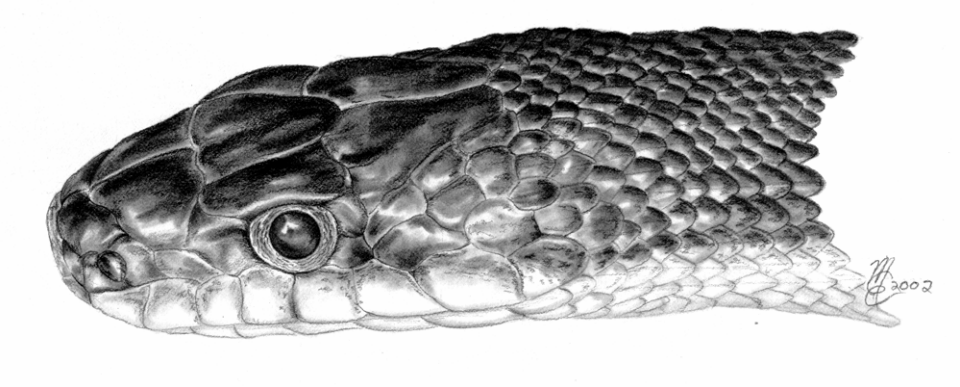
COSEWIC
Assessment and Update Status Report

on the

Gray Ratsnake
Elaphe spiloides

Great Lakes/St. Lawrence population
Carolinian population

in Canada



Great Lakes/St. Lawrence population - THREATENED
Carolinian population - ENDANGERED
2007

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION
DES ESPÈCES EN PÉRIL
AU CANADA

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

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).

Previous report:

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 Jeffrey Row for writing the status report on the Gray Ratsnake *Elaphe spiloides* (Great Lakes/St. Lawrence population and Carolinian population) in Canada, prepared under contract with Environment Canada, overseen and edited by Ron Brooks, Co-chair of the COSEWIC Amphibians and Reptiles Specialist Subcommittee.

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Gray Ratsnake — Illustration by Mandi Eldridge, Guelph, Ontario.

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COSEWIC
Assessment Summary

Assessment Summary – April 2007

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

Scientific name
Elaphe spiloides

Status
Threatened

Reason for designation
This large snake occupies a restricted region in Ontario and is threatened by ongoing development and by expansion of the road network. Development is especially a threat to hibernacula, which may be limiting. Roads represent a significant threat because of the snakes' late age of maturity and low reproductive rate. Snakes are also killed on roads because they move slowly and may bask on roads.

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.

Assessment Summary – April 2007

Common name
Ratsnake – Carolinian population

Scientific name
Elaphe spiloides

Status
Endangered

Reason for designation
This population consists of only 4 highly disjunct subpopulations in southwest Ontario, all of which are small and isolated, and surrounded by agricultural and developed terrain. Their slow rate of reproduction and late age of maturity makes them especially vulnerable to increases in adult mortality from road traffic and agricultural machinery.

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.

COSEWIC
Executive Summary

Gray Ratsnake
Elaphe spiloides

Great Lakes/St. Lawrence population
Carolinian population

Species information

The Gray Ratsnake (*Elaphe spiloides*) is the largest snake in Canada, reaching a maximum snout-vent length (SVL) of approximately 190 cm. The colour pattern of adult Eastern Ratsnakes is widely variable across the species' range. Throughout all populations in Canada, adult Gray Ratsnakes are typically plain, shiny black with white, yellow, orange or red colouration on the skin between the scales. The ventral surface is typically white or yellowish with a clouded grey or brown pattern, often resulting in a checkerboard appearance. Ratsnakes can often be distinguished from other snakes by their throat, which has a plain white or cream colour. In contrast to adults, juveniles are dorsally patterned with dark grey or brown blotches on a pale grey background.

Distribution

The Gray Ratsnake is widely distributed and commonly found throughout the forested areas of the eastern and central United States. However, within Canada, the Gray Ratsnake is confined to two geographically disjunct regions in southwestern (Carolinian Faunal Province) and southeastern (Great Lakes/St. Lawrence Faunal Province) Ontario. In this report, populations from these two regions will be treated as two Designatable Units referred to as the Carolinian and Great Lakes/St. Lawrence populations. In southwestern Ontario, the Carolinian population is associated with the Carolinian forest along the northern edge of Lake Erie and is limited to four very small, isolated populations in Middlesex, Elgin, Haldimand-Norfolk and Niagara counties. The Great Lakes/St. Lawrence population is associated with the Frontenac Axis in Frontenac, Lanark, and Leeds and Grenville counties.

Habitat

The Gray Ratsnake is semi-arboreal and typically found in a wide variety of woodland habitats across its range. At the home range scale, they seem to prefer a mosaic of forest and open habitat (fields; bedrock outcrops) with a high amount of edge. Detailed studies of habitat use on the Frontenac Axis have established that ratsnakes

require a variety of habitat types throughout their life cycle. In winter, ratsnakes hibernate below ground in communal hibernacula that provide shelter from both freezing temperatures and dehydration. 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 approximately 30ºC.

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 in early July to 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 harsh climate in Canada restricts the active season of ratsnakes to approximately 5 months (May – October). During this active season, ratsnakes have relatively large home ranges (~18 ha) and disperse as far as 4 km from their hibernacula. Adults demonstrate strong site fidelity by often using the same home range locations both within and between years.

Gray Ratsnakes are both predators and prey of numerous species. They feed mainly on small mammals (~65%) and birds (~30%) and known predators include a number of large birds of prey (e.g. red shouldered hawk (*Buteo lineatus*), osprey (*Pandion haliaetus*), red tailed hawk (*Buteo jamaicensis*)) and medium-sized mammals (e.g. fisher (*Martes pennanti*), mink (*Mustela vison*)).

Population sizes and trends

Due to the secretive nature of snakes, it is extremely difficult to estimate the extent and size of populations accurately. Based on habitat suitability models and density estimates, the Great Lakes/St. Lawrence population has been estimated to contain between 25 000 – 85 000 individuals. Although no population-wide census information is available, 2 populations on the Frontenac Axis were shown to be declining slightly over an 18-year period. No demographic sampling has been conducted on the Carolinian populations. However, based on the amount of suitable habitat available and the small number of sightings, these populations are likely small and declining.

Limiting factors and threats

Life-history characteristics such as biennial reproduction, delayed age at maturity (~7 years) and slow growth rates make Canadian populations of Gray Ratsnakes particularly sensitive to disturbances. Mortality caused by increased contact with humans (e.g. road mortality, destruction of hibernacula, deliberate killing of ratsnakes by people) can therefore have significant impacts on populations. Furthermore, the suitable

habitat in the Carolinian region is severely restricted and heavily fragmented, and it is unknown whether enough habitat remains to support viable populations of ratsnakes. Suitable habitat on the Frontenac Axis is much more abundant, but increased recreational activity in the area has led to increased development and will likely reduce and fragment the existing habitat.

Special significance of the species

Both the Great Lakes/St. Lawrence and Carolinian populations are geographically isolated and genetically distinct from each other and from populations in the United States. Both populations 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, any efforts toward preservation would benefit many other species.

Existing protection

The Gray Ratsnake does not have a global rank, but individual states within the range of the species list ratsnakes as secure (S5) or apparently secure (S4), except in Wisconsin where they are listed as imperiled (S2) (ratsnakes have not been ranked or are under review in some States). Within Canada, they are protected under Schedule 1 (Threatened) of the *Species at Risk Act* (SARA), ranked within Ontario as S3 (NHIC) and as Threatened by the Committee on the Status of Species at Risk in Ontario (COSSARO). They are also protected in Ontario under the *Fish and Wildlife Conservation Act*, in which *Elaphe spiloides* is listed as a “Specially Protected Reptile under Schedule 10). Very little (< 5%) of the Canadian range of ratsnakes is within protected areas.

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

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

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

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

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

Environment Canada / Canadian Wildlife Service
Environnement Canada / Service canadien de la faune
Canada

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

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SPECIES INFORMATION

Name and classification

The Eastern Ratsnake was originally named and classified by Say (1823), and since that time has been divided into 5 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 this species. All Canadian populations were classified as Black Ratsnakes (*Elaphe obsoleta obsoleta*).

Recently the classification and nomenclature of the Eastern Ratsnakes (*Elaphe obsoleta*) has come into question (Burbrink *et al*. 2000; Burbrink, 2001). Using two mitochondrial gene sequences and 67 morphological characteristics, Burbrink (2001) determined that the previously recognized 5 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), 3) *Elaphe alleghaniensis* (eastern clade), and included the Canadian populations as part of the central clade (Burbrink, 2001) (Fig. 1). The Canadian populations were classified based on geographic trends, however, and no samples were collected from individuals in any Canadian population. Recent morphological and genetic evidence (Gibbs *et al*. 2006) suggests that the ratsnake populations in southwestern Ontario are part of the central clade (*Elaphe spiloides*), whereas the Great Lakes/ St. Lawrence populations are hybrids between the central (*Elaphe spiloides*) and eastern clade (*Elaphe alleghaniensis*). If the two Ontario populations are considered separate species from each other, it would have important implications for conservation efforts in Canada. Gibbs *et al*. (2006) suggest, however, that these *E. spiloides* and *E. alleghaniensis* are not separate “species” because of the hybridization between the two proposed species. Given these taxonomic uncertainties, this report will retain the current name for the central clade, *Elaphe spiloides*, for all Ontario ratsnakes, recognizing that there are genetic differences between the ratsnakes in southwestern versus southeastern Ontario (see section on Designatable Units). The common name for *E. spiloides* is Gray Ratsnake (Crother *et al*. 2003).

Morphological description

Throughout all populations in Ontario, adult Gray Ratsnakes are typically a plain, shiny black snake with white, yellow, orange or red colouration on the skin between the scales. The ventral surface is typically white or yellowish with a clouded grey or brown pattern, often resulting in a checkerboard appearance. They can often be distinguished from other snakes by their throat, which has a plain white or cream colour (Conant and Collins, 1998) and the anal plate, which is usually divided or semi-divided (Ernst and Barbour, 1989). In contrast to the adults, juveniles are dorsally patterned with dark grey or brown blotches on a pale grey background.

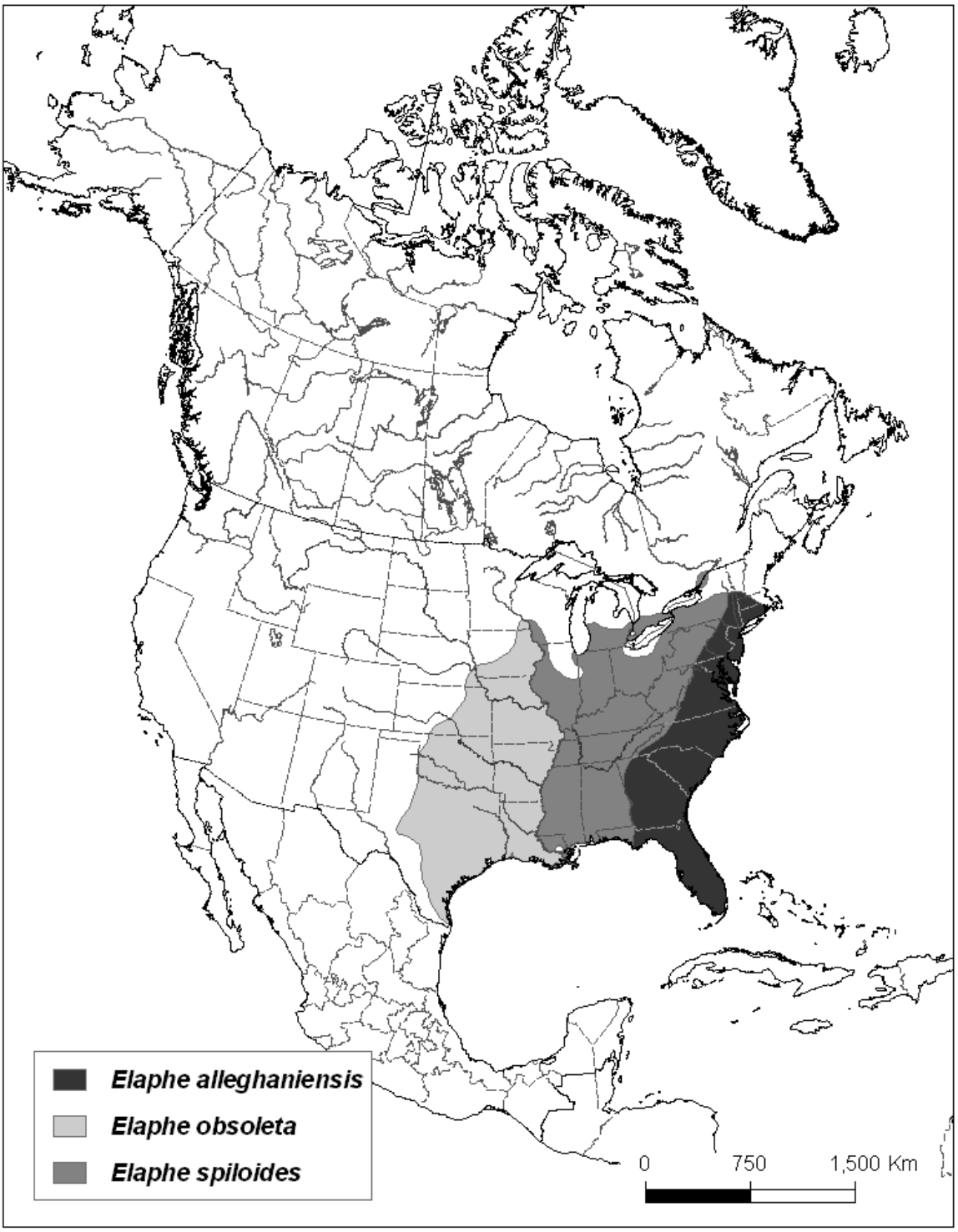

Figure 1. North American distribution of Gray Ratsnakes (Elaphe spiloides) and other putative species of the Eastern Ratsnake complex. Adapted from Burbrink 2001.

The Gray Ratsnake is the largest snake in Canada, often exceeding 130 cm in snout-vent length (SVL) and reaching a maximum SVL of approximately 190 cm. Sexual dimorphism is present in adults; males have longer tails relative to their total body length (males 16 – 19%; females 14 – 18%; Ernst and Barbour, 1989), and attain greater maximum lengths. The size dimorphism is the result of faster growth rates and larger asymptotic sizes in males (Blouin-Demers *et al*. 2002).

Similar species to adult Gray Ratsnakes in Ontario are: Northern Watersnakes (*Nerodia s. sipedon*), melanistic Eastern Gartersnakes (*Thamnophis s. sirtalis*), and Blue Racers (*Coluber constrictor foxii*), but as adults all of these snakes can be relatively easily distinguished from Gray Ratsnakes. Northern Watersnakes have strongly keeled scales and dark brown bars on their neck. Melanistic gartersnakes are jet black, have keeled scales and the anal plate is not divided. 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. Blue Racers are now only found on Pelee Island, Ontario, where ratsnakes no longer occur. Juvenile Gray Ratsnakes can be readily confused with juvenile Eastern Foxsnakes (*Elaphe gloydi*) and juvenile Eastern Milksnakes (*Lampropeltis triangulum*). Eastern Milksnakes, however, have single anal plates and foxsnakes have 216 or fewer ventral scales whereas Gray Ratsnakes will have 221 or more (Conant and Collins, 1998).

Genetic description

Genetic Structure

Adult Gray Ratsnakes exhibit home range fidelity for several years (Weatherhead and Hoysak, 1989) and overwinter in communal hibernacula (Blouin-Demers *et al*. 2000), to which they exhibit strong fidelity (Prior *et al*. 2001). These life-history traits have the potential to lead to genetic structuring at fine geographic scales (Gannon, 1978). The genetic structure of Gray Ratsnakes has been examined at regional (> 400 km), subpopulation (15-50 km), and local scales (1 – 5 km) using 2 different genetic markers.

Prior *et al*. (1997) used 7 RAPD markers to analyze blood samples from southeastern Ontario, southwestern Ontario, Maryland, and Arkansas (see Prior *et al*. 1997 for specific information and the map of population locations). The distances between these regional populations ranged from 500 – 1500 km and the researchers found significant genetic variation at this scale (F_{ST} = 0.266 $\pm$ 0.062 SE). They did not, however, find significant differentiation between the two Canadian populations (F_{ST} = 0.019). At the subpopulation scale, they analyzed five subpopulations in southeastern Ontario (Distance: mean = 34.4 km; range = 15 – 50 km) and found significant variation (F_{ST} = 0.130, $p < 0.001$). Finally at the local scale, there was no significant genetic differentiation (F_{ST} = 0.006) between 2 hibernacula (distance = 1.6 km) within one population in southeastern Ontario. This was expected given that home ranges of individuals from different local hibernacula regularly overlap (Weatherhead and Hoysak, 1989; Blouin-Demers and Weatherhead, 2002a).

Lougheed *et al*. (1999) generally came to similar conclusions analyzing blood samples from the same populations using 6 microsatellite loci (40 alleles). At both the regional (mean F_{ST} = 0.168) and subpopulation (mean F_{ST} = 0.06) scales, Lougheed *et al*. (1999) found significant genetic differentiation. This included a significant divergence between the Carolinian and Great Lakes/St. Lawrence populations, although these populations were not significantly different according to RAPD markers (Prior *et al*. 1997). Lougheed *et al*. (1999) also analyzed samples from 11 hibernacula within 3 different subpopulations in southeastern Ontario (mean distance = 2.46 km, range = 0.5 – 4.9 km) and found no differentiation (mean F_{ST} = 0.01) at this scale, supporting the results from the RAPD markers.

Genetic Diversity

Using 7 RAPD markers, Prior *et al*. (1997) determined that the Great Lakes/ St. Lawrence (0.144 $\pm$ 0.51 SE) and Carolinian (0.104 $\pm$ 0.055 SE) populations were less heterozygous than the populations from Maryland (0.213 $\pm$ 0.069 SE) and Arkansas (0.162 $\pm$ 0.069 SE). These differences, however, were non-significant. Similarly, Lougheed *et al*. (1999) also looked for heterozygote deficiencies using 6 microsatellite loci. Heterozygote deficiencies can be a result of genetic inbreeding, which can lead to a reduction in fitness and increase local extinction risk. Mean heterozygosity ranged from 0.56 to 0.75 for 9 hibernacula in southeastern Ontario, and none tested significant for deficiencies using the exact test of GENEPOP.

Designatable units

The Canadian population of Gray Ratsnakes consists of populations in 2 geographically disjunct regions in southwestern and southeastern Ontario. These populations are separated by approximately 300 km, and show some genetic differentiation (Lougheed *et al*. 1999). Evidence suggests that this disjunction likely preceded European settlement (See **Distribution - Canadian Range**). Because of the large separation, and the amount of unsuitable habitat between these populations, they will almost certainly remain isolated. Based on genetic differences, spatial separation and different conservation status these populations should be considered as separate designatable units. The southeastern Ontario ratsnakes are the Great Lakes/St.Lawrence population and the southwestern Ontario snakes are the Carolinian population.

DISTRIBUTION

Global range

The Gray Ratsnake is widely distributed throughout the forested areas of eastern and central United States, but occur in only two small disjunct regions in Ontario. The rest of its distribution occurs relatively continuously 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 southwest Wisconsin (Fig. 1).

Canadian range

The Canadian distribution of Gray Ratsnakes is limited to southern Ontario and represents a small proportion of the global distribution (<5%; Fig. 2). Within Ontario, ratsnakes are associated with two regions which are discussed separately below.

Carolinian Population

In southwestern Ontario, ratsnakes currently inhabit small parts of the Carolinian forest running along the northern shore of Lake Erie. Prior to European settlement, large tracts of deciduous forest intermixed with open savanna would likely have provided an abundance of suitable habitat in this region. Records of Gray Ratsnakes extend from 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. As discussed by Prior and Weatherhead (1996), Gray Ratsnakes most likely migrated into Canada around both sides of Lake Erie following the retreat of the Laurentide ice sheet (~7000 years ago) and subsequent northward advance of deciduous forest (Smith, 1957; Pielou, 1991).

The current extent of occurrence of the Carolinian population is relatively large (7 300 km^2), but this distribution is severely fragmented and the area of occupancy is only around 320 km^2. The area of occupancy for all of the Carolinian populations was determined by outlining the post-1985 occurrence records and the extent of occurrence was calculated by outlining the areas of occurrence with a convex polygon. The previous COSEWIC status report (Prior and Weatherhead, 1996) recognized the persistence of only 4 very small, isolated Carolinian populations (Fig. 2) and each of these is discussed below.

1. The Skunk's Misery population is generally located north of the Thames River between Wardsville and Bothwell. The most recent verifiable observations for this population are from 1984 (Prior and Weatherhead, 1996; Oldham and Weller 2000) and 1997 (A. Woodliffe pers. comm. 2006); however, there are also recent reports (<10 years) of snakes resembling Gray Ratsnakes from this region (D. Martin pers. comm. 2006). Records near the towns of Rodney and New Glasgow (1987) south of Highway 401 may represent a separate population associated with 16 Mile Creek (Prior and Weatherhead, 1996; Oldham and Weller 2000). Because of the limited number of observations for this population the 1984 observations were also used in the area of occupancy calculation.

2. The Big Creek population seems to be the largest of the Carolinian populations and ranges approximately from the base of Long Point to the town of Langton in the north, Turkey Point P.P. in the east, and Port Burwell in the west. The total area of occupancy is approximately 260 km^2 and is based on approximately 25 relatively recent (post-1985) NHIC observations.

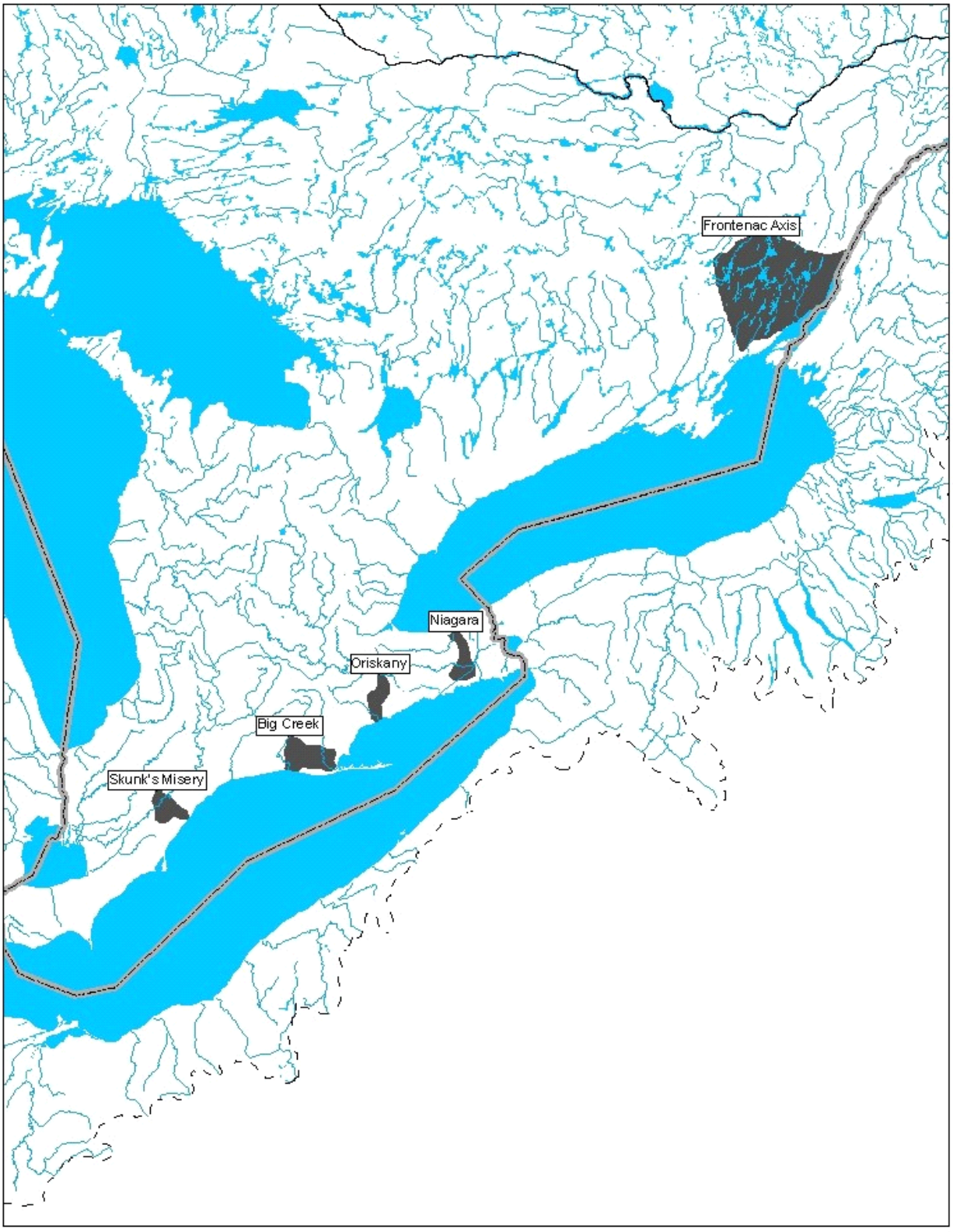

Figure 2. Canadian distribution of Gray Ratsnakes (*Elaphe spiloides*).

3. The Oriskany Sandstone population 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. Up until 2000, the most recent confirmed sighting was 1990 (Prior and Weatherhead, 1996). Recently, two individuals from this population were located and radio-tracked and one other road-killed individual was found during the study (Yagi and Tervo, 2006). Both radio-tracked individuals hibernated in close proximity, but despite efforts to fence and trap this area, no other individuals were captured and the size of the hibernaculum is unknown.

4. As discussed in the previous status report (Prior and Weatherhead, 1996), the Niagara population is poorly defined and most likely consists of a few small disjunct populations. Verifiable occurrences are located around the towns of Fonthill and Ridgeway. Another recent occurrence record from the town of Winger could represent another disjunct population.

Great Lakes/St. Lawrence Population

In southeastern Ontario, the Gray Ratsnake population is typically associated with the Frontenac Axis, which is a southeast extension of the Canadian Shield that connects with the Adirondacks in northern New York State. The bulk of this population lies in Frontenac, and Leeds and Grenville Counties; however, a small portion of the range crosses over the St. Lawrence River into Jefferson and St. Lawrence Counties in upper New York State. Using the NHIC records and knowledge from experts in the field (S. Thompson pers. comm. 2005; J. Leggo pers. comm. 2005; T. Norris pers. comm. 2005), the extent of occurrence of the Canadian portion of this population was determined to be roughly bordered by Highway 7 in the north, the St. Lawrence River in the south, Highway 38 in the west and Highway 29 in the east.

The extent of occurrence of the Great Lakes St.Lawrence population in Canada spans approximately 4000 km^2 and is separated from the populations in southwestern Ontario and southern New York State by approximately 300 and 150 km respectively. The isolation of this population has been recognized since the early 1900s (Lindsay, 1931; Toner, 1934; Logier, 1957), and the absence of historic records of Gray Ratsnakes 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 (Prior and Weatherhead, 1996). Recent genetic and morphological evidence (Gibbs *et al*. 2006) suggest that the Great Lakes/St.Lawrence population is a hybrid between the central and eastern ratsnake clades (as proposed by Burbrink, 2001; see **Species Information - Name and classification**), implying that this population was colonized by an eastern expansion of the central clade along the northern shore of Lake Ontario, and a northward expansion of the eastern clade along the eastern edge of Lake Ontario.

HABITAT

Habitat requirements

Active season

The Gray Ratsnake is semi-arboreal and typically associated with a wide range of woodland and scrub habitats across its distribution (Ernst and Barbour, 1989; Durner and Gates, 1993). Within Canada, Gray Ratsnakes inhabit two regions in Ontario with significantly different habitats. The Frontenac Axis is dominated by rolling terrain of mature, second-growth deciduous forest, intermixed with numerous lakes, wetlands, abandoned agricultural fields and bedrock outcrops (Beschel, 1962), whereas the Carolinian forest region is dominated by agricultural land mixed with smaller patches of open deciduous forest (Kelly, 1990) and a dense network of roads.

On the Frontenac Axis, detailed assessments of habitat use have been undertaken at two different scales (home-range scale; location scale) and for four reproductive classes (males; non-gravid females; gravid females; juveniles), using data collected from a long-term radio-telemetry study (1996 – 2004) conducted at the Queen's University Biology Station (QUBS). Because of the large differences in habitat availability between the two regions, it is unlikely that habitat patterns observed on the Frontenac Axis can be directly extrapolated to the populations in the Carolinian forest region. No assessments of habitat use have been conducted on individuals from any Carolinian populations and, therefore, the patterns discussed below relate to the Great Lakes/St. Lawrence population (Frontenac Axis).

Large-scale assessments of habitat use have revealed that ratsnakes use habitat non-randomly at the home-range scale, and that there is no significant difference in habitat use between any of the reproductive classes. All reproductive classes preferred home ranges containing >28% edge habitat (10 m buffer on either side of forest) and modest amounts of forest cover (41% - 53%), and avoided home ranges with >17% marsh habitat (Row, 2006). At the location scale, ratsnakes again used habitat non-randomly, but males and non-gravid females demonstrated habitat use patterns that significantly differed from gravid females (Blouin-Demers and Weatherhead, 2001a). At this scale, all adult reproductive groups preferred locations close to trees and edges, with a high ground cover of logs. Gravid females were distinguished from the other two reproductive classes by preferring locations closer to large trees and further from rocks and smaller trees (Blouin-Demers and Weatherhead, 2001a). Based on these results, ratsnakes seem to require a mosaic of forest and open habitat with a high edge to area ratio. These results are consistent with radio-telemetry studies conducted in other portions of ratsnake's range (Durner and Gates, 1993). These habitat preferences were combined with road density and patch size estimates to rank (between 0 – 1) the suitability of habitat within 500 ha grid cells, overlaid across the Frontenac Axis (Row, 2006; Fig. 3). Although no extensive efforts have been made to systematically quantify ratsnake distribution across this area, higher-ranking cells correlated well with recent occurrence records.

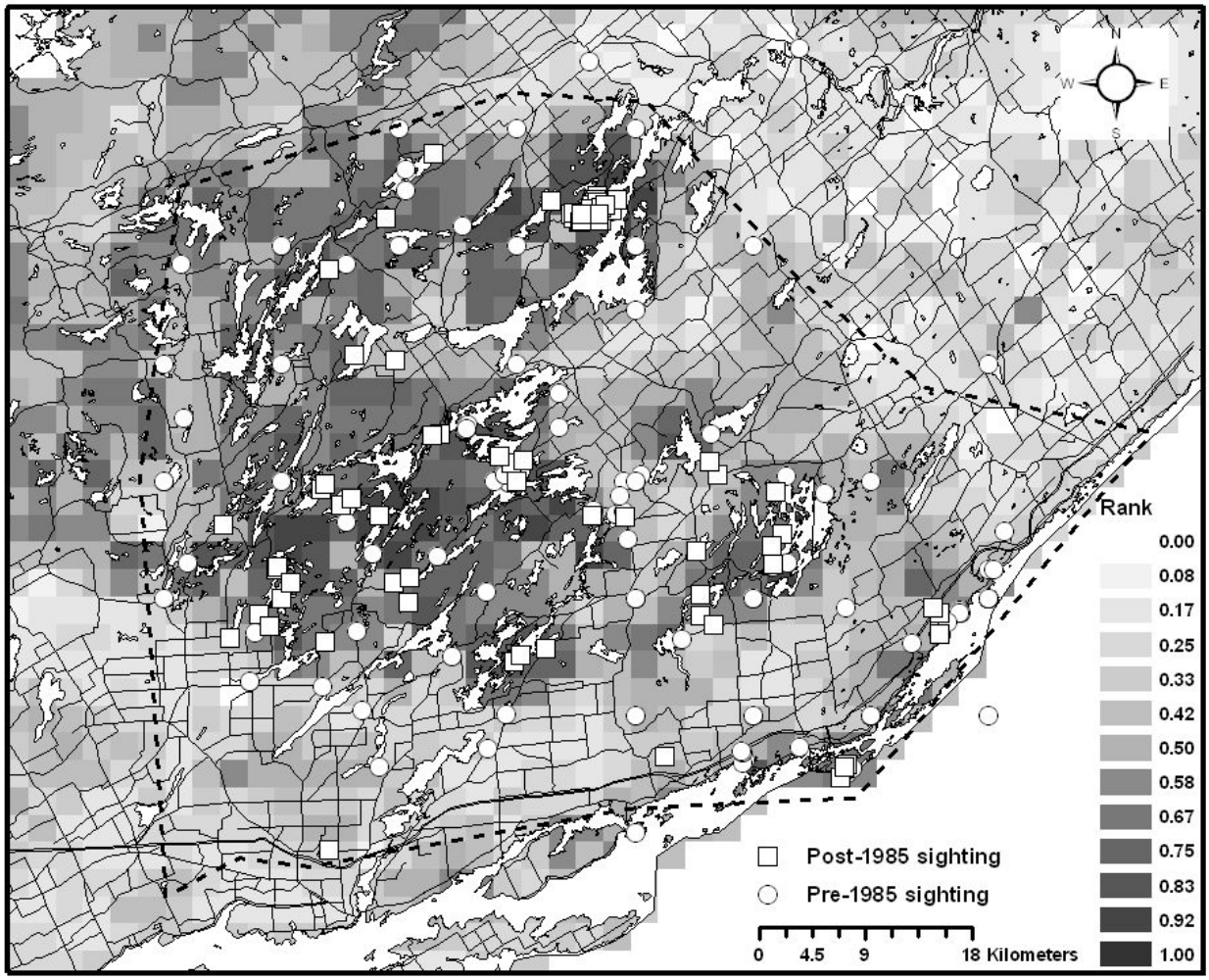

Figure 3. Rank of habitat inside 500 ha grid squares overlaid across the Frontenac Axis. Habitat was ranked from least (0) to most (1) suitable.

Throughout the active season, the location of appropriate basking and retreat sites is necessary for thermoregulation, ecdysis, and predator avoidance. Retreat sites and basking sites are often used multiple times by an individual throughout the active season, and over multiple years. Retreat sites that are commonly used on the Frontenac Axis are the inside of hollow logs and trees, under rocks or in rock crevices; individuals were concealed in retreat sites in approximately 65% of radio telemetry locations (Blouin-Demers and Weatherhead, 2001a). Communal use of shedding sites is frequently observed and the same individuals will often show a high fidelity to these sites (Blouin-Demers and Weatherhead, 2001a). Snakes have impaired vision and maintain body temperatures closer to their preferred range prior to ecdysis (Gibson *et al*. 1989; Blouin-Demers and Weatherhead, 2001b), therefore, these locations must provide both higher thermal quality and increased protection from predators. The aggregation observed at these sites may be due to a limited number of suitable

locations. On the Frontenac Axis, ratsnakes will typically use standing hollow snags as shedding sites (43% of the time), but have also been observed to use old buildings (20%), rock crevices (16%), hay piles (10%), and hollow logs (8%; Blouin-Demers and Weatherhead 2001a). These shedding sites are also more likely to be located in edges, most likely because of the higher thermal quality of this habitat type.

Hibernacula

Throughout most of their range, Gray Ratsnakes hibernate during the winter months. In the more southern populations, hibernation only lasts a few months (November – February), but in the Canadian portion of their range, winters are much longer and ratsnakes typically hibernate for 6 months of the year (late October – early mid-April) (Weatherhead, 1989) making hibernation an important aspect of their ecology. Due to the extreme temperatures and long periods of inactivity, mortality can easily occur during hibernation or shortly after emergence if suitable hibernacula are not found (Prior and Shilton, 1996).

On the Frontenac Axis, 10 – 60 individuals typically aggregate for hibernation (Blouin-Demers *et al*. 2000) and individuals generally show strong fidelity to their hibernacula (98%; Weatherhead and Hoysak, 1989; Prior *et al*. 2001). Prior and Weatherhead (1996) measured a number of habitat variables at 10 communal hibernacula and paired random locations throughout the Frontenac Axis. Their analysis suggested that hibernacula were generally located on relatively rocky, south-facing slopes and could be distinguished from paired random locations based on these characteristics. They could not, however, be distinguished from potential hibernacula, intuitively identified by the researchers. There was also large variation in the habitat characteristics for the hibernacula, and several new hibernacula located since this study was conducted suggest that these trends do not extend to all hibernacula. It is more likely that subterranean structural features are more important than above-ground features in providing appropriate hibernacula. Although, subterranean features have not been quantified, ratsnakes are not freeze tolerant and, therefore, hibernacula must be below the frost line. The body temperatures of hibernating ratsnakes on the Frontenac Axis ranged from 3 to 7ºC (Weatherhead, 1989). Hibernacula would also have to be sufficiently humid to protect against dehydration (Costanzo, 1989).

Oviposition sites

Incubation conditions can affect the phenotype (e.g. speed, aggressiveness, size) of offspring (Qualls and Andrews, 1999; Brana and Ji, 2000) in ways likely to affect their fitness. On the Frontenac Axis, Gray Ratsnakes have been observed to oviposit in the decaying matter inside standing snags, stumps or logs and also in compost piles (pers. obs.). In a nesting thermal gradient, females selected nest temperatures around 31ºC. Also, eggs incubated at 30ºC produced offspring more fit (e.g. faster, larger) than eggs incubated at 25ºC (Blouin-Demers *et al*. 2004). Both of these results suggest that the most ideal temperature for egg incubation is approximately 30ºC. Nests on the Frontenac Axis are often communal and are used for multiple years by multiple females

(Blouin-Demers *et al*. 2004). Although some females will nest singularly, the thermal conditions in non-communal nests are generally not as ideal (Blouin-Demers *et al*. 2004). In non-communal nests, however, there has been no evidence of the nest parasite *Nicrophorus pustulatus* (see **Biology – Interspecific interactions**) and the choice between communal and non-communal nests may represent a trade-off between superior thermal conditions and risk of parasitism (Blouin-Demers *et al.* 2004). Communal nesting may also result from a shortage of suitable nesting sites. The availability of appropriate nesting conditions is essential to the viability of ratsnake populations, and at the Queen's University Biological Station (QUBS) efforts have been made to provide a number of 'predator safe' nests with little success in achieving the appropriate nest conditions or attracting females (Row, pers. obs.). OMNR and Leeds Stewardship have constructed and monitored nests in several areas in southeastern Ontario with slight success (9/13 eggs hatched from one clutch laid in an artificial nest box in 2005) (S.Thompson, pers. comm. 2007).

Habitat trends

The marginal agricultural conditions on the Frontenac Axis have led to the abandonment of farmland over the last 60 years and allowed for large tracts of suitable habitat to remain (McKenzie, 1967). Suitable habitat mapped across the range of the Great Lakes/St. Lawrence population (Fig. 3), however, suggests that in the southern and northwestern portions of the range of this population the habitat is much less suitable. In these regions, cropland is more extensive and road density is much greater resulting in lowered suitability. Because of the poor agricultural quality of the remaining suitable habitat, further agricultural clearing is unlikely. The increasing recreational activity in the heart of the Rideau Canal (Prior and Weatherhead, 1996), however, is likely to increase development pressure and concomitant reduction and fragmentation of the remaining suitable habitat.

In contrast to the Frontenac Axis, more than 80% of the original forest cover in the Carolinian region has been removed (Kelly, 1990). Intensive agriculture and an extensive network of roads dominate the Carolinian landscape. These changes have resulted in major range reductions for a number of reptiles and amphibians in the area, including Gray Ratsnakes, presumably by causing a drastic reduction in the amount of suitable habitat for ratsnakes in this region. It is currently unknown whether the remaining habitat is sufficient to support viable ratsnake populations. The area surrounding the Big Creek population has some of the largest tracts of Carolinian forest remaining in Ontario, which is likely why this area seems to support the largest populations of Gray Ratsnakes in southwestern Ontario (see **Distribution – Carolinian**).

Habitat protection/ownership

On the Frontenac Axis, the Great Lakes/St. Lawrence ratsnakes occur 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), St. Lawrence

Islands National Park (~24 km^2) and the Queen's University Biological Station (~30 km^2). In addition, there are Gray Ratsnakes in some of Parks Canada's Rideau Canal properties, and the Rideau Valley C. A. has ~700ha under protection that include records of Gray Ratsnakes. The Cataraqui C. A. has 400ha within the ratsnake's range (S. Thompson, pers. comm. 2007). In total, these areas only protect approximately 4% of the 4000 km^2 extent of occurrence on the Frontenac Axis. All of these protected areas are isolated from each other and the largest continuous tract of land (Frontenac Park) is approximately 50 km^2.

The distribution of the Carolinian populations is less clearly defined and therefore, the amount of protection for these populations is more difficult to quantify. Numerous small tracts of land in the Big Creek NWR area, however, have been purchased and protected through the Nature Conservancy of Canada and local conservation groups (M. Gartshore, pers. comm. 2006).

BIOLOGY

Most of the biological information used in this report is from long-term published research on Gray Ratsnakes at the Queen's University Biological Station (QUBS). Research conducted on other populations in the United States is also included; however, this research is less extensive and less applicable to the Canadian populations.

The Queen's University Biological Station is close to the geographic centre of the Frontenac Axis and the biology of this population should be fairly indicative of ratsnakes across the Frontenac Axis. Although there are differences in habitat and climate between the Frontenac Axis and the Carolinian region, the general biology of the two populations should be similar.

Life cycle and reproduction

Because of the extreme climate in Ontario, Gray Ratsnakes are only active approximately 6 months (mid-April – mid-October) of the year (S. Thompson, pers. comm.), leading to slow growth rates and delayed sexual maturity (Blouin-Demers *et al*. 2002). Using growth models to predict the age of individuals based on their size, Blouin-Demers *et al*. (2002) estimated the maximum life span of ratsnakes in the Great Lakes/St. Lawrence population to be 25-30 years, and the age of sexual maturity for males and females to be 9.1 and 9.7 years, respectively. Recently, these estimates have been modified to an age of maturity of approximately 7 years (G. Blouin-Demers pers. comm., 2005), and the average age of reproducing individuals in the Great Lakes/ St. Lawrence population is approximately 10 years (unpublished raw data used in Blouin-Demers and Weatherhead, 2006).

Gray Ratsnakes are oviparous, and once sexually mature, females will produce a clutch every 2-3 years, but occasionally females will produce clutches 2 or 3 years in a

row (Blouin-Demers *et al*. 2004). In Ontario, the mating season typically spans from late May to mid-June, well after individuals have dispersed from their hibernacula. Because of the low density of Gray Ratsnakes during the active season, females are likely courted by only one male at a time (Blouin-Demers and Weatherhead, 2002a). If males encounter each other while courting, they will compete for access to the female in a ritualized physical combat (Rigley, 1971; Gillingham, 1980). Despite the low density, 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 typically a gestation period of approximately 30 - 50 days before females will oviposit a clutch of approximately 10 - 15 eggs (N = 84 clutches; mean = 13 eggs; range 7-23; Blouin-Demers *et al*. 2005) in late June to early August. The incubation period depends on incubation temperature with means ranging from 52 (incubation temperature = 30°C) to 62 days (incubation temperature = 25°C). The average temperature within natural communal nests in the field is 28°C and highly variable (Blouin-Demers *et al*. 2004) and, therefore, it is likely that incubation times will be closer to 60 or more days in the wild, 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 SVL and there is no significant difference in SVL 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. This estimate was generated from the long-term monitoring of 4 hibernacula from 2 different populations (2 in each population). Size specific survival rates do not differ significantly between males and females (Blouin-Demers *et al*. 2002), but males grow faster than females and survival significantly increases with size, resulting in a male-biased sex ratio in the larger size classes (Blouin-Demers *et al*. 2002).

Predation

Known predators of adult Gray Ratsnakes include a number of large birds of prey (e.g. red shouldered hawk (*Buteo lineatus*), osprey (*Pandion haliaetus*), red-tailed hawk (*Buteo jamaicensis*)) and medium-sized mammals (e.g. fisher (*Martes pennanti*), mink (*Mustela vison*) and raccoon (*Procyon lotor*)). Potentially, young and sub-adults would be susceptible to the same predators, as well as a number of smaller predators such as American crows (*Corvus brachyrhynchos*). 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).

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 raccoons or skunks

(*Mephitis mephitis*), but these sources of predation have rarely been observed at several communal nests at QUBS (G. Blouin-Demers pers. comm. 2005). Evidence of the burying beetle, *Nicrophorus pustulatus*, however, has been found at most communal nests at QUBS and in other populations and can cause significant mortality (see **Biology - Interspecific interactions**) (Blouin-Demers and Weatherhead, 2000). Several Eastern Milksnakes (*Lampropeltis triangulum*) were also radio-tracked to communal ratsnake nests after the laying season, and on one occasion, a milksnake was observed preying on ratsnake eggs (pers. obs.).

Physiology

Gray Ratsnakes are ectotherms and, therefore, thermoregulate mainly through behavioural mechanisms. Because most physiological processes are temperature dependent (Peterson *et al*. 1993), thermoregulation can have important implications for survival and, therefore, fitness (Christian and Tracey, 1981; Huey and Kingsolver, 1989). Within Canada, ratsnakes are at the northern extreme of their range in a thermally challenging environment, which makes thermoregulation particularly important (Blouin-Demers and Weatherhead, 2001b).

In a thermal gradient set up in the laboratory, ratsnakes demonstrated preference for body temperatures between 27°C and 30°C (Blouin-Demers and Weatherhead, 2001b). The optimal temperatures for tongue flicking (30°C), striking speed (29°C), and swimming speed (27°C) all fell within, or close to this range (Blouin-Demers *et al*. 2003). Within the Canadian populations, environmental temperatures are often well outside this range (Blouin-Demers and Weatherhead, 2001b) forcing ratsnakes to invest a lot of time and energy into maintaining body temperatures, especially in low thermal quality habitats (Blouin-Demers and Weatherhead, 2001b). Ratsnakes maintain body temperatures through habitat selection and choice of microclimate; gravid females and recently fed individuals maintain more preferable body temperatures by selecting higher thermal quality habitats, such as edges and retreat sites (Blouin-Demers and Weatherhead 2001b, Blouin-Demers and Weatherhead 2001c). Ratsnakes cannot tolerate temperatures below freezing and, therefore, hibernate underground during the winter months (see **Habitat – Hibernation**).

Dispersal/migration

Although there is large individual variation, the size of an average adult ratsnake's home range (Minimum Convex polygon (MCP)) is approximately 18.5 ha (Blouin-Demers and Weatherhead, 2002). Ratsnakes will often over-winter in hibernacula not located within their home range and commute (mean distance = 454 m; range 0 – 4km) (Blouin-Demers and Weatherhead, 2002) to their home range shortly (3-7 days) after emerging from hibernation, and return shortly before hibernation (~mid-September). The emergence period lasts about 5 weeks starting in late April (Blouin-Demers *et al*. 2000) and most snakes are within their home range by early June (Blouin-Demers and Weatherhead, 2002).

Adult ratsnakes demonstrate strong fidelity to both their hibernacula (see **Habitat – Hibernation**) 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 (Bjorgan, 2005), demonstrating a greater potential for dispersal. Because of the numerous gaps in understanding the neonatal life stage, actual dispersal distances from hatching until maturity have not been estimated, and home range data are lacking for this age class. At the QUBS study site, over 1800 neonates have been hatched in the lab since 1996. All of these individuals have been marked with a passive integrative transponder (PIT tag) and eventually may provide greater insight into neonatal dispersal distances (pers. obs.).

Interspecific interactions

Blouin-Demers and Weatherhead (2000) discovered that the burying beetle, *Nicrophorus pustulatus*, parasitizes ratsnake eggs on the Frontenac Axis and could be a significant cause of mortality. Evidence of *N. pustulatus* was found in 6 of 7 nests and caused close to 100% mortality of clutches when present. Similar reports of beetle larvae in snake eggs from Illinois and Pelee Island (not ratsnakes) (Blouin-Demers and Weatherhead, 2000) suggest that this problem is not unique to the Frontenac Axis.

Gray Ratsnakes are generalist foragers mainly feeding on small mammals and birds (Fitch, 1963; Weatherhead *et al*. 2003). Weatherhead *et al*. (2003) analyzed the scat of ratsnakes on the Frontenac Axis and found that mammals made up approximately 65% of the diet, while birds made up about 30%. Ratsnakes are efficient avian nest predators, and the proportion of avian prey in the diet increased to a maximum of 45% in June; the height of the bird nesting season on the Frontenac Axis. Fitch (1963) found similar prey ratios for a population in Kansas and, therefore, it is likely that foraging behaviour is similar for all Canadian populations.

Adaptability

The Gray Ratsnake is a relatively common snake throughout the eastern United States 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 ratsnakes can readily be found in open fields and abandoned buildings (pers. obs.), they will rarely be found far from woodlands and prefer edges between woodlands and fields, even in more disturbed habitats (Durner and Gates, 1993). These results suggest that they do 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.

Canadian populations of ratsnakes are at the northern extreme of their range and in a thermally challenging environment. This results in slow growth rates and late maturity, significantly increasing their generation time (Blouin-Demers *et al*. 2002) (see

Biology - Life cycle) and making them significantly more vulnerable to disturbances than populations in less challenging environments. This will also significantly reduce their ability to adapt to a rapidly changing environment.

POPULATION SIZES AND TRENDS

Search effort

There have been approximately 650 sightings of Gray Ratsnakes reported to the Ontario Herpetofaunal Summary since 1905 (Oldham and Weller, 2000). A majority (430) of the records are from the Great Lakes/St. Lawrence population, while the rest are spread across the 4 southwestern populations. The sightings are reported by researchers, naturalists and wildlife managers and do not represent a systematic quantification of the presence or absence of ratsnakes. There have been no attempts to accurately quantify the distribution of ratsnakes on the Frontenac Axis or in the Carolinian region.

Research and monitoring efforts across the Frontenac Axis have identified hibernacula and directly established the presence of populations in and around the Queen's University Biological Station (QUBS), St. Lawrence Islands National Park, Murphy's Point Provincial Park, Charleston Lake Provincial Park and Frontenac Provincial Park. Currently, population monitoring efforts are being continued at QUBS, St. Lawrence Islands National Park and Murphy's Point Provincial Park.

There has been virtually no research conducted on the Carolinian populations and most of the information on the distribution is from NHIC records and anecdotal information. From 2001 – 2003 two individuals were radio tracked from the Oriskany population. 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

<u>Great Lakes/St. Lawrence Population</u>

On the Frontenac Axis, Blouin-Demers and Weatherhead (2002a) estimated the density of ratsnakes in the QUBS study area to be 0.261 mature adults/hectare. The habitat quality is not uniform across the Frontenac Axis, however, and it is likely that the density is also variable. The quality of habitat across the Frontenac Axis was ranked using habitat suitability predictors, road density and patch size (See **Habitat – Habitat requirements**) (Figure 3) and the quality of habitat at QUBS was relatively high (mean = 0.70 in a scale between 0 and 1). To estimate the abundance of the entire Great Lakes/St. Lawrence population, 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 adults. Because ratsnakes likely 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 85 000 adults. These are very rough estimates of abundance and because there have been no efforts to systematically and accurately quantify the extent of Gray Ratsnakes within this population, it would be difficult to make a more accurate estimate at this time. There are no estimates of density or habitat use patterns for any of the Carolinian populations, making estimates of abundance impossible.

Fluctuations and trends

Great Lakes/St. Lawrence Population

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 4 hibernacula in 2 subpopulations (QUBS and Hill Island in the St. Lawrence River). All of these hibernacula were located in protected areas. Over the study, the overall population size at both QUBS (slope of the regression of the log of population size on year = -0.013, $p = 0.05$) and Hill Island (slope of the regression of the log of population size on year = -0.009, $p = 0.34$) showed a slight decrease. This decrease, however, was only significant at QUBS (Weatherhead *et al*. 2002). At QUBS, the negative population growth was attributed to a declining recruitment rate (slope of the regression of the log of recruitment rate on year = -0.27, $p = 0.09$), which also caused a shift in the age structure towards more mature individuals. Population monitoring at more locations and for longer time periods is required to gain more insight into the factors behind this apparent decline (anthropogenic factors vs. natural fluctuations) and also to determine if this trend is consistent across the entire Great Lakes/St. Lawrence population.

Carolinian Population

The lack of current or past demographic data from these populations makes it impossible to accurately estimate population trends. Because 80 - 95% of the forest cover has been removed from this region since European settlement (see **Habitat – Habitat trends**), it is inevitable that populations of Gray Ratsnakes have been drastically reduced in this region.

Rescue effect

Gray Ratsnakes are widespread and common throughout the eastern-central United States. Both the Great Lakes/St.Lawrence and Carolinian populations, however, are genetically distinct and geographically disjunct from continuous portions of the species' range in the United States. A small portion of the Great Lakes/St. Lawrence population ranges into upper New York State and it is likely that these populations exchange individuals, but the majority of this population resides within Canada. Rescue is unlikely because of the St. Lawrence River and highway 401, which are major barriers.

LIMITING FACTORS AND THREATS

Limiting Factors

A number of intrinsic life-history characteristics make Gray Ratsnakes particularly vulnerable to disturbances. Biennial reproduction, delayed age of maturity (~7 years), and slow growth rates can cause seemingly small increases in mortality to have significant population level impacts (Brooks *et al*. 1991; Congdon *et al*. 1993). Furthermore, suitable habitat for Gray Ratsnakes consists of a mosaic of forested and open habitats and large areas of suitable habitat are required to support viable populations. Individuals can travel at least 4 km from their hibernacula. Within Ontario, the Great Lakes/St. Lawrence and Carolinian populations face similar threats, but with different degrees of imminence and importance, and are discussed separately below.

Threats to the Great Lakes/St. Lawrence Population

This population has a relatively small extent of occurrence (~4000 km^2), but there are no hard data defining the extent of existing populations within this area. The distribution of suitable habitat (Fig. 3) across the Frontenac Axis (see **Habitat – Habitat requirements**) suggests that although there are still large tracts of continuous suitable habitat, the total amount is much less than 4000 km^2 and becoming increasingly fragmented. Recreational activities have been increasing in the heart of the Rideau Canal (Prior and Weatherhead, 1996) leading to much more development in the area (S. Thompson pers. comm. 2006). To maintain viable populations, continuous tracts of suitable habitat must be preserved to maintain connectivity between existing populations. The expansion of the road network, especially major paved roads like highway 401, and the loss of continuity between habitat patches has made the Great Lakes/St. Lawrence population increasingly fragmented or even severely fragmented in the case of populations away from the centre of the Frontenac Axis range (see Fig. 3). Because ratsnakes hibernate in communal hibernacula, development can also be particularly detrimental to populations when existing hibernacula are eliminated.

Another significant threat facing all populations of Gray Ratsnakes is road mortality. Previous studies have documented the negative effects roads can have on reptile populations, either through direct mortality (Rodda 1990, Ashley and Robinson 1996) or by fragmenting populations (Shine *et al*. 2004, Andrews and Gibbons 2005). Gray Ratsnakes have large home ranges and dispersal distances which allows local subpopulations to interchange individuals and genes, but also makes this species vulnerable to proliferating road networks, which in turn increases fragmentation of populations and habitat. Although no quantitative data exist on the direct effect of road mortality, across the Frontenac Axis, a mean of 6 dead ratsnakes (Range = 1 – 9) are found each year on a 10 km stretch of road inside the QUBS study area (Row *et al*. 2007). Similarly, at Murphy's Point PP, 16 dead ratsnakes were found on 18 km of road over 10 y, and in Clara Lake PP there were 8 dead over 7 km in 2 y (S. Thompson, pers. comm. 2007).These rates likely represent a significant mortality for ratsnake populations given their life history. Indeed, a recent Population Viability Analysis (PVA)

conducted on the study population in the protected QUBS study area within ideal habitat in the Frontenac Axis indicated that observed rates of adult mortality (estimated at 9 adults per year) on local (gravel) roads increased the probability of extinction from 7.3% to 99% in 500 years. Only as few as three adult females being killed on the roads each year raised extinction probability to > 90% per 500 years (Row *et al*. 2007). Many areas on the Frontenac Axis have a much higher road density and speed limits and poorer habitat quality than do these protected areas and hence their ratsnake populations should suffer even greater risk of extinction from road mortality.

Carolinian Population

Although no studies have quantified the patterns of habitat use by Gray Ratsnakes in the Carolinian region, studies in a variety of habitat types and regions have all shown that ratsnakes will rarely be found far from forest habitat, and greatly prefer a habitat mosaic of forest and open habitats (Fitch, 1963; Durner and Gates, 1993, Blouin-Demers and Weatherhead, 2001a). Across the Carolinian region, the landscape is dominated by intensive agriculture and a dense network of roads; any remaining suitable habitat is limited and severely fragmented. This lack of suitable habitat is reflected in the small and extremely fragmented populations of ratsnakes remaining in the Carolinian region. It is unknown if the remaining suitable habitat is sufficient for the long-term survival of any of the existing populations.

Population viability analysis on the Great Lakes/St. Lawrence population suggests that a population of at least 141 mature individuals (network of ~8 hibernacula) was needed to support a viable population (Tews, 2005). On the Frontenac Axis, this translated to an area of at least 540 ha of continuous suitable habitat. In the Carolinian region, density is likely much lower and mortality is likely higher (higher road density), and therefore a forested area much larger than 540 ha of continuous suitable habitat will be needed to support a viable population. The persistence of the remaining Carolinian populations is likely jeopardized by their small size and isolation and by the reduced, small areas of suitable habitat.

SPECIAL SIGNIFICANCE OF THE SPECIES

The Canadian populations of Gray Ratsnakes represent only a small proportion of this species' total global range. Despite this fact, there are a number of genetic, ecological and cultural factors that make both the Great Lakes/St. Lawrence and Carolinian populations significant.

Genetic

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 (discussed in Lesica and Allendorf, 1995; Keller and Waller, 2002). Although peripheral populations may have reduced genetic diversity,

they often contain a proportionately higher amount of rare alleles (Gapare *et al*. 2005), and are considered to be the most active areas of speciation (Simpson, 1944; Carson, 1959; Levin 1993). These factors often make peripheral populations proportionately more important in preserving the total genetic diversity, especially when the peripheral populations are disjunct, genetically differentiated and under different selection pressures (Lesica and Allendorf, 1995).

The Carolinian and Great Lakes/St. Lawrence ratsnake populations are geographically disjunct and genetically distinct from each other, and from populations in the United States. The Canadian populations are also at the northern extreme of the species' range and face more extreme temperatures than most populations. Furthermore, studies using RAPD markers and microsatellite DNA have estimated the amount of genetic variation accounted for by differences between regional populations to be as high as 13% (Prior *et al*. 1996) and 20% (Lougheed *et al*. 1999) respectively. All of these factors make preserving the Canadian populations important for preserving the total genetic diversity of Gray Ratsnakes.

Ecological

Although their importance is often under-estimated, snakes 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 have also been shown to be major prey items for birds of prey (Fitch, 1963). Gray Ratsnakes also require and occupy a wide variety of habitats (See **Habitat – Habitat requirements**) and have relatively large home ranges. Ratsnakes can disperse as far as 4 km from their hibernacula and, therefore, efforts to preserve hibernacula could encompass as much as 50 km^2 of surrounding habitat and would benefit many other species.

Cultural

The Gray Ratsnake is Canada's largest snake and the presence of populations in Ontario is widely recognized by herpetologists and naturalists. This is especially true for the Great Lakes/St. Lawrence population, which is recognized as a distinct population in many field guides and textbooks (e.g. Ernst and Barbour 1989; Conant and Collins, 1998; Futuyma, 1986).

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

The Gray Ratsnake, as a recently redefined species, does not have a global rank yet. However, at the state level, ranks for those states within the range of the new species apply: all states, excluding those where ratsnakes have not been ranked or are under review, list ratsnakes as secure (S5) or apparently secure (S4); an exception is Wisconsin where ratsnakes are listed as imperiled (S2) (NatureServe, 2007). Within Canada, they are protected under Schedule 1 (Threatened) of the *Species at Risk Act* (SARA). Within Ontario they are ranked as S3 (NHIC) and threatened by COSSARO.

They are also protected in Ontario under the *Fish and Wildlife Conservation Act*, in which *Elaphe spiloides* is listed as a “Specially Protected Reptile” under Schedule 10. Very little (< 5%) of the Canadian range of ratsnakes is within protected areas (See **– Habitat – Habitat protection**).

TECHNICAL SUMMARY

Elaphe spiloides
Gray Ratsnake — Couleuvre obscure de l'Est
Great Lakes/St. Lawrence population
Range of Occurrence in Canada: Frontenac Axis (southeastern Ontario)

Extent and Area Information	
• *Extent of occurrence (EO)(km²)* **Generated using the NHIC records and knowledge from experts in the field (S. Thompson, J. Leggo and T. Norris pers. comm. 2005) (see Distribution – Great Lakes/ St. Lawrence population, and Fig. 3).**	4114 km^2
• *Specify trend in EO*	Decline
• *Are there extreme fluctuations in EO?*	No
• *Area of occupancy (AO) (km²)* **Based on the distribution of post 1985 occurrence records and suitable habitat map (see Habitat – Habitat Trends; and Fig 3).**	<1500 km^2
• *Specify trend in AO*	Decline
• *Are there extreme fluctuations in AO?*	No
• *Number of known or inferred current locations* see Fig. 3	~ 8-10
• *Specify trend in #*	Decline
• *Are there extreme fluctuations in number of locations?*	No
• *Specify trend in area, extent or quality of habitat*	Decline
Population Information	
• *Generation time (average age of parents in the population)Age Mat +1/mort rate=7 = 1/.32=10*	~10 years
• *Number of mature individuals*	25 000 – 85 000
• *Total population trend:*	Decline likely, based on two long-term studies, but unknown for whole area
• *% decline over the last/next 10 years or 3 generations.*	Unknown
• *Are there extreme fluctuations in number of mature individuals?*	No
• *Is the total population severely fragmented? See p 21*	Yes
• *Specify trend in number of populations*	Unknown
• *Are there extreme fluctuations in number of populations?*	No
• List populations with number of mature individuals in each: Unknown	
Threats (actual or imminent threats to populations or habitats)	
– Habitat loss and fragmentation by roads and various developments – Mortality by human activities (e.g. road mortality, persecution, destruction of hibernacula) – Disruption of communal hibernacula	

Rescue Effect (immigration from an outside source)	
• *Status of outside population(s)?* **USA:** Stable	
• *Is immigration known or possible?*	Yes
• *Would immigrants be adapted to survive in Canada?*	Unknown, probably some populations (ie, NY)
• *Is there sufficient habitat for immigrants in Canada?*	Yes
• *Is rescue from outside populations likely?*	No. Barriers including highway 401 and the St. Lawrence River would make rescue from the US unlikely.
Quantitative Analysis	
Current Status COSEWIC: Threatened (1998, 2000 and 2007) Ontario: S3 (NHIC) and Threatened under COSSARO	

Status and Reasons for Designation

Status: Threatened	**Alpha-numeric code**: B1ab(i,ii,iii)+2ab(i,ii,iii)

Reasons for Designation:

This large snake occupies a restricted region in Ontario and is threatened by ongoing development and by expansion of the road network. Development is especially a threat to hibernacula, which may be limiting. Roads represent a significant threat because of the snakes' late age of maturity and low reproductive rate. Snakes are also killed on roads because they move slowly and may bask on roads.

Applicability of Criteria

Criterion A: (Declining Total Population): Not applicable.

Criterion B: (Small Distribution, and Decline or Fluctuation): Meets Endangered B1ab(i,ii,iii) but population is still fairly large and widespread and not apparently in imminent danger of extinction. Meets Threatened because the Extent of Occurrence and Area of Occupancy are less than 20,000km^2 and 2,000km^2 respectively, populations are severely fragmented, and there is ongoing loss of habitat and snakes from development and road network expansion.

Criterion C: (Small Total Population Size and Decline): Not applicable. Population exceeds criteria.

Criterion D: (Very Small Population or Restricted Distribution): Not applicable. Population too large.

Criterion E: (Quantitative Analysis): Quantitative analysis incomplete and unpublished.

TECHNICAL SUMMARY

Elaphe spiloides

Gray Ratsnake — Couleuvre obscure de l'Est
Carolinian population
Range of Occurrence in Canada: southwestern Ontario

Extent and Area Information	
• *Extent of occurrence (EO)(km²)* **NHIC records See Fig. 2.**	7 300 km^2
• *Specify trend in EO*	Decline
• *Are there extreme fluctuations in EO?*	No
• *Area of occupancy (AO) (km²)* **NHIC records See Fig.2.**	320 km^2
• *Specify trend in AO*	Decline
• *Are there extreme fluctuations in AO?*	No
• *Number of known or inferred current locations*	4
• *Specify trend in #*	Currently stable but likely to decline
• *Are there extreme fluctuations in number of locations?*	No
• *Specify trend in area, extent or quality of habitat*	Decline
Population Information	
• *Generation time (average age of parents in the population)*	~10 years
• *Number of mature individuals*	Unknown, but small
• *Total population trend:*	Decline
• *% decline over the last/next 10 years or 3 generations.*	Unknown
• *Are there extreme fluctuations in number of mature individuals?*	No
• *Is the total population severely fragmented?*	Yes
• *Specify trend in number of populations*	Currently stable but likely to decline
• *Are there extreme fluctuations in number of populations?*	No
• List populations with number of mature individuals in each: Skunk's Misery, Big Creek, Oriskany, Niagara	
Threats (actual or imminent threats to populations or habitats)	
– Insufficient amount of suitable habitat – Habitat loss and fragmentation – Mortality by humans (e.g. road mortality, persecution) – Stochastic effects of isolated small populations	
Rescue Effect (immigration from an outside source)	
• *Status of outside population(s)?* **USA:** Stable	
• *Is immigration known or possible?*	No
• *Would immigrants be adapted to survive in Canada?*	Unknown
• *Is there sufficient habitat for immigrants in Canada?*	No
• *Is rescue from outside populations likely?*	No
Current Status COSEWIC: Threatened (1998, 2000); Endangered (2007) Ontario: S3 (NHIC) and Threatened under COSSARO	

Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code**: **B2ab(iii,iv,v)**

Reasons for Designation:

This population consists of only 4 highly disjunct subpopulations in southwest Ontario, all of which are small and isolated, and surrounded by agricultural and developed terrain. Their slow rate of reproduction and late age of maturity makes them especially vulnerable to increases in adult mortality from road traffic and agricultural machinery.

Applicability of Criteria

Criterion A: (Declining Total Population): Not applicable.

Criterion B: (Small Distribution, and Decline or Fluctuation): Meets Endangered because the Area of Occupancy is < 500km^2, fewer than 5 populations, and there is ongoing loss of habitat and snakes from development, agriculture and road network expansion.

Criterion C: (Small Total Population Size and Decline): The population very likely has fewer than 2,500 adults, as only a handful of these very large snakes have been found over the past 2 decades. Decline is likely to continue given continuing development, the isolation of the small populations and the ubiquity of the road network. No population is likely to have more than 250 adults.

Criterion D: (Very Small Population or Restricted Distribution): Not applicable. Population may be too large

Criterion E: (Quantitative Analysis): Not applicable.

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