid mature females were typically underweight (Platt 1969).

Eggs are laid in late June through late July at Canadian sites, similar to US sites (Kansas) (Moore 1953; Platt 1969; Pendlebury 1976; Leavesley 1987). Hatching dates are inferred from incubation times in captivity and the earliest dates of capture of hatchling individuals. The mean incubation period for three clutches of eggs from Kansas was 56 days at a mean daily temperature of 26.7°C (Platt 1969), with hatching from late August to mid-September. In Manitoba, most hatchlings were captured in August (Leavesley 1987). Sex ratios of hatchlings in Manitoba were 1:1 (Leavesley 1987).

Movements, Dispersal, Migration and Activity

Individual Plains Hog-nosed Snakes typically move shorter distances than reported for other large-bodied snakes (Alberta Environment and Sustainable Resource Development and Alberta Conservation Association 2012). Also, unlike other large-bodied snakes, there was no evidence of long-range movements between summer foraging and winter hibernation habitats in Kansas (Platt 1969), although this has not been confirmed for snakes in Canada.

Three studies have investigated movements of Plains Hog-nosed Snakes in detail: Leavesley (1987) in Manitoba, Platt (1969) in Kansas, and Hoaglund *et al*. (2018) in Minnesota. In all studies, individual snakes showed high variability in movement patterns.

Manitoba:

From 1981–1982, movement data were obtained for Plains Hog-nosed Snake at a Manitoba site using mark-recapture methods with pedestrian surveys and radio telemetry

(N = 62 marked individuals, including 16 adults with SVL>350 mm equipped with radio-transmitters force-fed to the snakes; Leavesley 1987). Pitfall traps and drift fences were also employed, but no snakes were captured in the traps. Each individual was located 1 to 7 times daily. Individual snakes varied their habitat use among the seasons (Leavesley 1987). From mid-June to early August, they were captured in mixed savanna and mixed prairie, as well as at disturbed (opportunistic) sites. They occupied forest sites from early August to late September. Ten snakes retained their transmitters for >48 h and/or were recaptured at a later date during a pedestrian survey. Their movements were usually less than 40 m, and their initial- to final-capture distances ranged from 13 to 442 m over 6 to 157 days. Movement polygon areas ranged from 129 m^2 to 92,289 m^2 (Leavesley 1987). Nine of ten snakes maintained smaller activity centres within their polygon; activity centres ranged from 7 m^2 to 454 m^2. The activity centres always included one or more burrows that were used repeatedly for shelter during the night. One male appeared to be utilizing a large area on a daily basis (polygonal area = 963 m^2 over eight days). Males tended to have larger activity centres than females, although this was not statistically significant. In addition, gravid females appeared to be more sedentary than other snakes.

US studies:

In Kansas, between-capture movements of individuals were highly variable (13–1,609 m), based on data collected from a mark-recapture study (N = 26 and 32 snakes; mean time between captures 98 and 134 days at two sites, respectively; Platt 1969). In this study, five individuals (4 males and 1 female) exhibited large-scale movement ranging from 378 to 1609 m (Platt 1969). The movements of the males were during the breeding season and likely reflected males searching for females and may have been individuals shifting to new home ranges.

In Minnesota, Hoaglund *et al*. (2018) used telemetry with surgical subcutaneous implantation of transmitters to track 33 individual Plains Hog-nosed Snakes. Home range size was estimated by calculating minimum convex polygons (MCP) and Kernel Density (95%). Of the total number of individuals that were implanted with either harmonic radar tags (HR) or VHF transmitters, sufficient data were obtained for 16 individuals. Individuals tracked with HR had significantly smaller home ranges and 95% Kernel Densities than individuals tracked using VHF. Home range sizes were variable (MCP: 0.22–33.29 ha; 95% KD: 0.82–72.08 ha), as were estimates of the activity centres within the home ranges (0.24–15.57 ha) and maximum distances moved (65–1137 m). There were no differences between the sexes in the size of the home range or the activity centres. The maximum distance moved was also similar between the sexes, 567 ± 109 m for males and 546 ± 100 m for females.

The sizes of home ranges in Hoaglund *et al*. (2018) were substantially larger than reported by Leavesley (1987), which may reflect differences in methodology or in movement patterns at different sites. Overall, males tended to use larger areas, and both females and males made maximum distance movements that could be over 1 km in length (1,137 m; Hoaglund *et al.* 2018).

Physiology

In Kansas, cloacal temperatures of 26 individuals ranged from 21.4 to 36.2℃ (mode = 30.5℃; Platt 1969). In Manitoba, oral temperatures of 22 snakes were comparable (range = 19.0 to 35.0℃; median = 30.5℃; Leavesley 1987). At both localities, ground temperatures can reach 50℃, which is substantially higher than the snakes' voluntary thermal maximum of 36.2℃ in Kansas (Platt 1969) and 36.5℃ in Minnesota (Hoaglund *et al.* 2012), or their preferred core temperature (range = 29.5 to 33.0℃; Leavesley 1987). Temperatures within the burrows were consistently below the snakes' preferred temperature (Platt 1969; Leavesley 1987). Therefore, the snakes are likely dependent on retreat sites to avoid extreme ground temperatures. Plains Hog-nosed Snake also burrows in response to low temperatures (Platt 1969; Leavesley 1987), which further highlights the importance of the availability of burrows and suitable substrates and refuge sites for this species.

Interspecific Interactions

Plains Hog-nosed Snake often preys upon amphibians (Platt 1969), and the snakes have been documented feeding on Plains Spadefoot in Canada (Pendlebury 1976). In the US, toads (family Bufonidae) are considered a common food item (Pendlebury 1976), and the snakes have been documented excavating burrows to locate toads (Platt 1969) and turtle eggs (Stanley 1941). They also prey upon small snakes, small mammals, ground-nesting birds, turtle eggs, and lizards (Platt 1969; Leavesley 1987; Rutherford *et al.* 2010; Durso and Mullin 2017). In Illinois, a stable isotope study revealed a shift from a predominance of lizards in the diets of juveniles (31–63%, composed of Six-lined Racerunner, *Aspidoscelis sexlineatus*) to turtle eggs (44–56%, composed of eggs of Western Painted Turtle, *Chrysemys picta* and Snapping Turtle, *Chelydra serpentina*) and toads (6–27%) in the diet of adults (Durso and Mullin 2017). Whether such shifts are a common phenomenon is unknown.

Because of Plains Hog-nosed Snake's proclivity for using burrows throughout its lifecycle, it may benefit from the presence of burrowing mammals (e.g., Thirteen-lined Ground Squirrel, *Spermophilus tridecemlineatus*; Platt 1969; Leavesley 1987) and Plains Pocket Gopher (*Geomys bursarius*; Hoaglund *et al.* 2012). The snakes have also been found burrowing into anthills, although their use of anthills does not appear extensive (Platt 1969).

The species is slow-moving and often remains inactive in response to a threat (Platt 1969; Leavesley 1987). The elaborate defensive behaviours exhibited by Plains Hog-nosed Snake against predators may result in persecution by humans.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Survey efforts for Plains Hog-nosed Snake have been limited (see **Search Effort**). Little is known of its pattern of abundance in Canada, except for a mark-recapture study from 1981–1983 in Manitoba (Leavesley 1987).

Abundance

Density estimates were considerably higher in southern populations of Plains Hog-nosed Snake (Platt 1969) than in Canada (Leavesley 1987). The estimate of population density in Kansas was 2.5 snakes/acre (625 snakes/km^2) at one site, and 1.25 snakes/acre (312 snakes/km^2) at another site (Platt 1969). These estimates include juveniles and adults, but do not include hatchlings.

In Manitoba, 58 Plains Hog-nosed Snakes (including hatchlings and juveniles) were located within a study area of approximately 5 km² (Leavesley 1987). The population size in 1987 may have been as large as 100 individuals (estimated); therefore, the estimated population density ranged from 11.6 to 20 individuals/km^2. Of the 71 individuals captured throughout the study, there were 24 adults (> 505 mm SVL); therefore, the adult to juvenile ratio was 1:2. This ratio was comparable to Platt (1969). Using this adjustment, the estimated population density at this site in 1987 ranged from 3.9 to 6.7 adults/km^2. It is plausible that the density is lower across the remainder of the Canadian range, because this site is anecdotally known to contain high densities of individuals (N. Cairns pers. comm. 2018; N. Gushulak pers. comm. 2018).

Plains Hog-nosed Snakes were captured in Alberta in 2002 from grids of drift fences established at Suffield National Wildlife Area (Didiuk unpubl. data). The researchers used 100 m drift fences with 11 traps/fence that were monitored daily from May to early October. In total, there were 27 drift fences covering approximately 54 km^2. A total of 164 captures (117 new and 47 recaptures) of Plains Hog-nosed Snake were made. New captures included 109 adults, four first-year snakes, and four neonates. The estimated population density of adults at this site is 2.2 adults/km^2, which is slightly lower than the population density calculated for the Manitoba site.

Applying the above population densities to the calculated values for IAO (428 km^2 for records since 1991; 640 km^2 for records since 1927) results in a rough estimate of population size. The estimate ranges from a low of 942 and 1408 adults (density of 2.2/km^2) to 1408 and 4,288 adults (density of 6.7/km^2) based on records since 1991 and 1927, respectively. However, there are many assumptions associated with these calculations. The actual size of the Canadian population is unknown but is most likely below 10,000 mature individuals. There would have to be an increase in IAO by 133% to 249% (using the least and most conservative assumptions, respectively) for the population to reach 10,000.

Fluctuations and Trends

There are insufficient data to quantify trends or fluctuations in the Plains Hog-nosed Snake population in Canada, but the population may be declining due to ongoing habitat degradation and road mortality (see **THREATS AND LIMITING FACTORS**). The EOO estimates based on historical records (1927–1990) and on more recent records (1991–2015) were similar. IAOs between these periods cannot be compared directly due to bias in search effort, which has increased greatly in recent years in Manitoba and Alberta. However, the existence of a cluster of only historical (1940s to 1960s) records from the Big Muddy River drainage in southeastern Saskatchewan suggests a decline (Figure 3). Snake surveys, targeting other species of snakes throughout the active season in 2013 and 2016 and dozens of searches there between 2009 and 2019, have resulted in no observations of this species (R. Poulin pers. comm. 2019). There is a similar lack of recent records from the southern part of the Milk River drainage in southeast Alberta; this drainage has been surveyed recently several times for other species of snakes (N. Cairns pers. comm. 2019).

Population Fragmentation

It is unknown whether the Plains Hog-nosed Snake population in Canada is severely fragmented as per the COSEWIC definition, i.e., whether 50% or more of the population occurs in habitat patches smaller than required to support viable subpopulations. The distribution of the species, as currently understood, suggests some degree of fragmentation. Many of the areas known to support subpopulations of Plains Hog-nosed Snake are widely separated, and grassland habitat in the Canadian prairies is highly fragmented (Riley *et al.* 2007). Avoidance of paved roads has been shown for Eastern Hog-nosed Snake, *Heterodon platirhinos* (Robson and Blouin-Demers 2013), and roads may further contribute to habitat patchiness and population fragmentation. However, the extent to which the distribution of Plains Hog-nosed Snake records reflects uneven survey effort rather than patchiness of suitable habitat is unclear.

Rescue Effect

There are records in Alberta and Saskatchewan that are on the border of Montana and North Dakota. Therefore, rescue from the United States may be possible, but it is deemed of limited importance to the Canadian population as a whole due to relatively low dispersal ability and short documented movement distances of individuals. Typical movements in Manitoba were up to 500 m (Leavesley 1987), while some long-distance movements (up to 1600 m) were recorded for snakes from Kansas (Platt 1969).

THREATS AND LIMITING FACTORS

The IUCN Threats Calculator was applied to Plains Hog-nosed Snake by a panel of experts. The overall threat impact was calculated as “Medium”, based on four low level threats (Appendix 1). The applicable threats are discussed below in approximate perceived order of importance.

Transportation and Service Corridors (threat impact Low)

The following list details aspects of the snakes’ morphology and behaviour that affect susceptibility to road mortality:

- High encounter rates of the snakes with roads are likely within portions of the species’ range (Tables 1 to 3). However, the snakes may exhibit some avoidance of paved roads similar to Eastern Hog-nose Snake (Robson and Blouin-Demers 2013). Their relatively small home ranges and limited seasonal movements may also reduce their encounter rates with roads.
- Large size makes Plains Hog-nosed Snakes more likely to be accidentally hit on roads and easy targets for intentional killing (Martinson 2009).
- The snakes move slowly, exposing them to mortality for an extended period when crossing a road.
- Plains Hog-nosed Snake may thermoregulate on road surfaces, similar to other reptile species (Ashley and Robinson 1996; Gardiner *et al.* 2013).
- Plains Hog-nosed Snake’s defensive behaviour (death feigning) makes it less likely to flee when a vehicle is approaching.

Within the EOO for Plains Hog-nosed Snake, the most common roads across the species’ range are Collectors (70%; a minor thoroughfare mainly used to access properties and to feed traffic with right-of-way; Table 1). The second most common road type is Resource/Recreation (16%; a narrow passage whose primary function is to provide access for resource extraction and may also serve in providing public access to the backcountry); this road type is most common in Saskatchewan (19%) but rare in Manitoba (0%). Arterial roads (a major thoroughfare with medium to large traffic capacity) constitute only 1% of the roads across the EOO but are more common in Alberta (11%) than in either Saskatchewan or Manitoba (0%). Unpaved roads are most common (86.9%), and this pattern is similar for all three provinces. Road densities are high across the EOO (0.74 km/km^2) but vary among road types and across the provinces (0-0.52 km/km^2; Table 2).

Table 1. A) Lengths of roads (National Road Network - categorized by type within each province) and B) type of surface (paved versus unpaved) within the extent of occurrence (EOO) of Plains Hog-nosed Snake for each prairie province (AB-Alberta, SK-Saskatchewan, and MB-Manitoba). Percentages represent the proportion of each road type by region. See text for detailed explanation of main road types. All road types have a mix of paved and unpaved roads.

A)

Road Type	AB (km)	AB (%)	SK (km)	SK (%)	MB (km)	MB (%)	TOTAL (km)	TOTAL (%)
Collector	7073	72.1	61694	69.5	6008	71.8	74775	69.9
Resource/ Recreation	846	8.6	16430	18.5	1	0.0	17276	16.2
Arterial	1034	10.5	2	0.0			1036	1.0
Local/Street	568	5.8	2820	3.2	780	9.3	4169	3.9
Expressway/ Highway	264	2.7	6776	7.6	1570	18.8	8610	8.1
Ramp	23	0.2	88	0.1	12	0.1	122	0.1
Local/Strata	9	0.1					9	0.0
Alleyway/Lane			839	0.9			839	0.8
Freeway			51	0.1			51	0.0
Service Lane	1	0.0	11	0.0	1	0.0	12	0.0
Local/Unknown			1	0.0			1	0.0
Total	**9816**	**9.2**	**88,712**	**83.0**	**8372**	**7.8**	**112,373**	

B)

Paved	1959	20.0	10370	11.7	1698	20.3	14027	13.1
Unpaved	7857	80.0	78342	88.3	6674	79.7	92874	86.9

Table 2. Road density (km of road/km^2) for each road type within the extent of occurrence (EOO) of Plains Hog-nosed Snake for each prairie province (AB-Alberta, SK-Saskatchewan, and MB-Manitoba). See text for explanation of main road types.

Road Type	AB	AB Density	SK	SK Density	MB	MB Density	TOTAL	TOTAL Density
Collector	7073	0.36	61694	0.55	6008	0.52	74775	0.52
Resource/Recreation	846	0.04	16430	0.15	1	0.00	17276	0.12
Arterial	1034	0.05	2	0.00			1036	0.01
Local/Street	568	0.03	2820	0.03	780	0.07	4169	0.03
Expressway/ Highway	264	0.01	6776	0.06	1570	0.14	8610	0.06

Road Type	AB	AB Density	SK	SK Density	MB	MB Density	TOTAL	TOTAL Density
Ramp	23	0.00	88	0.00	12	0.00	122	0.00
Local/Strata	9	0.00					9	0.00
Alleyway/Lane			839	0.01			839	0.01
Freeway			51	0.00			51	0.00
Service Lane	1	0.00	11	0.00	1	0.00	12	0.00
Local/Unknown			1	0.00			1	0.00
Total (km)	**9816**	**0.50**	**88712**	**0.79**	**8372**	**0.73**	**106900**	**0.74**
Area (km^2)	**19,627**		**112,521**		**11,495**		**143,643**	

Road type (gravel versus paved) and traffic density will likely affect mortality patterns. Eastern Hog-nosed Snake avoided paved roads (Robson and Blouin-Demers 2013), which may decrease road mortality but increase genetic isolation of subpopulations. In Saskatchewan, road mortality was higher on paved than gravel roads for Eastern Yellow-bellied Racer (*Coluber constrictor flaviventris*) and Bullsnake, and radio-tracked individuals used roads more than expected (Fortney *et al.* 2012). Throughout the range of Plains Hog-nosed Snake there are more unpaved roads than paved roads, although the proportion differs among the three provinces (Table 1).

Roadkill has been reported from several areas in Alberta and from around Brandon in Manitoba (N = 28). Of 195 recent (1991–2015) records in Canada, 54% were within 555 m of at least one road (Table 3); this distance was used in the analysis because it is the average maximum distance moved (males and females combined) as determined by Hoaglund *et al*. (2018). While this analysis may simply reflect the use of road surveys to locate individuals, it does indicate that these snakes interact with roads. Of the 195 relatively recent records near roads, 5% (N = 9) were roadkill (Table 3). One-third (34%, N = 36) were from paved roads (Table 3).

Table 3. Number and percentages of recent records (1991–2015) of Plains Hog-nosed Snake found within 555 metres of a road in each prairie province (AB-Alberta, SK-Saskatchewan, and MB-Manitoba). Within those individuals located near roads, roads are categorized by their paved status (paved versus gravel). Within each road type the captures are identified as a live capture, dead, or unknown.

	AB	AB (%)	SK	SK (%)	MB	MB (%)	Total	Total (%)
Not near road	26	38	3	19	61	55	90	46
Near road	43	62	13	81	49	45	105	54
Gravel	37	86	8	62	24	49	69	66
Live	*33*	*89*	*2*	*25*	*24*	*100*	*59*	*86*
Dead	*3*	*8*	*1*	*13*	*0*	*0*	*4*	*6*

	AB	AB (%)	SK	SK (%)	MB	MB (%)	Total	Total (%)
Unknown	*1*	*3*	*5*	*63*	*0*	*0*	*6*	*9*
Paved	6	14	5	38	25	51	36	34
Live	*4*	*67*	*0*	*0*	*22*	*88*	*26*	*72*
Dead	*2*	*33*	*0*	*0*	*3*	*12*	*5*	*14*
Unknown	*0*	*0*	*5*	*100*	*0*	*0*	*5*	*14*
Total	**69**		**16**		**110**		**195**	

Plains Hog-nosed Snake may be intentionally or inadvertently killed and its habitat damaged or destroyed during road construction activities. Throughout the species' Canadian distribution, the creation and maintenance of service corridors likely have adverse effects on individuals and habitat. Construction activities such as grubbing, clearing, and trenching for pipelines and other linear infrastructure projects, can accidentally kill snakes, as well as damage habitat.

Across the species' Canadian range, the scope of transportation and service corridors is considered Large (31–70% of the population exposed to the threat over the next 10-year period) and the severity Slight (approximately 1% population decline predicted), resulting in an overall threat impact of Low. However, local impacts may be significant in some areas.

Agriculture (threat impact Low)

Historically, conversion of prairie grasslands and parklands to agricultural uses was a primary threat to Plains Hog-nosed Snake and resulted in extensive habitat loss and fragmentation.

Since the 1920s, land area devoted to agriculture has not changed substantially, but the land use has changed (Statistics Canada 2017). In this region, habitat loss is primarily conversion to agriculture and primarily to cropland (Figure 3).In Canada, the percentage of total farm area that is cropland has increased from approximately 30% in the 1920s to approximately 55% in 2016 (Statistics Canada 2017). Most of this increase occurred up to 1990, and there has been little change from 1990 to 2016. Within the EOO, Alberta has the lowest percentage of cropland (26%); Saskatchewan and Manitoba have similarly high percentages (70–71%; Table 4A). Alberta has a higher proportion of managed grassland (69%), followed by Saskatchewan (21%), and Manitoba (10%; Table 4A).

Conversion of land into cropland will likely have a stronger negative impact on Plains Hog-nosed Snake than livestock use, except where lands are overgrazed and/or have high stocking densities (COSEWIC 2013). Moderate grazing can maintain suitable habitat for reptiles, although not all species respond to grazing intensity the same way (Howland *et al.* 2014). The effects of grazing on Plains Hog-nosed Snake are unknown. Agricultural activities in Saskatchewan and Manitoba (compared to Alberta) are likely a higher impact threat because of the higher proportions of croplands in these two provinces. Of 191 recent records that could be categorized by land use, almost two-thirds (65%) of the captures

were in managed grasslands,14% were in forests, and 8% were in water (Table 4B). These three land use categories make up only one-third (33%) of the available area within the EOO (Table 4A). Only 6% of captures were in cropland, which makes up almost two-thirds (64%) of the available area within the EOO.

The severity of agriculture as a threat is considered moderate (11–30%), but the scope over the next 10 years is small (1–10%) because much of the available habitat has already been converted to agriculture. The overall threat impact is Low.

Table 4. A) Area (km^2) and percentage of total area classified by land use within EOO of Plains Hog-nosed Snake by prairie province (AB-Alberta, SK-Saskatchewan, and MB-Manitoba; Agriculture and Agri-Food Canada 2010). B) Numbers of recent records (1991–2015) and percentages in each of the land use categories within EOO for each prairie province.

A)

Land Use	AB (km^2)	AB (%)	SK (km^2)	SK (%)	MB (km^2)	MB (%)	Total (km^2)	Total (%)
Cropland	5025	26	77856	71	7638	70	90519	64
Grassland Managed	13604	69	23041	21	1132	10	37776	27
Water	405	2	3689	3	394	4	4488	3
Forest	217	1	2508	2	1264	12	3989	3
Roads	179	1	1551	1	193	2	1923	1
Settlement	74	0	529	0	105	1	708	1
Wetland	46	0	610	1	17	0	672	0
Other land	24	0	141	0	6	0	170	0
Forest Wetland	3	0	10	0	89	1	101	0
Trees	11	0	83	0	3	0	97	0
Wetland Herb		0	1	0	30	0	32	0
Wetland Shrub	5	0	12	0	13	0	30	0
Treed Wetland	0	0	5	0	4	0	9	0
Grassland Unmanaged	0	0		0		0	0	0

B)

Land Use	AB	AB (%)	SK	SK (%)	MB	MB (%)	Total	Total (%)
Cropland	3	5	4	24	4	4	11	6
Grassland Managed	59	89	11	65	54	50	124	65
Water	1	2	0	0	14	13	15	8
Forest	0	0	0	0	26	24	26	14
Roads	2	3	1	6	4	4	7	4
Settlement	0	0	1	6	4	4	5	3
Wetland	1	2	0	0	0	0	1	1
Other land	0	0	0	0	2	2	2	1

Land Use	AB	AB (%)	SK	SK (%)	MB	MB (%)	Total	Total (%)
Forest Wetland	0	0	0	0	0	0	0	0
Trees	0	0	0	0	0	0	0	0
Wetland Herb	0	0	0	0	0	0	0	0
Wetland Shrub	0	0	0	0	0	0	0	0
Treed Wetland	0	0	0	0	0	0	0	0
Grassland Unmanaged	0	0	0	0	0	0	0	0
Total	**66**		**17**		**108**		**191**	

Energy Production and Mining (threat impact Low)

There is a high density of oil wells throughout the species' Canadian distribution with the highest density in Alberta (Table 5). Saskatchewan and Manitoba have similar well densities, but there are more wells in Saskatchewan because more of the EOO is located within Saskatchewan. Approximately 1/4 to 1/3 of the wells have been abandoned (22–33%), 10–59% are active, and 0-59% are planned. The highest percentage of planned wells is in Alberta.

Table 5. Numbers and percentages of oil, gas and potash wells and their current status located within the extent of occurrence (EOO) of Plains Hog-nosed Snake for each prairie province (AB-Alberta, SK-Saskatchewan, and MB-Manitoba). Data from Alberta Energy Regulator (2019), Saskatchewan Mining and Petroleum GeoAtlas (2019), and Manitoba Petroleum Branch (2019).

Licence Status	AB	AB (%)	SK	SK (%)	MB	MB (%)
Abandoned	10721	22	15801	31	2071	33
Active	4731	10	25136	49	3745	59
Drilling		0	1189	2	188	3
Planned (cancelled)	unknown	0	1493	3	242	4
Planned (licensed)	28468*	59	190	0	47	1
Suspended	4516	9	7828	15	37	1
Total	**48436**		**51637**		**6330**	
Density (wells/km^2)	**2.47**		**0.46**		**0.55**	

*Also includes any wells that are currently being drilled.

The impact of energy production on Plains Hog-nosed Snake may be minimal because there is little overlap between the areas with high densities of well sites and high numbers of Plains Hog-nosed Snake records. The impacts on the snakes are from disturbance during construction of well sites and associated habitat modification and fragmentation. Most of the impact is probably from access roads that are considered separately under **Transportation and Service Corridors**. The scope of this threat is deemed Restricted - Small (1–30% of the population exposed to the threat over the next

10-year period), and the severity Slight (1–10% population decline), resulting in a threat impact of Low.

Natural System Modifications (threat impact Low)

Changes in prairie vegetation due to invasive plants, such as Crested Wheatgrass (*Agropyron cristatum*) and Yellow Sweet Clover (*Melilotus officinalis*), may have a negative impact on the species' habitat. In Saskatchewan, invasive species are encroaching into sandy areas. Sweet Clover is more of a problem in moister areas and heavier soils than inhabited by Plains Hog-nosed Snake. Crested Wheatgrass is potentially a problem, but impacts are unknown. The scope of this threat was scored as Small (1–10% of the population exposed to the threat over the next 10-year period), and severity as Moderate to Slight (30–1% population decline), reflecting the high degree of uncertainty associated with this impact, resulting in a threat impact of Low.

Threats with Unknown Impacts

- Invasive and Other Problematic Species: Snake fungal disease is now in Minnesota, and although it is not yet known within the Plains Hog-nosed Snake's range, its spread is considered a possibility.
- Climate Change and Severe Weather: The global distribution of the species covers a wide climatic range, but increased unpredictability and climatic extremes may pose a problem to the species. The effects on the species may be positive due to a longer growing season and milder winters. However, loss of open habitats may occur from shrubification and aspen encroachment facilitated by increased precipitation. There is much uncertainty about the speed of change and its effects on this species, hence the severity is scored as unknown.

Number of Threat-based Locations

The number of locations depends on the threats. The most significant threats are road mortality, agriculture, and off-road vehicle recreation. These threats differ among the prairie provinces. Sites in Alberta (N =112; 42%), primarily around Medicine Hat, experience the most significant impact from road mortality. All sites may experience negative impacts of road mortality on gravel roads because of the high density of roads throughout the EOO. Sites in Saskatchewan and Manitoba (N = 152; 58%) are most impacted by agriculture (croplands, in particular). Three sites in Manitoba and two in Saskatchewan (2%) occur in areas with a high density of oil and gas wells, and Plains Hog-nosed Snake in these sites may be negatively impacted by development of the wells and associated vehicle traffic.

Combining the above sites into threat-based locations is difficult and subject to uncertainty. However, given the most plausible threat of road mortality, there may be over 100 locations.

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

COSEWIC assessed Plains Hog-nosed Snake as Special Concern in November 2019. It currently has no status under the *Species at Risk Act*. Federally, this species is protected within the boundaries of national parks (Grasslands National Park, East and West Blocks). Collection and harassment of Plains Hog-nosed Snake are regulated under the National Parks General Regulations (Government of Canada 2018). Within national parks, it is prohibited to: 1) carry out any action that unreasonably interferes with fauna, or 2) traffic in any wild animal. In addition, under the National Parks Wildlife Regulations [4(1) (a)] no person shall hunt, disturb, hold in captivity or destroy any wildlife within, or remove any wildlife from, a park.

Provincially, Plains Hog-nosed Snake is protected under the wildlife acts of Alberta, Saskatchewan and Manitoba. In all three provinces, Plains Hog-nosed Snake is considered a non-game animal, making it unlawful to kill, possess, buy or sell the snakes without a permit (Government of Saskatchewan 2015; Government of Manitoba 2016; Government of Alberta 2018a). It is listed as Threatened under Manitoba's *Endangered Species and Ecosystems Act*. The Alberta *Wildlife Act*, Saskatchewan *Wildlife Act* and Manitoba *Wildlife Act* also protect Plains Hog-nosed Snake hibernacula year-round from disturbance and destruction.

Within provincial park boundaries (Writing-on-Stone Provincial Park, Alberta; Douglas Provincial Park, Saskatchewan; Spruce Woods Provincial Park, Manitoba), Plains Hog-nosed Snake is afforded additional protection through the Alberta, Saskatchewan, and Manitoba provincial parks acts (Government of Manitoba 2015; Government of Saskatchewan 2017; Government of Alberta 2018b). Under the Alberta *Provincial Parks Act* and the Manitoba *Provincial Parks Act* it is illegal to collect, destroy, damage, remove or move any plant life or animal life.

Non-Legal Status and Ranks

NatureServe (2016) indicates the following status designations for Plains Hog-nosed Snake: Global - G5 (Secure); National for United States - N5 (Secure); National for Canada - N3 (Vulnerable); Subnational for Alberta - S2 (Imperilled); Subnational for Saskatchewan - S3 (Vulnerable); Subnational for Manitoba - S1S2 (Critically Imperilled/Imperilled); IUCN Red List Category (for Western Hog-nosed Snake): LC - Least concern.

In Alberta, Plains Hog-nosed Snake was designated as a species that May Be at Risk in 2005, 2010 and 2015 (Alberta Environment and Parks 2015). The species is described as extremely rare, fewer than 100 site or specimen records from Alberta, and the current population trend is unknown.

Habitat Protection and Ownership

Plains Hog-nosed Snake habitat within national parks is protected, and at least to some degree, it is protected within provincial parks within Alberta, Saskatchewan, and Manitoba. The only national park where Plains Hog-nosed Snake is known to occur is Grasslands National Park. The species is also known to occur in three provincial parks: Writing-on-Stone Provincial Park, Alberta, Douglas Provincial Park, Saskatchewan, and Spruce Woods Provincial Park, Manitoba. The level of protection afforded to habitat within national wildlife areas (e.g., Suffield National Wildlife Area in Alberta and Assiniboine Corridor Wildlife Management Area in Manitoba) is variable.

Plains Hog-nosed Snake occurs on two military bases: Canadian Forces base Shilo (CFB Shilo) and Canadian Forces Base Suffield (CFB Suffield). Habitat on military bases is protected by federal legislation.

Additional areas in Saskatchewan are protected to some extent within the federal Prairie Farm Rehabilitation Administration pastures (PFRA; Government of Canada 1985). The PFRA pastures in Saskatchewan were divested in 2017, but they are still operated as pastures through Saskatchewan Environment. Community patron groups apply for leases to be approved for grazing (i.e., they are operated more like Provincial Community Pastures now). The closest pasture to Grasslands National Park, which used to be called the “Val Marie PFRA Pasture” is now leased to the Val Marie Grazing Corporation.

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Rob Willson obtained his BSc and MSc from the University of Guelph. He conducted research on Pelee Island's snakes from 1994 to 2004. Additional investigations of snake ecology and conservation include eight years working on Eastern Massasaugas and Eastern Hog-nosed Snakes in Ontario. Rob has prepared COSEWIC reports and recovery strategies for several snakes, including the recent draft COSEWIC report on Bullsnake. He currently works as an ecological consultant in Ontario.

Pamela Rutherford obtained her BSc from University of Toronto, MSc from University of Western Ontario, and PhD from University of Victoria. She conducted research on lizards in British Columbia from 1996-2000, amphibians in Ontario from 2002-2005, and amphibians and reptiles in Manitoba from 2005-2018. She currently works as an Associate Professor at Brandon University in Brandon, Manitoba.

COLLECTIONS EXAMINED

No collections were examined for this report.

Appendix 1. Threats calculator spreadsheet for Plains Hog-nosed Snake (*Heterodon nasicus*).

Species or Ecosystem Scientific Name	Plains Hog-nosed Snake (*Heterodon nasicus*)			
Element ID			**Elcode**	
Date (Ctrl + ";" for today's date):	2018-06-22			
Assessor(s):	Connie Browne, Andy Didiuk, Chris Edge, Laura Gardiner, Tom Herman, Phil McLoughlin, Njal Rollinson, Pamela Rutherford, Kristiina Ovaska (facilitator)			
References:	COSEWIC status report (6-month interim report, May 2018)			
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	0	0
	D	Low	4	4
		Calculated Overall Threat Impact:	Medium	Medium
		Assigned Overall Threat Impact:	**C = Medium**	

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
1.1	Housing & urban areas		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	All urban areas are relatively small and comprise a small percentage of the species' Extent of Occurrence, accounting for expansion around these centres. Therefore, residential development is likely not a significant threat to Plains Hog-nosed Snake.
1.2	Commercial & industrial areas		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	Scores mirror Housing & urban areas
1.3	Tourism & recreation areas		Negligible	Negligible (<1%)	Moderate - Slight (1-30%)	High (Continuing)	In Grasslands National Park, expansion of infrastructure (roads, trails, campgrounds) continues, but an environmental impact assessment process is in place. The placement of infrastructure usually targets areas that are already disturbed and have invasive species. Habitat destruction & direct mortality during construction are main potential impacts (roads dealt with elsewhere).
2	Agriculture & aquaculture	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.1	Annual & perennial non-timber crops	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	Agricultural activities are likely a higher threat in Saskatchewan and Manitoba than in Alberta because of the higher proportions of croplands in these two provinces. Habitat loss from land conversion is mostly a historical threat; little additional conversion is likely over the next 10 years. Is there intensification or changing of crops that would affect the snakes? Unknown. Agricultural fields in some areas may be diminishing due to poor conditions for crops in snake habitats (e.g., badlands). Little is known about the species' ability to survive in crop fields and along their edges. Potentially, existing fields may affect movements and increase mortality risk for snakes travelling across them in patchy habitat (note that Plains Hog-nosed Snake is less mobile than Bullsnake, *Pituophis catenifer sayi*, which reduces risk). The snakes are known to use rights-of-way to some extent, and there may be some future habitat loss from this cause.
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Conversion of land into cropland will likely have a stronger negative impact on Plains Hog-nosed Snake than livestock ranching, except where lands are overgrazed and/or have high stocking densities (COSEWIC 2013). Moderate grazing can maintain suitable habitat for reptiles, although not all species respond to grazing intensity the same way (Howland *et al*. 2014). The effects of grazing on Plains Hog-nosed Snake are unknown. In Manitoba, the snakes are often found in grazed lands. The species has evolved with Bison and is hence expected to be tolerant to some grazing. It was noted that community pastures in Saskatchewan are often overgrazed but usually at least patches are left (especially of unpalatable plants). There is an economical loss to farmers from overgrazing, so efforts to control stock densities are usually in place. Effects of grazing on Plains Hog-nosed Snake are unknown (little data), and scoring here is based on speculation and conjecture.
2.4	Marine & freshwater aquaculture						
3	Energy production & mining	D	Low	Restricted - Small (1-30%)	Slight (1-10%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3.1	Oil & gas drilling	D	Low	Restricted - Small (1-30%)	Slight (1-10%)	High (Continuing)	The impact of energy production on Plains Hog-nosed Snake may be minimal, because there is little overlap between areas with high numbers of well sites and occurrences of Plains Hog-nosed Snake. Oil & gas drilling is not as active as in the past and may not be expanding at same rate as previously; it may be declining due to market saturation. Impacts on snakes would be from construction and maintenance of wells (note that roads discussed elsewhere; biggest impact from operations). There was discussion on fracking and its effects on geological structure of the habitat - impacts unknown in sandy habitats but probably not as big an issue as in rocky substrates. Also, bringing in large quantities of water for this purpose may have unknown impacts on the habitat.
3.2	Mining & quarrying		Negligible	Negligible (<1%)	Extreme (71-100%)	Unknown	
3.3	Renewable energy						The group was not aware of new windmill developments. Areas economically viable for wind farms cover 30% of Hog-nosed Snake's range, but a minimal area within this 30% is likely to be developed.
4	Transportation & service corridors	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	
4.1	Roads & railroads	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	Transportation is likely a threat to Plains Hog-nosed Snake because of the high density of roads and the snakes' susceptibility to road mortality. During construction of new roads, Plains Hog-nosed Snakes can be inadvertently killed and their habitat damaged or destroyed. Roadkill has been reported from across the species' Canadian range (see maps in report). This species is more sedentary than many other large snakes and undertakes no long-distance migratory movements, so reducing risk of roadkill. Severity is likely to be at the lower end of Slight (near 1%). It is possible that their sedentary behaviour makes them more susceptible to roadkill, but they are cryptic, especially on gravel roads, and unlikely to be deliberate targets.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.2	Utility & service lines		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	Throughout the range of Plains Hog-nosed Snake, the creation and maintenance of service corridors likely have adverse effects on individuals and habitat. Construction activities such as grubbing, clearing, and trenching for pipelines and other linear infrastructure projects, can accidentally kill snakes, as well as damage habitat. Replacement of poles results in habitat disturbance. However, there is limited maintenance after construction. Opening of the habitat may also have positive effects in some areas by creating edge habitats suitable for foraging. We know very little of the responses of snakes to service corridors, in general, and studies are needed.
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use		Negligible	Negligible (<1%)	Serious (31-70%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals		Negligible	Negligible (<1%)	Serious (31-70%)	High (Continuing)	Plains Hog-nosed Snakes are rarely present at communal hibernacula, and they are difficult to find because of their cryptic colouration and low densities. Therefore, biological resource use is not considered a significant threat to Plains Hog-nosed Snake. This category includes intentional killing, which may happen due to their superficial resemblance to rattlesnakes, but probably not often due to their cryptic behaviour.
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting						
5.4	Fishing & harvesting aquatic resources						
6	Human intrusions & disturbance		Negligible	Negligible (<1%)	Moderate (11-30%)	High (Continuing)	
6.1	Recreational activities		Negligible	Negligible (<1%)	Moderate (11-30%)	High (Continuing)	Off-road vehicle recreation is a significant threat to Plains Hog-nosed Snake in local areas, but its impact on the Canadian population as a whole is probably minimal.
6.2	War, civil unrest & military exercises		Negligible	Negligible (<1%)	Moderate (11-30%)	High (Continuing)	Activities within Canadian Forces Base Shilo and Suffield are not considered a significant threat. A small proportion of snakes would be affected by military traffic. Shilo has no more tank traffic, but Suffield has high impact activities with large machinery. Digging as part of military exercises continues at both sites. There is a good response program to accidental grass fires, but fires do happen; follow up research has focused only on vegetation responses (fires are considered in Section 7.1).

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
6.3	Work & other activities						
7	Natural system modifications	D	Low	Small (1-10%)	Moderate - Slight (1-30%)	High (Continuing)	
7.1	Fire & fire suppression		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	This category includes direct effects of fire and fire suppression (indirect effects on habitat are included in 7.3). In Manitoba, wildfires occur fairly regularly, including in military areas; in Saskatchewan, fires occur regularly in and around Grasslands National Park, but they are usually dealt with quickly; large ones sometimes get away. There is also prescribed burning to improve habitat in the park, but not much in sandy habitats. Direct mortality of snakes is possible in the short term, but subsequent habitat enhancement via vegetation regeneration can be rapid. Typically, fires are fast and patchy. Also, the snakes are likely to escape fires by retreating further into their burrows. Net severity is considered negligible with the recognition that local effects may be higher. A bigger problem is aspen encroachment (see 7.3).
7.2	Dams & water management/use						
7.3	Other ecosystem modifications	D	Low	Small (1-10%)	Moderate - Slight (1-30%)	High (Continuing)	Aspen encroachment is a problem in some areas in Manitoba but not an issue at present over vast majority of range. The effects are gradual over longer time frame than considered here (next 10 years). Changes in prairie vegetation due to invasive plants, such as Crested Wheatgrass and Sweet Clover, may have a negative impact on the species' habitat, but there are no studies. In Saskatchewan, invasive species are encroaching into sandy areas; restoration/habitat assessment has been more focused on Short-horned Lizard (*Phrynosoma hernandesi*) habitat than on snake habitats. Sweet Clover is more of a problem in moister areas and heavier soils than areas inhabited by Plains Hog-nosed Snake. Crested Wheatgrass is potentially a problem, but impacts unknown. There was much discussion on severity: Moderate - Slight score reflects the high uncertainty associated with this impact.
8	Invasive & other problematic species & genes		Unknown	Unknown	Unknown	Moderate (Possibly in the short term, < 10 yrs)	
8.1	Invasive non-native/alien species		Unknown	Unknown	Unknown	Moderate (Possibly in the short term, < 10 yrs)	Snake fungal disease is now in Minnesota, and although it is not yet known within the Plains Hog-nosed Snake's range, its spread is considered a possibility.
8.2	Problematic native species						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.3	Introduced genetic material						
9	Pollution		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	
9.1	Household sewage & urban waste water						
9.2	Industrial & military effluents						
9.3	Agricultural & forestry effluents		Negligible	Small (1-10%)	Negligible (<1%)	High (Continuing)	The scores are the same as to those for Bullsnake, which occurs in similar habitats. The snakes may be at risk from indirect poisoning via rodenticides that are ingested when consuming rodents considered to be agricultural pests (Martino *et al*. 2012). This threat was assessed to be a risk for Great Basin Gophersnake, *Pituophis catenifer deserticola*, in the Okanagan Valley, B.C. through a modelling exercise (Williams and Bishop 2011). Plains Hog-nosed Snake tends to avoid croplands, as far it is known, and so would be less likely to encounter agricultural chemicals than Great Basin Gophersnake, which uses orchards. Most rodent control takes place at the edges of prairies, with some local applications within grasslands.
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		Unknown	Pervasive - Restricted (11-100%)	Unknown	High (Continuing)	Potential but unknown impacts are predicted. The global distribution of the species includes a wide climatic range, but increased unpredictability and climatic extremes may pose a problem to the species. All categories below are predicted by climate models for the prairies. The effects on the species may be positive due to a longer growing season and milder winters. However, loss of open habitats may occur from shrubification (increase in shrub cover) and aspen encroachment facilitated by increased precipitation. There is much uncertainty about the speed of change and its effects on this species; hence the severity is scored as unknown.
11.1	Habitat shifting & alteration						The species was probably more widespread during the Hypsithermal period, which was warmer and drier. The snakes can probably handle warmer, drier weather.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.2	Droughts						
11.3	Temperature extremes						
11.4	Storms & flooding						Burrows tend to be along river basins (based on anecdotal observations) and may be subjected to flooding.

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