COSEWIC
Assessment and Status Report

on the

Gray Ratsnake
Pantherophis spiloides

Great Lakes / St. Lawrence population
Carolinian population

in Canada

Great Lakes / St. Lawrence population - THREATENED
Carolinian population - ENDANGERED
2018

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

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Previous report(s):

COSEWIC 2007. COSEWIC assessment and update status report on the Gray Ratsnake *Elaphe spiloides* (Great Lakes/St. Lawrence population and Carolinian population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 33 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC 2000. COSEWIC assessment and status report on the Eastern Ratsnake *Elaphe obsoleta obsoleta* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 35 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Prior, K.A., and P.J. Weatherhead. 1998. COSEWIC status report on the Eastern Ratsnake *Elaphe obsoleta obsoleta* in Canada. Committee on the Status of Endangered Wildlife in Canada. 1-35 pp.

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COSEWIC would like to acknowledge Gabriel Blouin-Demers for writing the status report on Gray Ratsnake, *Pantherophis spiloides*, prepared under contract with Environment and Climate Change Canada. This report was overseen by Jim Bogart and subsequently by Tom Herman, Co-chairs of the COSEWIC Amphibians and Reptiles Specialist Subcommittee (A&R SSC). Modifications to the status report after acceptance of the provisional report were overseen by Tom Herman, based on comments from jurisdictions, experts, A&R SSC, and COSEWIC members.

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Gray Ratsnake — Gray Ratsnake, *Pantherophis spiloides*, by Gabriel Blouin-Demers.

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COSEWIC
Assessment Summary

Assessment Summary – April 2018

Common name
Gray Ratsnake - Great Lakes / St. Lawrence population

Scientific name
Pantherophis spiloides

Status
Threatened

Reason for designation
One of the largest snakes in Canada, this species is characterized by late age of maturity and low reproductive rates. It occupies an increasingly fragmented region of southern Ontario and is threatened by ongoing development and by expansion of road networks. The extent of its occurrence appears to have declined significantly. Mark-recapture analyses from several subpopulations indicate decreasing population trends at some sites, although widespread estimates of abundance or population trend are lacking. Development especially threatens communal hibernacula. Traffic on roads where snakes bask represents a significant mortality threat. Additionally, this species is intentionally killed, both along roads and at hibernacula. Rescue from other populations is unlikely since this population is already separated from upstate New York by the St. Lawrence River and by at least 100 km from the main species range in New York.

Occurrence
Ontario

Status history
The species was considered a single unit and designated Threatened in April 1998 and in May 2000. Split into two populations in April 2007. The Great Lakes / St. Lawrence population was designated Threatened in April 2007. Status re-examined and confirmed in April 2018.

Assessment Summary – April 2018

Common name
Gray Ratsnake - Carolinian population

Scientific name
Pantherophis spiloides

Status
Endangered

Reason for designation
One of the largest snakes in Canada, this species is characterized by late age of maturity and low reproductive rates. Once spread across most of the Carolinian zone of southwestern Ontario, it occupies an increasingly fragmented region of Ontario and is threatened by ongoing development and expansion of road networks. This population presently contains only two small disjunct subpopulations, surrounded by intensive agriculture, and residential and commercial development. Although accurate estimates of abundance are lacking, the number of mature individuals is most likely less than 250. Two additional subpopulations in this population appear to have been extirpated in the past 10 years, and its geographic range has declined precipitously over that same period. Development especially threatens communal hibernacula. Roads represent a significant mortality threat as snakes bask on them. Additionally, this species is persecuted, both along roads and at hibernacula. Rescue from other populations is unlikely as the Carolinian population is disjunct and separated from adjacent populations in the U.S. by Lake Erie.

Occurrence
Ontario

Status history
The species was considered a single unit and designated Threatened in April 1998 and in May 2000. Split into two populations in April 2007. The Carolinian population was designated Endangered in April 2007. Status re-examined and confirmed in April 2018.

COSEWIC
Executive Summary

Gray Ratsnake
Pantherophis spiloides

Great Lakes / St. Lawrence population
Carolinian population

Wildlife Species Description and Significance

Gray Ratsnake (*Pantherophis spiloides*) is one of the largest snakes in Canada, reaching a maximum snout-vent length of approximately 190 cm and a maximum length of 255 cm. The colour pattern of mature Gray Ratsnakes is variable. In Canada, mature Gray Ratsnakes are typically plain, shiny black with white, yellow, orange or red colouration on the skin between the scales. The labial scales, chin and throat are white and the ventral surface is white, light yellow or cream-coloured. In contrast to adults, juveniles are dorsally patterned with dark grey blotches on a pale grey background.

Two discrete designatable units (DU), Great Lakes / St. Lawrence and Carolinian, occur in Canada. Both are geographically isolated and genetically distinct from each other and from populations in the United States of America. Both DUs are therefore valuable for the preservation of the total genetic diversity of this species. Gray Ratsnakes also contribute significantly to the ecological communities in which they exist. They are generally near the middle of the food chain and are both predators and prey of numerous species. Gray Ratsnakes require large continuous tracts of land and, therefore, may serve as an umbrella species for other biodiversity.

Distribution

Gray Ratsnake is widely distributed and commonly found throughout the forested areas of the eastern and central United States of America. Within Canada, however, Gray Ratsnake is confined to two geographically disjunct regions in southeastern Ontario (Great Lakes / St. Lawrence DU) and in southwestern Ontario (Carolinian DU). The Great Lakes / St. Lawrence DU is within the Eastern Great Lakes and Hudson Lowlands ecoregion and is associated with the Frontenac Arch in Frontenac, Lanark, and Leeds and Grenville counties. The Carolinian DU is within the Lake Erie Lowland ecoregion and associated with Carolinian forest along the northern edge of Lake Erie. Historically, this DU was limited to four very small, isolated subpopulations in Middlesex, Elgin, Norfolk, Haldimand, and Niagara counties. Currently, only the two subpopulations in Elgin, Norfolk and Haldimand counties appear extant.

Habitat

Gray Ratsnake is semi-arboreal and typically found in a wide variety of woodland habitats across its range. At the home range scale, Gray Ratsnakes prefer a mosaic of forest and open habitat. In winter, Gray Ratsnakes hibernate below ground in communal hibernacula that provide shelter from freezing temperatures. During the active season, individuals seek shelter in standing snags, hollow logs, rock crevices, and under rocks to avoid high temperatures and predators. Females nest in decaying matter inside standing snags, stumps, logs, and compost piles where conditions are humid and temperatures are appropriate for incubation.

Biology

Gray Ratsnakes reach maturity in approximately 7-9 years. Once sexually mature, females produce a clutch of 8-15 eggs every 2-3 years. In Ontario, females nest between early July and early August, approximately one month after the mating season, which spans from late May to early June. The eggs hatch between late August and late September following an incubation period of around 60 days.

The climate in Canada restricts the active season of Gray Ratsnake to approximately 5 months (May – September). During this active season, Gray Ratsnakes have relatively large home ranges (~18 ha) and disperse as far as 4 km from their hibernacula. Mature individuals demonstrate strong site fidelity by often using the same home range, and specific locations within that home range, between years. Gray Ratsnakes hibernate communally and also show strong fidelity to their hibernacula.

Gray Ratsnakes feed mainly on small mammals and birds, and known predators include a number of large birds of prey and medium-sized mammals.

Population Sizes and Trends

A vast majority of observations for the species is from the Great Lakes / St. Lawrence DU. For the Great Lakes / St. Lawrence DU, population size has been estimated to be between 25 000 and 67 000 mature individuals. These are very rough estimates of abundance. For the Carolinian DU, there are no accurate estimates of abundance. It is unlikely, however, that it comprises more than a few hundred individuals.

For the Great Lakes / St. Lawrence DU, long-term monitoring at several sites indicates population declines. The extent of occurrence also appears to have declined since the previous status report. For the Carolinian DU, it appears that two of the four subpopulations originally comprising that DU are now extirpated. As a result, the extent of occurrence and index of area of occupancy have declined dramatically.

Threats and Limiting Factors

Life-history characteristics such as biennial reproduction, delayed age at maturity and slow growth rates, make Canadian populations of Gray Ratsnake particularly sensitive to anthropogenic sources of mortality (e.g., road mortality, destruction of hibernacula, deliberate killing), which can therefore have significant impacts on populations. Furthermore, the suitable habitat in the Carolinian DU is severely restricted and heavily fragmented, and it is unknown whether enough habitat remains to support viable subpopulations of Gray Ratsnake. Suitable habitat on the Frontenac Arch is more abundant, but increased recreational activity in the area has led to increased development and will likely further reduce and fragment the existing habitat.

Protection, Status and Ranks

Gray Ratsnake has a global status of G5 (secure), and individual states within the range of the species list Gray Ratsnake as secure (S5) or apparently secure (S4), except in Michigan and Wisconsin where they are listed as vulnerable (S3). In Canada, they are ranked in Ontario as S3. The Great Lakes / St. Lawrence DU is listed under Schedule 1 of the *Species at Risk Act* as Threatened and the Carolinian DU is listed under Schedule 1 as Endangered. The Gray Ratsnake Great Lakes / St. Lawrence DU is listed as Threatened and the Carolinian DU listed as Endangered in Ontario under the *Ontario Endangered Species Act*. Gray Ratsnake is also protected in Ontario under the *Fish and Wildlife Conservation Act*, in which they are listed as a Specially Protected Reptile. Very little (ca. 6%) of the Canadian range of Gray Ratsnake is within protected areas.

TECHNICAL SUMMARY - Great Lakes / St. Lawrence population

Pantherophis spiloides

Gray Ratsnake, Great Lakes / St. Lawrence population

Couleuvre ratière grise, Population des Grands Lacs et du Saint-Laurent

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

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used)	10 years
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes. There is an observed decline at several hibernacula, an inferred decline based on habitat loss, and a projected decline based on threats.
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].	>30% decline over last 3 generations, inferred from a combination of 22% decline in EOO over 2 generations and significant threats.
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	>30% decline projected and suspected from continuing threats, particularly road mortality. Threats Calculator results indicate a possible 10-70% population reduction (per Table 4 of Threats Calculator Guidelines).
[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.	>30% decline based on inferred decline from reduction of EOO and projected and suspected decline based on continuing threats.
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. Not easily b. Yes c. No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence	2565 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	612 km²

Is the population "severely fragmented" i.e., is >50% of its total area of occupancy is in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of "locations" (use plausible range to reflect uncertainty if appropriate)	Probably more than 50 based on road mortality.
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Yes. There is an observed 22% decline in EOO over 2 generations, but search effort in the areas of apparent decline is unknown.
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes, inferred decline based on decline in EOO. However, there is an increase in the known IAO over 2 generations, reflecting increased search effort
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Unknown but likely. There is an inferred decline based on the declining EOO and continuing threats.
Is there an [observed, inferred, or projected] decline in number of "locations"?	Yes. There is an inferred decline based on the declining EOO, and continuing threats.
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes. There is an inferred and projected decline in area, extent, and quality based on the declining EOO, habitat trends, and threats from road mortality.
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of "locations"?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	N Mature Individuals
Total	25 000 – 67 000

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	Not conducted.

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

Was a threats calculator completed for this species? Yes, on 15 March 2016. Cumulative Overall Threat Impact: High, suggesting a possible 10-70% population reduction over the next 3-generations from threats operating for the next 10-years. Transportation & service corridors: high – medium Residential & commercial development: low Agriculture & aquaculture: low Energy production & mining: low Biological resource use: low Human intrusions & disturbance: negligible Natural system modifications: negligible Invasive & other problematic species: unknown

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	S4 (apparently secure) in New York.
Is immigration known or possible?	Unknown and probably impossible given the St. Lawrence River.
Would immigrants be adapted to survive in Canada?	Probably.
Is there sufficient habitat for immigrants in Canada?	Unknown, although habitat loss is a major issue.
Are conditions deteriorating in Canada?[+]	Yes
Are conditions for the source population deteriorating?[+]	Yes
Is the Canadian population considered to be a sink?[+]	No because it is probably not receiving immigrants.
Is rescue from outside populations likely?	Very unlikely given the barrier posed by St. Lawrence River.

Data Sensitive Species

Is this a data sensitive species? No, but locations of hibernacula, where the species may be susceptible to poachers, are sensitive.

Status History

COSEWIC: The species was considered a single unit and designated Threatened in April 1998 and in May 2000. Split into two populations in April 2007. The Great Lakes / St. Lawrence population was designated Threatened in April 2007. Status re-examined and confirmed in April 2018.

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

Status and Reasons for Designation:

Status: Threatened	**Alpha-numeric codes:** A2acd+3cd+4cd
Reasons for designation: One of the largest snakes in Canada, this species is characterized by late age of maturity and low reproductive rates. It occupies an increasingly fragmented region of southern Ontario and is threatened by ongoing development and by expansion of road networks. The extent of its occurrence appears to have declined significantly. Mark-recapture analyses from several subpopulations indicate decreasing population trends at some sites, although widespread estimates of abundance or population trend are lacking. Development especially threatens communal hibernacula. Traffic on roads where snakes bask represents a significant mortality threat. Additionally, this species is intentionally killed, both along roads and at hibernacula. Rescue from other populations is unlikely since this population is already separated from upstate New York by the St. Lawrence River and by at least 100 km from the main species range in New York.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Threatened, A2acd, because there is an inferred decline of >30% in the number of mature individuals extrapolated from 22% decline over the last 2 generations (20 years); subcriterion (a) applies because declines have been observed at some monitoring sites; (c) applies because there is a decline in EOO and habitat quality; (d) applies because of deliberate killing and accidental mortality on roads. Meets Threatened, A3cd, because there is a projected decline of >30% in the number of mature individuals based on continuing decline in quality of habitat and deliberate and accidental killing including road mortality, which is expected to continue and increase in the future. Meets Threatened, A4cd, because there is an inferred decline from reduction of EOO, and projected and suspected decline, based on past and continuing decline in quality of habitat and deliberate and accidental killing. This includes road mortality, which is expected to continue and increase in the future.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. Although EOO meets threshold for Endangered (B1) and IAO meets threshold for Threatened (B2), it meets only one (b) of subcriteria a-c.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Total number of mature individuals exceeds 10,000.
Criterion D (Very Small or Restricted Population): Not applicable. Population exceeds 1,000 individuals, and IAO >20 km^2.
Criterion E (Quantitative Analysis): Insufficient data available to perform analysis.

TECHNICAL SUMMARY - Carolinian population

Pantherophis spiloides

Gray Ratsnake, Carolinian population

Couleuvre ratière grise, population carolinienne

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

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2011) is being used)	10 years
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes. There is an inferred decline for the DU. This decline is projected to continue because the causes have not been reversed and threats continue.
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	>50% decline inferred from 89% and 81% declines in EOO and IAO respectively in last 10 years (1 generation).
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	>50% decline inferred from 89% and 81% declines in EOO and IAO respectively in last 10 years (1 generation).
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown. Threats Calculator results indicate a possible approx. 10-100% population reduction (per Table 4 of Threats Calculator Guidelines)
[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.	>50% decline inferred from 89% and 81% declines in EOO and IAO respectively as well as continuing significant threats.
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. Not easily b. Yes c. No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence	826 km²
Index of area of occupancy (IAO) (Always report 2x2 grid value).	60 km²
Is the population “severely fragmented” i.e., is >50% of its total area of occupancy is 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. Yes because PVA indicates that 141 individuals are required for population viability and the vast majority of remaining habitat patches are too small to support that many individuals. b. Yes because the remaining habitat patches are separated by long stretches of inhospitable habitat.

Number of “locations” (use plausible range to reflect uncertainty if appropriate)	2-3, one for each small extant subpopulation, which could be adversely affected by a single new road or development.
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Yes. There is an observed 89% decline from the last report (2007).
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes. There is an observed 81% decline from the last report (2007).
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Yes. There is an inferred decline of 50% of the known subpopulations since the last report based on a lack of recent, verified observations at two of the four previously identified subpopulations, as well as overall lack of current habitat at those sites
Is there an [observed, inferred, or projected] decline in number of “locations”?	Yes. There is an inferred decline of 50% in the number of locations since the last report based on a lack of recent, verified observations at two of the four previously identified locations, as well as extensive habitat loss at those sites.
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes. There is an inferred decline in area, extent, and quality based on the declining EOO and IAO and continuing threats.
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of “locations”?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	N Mature Individuals
Total	Unknown, but likely <<250 individuals

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years]	Not conducted.

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

Was a threats calculator completed for this species? Yes, on 17 September 2017 for the Carolinian DU. Cumulative Overall Threat Impact: Very High – High. Threats Calculator results indicate a possible approx. 10-100% population reduction over the next 3-generations from threats operating for the next 10-years. Transportation & service corridors: high – medium Energy production & mining: medium Agriculture & aquaculture: medium - low Residential & commercial development: low Biological resource use: low Natural system modifications: low Invasive & other problematic species: unknown Climate change & severe weather: unknown

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	S4 (apparently secure) in New York, S3 in Michigan, and SNR in Ohio.
Is immigration known or possible?	Unknown and probably impossible given the barrier posed by Lake Erie.
Would immigrants be adapted to survive in Canada?	Probably.
Is there sufficient habitat for immigrants in Canada?	No, habitat loss has been extensive throughout the DU, and it is unclear if enough habitat remains to sustain viable populations.
Are conditions deteriorating in Canada?[+]	Yes
Are conditions for the source population deteriorating?[+]	Yes
Is the Canadian population considered to be a sink?[+]	No because it is not receiving immigrants.
Is rescue from outside populations likely?	Very unlikely given Lake Erie.

Data Sensitive Species

Is this a data sensitive species? No, but locations of hibernacula, where the species may be susceptible to poachers, are sensitive.

Status History

COSEWIC: The species was considered a single unit and designated Threatened in April 1998 and in May 2000. Split into two populations in April 2007. The Carolinian population was designated Endangered in April 2007. Status re-examined and confirmed in April 2018.

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

Status and Reasons for Designation:

Status: Endangered	**Alpha-numeric codes:** A2cd+4cd; B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v); C2a(i); D1
Reasons for designation: One of the largest snakes in Canada, this species is characterized by late age of maturity and low reproductive rates. Once spread across most of the Carolinian zone of southwestern Ontario, it occupies an increasingly fragmented region of Ontario and is threatened by ongoing development and expansion of road networks. This population presently contains only two small disjunct subpopulations, surrounded by intensive agriculture, and residential and commercial development. Although accurate estimates of abundance are lacking, the number of mature individuals is most likely less than 250. Two additional subpopulations in this population appear to have been extirpated in the past 10 years, and its geographic range has declined precipitously over that same period. Development especially threatens communal hibernacula. Roads represent a significant mortality threat as snakes bask on them. Additionally, this species is persecuted, both along roads and at hibernacula. Rescue from other populations is unlikely as the Carolinian population is disjunct and separated from adjacent populations in the U.S. by Lake Erie.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered, A2cd, because there is an inferred decline of > 50% in number of mature individuals over the past 3 generations (30 years), extrapolated from decline in IAO and quality of habitat (c); (d) applies because of deliberate killing and accidental mortality of roads. Meets Endangered, A4cd, because there is a decline of >50% in the number of mature individuals based on past and future projected declines.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered, B1ab(i,ii,iii,iv,v)+2ab(i,ii,iii,iv,v) because EOO of 826 km² and IAO of 60 km² are less than the thresholds; species is severely fragmented; and there is a continuing observed and inferred decline in EOO, IAO, area and quality of habitat, number of locations, and number of mature individuals.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered, C2a(i). The total number of mature individuals <2,500, with an inferred continuing decline and no subpopulation containing greater than 250 individuals.
Criterion D (Very Small or Restricted Population): Meets Endangered, D1. Although actual population size is unknown, it is likely <250 mature individuals.
Criterion E (Quantitative Analysis): Insufficient data available to perform analysis.

PREFACE

Since the previous COSEWIC status assessment for Gray Ratsnake (2007), very few new observations of the species from southwestern Ontario have been received by the Ontario Natural Heritage Information Centre. The recent observations suggest strongly that one, and probably two of the historical four subpopulations of the species in the Carolinian DU may now be considered extirpated. Additional scientific articles have been published on the Queen's University Biological Station (QUBS) subpopulation. Mark-recapture data from several subpopulations in the Great Lakes / St. Lawrence DU were analyzed and confirmed previously established decreasing trends in population size at some sites. Finally, modelling of road mortality conducted for this report demonstrates significant risk to this species.

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
(2018)

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.

COSEWIC Status Report

on the

Gray Ratsnake
Pantherophis spiloides

Great Lakes / St. Lawrence population
Carolinian population

in Canada

2018

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

The species was originally named and classified by Say (1823), and since that time it has been divided into five subspecies: *Elaphe obsoleta obsoleta* (Say 1823), *Elaphe obsoleta lindheimeri* (Baird and Girard 1853), *Elaphe obsoleta quadrivittata* (Holbrook 1836), *Elaphe obsoleta rossalleni* (Neill 1949), and *Elaphe obsoleta spiloides* (Duméril *et al.* 1854). This classification was based mainly on the colour pattern variation observed across the range of the species. All Canadian populations were classified as Black Ratsnake (*Elaphe obsoleta obsoleta*).

The classification and nomenclature of Eastern Ratsnake (*Elaphe obsoleta*) has come into question (Burbrink *et al.* 2000; Burbrink 2001). Using two mitochondrial gene sequences and 67 morphological characters, Burbrink (2001) determined that the previously recognized five subspecies did not represent separate evolutionary lineages and instead suggested that Eastern Ratsnakes comprised three distinct clades, and proposed separating them into three species: 1) *Elaphe obsoleta* (western clade), 2) *Elaphe spiloides* (central clade), and 3) *Elaphe alleghaniensis* (eastern clade), and included the Canadian subpopulations as part of the central clade (Burbrink 2001). The Canadian subpopulations were classified based on geographic trends, however, and no samples were collected from individuals in any Canadian subpopulation. Morphological and genetic evidence (Gibbs *et al.* 2006) suggest that ratsnakes in southwestern Ontario are part of the central clade (*Elaphe spiloides*), whereas ratsnakes in southeastern Ontario are hybrids between the central clade (*Elaphe spiloides*) and the eastern clade (*Elaphe alleghaniensis*). Gibbs *et al.* (2006) suggested that because of this hybridization, the two clades may not be separate species under the Biological Species Concept, but, as geographically distinct lineages they may qualify as species under the General Lineage Species Concept (de Queiroz 1998).

Crother (2012) recommended the genus name *Pantherophis* for most North American *Elaphe* following the division of *Elaphe* into multiple genera. Given these taxonomic uncertainties, the current name for the central clade, *Pantherophis spiloides*, was retained for all Ontario ratsnakes, recognizing that there are significant genetic differences between the ratsnakes in southwestern versus southeastern Ontario. The common name for *Pantherophis spiloides* is Gray Ratsnake (Crother 2012).

Morphological Description

In Ontario, mature Gray Ratsnakes are typically shiny black with white, yellow, orange or red colouration on the skin between the scales. The labial scales, chin and throat are white and the ventral surface is white, light yellow or cream-coloured with a clouded grey or brown pattern, often resulting in a checkerboard appearance. In contrast to adults, juveniles are dorsally patterned with dark grey blotches on a pale grey background.

Gray Ratsnake is one of the largest snakes in Canada, often exceeding 130 cm in snout-vent length and reaching a maximum snout-vent length of approximately 160 cm

(Prior and Weatherhead 1996; Prior 1997); the maximum total length recorded in Canada is reportedly 213 cm (Curran 1971). Sexual dimorphism is present in mature individuals; males have longer tails relative to their total body length and become longer than females (Blouin-Demers *et al.* 2005). The size dimorphism is the result of faster growth rates and larger maximum sizes in males than in females (Blouin-Demers *et al.* 2002).

Adult Northern Watersnakes (*Nerodia sipedon*), melanistic Eastern Gartersnakes (*Thamnophis sirtalis*), and Blue Racers (*Coluber constrictor*) are superficially similar in appearance to adult Gray Ratsnakes in Ontario, but these snakes can be relatively easily distinguished from Gray Ratsnake. Northern Watersnakes have strongly keeled scales and are dark brown. Remains of the bands present in juveniles are also often visible on mature Watersnakes. Melanistic Gartersnakes are jet black and have keeled scales. Blue Racers have no pattern as adults and smooth scales with blue-green to dark-blue on the dorsal surface and light grey to white on the ventral surface. Juvenile Gray Ratsnakes can be easily confused with juvenile Eastern Foxsnakes (*Pantherophis gloydi*) and juvenile Eastern Milksnakes (*Lampropeltis triangulum*). Eastern Milksnakes, however, have single anal plates and Eastern Foxsnakes have 216 or fewer ventral scales whereas Gray Ratsnakes have 221 or more.

Population Spatial Structure and Variability

Mature Gray Ratsnakes exhibit home range fidelity (Blouin-Demers and Weatherhead 2002a) and overwinter in communal hibernacula (Blouin-Demers *et al.* 2000) to which they exhibit strong fidelity (Blouin-Demers and Weatherhead 2002a). These life-history traits have the potential to lead to genetic structuring at fine geographic scales. The genetic structure of Gray Ratsnake has been examined at regional (> 400 km), landscape (15-50 km), and local scales (1-5 km).

Prior *et al.* (1997) used seven RAPD markers to analyze blood samples from southeastern Ontario, southwestern Ontario, Maryland, and Arkansas. The distances between these regional subpopulations ranged from 500 to 1500 km and they found significant genetic variation at this scale. They did not, however, find significant differentiation between the two Canadian regions. At the landscape scale, they analyzed five areas in southeastern Ontario (mean distance = 34.4 km) and found significant variation. Finally, at the local scale there was no significant genetic differentiation between snakes from two hibernacula (distance = 1.6 km) in southeastern Ontario.

Lougheed *et al.* (1999) analyzed blood samples from the same regions using six microsatellite loci, which are more variable genetic markers than RAPD and thus improve our ability to detect genetic differences. At both the regional and landscape scales, the authors found significant genetic differentiation. This included a significant divergence between the Carolinian and Great Lakes / St. Lawrence designatable units (DUs). Lougheed *et al.* (1999) also analyzed samples from 11 hibernacula within three areas in southeastern Ontario (mean distance = 2.5 km) and found no differentiation at this scale.

Howes *et al.* (2009) used microsatellite loci to identify directional gene flow among five subpopulations of Gray Ratsnake in the Great Lakes / St. Lawrence designatable unit (DU). Long-term gene flow estimates suggested low to moderate gene flow among local subpopulations. Short- and long-term directional gene flow estimates were discordant, suggesting that population dynamics have varied temporally among the subpopulations. For example, QUBS had the smallest net emigration rate according to the long-term estimates of gene flow. However, this subpopulation had the highest net emigration rate according to the short-term estimates of gene flow, suggesting it could be an important demographic and genetic source to other local subpopulations. Finally, the authors estimated effective population sizes for each of the five subpopulations ranging from 48 in the smallest subpopulation (Thousand Islands National Park) to 331 in the largest subpopulation (QUBS).

Designatable Units

In Canada, Gray Ratsnake is found in two geographically disjunct regions in southeastern and in southwestern Ontario. These regions are separated by approximately 300 km and are part of different ecoregions (Eastern Great Lakes and Hudson Lowlands, Lake Erie Lowland, respectively) characterized by very different faunal elements and habitats. The regions are recognized as distinct in both the original and updated maps of the COSEWIC Terrestrial Amphibians and Reptiles Faunal Provinces (Appendix F5 – Guidelines for Recognizing Designatable Units, COSEWIC Operations and Procedures Manual - Nov 2016). These maps in part reflect the major post-glacial recolonization routes for Canadian terrestrial herpetofauna.

The long-standing separation of the two populations is supported by the recent taxonomic revision of North American rat snakes (Gibbs *et al.* 2006). Ratsnakes inhabiting the two regions show significant genetic differentiation in both mtDNA and nuclear markers, although the divergence may reflect drift at neutral loci rather than selection at functional loci (Lougheed *et al.* 1999; Gibbs *et al.* 2006). The differentiation is consistent with two separate (one central, one eastern) post-glacial recolonization routes for ancestors of the two populations.

Because of the large separation, the amount of unsuitable habitat between these regions and significant barriers to dispersal, they will almost certainly remain isolated. These two units clearly meet the criterion of discreteness (genetic distinction, natural disjunction, differing ecoregions) and arguably meet the criterion of evolutionary significance (qualitative genetic differences in mtDNA, vulnerability to extensive range disjunction by loss of population, possible local adaptations reflecting different habitats) for designatable units. The southeastern Ontario ratsnakes comprise the Great Lakes / St. Lawrence DU and the southwestern Ontario ratsnakes comprise the Carolinian DU.

Special Significance

The Canadian populations of Gray Ratsnake represent only a small proportion (< 1%) of the species' total global range. Nonetheless, there are genetic, ecological and cultural factors that make both the Great Lakes / St. Lawrence and Carolinian DUs significant.

It is widely accepted that species conservation depends in part upon preserving the genetic diversity within species. Genetically diverse species are better able to adapt and survive in changing environments (Keller and Waller 2002). Although peripheral populations may have reduced genetic diversity, they often contain a proportionately higher number of rare alleles (Gapare *et al.* 2005), and are considered to be the most active areas of speciation (Levin 1993). These factors often make peripheral populations proportionately more important in preserving the total genetic diversity (Lesica and Allendorf 1995). Preserving the Canadian populations is important for preserving the total genetic diversity of Gray Ratsnake.

Snakes often play an important role in their ecological communities. Ratsnakes are major predators of many species of small mammals and birds (Weatherhead *et al.* 2003) and are also major prey items for birds of prey (Fitch 1963). Gray Ratsnakes also require and occupy a wide variety of habitats and have relatively large home ranges. Therefore, efforts to preserve ratsnake habitat could benefit many other species.

Gray Ratsnake is one of Canada's largest snakes and the presence of populations in Ontario is widely recognized as an important part of Canada's natural heritage by the herpetological community as well as by members of the general public.

DISTRIBUTION

Global Range

Gray Ratsnake is widely distributed throughout the forested areas of eastern and central United States (Figure 1), but occurs in only two small disjunct regions in Ontario. The rest of its distribution is relatively continuous from southwestern New England, south along the western edge of the Appalachian Mountains to the Gulf of Mexico, west to the Mississippi River, and north to southwestern Wisconsin.

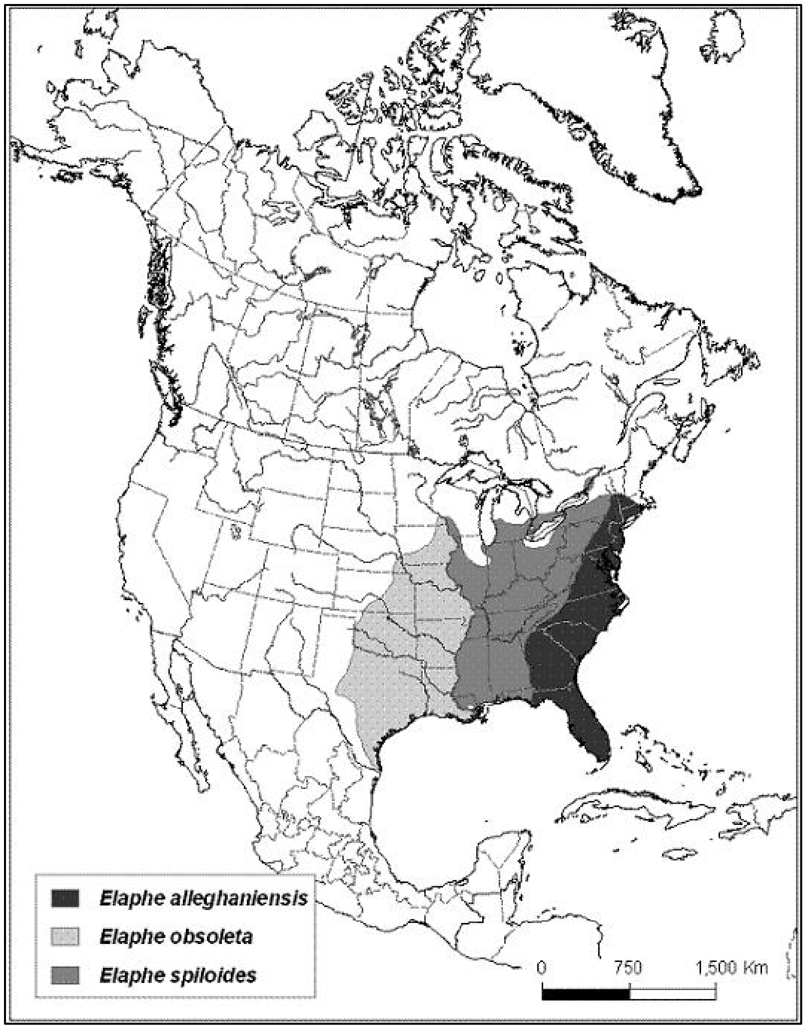


Figure 1. Global distribution of *Elaphe* (now *Pantherophis*) *alleghaniensis*, *obsoleta*, and *spiloides* (modified from Burbrink 2001).

Canadian Range

In southeastern Ontario, Gray Ratsnake is typically associated with the Frontenac Arch (Figure 2), which is a southeast extension of the Canadian Shield that connects with the Adirondack Mountains in northern New York State. The bulk of this DU lies in Frontenac and in Leeds and Grenville counties; however, a small portion of the range crosses the St. Lawrence River into Jefferson and St. Lawrence counties in upper New York State. The isolation of this DU has been recognized since the early 1900s (Lindsay 1931; Toner 1934), and the absence of historical records of Gray Ratsnake along the northern shore of Lake Ontario and upper New York State (Weber 1928) suggest that the separation between these populations may have preceded European settlement. This DU is within the Eastern Great Lakes and Hudson Lowlands 8.1.1 ecoregion according to the land classification of the Commission for Environmental Cooperation (2016), a joint commission between Canada, the United States of America, and the Estados Unidos Mexicanos.

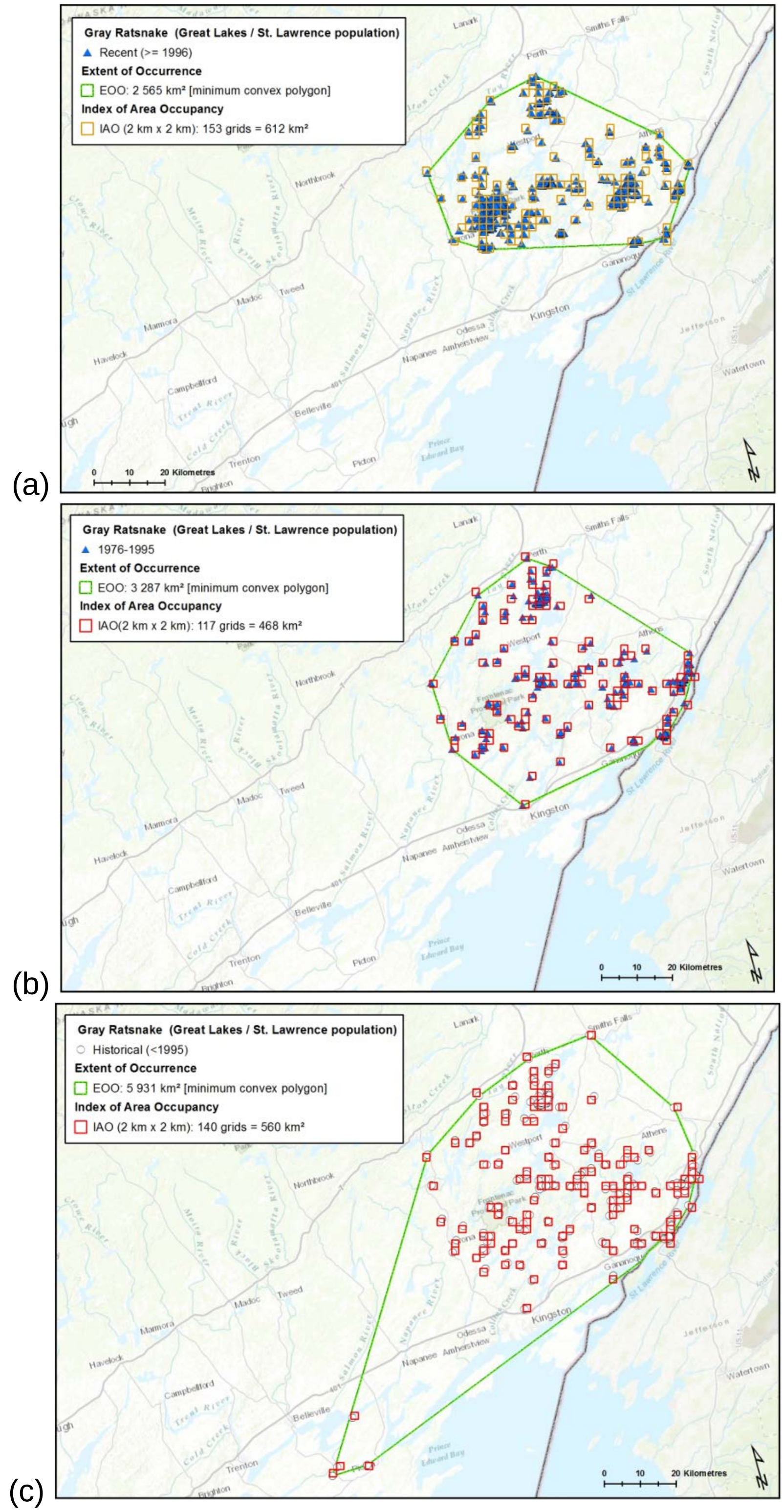
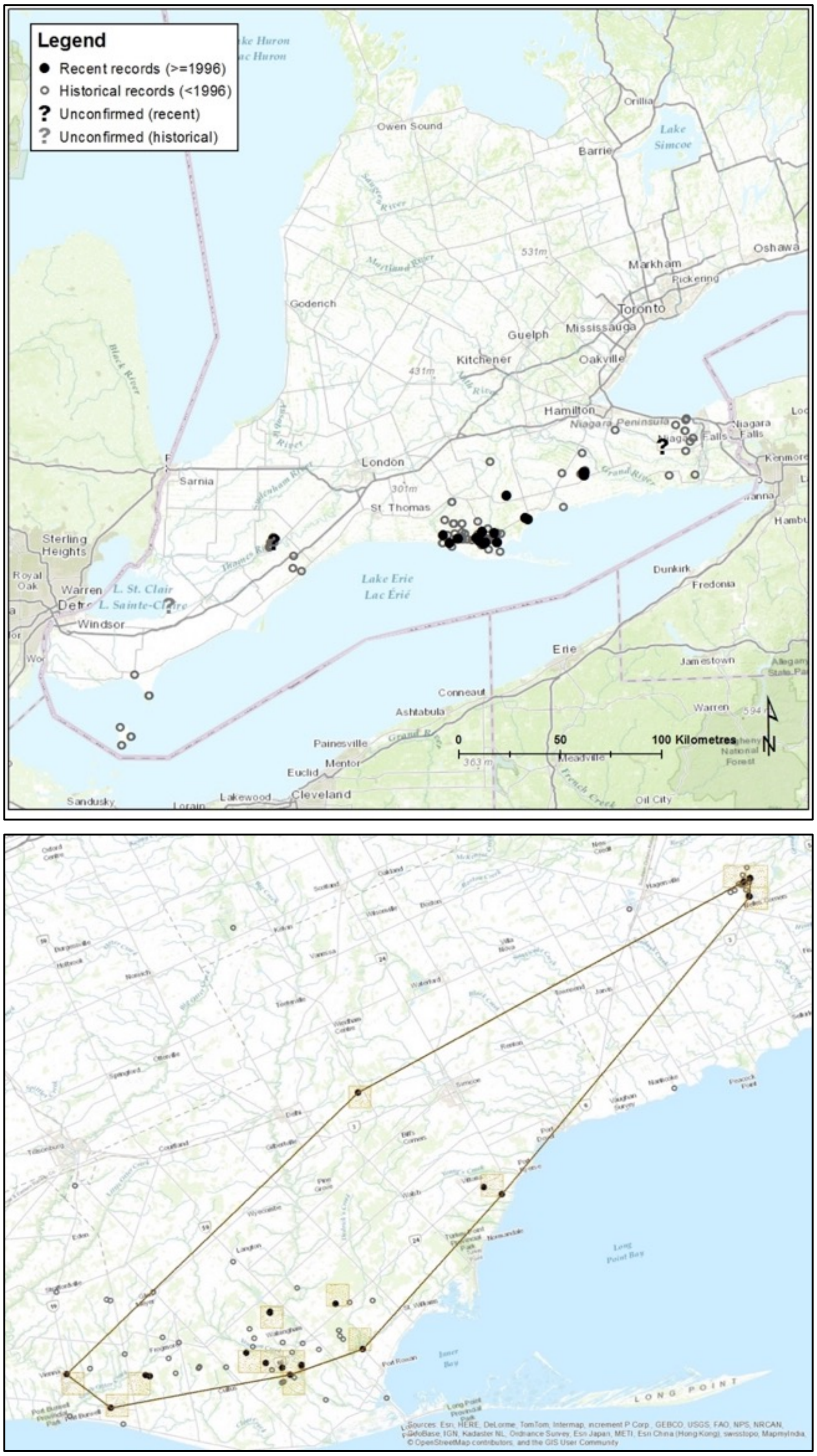


Figure 2. Distribution of *Pantherophis spiloides* of the Great Lakes / St. Lawrence DU and corresponding mapping of the extent of occurrence and index of area of occupancy. a) Recent (≥ 1996); b) 1976-1995; c) Historical (≤ 1995).



(a)

(b)

Figure 3. a) Recent (≥ 1996) and historical (< 1996) distribution of *Pantherophis spiloides* of the Carolinian DU and b) corresponding mapping of the extent of occurrence and index of area of occupancy.

In southwestern Ontario, Ratsnakes currently inhabit small parts of the Carolinian forest along the northern shore of Lake Erie (Figure 3). Prior to European settlement, large tracts of deciduous forest intermixed with open savannah would likely have provided an abundance of suitable habitat in this region. Records of Gray Ratsnake extend from Pelee Island and Point Pelee (Logier 1925) east to Fonthill (Lindsay 1931), and it is likely that Ratsnakes once extended continuously across most of the Carolinian zone of southwestern Ontario. The Carolinian DU is within the Lake Erie Lowland 8.1.2 ecoregion according to the land classification of the Commission for Environmental Cooperation.

The previous COSEWIC status report (2007) recognized the persistence of only four very small, isolated Carolinian subpopulations. For two of these subpopulations, however, there are no verified records in the past 20 years at the time of completing this report. Therefore, it is plausible, although unconfirmed, that these two subpopulations may now be extirpated. These two subpopulations have thus been excluded for the calculations of EOO and IAO.

1. The Big Creek subpopulation is the largest of the Carolinian subpopulations and ranges approximately from the base of Long Point to the town of Langton in the north, to the town of St. Williams in the east, and Port Burwell in the west. This subpopulation is still extant based on several recent and verified observations.
2. The Oriskany subpopulation is confined to a relatively small area (<10 km^2) in Cayuga and Oneida townships and is roughly bound by the towns of Nelles Corners, Cayuga, and Decewsville. Two individuals from this subpopulation were located and radio-tracked in 2001-2003 (Yagi and Tervo 2006). Both radio-tracked individuals hibernated in close proximity to each other, but despite efforts to fence and trap this area, no other individuals were captured and the size of the hibernaculum is unknown. This subpopulation is still extant based on a few, recent, and verified observations.
3. The Skunk's Misery subpopulation was generally located north of the Thames River between Wardsville and Bothwell. The most recent verifiable observations for this subpopulation are from 1984 (Oldham and Weller 2000). There is an unconfirmed record from 1997. Records near the towns of Rodney and New Glasgow (1987) south of Highway 401 may have represented a separate subpopulation associated with 16 Mile Creek (Oldham and Weller 2000). Based on the absence of recent and verified observations, and the high confidence expressed by OMNR that the species no longer occurs at Skunk's Misery (Crowley pers. comm. 2018), it appears this subpopulation is extirpated.
4. The Niagara subpopulation was poorly defined and most likely consisted of a few small disjunct subpopulations; verified historical observations (more than 20 years old) exist near the towns of Fonthill and Ridgeway. There are unconfirmed rumours of observations near Welland Canal and Short Hills Provincial Park (Yagi, pers. comm. 2015) and a 2010 observation in the NHIC database from the Niagara region, which to date has not been fully verified. OMNR personnel, although not 100% confident, pointed to the lack of fully verifed records over the past 20 years despite ongoing search effort and lack of opportunistic encounters despite high human population density in the area, as evidence that this subpopulation is probably extirpated (Crowley pers. comm. 2018).

5. Two “new” occurrences (which do not appear on the map in the 2007 status report) east of the main Big Creek subpopulation are indicated in Figures 3 and 5. One, near Delhi, is actually a record of a single dead snake from 1998 that was only recently reported. No recent records from this area exist. The Port Ryerse occurrence includes a historical 1996 record of a single live snake, again only recently reported, and a more recent 2013 record of a single live snake. The latter occurrence might represent an additional subpopulation, or an eastward extension of the Big Creek subpopulation.

Extent of Occurrence and Area of Occupancy

For the Great Lakes / St. Lawrence DU, based on observations after 1995, the extent of occurrence is 2565 km^2, while the index of area of occupancy based on 2 x 2 km grids is 612 km^2. In comparison to historical observations (1976-1995), this represents a ~22% decline in EOO and a ~30% increase in IAO over 2 generations (Figure 2). The apparent increase in IAO probably reflects increased search effort adjacent to grid squares where the species was previously recorded. Recent observations are significantly more clustered than historical ones, with significant gaps in distribution, particularly in the southern portion of the range (see **Habitat Trends**).

For the Carolinian DU, the Niagara and Skunk’s Misery subpopulations were excluded based on the absence of recent, verified observations from those sites. Based on observations after 1995, the extent of occurrence is 826 km^2, while the index of area of occupancy based on 2 x 2 km grids is 60 km^2. In comparison to observations from the previous status report (2007), based on records from 1985 to 2007, and in which 2 x 2 km grids were also used to calculate IAO, this represents a ~89% and 81% decline in EOO and IAO respectively in only 1 generation (Figure 3).

Although IAO values in the report (for both DUs) are based on all snake observations, they could arguably be more appropriately calculated based on the most limiting sites that are required to complete the species’ life cycle, e.g., hibernacula. This would dramatically reduce IAO values, since the species is wide-ranging, dispersing up to 4 km from hibernacula, which are often communal and threatened by development. Unfortunately too few observations of hibernacula have been reported to reliably calculate IAO with this metric.

Search Effort

There have been no large-scale systematic species-specific searches for Gray Ratsnake in Canada. The information on distribution presented herein is based on observations voluntarily submitted to the Natural Heritage Information Centre (including observations submitted to Ontario Nature) by researchers, government employees, naturalists, and the general public. Volunteer search effort across the range of both DUs has expanded substantially in recent years. In fact, the recent Ontario Reptile and Amphibian Atlas has more than tripled the number of herpetofauna occurrence data records for the province (CDC and the older Ontario Herpetofaunal Summary Atlas combined) over the past decade (Crowley pers. comm. 2018). There have also been localized targeted surveys conducted at several sites such as the QUBS, Murphy's Point Provincial Park, and Thousand Islands National Park, among others, but these localized surveys were conducted in areas where the species was already known to occur. Additionally there has been considerable recent print, digital and visual media attention paid to large snake species in Ontario.

HABITAT

Habitat Requirements

Gray Ratsnake is semi-arboreal and typically associated with a wide range of woodland and scrub habitats across its distribution (Durner and Gates 1993). Within Canada, Gray Ratsnake inhabits two regions in Ontario with significantly different habitats. The Frontenac Arch is dominated by rolling terrain of mature, second-growth deciduous forest, intermixed with numerous lakes, wetlands, abandoned agricultural fields and bedrock outcrops, whereas the Carolinian forest region is dominated by agricultural land mixed with smaller patches of open deciduous forest.

On the Frontenac Arch, assessments of habitat use have revealed that Gray Ratsnakes use habitat non-randomly at the home-range scale. Gray Ratsnakes prefer home ranges containing >28% edge habitat and modest amounts of forest cover (41% - 53%), and avoid home ranges with >17% marsh habitat (Row 2006). At the microhabitat scale, Gray Ratsnakes again use habitat non-randomly (Blouin-Demers and Weatherhead 2001a). At this scale, Gray Ratsnakes preferred areas close to trees and edges, with a high ground cover of logs. Based on these results, Gray Ratsnakes seem to require a mosaic of forest and open habitat.

Throughout the active season, appropriate basking and retreat sites are necessary for thermoregulation, shedding, and predator avoidance. Retreat sites and basking sites are often used multiple times by an individual throughout the active season, and over multiple years (Blouin-Demers and Weatherhead 2001a). Retreat sites that are commonly used on the Frontenac Arch are the inside of hollow logs and trees, under rocks or in rock crevices (Blouin-Demers and Weatherhead 2001a). Intraspecific communal use of shedding sites is frequently observed and individuals will often show a high fidelity to these sites (Blouin-Demers and Weatherhead 2001a). On the Frontenac Arch, Gray Ratsnakes typically use standing hollow snags as shedding sites, but have also been observed to use old buildings, rock crevices, hay piles, and hollow logs (Blouin-Demers and Weatherhead 2001a).

Throughout their range, Gray Ratsnakes hibernate during the winter months (Weatherhead *et al.* 2012). On the Frontenac Arch, Gray Ratsnakes hibernate for approximately 7 months of the year (October – April) (Weatherhead 1989). On the Frontenac Arch, 10 – 60 individual Gray Ratsnakes typically aggregate for hibernation (Blouin-Demers *et al.* 2000) and individuals generally show strong fidelity to their hibernacula (Blouin-Demers and Weatherhead 2002a). Hibernacula are typically found in a complex of underground crevices, deep enough to reach below the frost line, created by natural faults, fissures, or rotted tree root systems, often on rocky or forested slopes (Prior and Weatherhead 1996). Entrances into hibernacula may be small indistinct holes in the ground, some as small as 5 cm in diameter (Blouin-Demers, personal observation). There may be more than one entrance to each hibernaculum. Although hibernacula may be difficult to detect, areas with Gray Ratsnakes basking in close proximity in the fall or in the spring may be an indication that a hibernaculum is nearby. No comparable information is available for the Carolinian DU.

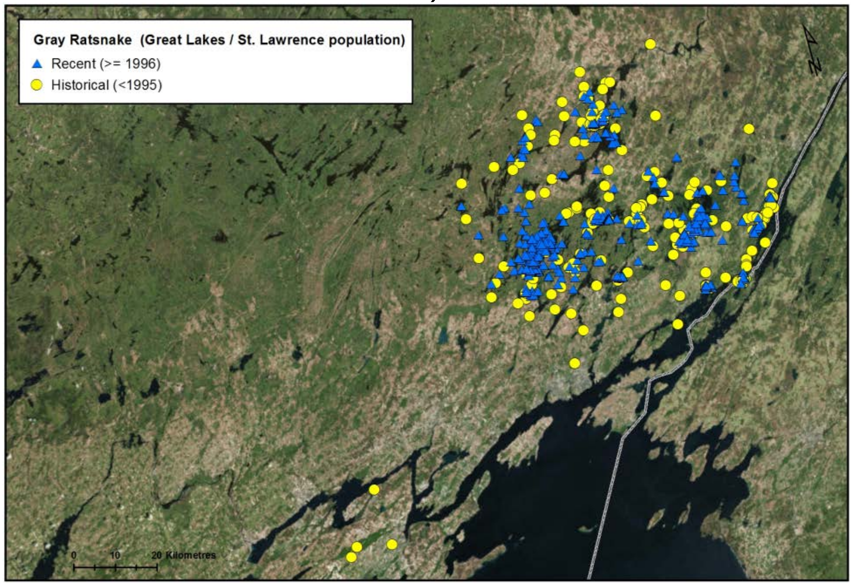
On the Frontenac Arch, Gray Ratsnakes have been observed to lay eggs in the decaying matter inside standing snags, stumps or logs and also in compost piles (Blouin-Demers *et al.* 2004). The ideal temperature for egg incubation is approximately 30°C (Blouin-Demers *et al.* 2004). Nests on the Frontenac Arch are often communal and are used for multiple years by multiple females (Blouin-Demers *et al.* 2004). No comparable information is available for the Carolinian DU.

Habitat Trends

The marginal agricultural conditions on the Frontenac Arch have led to the abandonment of farmland over the last 60 years (McKenzie 1967) and allowed for large tracts of suitable Gray Ratsnake habitat to remain. However, fragmentation and loss of habitat, primarily from intensive agriculture, and increasing road densities in the southern portion of the Great Lakes / St. Lawrence DU range is apparent in current satellite imagery from the area (Figure 4). Although historical (pre-1976) and old (1976-95) records of Gray Ratsnake exist from across the southern part of the Arch, recent records (post-1996) are lacking. The increasing recreational activity in the heart of the Rideau Canal, as well, is likely to increase development pressure and road density and lead to a reduction and fragmentation of remaining suitable habitat (Thompson pers. comm. 2015).

More than 80% of the original forest cover in the Carolinian region has been removed (Butt *et al.* 2005). Intensive agriculture and an extensive network of roads dominate the Carolinian landscape. This drastic reduction in the amount of suitable habitat and associated fragmentation, as well increased mortality from roads and other anthropogenic sources has resulted in large range reductions for a number of reptiles in this region, including Gray Ratsnake. It is currently unknown whether the remaining habitat is sufficient to support viable Gray Ratsnake subpopulations.

a)



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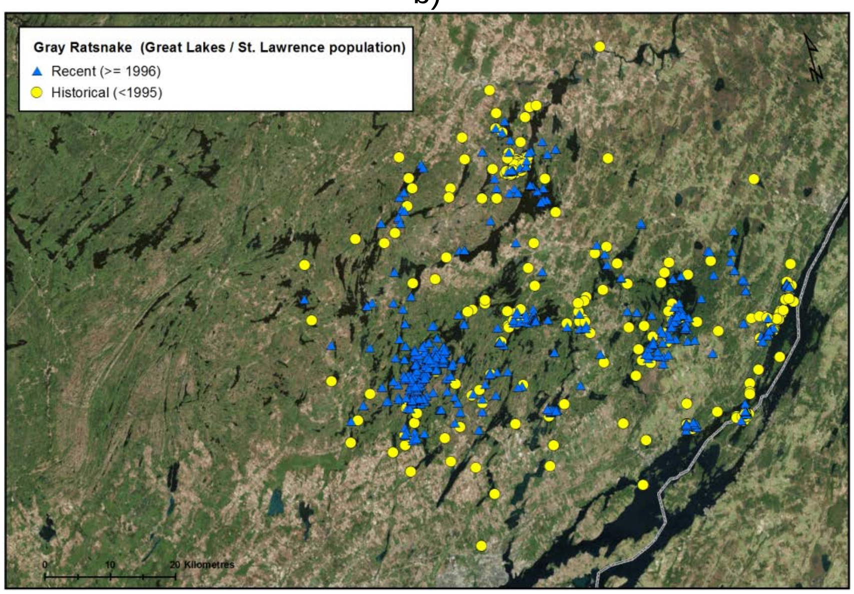

Figure 4. Current satellite imagery of recent (≥ 1996) and historical (≤ 1995) *Pantherophis spiloides* records from the Great Lakes / St. Lawrence DU: a) entire historical range; b) higher resolution of main body of range encompassing all recent and most historical records.

BIOLOGY

Life Cycle and Reproduction

Because of the relatively cold climate in Ontario, Gray Ratsnakes are only active approximately 5 months (May – September) of the year, leading to slow growth and delayed sexual maturity (Blouin-Demers *et al.* 2002). Using growth models, Blouin-Demers *et al.* (2002) estimated the maximum life span of Gray Ratsnake in the Great Lakes / St. Lawrence DU to be 25-30 years, and the age of sexual maturity for males and females to be 9.1 and 9.7 years, respectively. Based on additional data and marked neonates recaptured later in life, these estimates have been adjusted to an age of maturity of approximately 7 years (G. Blouin-Demers, unpublished data), and the mean age of reproducing individuals in the Great Lakes / St. Lawrence DU is approximately 10 years (unpublished raw data used in Blouin-Demers and Weatherhead (2007)). These ages are presumed to be similar in the Carolinian population.

Gray Ratsnakes are oviparous and, once sexually mature, females will produce a clutch every 2-3 years on average (Blouin-Demers *et al.* 2004). In Ontario, the mating season typically spans from late May to mid-June, after individuals have dispersed from their hibernacula. Despite low population densities, females will usually mate more than once and produce clutches that are sired by two or more males (88% of clutches have multiple paternity; Blouin-Demers *et al.* 2005).

After mating, there is a gestation period of approximately 30 - 50 days before females will lay a clutch of approximately 10 - 15 eggs (Blouin-Demers *et al.* 2005) in late June to early August. The incubation period depends on incubation temperature and lasts 50-60 days, translating to hatching dates ranging from late August to early October. There is genetic sex determination for embryos, which results in an even sex ratio (Blouin-Demers *et al.* 2004). Neonates are approximately 285 – 300 mm in snout-vent length and there is no significant difference between male and female neonates (Blouin-Demers *et al.* 2002).

After hatching, very little is known about the neonatal life stage until the young snakes join communal hibernacula, which is close to the time of sexual maturity. It is therefore impossible to estimate survival rates for juvenile life stages. Based on unpublished raw data used in Weatherhead *et al.* (2002), annual adult survivorship was estimated to be approximately 0.68.

Physiology and Adaptability

In Canada, Gray Ratsnakes are at the northern extent of their range in a thermally challenging environment, which makes thermoregulation particularly important (Blouin-Demers and Weatherhead 2001b). In a laboratory thermal gradient, Gray Ratsnakes preferred body temperatures between 27°C and 30°C (Blouin-Demers and Weatherhead 2001b). For Canadian Gray Ratsnake subpopulations, environmental temperatures are often well outside this range (Blouin-Demers and Weatherhead 2001b) forcing snakes to invest a lot of time maintaining body temperatures through behavioural thermoregulation (Blouin-Demers and Weatherhead 2001b). Ratsnakes cannot tolerate temperatures below freezing and, therefore, hibernate underground during the winter months.

Gray Ratsnake is a relatively common snake throughout the eastern United States of America and can be found in a variety of woodland habitats (Ernst and Ernst 2003), suggesting that they are adaptable to a wide variety of environments. Although Gray Ratsnakes can be found in open fields and abandoned buildings (Blouin-Demers and

Weatherhead 2002b), they are rarely found far from woodlands and prefer edges between woodlands and fields (Blouin-Demers and Weatherhead 2001a), even in more disturbed habitats (Durner and Gates 1993). These results suggest that Gray Ratsnake does not adapt particularly well to high levels of human disturbance where intense land clearing has taken place. This is evident from their virtual disappearance in the intense agricultural landscapes of southwestern Ontario.

The cold Canadian environment results in slow growth and late maturity, significantly increasing generation time (Blouin-Demers *et al.* 2002) and making Gray Ratsnake significantly more vulnerable to disturbances than populations in less challenging environments. The long generation time will also reduce the species' ability to adapt to a rapidly changing environment.

Dispersal and Migration

Although there is large individual variation, the size of an average mature Gray Ratsnake home range (minimum convex polygon) is approximately 18.5 ha (Blouin-Demers and Weatherhead 2002). Ratsnakes will often overwinter in hibernacula not located within their active season range and commute up to 4 km (Blouin-Demers and Weatherhead 2002a) to this range shortly (3-7 days) after emerging from hibernation, and return shortly before hibernation. The emergence period lasts about three weeks starting in late April (Blouin-Demers *et al.* 2000) and most snakes are within their active season range by early June (Blouin-Demers and Weatherhead 2002a). Mature Gray Ratsnakes demonstrate strong fidelity to both their hibernacula and general home ranges (Weatherhead and Hoysak 1989) each year, limiting the dispersal potential and rescue effect from other populations for this life stage. Juvenile Ratsnakes, however, frequently do not join communal hibernacula until they reach maturity and show a lower fidelity to both their hibernacula and home ranges (Blouin-Demers *et al.* 2007), demonstrating a greater potential for dispersal.

Interspecific Interactions

Known predators of mature Gray Ratsnakes include large birds of prey such as Red-shouldered Hawk (*Buteo lineatus*) and Red-tailed Hawk (*Buteo jamaicensis*) as well as medium-sized mammals such as Fisher (*Pekania pennanti*), American Mink (*Neovison vison*), and Raccoon (*Procyon lotor*). Neonates and juveniles are likely susceptible to the same predators, as well as smaller predators such as American Crow (*Corvus brachyrhynchos*) and possibly Wild Turkey (*Meleagris gallopavo*) (Prior and Weatherhead 1996). In late fall, several carcasses of Gray Ratsnakes bearing radio-transmitters were recovered from the dreys created by Gray Squirrels (*Sciurus carolinensis*) (G. Blouin-Demers, personal observation). In some areas, increased contact with humans can be a large source of mortality either by the direct intentional killing of individuals, or indirectly as a result of human activities (e.g., road mortality (Row *et al.* 2007)).

Some nests, especially those in compost piles and open stumps, would seem to be susceptible to a wide variety of typical nest predators such as Raccoon or Striped Skunk

(*Mephitis mephitis*), but these sources of predation have rarely been observed at several communal nests monitored over several years at QUBS (G. Blouin-Demers, personal observation). Such predation may be more common in areas with relatively higher densities of human-subsidized predators (e.g., southern Ontario). Blouin-Demers and Weatherhead (2000) discovered that the burying beetle, *Nicrophorus pustulatus*, parasitizes ratsnake eggs and could be a significant source of mortality.

Gray Ratsnakes are generalist foragers that mainly feed on small mammals and birds (Weatherhead *et al.* 2003). Weatherhead *et al.* (2003) analyzed the scat of ratsnakes on the Frontenac Arch and found that mammals made up approximately 65% of the diet, while birds made up about 30%.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

There are 1819 observations of Gray Ratsnake in the database of the Natural Heritage Information Centre, which includes observations submitted to the Ontario Herpetofaunal Summary and the more recent Ontario Reptile and Amphibian Atlas (Ontario Nature 2016). The vast majority (1692 or 93%) of the observations are from the Great Lakes / St. Lawrence DU, while only 127 observations are spread across the four subpopulations of the Carolinian DU. The observations are reported by researchers, government employees, naturalists, and the general public and do not represent a systematic quantification of the presence or absence of Gray Ratsnake. There have been no systematic attempts to quantify accurately the distribution of Gray Ratsnake in Canada.

Research and monitoring efforts across the Great Lakes / St. Lawrence have allowed the identification of several communal hibernacula, some of which were monitored during spring emergence for 1-20 years. Currently, population monitoring efforts are only being continued at Thousand Islands National Park and at Murphy’s Point Provincial Park.

There has been virtually no research conducted on the Carolinian DU. In 2001-2003, two individuals were radio-tracked from the Oriskany subpopulation. During this study, some effort was expended to search for individuals and to enclose and monitor the hibernaculum used by the two radio-tracked individuals. Aside from 1 road-killed individual in 2006, no other individuals were captured during this study (Yagi and Tervo 2006).

Abundance

For the Great Lakes / St. Lawrence DU, Blouin-Demers and Weatherhead (2002a) estimated the density of ratsnakes in the QUBS area to be 0.261 mature individuals/ha. The habitat quality is not uniform across the Frontenac Arch, however, and it is likely that the density is also variable. The quality of habitat across the Frontenac Arch was ranked using habitat suitability predictors, road density, and patch size (Row 2006) and the quality of habitat at QUBS was relatively high (mean = 0.70 on a scale between 0 and 1). To estimate the abundance of the entire Great Lakes / St. Lawrence DU, the area of land with similar habitat quality to QUBS (rank of > 0.70) was multiplied by the QUBS density, which gave an estimate of 25 000 mature individuals. Because ratsnakes also occur outside these high-quality habitat areas, this was considered to be a lower estimate. The upper estimate was determined by multiplying the total extent of occurrence by the density, which gave an abundance of 67 000 mature individuals (Row 2006). This is likely a large overestimate because habitat quality is not uniformly high in the DU. These are very rough estimates of abundance and because there have been no efforts to systematically and accurately quantify the spatial extent of this DU, it would be difficult to make a more accurate estimate at this time.

For the Carolinian DU, there are no estimates of density or habitat use patterns for any of the subpopulations, making accurate estimates of abundance impossible. Given the paucity and sparseness of records in the Natural Heritage Information Centre database and the small size of suitable remaining habitat fragments, however, it is unlikely that the Big Creek and Oriskany subpopulations comprise more than 200 and 30 mature individuals respectively.

Fluctuations and Trends

For the Great Lakes / St. Lawrence DU, no demographic data exist to allow for an estimation of population trends for the entire population. Weatherhead *et al.* (2002), however, examined the population trends from long-term (1981-1998) monitoring programs at four hibernacula in two subpopulations (QUBS and Hill Island in Thousand Islands National Park). All of these hibernacula were located in protected areas. Over 15 years, the overall subpopulation size at both QUBS and Hill Island showed a decrease of approximately 10% (Weatherhead *et al.* 2002). At QUBS the negative population growth was attributed to a declining recruitment rate, which also caused a shift in the age structure towards more mature individuals. Adding several years of more recent data and several new locations suggests that the downward trends at QUBS continue, whereas the subpopulations at Thousand Islands National Park may have stabilized (Browne 2014). An additional recent analysis (Browne pers. comm. 2018) of trends in QUBS hibernacula for which there were sufficient years of data revealed that of the seven largest hibernacula, four were decreasing and three showed no trend. Of the four remaining smaller hibernacula, two were increasing and two showed no trend. The apparent continuing population decline overall at Queen’s Biological University Station is potentially concerning as this subpopulation could be a genetic source to other local subpopulations (Howes *et al.* 2009).

The estimated extent of occurrence has declined from 3287 km^2 (based on 1976-1995 records) to an estimated 2565 km^2 in the present report (~22% decline). During the same interval, the index of area of occupancy increased ~30%, although the additional grid squares were highly clustered (Figure 2). There have been no large-scale systematic searches targeted specifically for Gray Ratsnake; rather, observations have come from the Ontario Herpetofaunal Summary and the more recent Ontario Reptile and Amphibian Atlas. This generalized search effort, along with media attention directed at large snake species, has increased in recent years. It is unlikely that apparent recent declines in EOO (and presumably population) have resulted from biased or diminished search effort. It is more likely that they have resulted from increased habitat fragmentation in the southern part of the DU's range (see **Habitat Trends**). The clustering of recent (>1995) observations, as well as recent satellite imagery (Figure 4), would also support that contention.

For the Carolinian DU, the lack of current or past demographic data from these subpopulations makes it impossible to accurately estimate population trends. Because at least 80% of the forest cover has been removed from this region since European settlement (Butt *et al.* 2005), Gray Ratsnake distribution and abundance have been drastically reduced in this region. In addition, it appears that two of the four subpopulations originally comprising that DU may now be extirpated. As a result, the estimated EOO has declined from 7300 km^2 in the previous report to the estimated 826 km^2 in the present report (89% decline). During the same interval, the estimated IAO declined from 320 km^2 to the current estimated 60 km^2 (81% decline), despite no evidence of decline in search effort.

Rescue Effect

Gray Ratsnake is widespread and common throughout the eastern and central United States of America. Both the Great Lakes / St. Lawrence and Carolinian DUs, however, are geographically disjunct from continuous portions of the species' range in the United States of America. The Carolinian DU is separated by Lake Erie. A small portion of the Great Lakes / St. Lawrence DU ranges into upper New York State and it is possible that there is some exchange of individuals between the two countries, although this would require individuals to cross the St. Lawrence River. The upper New York State Gray Ratsnake subpopulation is isolated and separated from the main population by at least 100 km. Therefore, rescue is unlikely for either of the Canadian subpopulations.

THREATS AND LIMITING FACTORS

Threats

Threats calculator worksheets were completed for the Great Lakes / St. Lawrence DU on 15 March 2016 (see Appendix 1) and for the Carolinian DU on 17 September 2017. The results of the threats calculator exercise, in order of decreasing impact, are as follows:

Great Lakes / St. Lawrence (Overall Threat Impact: High):

- Transportation & service corridors: high – medium
- Energy production & mining: low
- Agriculture & aquaculture: low
- Residential & commercial development: low
- Biological resource use: low
- Natural system modifications: negligible
- Human intrusions & disturbance: negligible

- Invasive & other problematic species: unknown

<u>Carolinian (Overall Threat Impact: Very High – High):</u>

- Transportation & service corridors: high – medium
- Energy production & mining: medium
- Agriculture & aquaculture: medium - low
- Residential & commercial development: low
- Biological resource use: low
- Natural system modifications: low
- Human intrusions & disturbance: negligible
- Invasive & other problematic species: unknown
- Climate change & severe weather: unknown

Recognized threats and their relative severity were similar between the two DUs, although the overall threat impact was greater in the Carolinian DU, reflecting both its smaller EOO and IAO and the greater intensity of development in its range. The cumulative overall threat impacts of High (Frontenac DU) and Very High – High (Carolinian DU) imply a 10-70% and 10-100% predicted population decline, respectively, over the next 3-generations from threats operating for the next 10-years, per Table 4 of Threats Calculator Guidelines.

<u>Roads</u>

Roads pose a significant threat to Canada's snake species and can result in high levels of annual mortality (Row *et al.* 2007; Baxter-Gilbert *et al.* 2015; Garrah *et al.* 2015; Stinnissen 2015; Choquette and Valliant 2016); which in turn can lead to long-term decline and local extirpation (Row *et al.* 2007; Reed 2013). Snakes are particularly susceptible to being struck and killed by vehicles because many species make large movements during the active season (e.g., Rouse *et al.* 2011), they may use roads for thermoregulation (Ashley and Robinson 1996; Andrews *et al.* 2008), and individuals of many species immobilize in response to passing vehicles, increasing the risk of being hit (Andrews and Gibbons 2005). Ashely *et al.* (2007) found that approximately 3% of drivers will intentionally swerve to hit snakes on the road, which further increases the risk of mortality for these species. Although road mortality tends to be highest on major roads, several studies have demonstrated that smaller, unpaved roads can also pose a significant risk to snake populations (Row *et al.* 2007; Stinnissen 2015).

All participants in threats assessments agreed that road mortality is an important threat facing all populations of Gray Ratsnake, with individual participants' estimates ranging from moderate to severe. Road networks have been expanding rapidly across the species' ranges in southern Ontario (Fenech *et al.* 2000), and traffic volume and speed are increasing on existing roads (Ontario Ministry of Transportation (OMTO) 2010). In the Carolinian the growth of the road network has been significant over the past century, and there are now few places in southwestern Ontario that are more than 1 km from a road. Although the growth of the road network has slowed significantly in the Carolinian, the threat of road mortality continues to grow: ongoing upgrades to the road network (unpaved to paved, 2-lane to 4-lane, etc.) are enabling higher traffic speeds, while a growing human population is resulting in an ongoing increase in traffic volume on existing roads. Gray Ratsnakes have large home ranges and disperse great distances, which allow local subpopulations to interchange individuals and genes. However, these characteristics also make the snakes vulnerable to proliferating road networks, and most individual ratsnakes probably encounter roads annually.

Although no quantitative data exist on the direct effect of road mortality across the two DUs, a case study at the QUBS illustrates the potential severity of this threat. A Population Viability Analysis indicated that observed rates of adult mortality (estimated at 9 mature individuals per year) on the local 10-km gravel road increased the probability of extinction from 7.3% to 99% over 500 years (Row *et al.* 2007). Road mortality of three mature females per year raised the extinction probability to > 90% over 500 years (Row *et al.* 2007). Although the road mortality rate documented in this study cannot be directly extrapolated across the entire species' distribution, Garrah *et al.* (2015) estimated a similar Gray Ratsnake annual road mortality rate at their study site along the St. Lawrence Parkway. Further to this, many areas in the Great Lakes / St. Lawrence DU, and especially in the Carolinian DU, have higher road density and poorer habitat quality than does QUBS (Figure 5). In fact, the road density in the Great Lakes / St. Lawrence DU is 0.97 km/km^2 while it is 1.29 km/km^2 in the Carolinian DU (Figure 5). Hence, ratsnake populations outside of QUBS could suffer even greater risk of extinction from road mortality.

Although the exact risk of road mortality across the species' ranges cannot be calculated with existing data, its effect can be evaluated by stage-based population modelling that examines a series of plausible subpopulations without road mortality and then modifies those models to incorporate road mortality. Such a process has been completed for the Great Basin Gopher Snake (*Pituophis catenifer*) by Reed (2013), who demonstrated that if road mortality results in additional 5% mortality, subpopulations in that species are expected to decline by > 30% over 3 generations.

Edge (unpublished) developed a similar stage-based population model for Gray Ratsnake, using adult survival estimates from QUBS Gray Ratsnake data and published estimates of juvenile survival (Row *et al.* 2007). Because egg and hatchling survival for this species are unknown, he iteratively increased egg and hatchling survival to create a stable population. Survival variation for adults was added based on estimates from each of the hibernacula evaluated by Browne (pers. comm. 2018). To evaluate the effect of road mortality on population persistence, adult and juvenile survival were decreased in intervals of 1% until the population decreased by 30% over 3 generations (30 years). Each survival estimate scenario was run 999 times and the mean and 95% confidence intervals were calculated. With 1% additional mortality the population of mature individuals is predicted to decline by 34% (CI 18-50%) over the next 3 generations; with 3% additional mortality, the confidence intervals no longer overlapped 30% (Mean 57.5% CI 38-77%).

Data from the QUBS subpopulation indicate that the subpopulation is likely declining due to road mortality and habitat alteration. To evaluate the current population trend, Edge created the most plausible model of present conditions for that subpopulation based on published survival estimates. The most plausible model predicts that the subpopulation will decline by 13.2% over the next three generations (30 years). Outside protected areas like QUBS, habitat is more fragmented, and road densities are higher across most of the DU’s range; hence interactions with roads and the potential for road mortality are substantially increased. A range-wide habitat analysis by Row (2006) revealed a mix of habitat quality throughout the range, with large areas of low quality habitat, but relatively few high quality sites like QUBS.

In addition to being a source of mortality, roads can also act as barriers to snake movement, either by physically preventing snakes from crossing them or by altering animal behaviour (Shine *et al.* 2004; Andrews and Gibbons 2005; Shepard *et al.* 2008). For a wide-ranging species such as Gray Ratsnake, roads can result in significant population and habitat fragmentation. Small population size in these fragments further increases vulnerability of ratsnakes to anthropogenic sources of mortality, population declines associated with stochastic events, and inbreeding depression.

Energy production & mining

In the Carolinian DU, limestone quarrying is ongoing and expanding, impacting a large proportion of the snakes' distribution in the Oriskany subpopulation, and threatening to alter or destroy hibernation sites and kill hibernating snakes. In the Great Lakes / St. Lawrence DU, aggregate, limestone, and granite extraction continues to grow, and increasing areas of suitable habitat are being developed for solar farms. These developments potentially threaten hibernation sites, and eliminate and fragment habitats for feeding and reproduction.

Agriculture

Intensive agricultural activities, e.g., haying, plowing, disturbance of manure piles, cause mortality (albeit unquantified) across the species’ ranges, particularly in the Carolinian DU. Marginal agricultural conditions in part of the Frontenac Arch have led to the abandonment of farmland over the last 60 years (McKenzie 1967), allowing for large tracts of suitable Gray Ratsnake habitat to remain. However, conversion of even marginal farmland for ethanol production and expansion of soybean production poses threats to foraging and basking ratsnakes.

Habitat loss

Collectively, habitat loss from an array of activities (*e.g.,* energy production, mining, agriculture, residential development, forest harvesting) is probably a major threat for Gray Ratsnake in Canada. Although the larger of the two, the Great Lakes / St. Lawrence DU has a relatively small extent of occurrence (2565 km^2). The distribution of suitable habitat across the Frontenac Arch suggests that although there are still large tracts of continuous suitable habitat, the total amount is much less than 2565 km^2 (Row 2006). Recreational activities have been increasing in the heart of the Rideau Canal leading to more development in the area (Thompson, pers. comm. 2015).

The extent of occurrence of the Carolinian DU (826 km^2) is very small and consists mostly of intensive agricultural land. This lack of suitable habitat is reflected in the very small and isolated subpopulations of ratsnakes remaining in the Carolinian DU. It is unknown whether the remaining suitable habitat is sufficient for the long-term survival of any of the existing subpopulations in southwestern Ontario.

The expansion of the road network and the loss of continuity between habitat patches has made the Great Lakes / St. Lawrence DU increasingly fragmented (Row 2006), and the current extent of habitat fragmentation is more dire for the Carolinian DU (Figure 5). Because Ratsnakes hibernate in communal hibernacula, conversion of natural habitat to urban or agricultural uses can also be particularly detrimental to subpopulations when existing hibernacula are eliminated.

Population viability analysis suggests that a population of at least 141 mature individuals (network of ~8 hibernacula) is needed to support a viable population (Tews 2005). For the Great Lakes / St. Lawrence DU, this translates to an area of at least 540 ha of continuous suitable habitat. In the Carolinian DU, ratsnake density is much lower and mortality is likely higher due to higher road densities. Therefore, a forested area much larger than 540 ha of continuous suitable habitat would be needed to support a viable subpopulation in the Carolinian DU. The persistence of the remaining Carolinian subpopulations is likely jeopardized by their small size and isolation and by the small, reduced areas of suitable habitat.

Other threats to the species exist, including intentional killing and emerging diseases (e.g., snake fungal disease). Their potential impacts at the population level, however, have not yet been quantified and their consequences are therefore presently unknown.

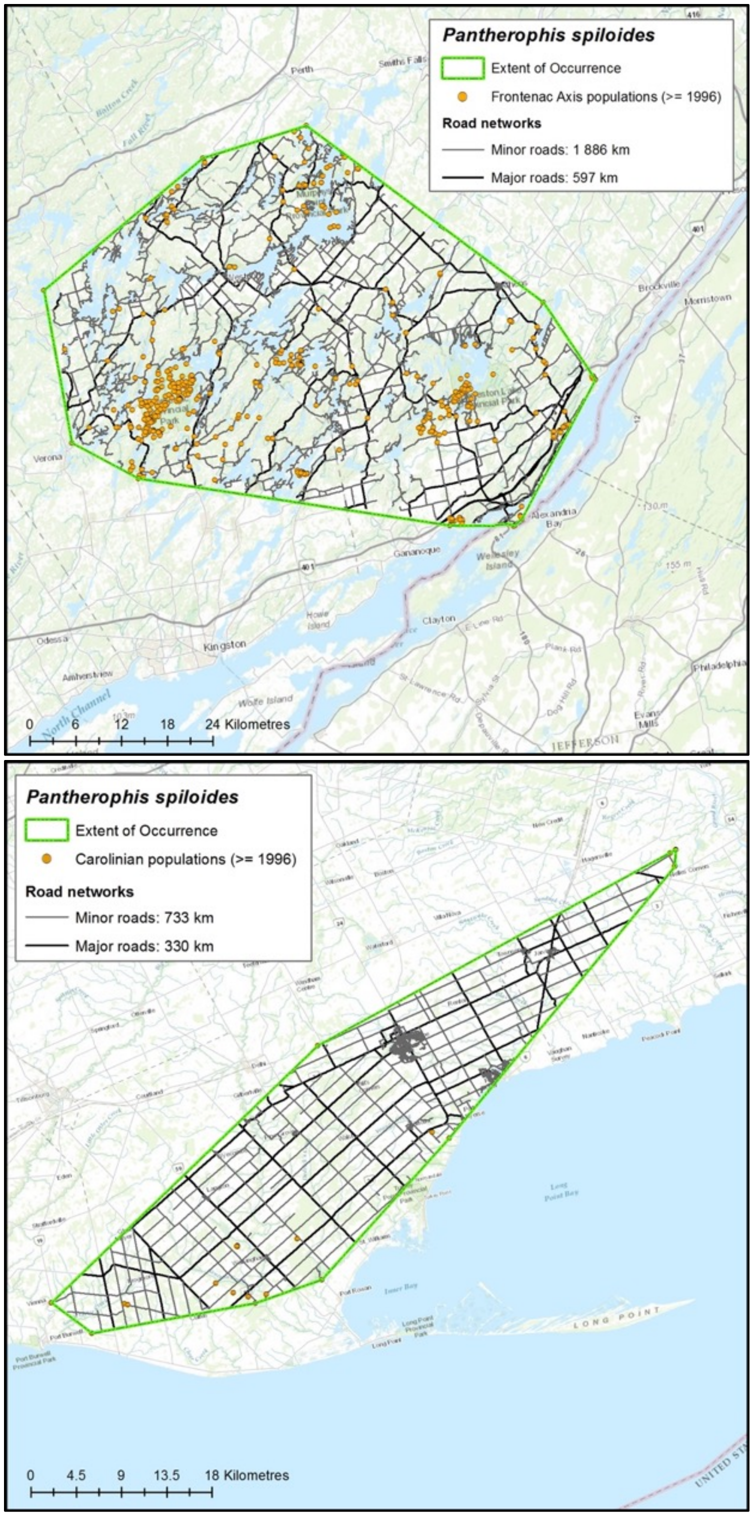

Figure 5. Road network within the range of *Pantherophis spiloides* of the Great Lakes / St. Lawrence and Carolinian DU.

Limiting Factors

A number of intrinsic life-history characteristics make Gray Ratsnake particularly vulnerable to disturbances. Biennial reproduction, delayed age of maturity, and slow growth rates can cause seemingly small increases in mortality to have significant population level impacts (Row *et al.* 2007). Furthermore, suitable habitat for Gray Ratsnake consists of a mosaic of forested and open habitats, and large areas of suitable habitat are required to support viable subpopulations. Individuals can travel at least 4 km from their hibernacula, making subpopulations especially vulnerable to the effects of roads (isolation, mortality).

Number of Locations

For the Great Lakes / St. Lawrence DU, the probable extent of the most likely and imminent threats (habitat loss and road mortality) is much smaller than the extent of occurrence or the area of occupancy. Thus, there are probably dozens of locations for this DU, but an exact calculation of this number is not possible given the variation in the spatial extent of the threats. For instance, the building of a new cottage would not have the same spatial impact as an entirely new subdivision, or the improvement of a short dirt road would not have the same spatial impact as the creation of a new four-lane highway. For the Carolinian DU, however, each of the two extant subpopulations are so small that they could easily be affected by a new road or a new development. Thus, the Carolinian DU probably consists of two (or possibly three [see **Distribution – Canadian Range**]) locations, one for each of the extant subpopulations.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

In Canada, the Gray Ratsnake Great Lakes / St. Lawrence DU is listed under Schedule 1 of the *Species at Risk Act* as Threatened and the Carolinian DU is listed under Schedule 1 of the *Species at Risk Act* as Endangered. The Gray Ratsnake Great Lakes / St. Lawrence DU is listed as Threatened and the Carolinian DU listed as Endangered in Ontario under the *Ontario Endangered Species Act*. The *Ontario Endangered Species Act* provides significant protection to Gray Ratsnake and its habitat. Gray Ratsnake is also protected in Ontario under the *Fish and Wildlife Conservation Act,* in which it is listed as a Specially Protected Reptile.

Non-Legal Status and Ranks

Gray Ratsnake has a global status of G5, and individual states within the range of the species list ratsnakes as secure (S5) or apparently secure (S4), except in Michigan, Wisconsin, and Ontario where they are listed as vulnerable (S3) (NatureServe 2016).

Habitat Protection and Ownership

The Great Lakes / St. Lawrence DU occurs within numerous protected areas such as Murphy's Point Provincial Park (~13 km^2), Frontenac Provincial Park (~50 km^2), Charleston Lake Provincial Park (~25 km^2), Thousand Islands National Park (~24 km^2), Elbow Lake Environmental Education Centre (~425 ha), and QUBS (~40 km^2). In addition, there are Gray Ratsnakes in some of Parks Canada's Rideau Canal properties. The Rideau Valley Conservation Authority has ~700 ha under protection that includes some areas that are inhabited by Gray Ratsnake, and the Cataraqui Conservation Authority owns 400 ha within the Gray Ratsnake range. Finally, the Nature Conservancy of Canada has been purchasing hundreds of hectares of land which will increase protection for Gray Ratsnake. In total, these areas only protect approximately 6% of the 2565 km^2 extent of occurrence on the Frontenac Arch. All of these protected areas are isolated from each other by roads and the largest continuous tract of land (Frontenac Park) is approximately 50 km^2.

The distribution of the Carolinian DU is less clearly defined and, therefore, the amount of protection for these subpopulations is more difficult to quantify. In Haldimand and in Norfolk, harbouring the apparently largest ratsnake subpopulation of the DU, numerous small tracts of land that may contain Gray Ratsnakes have been purchased and protected by the Nature Conservancy of Canada and local conservation groups. In general, however, there appear to be few large, protected tracts of lands that harbour Gray Ratsnake in southwestern Ontario.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Gabriel Blouin-Demers is a Full Professor in the Department of Biology at the University of Ottawa. He teaches conservation biology and several field courses. His fundamental research program aims at explaining (1) spatial patterns of variation in density of ectotherms and (2) the evolutionary maintenance of within-population polymorphisms. He also conducts applied conservation projects on reptiles at risk. Gray Ratsnake was his first love, having done his PhD on the species from 1996 to 2001. He has published extensively on the ecology of the majority of reptiles in eastern Canada, including on the ecology of Gray Ratsnake.

COLLECTIONS EXAMINED

None.

Appendix 1: Threats calculator worksheet for the Great Lakes / St. Lawrence population.

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	Gray Ratsnake Great Lakes / St. Lawrence Population			
Element ID			**Elcode**	
Date (Ctrl + ";" for today's date):	15/03/2016			
Assessor(s):	Gabriel Blouin-Demers (status report writer), Jim Bogart (COSEWIC Amphibians and Reptiles SSC), Kristiina Ovaska (facilitator), Tobi Kiesewalter (Ontario Parks), Shaun Thompson, Joe Crowley (Amphibians and Reptiles SSC), Mary Beth Lynch (Parks Canada), Kent Prior (Parks Canada). COSEWIC Secretariat: Bev McBride, Joanna James (non-assessors)			
References:	COSEWIC status report, draft			

Overall Threat Impact Calculation Help:			**Level 1 Threat Impact Counts**	
	Threat Impact		**high range**	**low range**
	A	Very High	0	0
	B	High	1	0
	C	Medium	0	1
	D	Low	4	4
		Calculated Overall Threat Impact:	High	High
		Assigned Overall Threat Impact:	**B = High**	
		Impact Adjustment Reasons:		
		Overall Threat Comments	***Generation time: 10 years; EOO: 2565 km²; IAO: 612 km²; Population size: 27 - 67K***	

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development	D	Low	Small (1-10%)	Extreme - Serious (31-100%)	High (Continuing)	
1.1	Housing & urban areas	D	Low	Small (1-10%)	Extreme - Serious (31-100%)	High (Continuing)	Effects on hibernacula would be extreme, but some mitigation is likely required for any new developments (e.g., threat mitigation, habitat protection/enhancement)
1.2	Commercial & industrial areas		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
1.3	Tourism & recreation areas	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	Golf course development (1 recent example known). There is currently a push to promote/increase tourism, which could lead to more developments
2	Agriculture & aquaculture	D	Low	Small (1-10%)	Serious (31-70%)	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%)	Serious (31-70%)	High (Continuing)	The marginal agricultural conditions on the Frontenac Arch have led to the abandonment of farmland over the last 60 years (McKenzie 1967) and allowed for large tracts of suitable Gray Ratsnake habitat to remain. However, there are examples of land turned into cornfields, even on marginal farming land. There is a new trend to grow corn for ethanol & soybeans as a new crop (intensification of agriculture). The snakes are not tolerant of row crops - foraging & basking habitat affected - but hibernacula are unlikely to be impacted.
2.2	Wood & pulp plantations		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Risk would be from the conversion of meadow/forest habitat into plantations; also mortality of snakes could occur during planting/thinning processes but have negligible population effects. Conversions are occurring more frequently in deeper soil areas.
2.3	Livestock farming & ranching		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Small scale operations are disappearing. Flipside is increased foraging opportunities that may counteract habitat loss/deterioration.
2.4	Marine & freshwater aquaculture						
3	Energy production & mining	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	
3.1	Oil & gas drilling						
3.2	Mining & quarrying	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	Many new applications have been received for sand, gravel, limestone, granite excavation.
3.3	Renewable energy	D	Low	Small (1-10%)	Serious (31-70%)	High (Continuing)	Solar power farms are increasing (cover 100 - 200 acres per site). Expansion still going on but may be slowing down. The scope may be towards the higher end of Small. Every type of habitat (except wetlands & good agricultural lands) can be converted. Large poured concrete pads result in habitat loss. Wind farms: not many are proposed within this area.
4	Transportation & service corridors	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (11-70%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.1	Roads & railroads	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (11-70%)	High (Continuing)	Road improvements are ongoing, and traffic is increasing on existing roads. Most ratsnakes probably encounter a road of some type. Gray Ratsnakes have large home ranges and dispersal distances which allow local subpopulations to interchange individuals and genes, but also make the species vulnerable to proliferating road networks, which in turn increase fragmentation of subpopulations and habitat. A Population Viability Analysis indicated that observed rates of adult mortality (estimated at 9 mature individuals per year) on the local 10-km gravel road increased the probability of extinction from 7.3% to 99% over 500 years (Row *et al.* 2007). As few as three mature females killed on the road each year raised the extinction probability to > 90% over 500 years (Row *et al.* 2007). Many areas in the Great Lakes / St. Lawrence DU have a much higher road density and poorer habitat quality than at QUBS. There was some discussion and differing opinions of the severity of the threat and a range of values was used. While all participants agreed that the severity is at least moderate, others felt that "serious" may be an overestimate.
4.2	Utility & service lines		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Some new lines are going in (e.g., gas pipeline) but rigorous process for env impact assessment and effects mainly restricted to construction.
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	Intentional killing is included here but is hard to assess. Negative attitudes are still out there & some landowners would kill all snakes encountered. Scope was assessed as the proportion of snakes that encounter landowners or individuals who are inclined to harm snakes. Poaching for pet trade is probably not an issue (not very valuable and bred easily).
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Logging occurs mostly on private lands, where poor forestry practices are frequently used. Typically white pine or hardwoods are removed, and clearcutting is common; there are usually no surveys for species at risk. Also, firewood collection is prevalent. Impacts would be low if good forestry practices are used. Downed woody debris is created and regeneration will restore habitat (positive).

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.4	Fishing & harvesting aquatic resources						
6	Human intrusions & disturbance		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
6.1	Recreational activities		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	There is increasing recreational activity in the heart of the Rideau Canal. Greatest effect is from ATVs (sporadic only), but most recreational activities such as hiking would have little impact on the snakes.
6.2	War, civil unrest & military exercises						
6.3	Work & other activities						
7	Natural system modifications		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	
7.1	Fire & fire suppression		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Prescribed fires occur within the range and can cause mortality if done when the snakes active. Not much wildfire activity occurs within the snakes' range.
7.2	Dams & water management/use						
7.3	Other ecosystem modifications		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Roadside mowing may be an issue, as can mowing in general on private lands.
8	Invasive & other problematic species & genes		Unknown	Small (1-10%)	Unknown	High (Continuing)	
8.1	Invasive non-native/alien species		Unknown	Unknown	Unknown	High (Continuing)	Snake fungal disease - many unknowns about prevalence and impacts.
8.2	Problematic native species		Unknown	Small (1-10%)	Unknown	High (Continuing)	Predation of nest sites by subsidized predators (Raccoon, Striped Skunk, Coyote) has been documented. Burying Beetles (*Nicrophorus pustulatus*) parasite eggs (but have always been around), and threats probably haven't increased. Reintroduction of Wild Turkey is considered in this category. Turkeys prey on small snakes.
8.3	Introduced genetic material						
9	Pollution						
9.1	Household sewage & urban waste water						
9.2	Industrial & military effluents						
9.3	Agricultural & forestry effluents						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
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						
11.1	Habitat shifting & alteration						
11.2	Droughts						
11.3	Temperature extremes						
11.4	Storms & flooding						

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

Appendix 2: Threats calculator worksheet for the Carolinian population.

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	Gray Ratsnake, Carolinian Population		
Element ID		**Elcode**	
Date (Ctrl + ";" for today's date):	17/09/2017		
Assessor(s):	Tom Herman (COSEWIC Amphibians and Reptiles SSC cochair), Kristiina Ovaska (COSEWIC Amphibians and Reptiles SSC), Anne Yagi (species expert); Joe Crowley (COSEWIC Amphibians and Reptiles SSC member & OMNR)		
References:	COSEWIC status report, draft		

Overall Threat Impact Calculation Help:

Threat Impact		**Level 1 Threat Impact Counts** high range	low range
A	Very High	0	0
B	High	1	0
C	Medium	2	2
D	Low	3	4
	Calculated Overall Threat Impact:	Very High	High

Assigned Overall Threat Impact:	**AB = Very High - High**
Impact Adjustment Reasons:	
Overall Threat Comments	***Generation time: 10 years***

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	
1.1	Housing & urban areas	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	Effects from new housing developments on hibernacula would be extreme, but some mitigation is likely required for any new developments (e.g., threat mitigation, habitat protection/enhancement) .
1.2	Commercial & industrial areas		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
1.3	Tourism & recreation areas		Negligible	Negligible (<1%)	Moderate (11-30%)	High (Continuing)	
2	Agriculture & aquaculture	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.1	Annual & perennial non-timber crops	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	Continuing agricultural activities, e.g., haying, plowing, disturbance of manure piles, lead to mortality. The snakes are exposed to these activities throughout the species' range.
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Livestock farming is ongoing but occurs at a small scale with limited impacts on the snakes.
2.4	Marine & freshwater aquaculture						
3	Energy production & mining	C	Medium	Restricted (11-30%)	Extreme - Serious (31-100%)	High (Continuing)	
3.1	Oil & gas drilling						
3.2	Mining & quarrying	C	Medium	Restricted (11-30%)	Extreme - Serious (31-100%)	High (Continuing)	Limestone quarrying is ongoing and is expanding and impacts a large proportion of the snakes' distribution within one portion of the range. Destruction and alternation of hibernation sites and mortality of hibernating snakes are of concern.
3.3	Renewable energy		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Solar power and wind farms are already in existence within the range of this population. The group was not aware of new proposals or projects.
4	Transportation & service corridors	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (11-70%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
4.1	Roads & railroads	BC	High - Medium	Pervasive (71-100%)	Serious - Moderate (11-70%)	High (Continuing)	Road improvements are ongoing, and traffic is increasing on existing roads. Most ratsnakes probably encounter a road of some type. Gray Ratsnakes have large home ranges and long dispersal distances, which allow local subpopulations to interchange individuals and genes. However, these characteristics also make the snakes vulnerable to proliferating road networks, which in turn increase fragmentation of subpopulations and habitat. Small population size of this population of ratsnakes further increases its vulnerability to anthropogenic sources of mortality.
4.2	Utility & service lines		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Mitigation is possible under normal environmental assessment process.
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	Intentional killing is included here but is difficult to assess. Negative attitudes still exist, and some landowners may indiscriminately kill all snakes encountered. Scope was assessed as the proportion of snakes that encounter landowners or individuals who are inclined to harm snakes. Scope may be underestimated; however, while likelihood of encounter with humans is probably higher in this DU than in the Great Lakes/St. Lawrence DU, so is the level of awareness. Poaching for pet trade is probably not an issue (not very valuable and easily bred in captivity).

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Logging occurs mostly on private lands. Firewood collection is prevalent within the species' range. Impacts can be mitigated with good forestry practices. Down woody debris is created, and if left in place, is beneficial to the snakes. In addition, regeneration will restore habitat.
5.4	Fishing & harvesting aquatic resources						
6	Human intrusions & disturbance		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	
6.1	Recreational activities		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Greatest effect is from ATVs & motorcycles, which occur sporadically. Most recreational activities such as hiking would have little impact on the snakes.
6.2	War, civil unrest & military exercises						
6.3	Work & other activities						
7	Natural system modifications	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	
7.1	Fire & fire suppression		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Prescribed fires occur within the range and can cause mortality if done when the snakes active. Not much wildfire activity occurs within the snakes' range.
7.2	Dams & water management/use	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Dam removal is ongoing and may affect habitat; mitigation of the impacts is possible.
7.3	Other ecosystem modifications						
8	Invasive & other problematic species & genes		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.1	Invasive non-native/alien species		Unknown	Unknown	Unknown	High (Continuing)	Snake fungal disease is of concern, but there are many unknowns about its prevalence and impacts.
8.2	Problematic native species		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Wild Turkey has been reintroduced to the area and may prey on small snakes, including juvenile ratsnakes. Predation of nest sites by subsidized predators (Raccoon, Striped Skunk, Coyote) has been documented. Burying Beetles (*Nicrophorus pustulatus*) parasite eggs but do not constitute a new threat; the threat from this source probably has not increased.
8.3	Introduced genetic material						
9	Pollution						
9.1	Household sewage & urban waste water						
9.2	Industrial & military effluents						
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste						
9.5	Air-borne pollutants						
9.6	Excess energy						
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
11.1	Habitat shifting & alteration						
11.2	Droughts						

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.3	Temperature extremes		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Winter warming events are expected to result in increased stress and also to increase vulnerability to predation as the snakes may emerge prematurely from hibernation during warm spells.
11.4	Storms & flooding						Flooding of hibernacula during severe rain events is of concern.
Classification of Threats adopted from IUCN-CMP, Salafsky *et al.* (2008).							