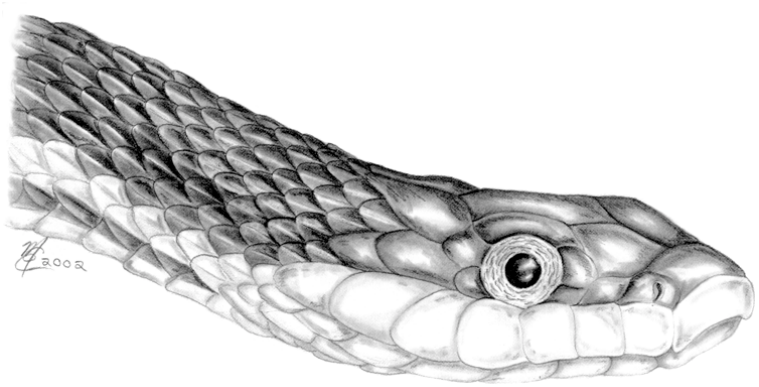
COSEWIC
Assessment and Status Report

on the

Queen Snake
Regina septemvittata

in Canada



THREATENED
2000

COSEWIC
COMMITTEE ON THE STATUS OF
ENDANGERED WILDLIFE
IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION DES
ESPÈCES EN PÉRIL
AU CANADA

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Queen snake — Mandi Eldridge, Guelph, Ontario

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COSEWIC
Assessment Summary

Assessment Summary – May 2000

Common name
Queen snake

Scientific name
Regina septemvittata

Status
Threatened

Reason for designation
This snake is confined to small areas in southwestern Ontario and requires specific habitats and food (newly molted crayfish), which are both declining.

Occurrence
Ontario

Status history
Designated Threatened in April 1999. Status re-examined and confirmed in May 2000. May 2000 assessment based on new quantitative criteria applied to information from the existing 1999 status report.

COSEWIC
Executive Summary

Queen snake
Regina septemvittata

Species information

The queen snake *(Regina septemvittata*) is a slender, moderately sized, semi-aquatic snake. Its dorsal ground colour is brownish olive with three narrow black stripes running longitudinally down the midline and along each side on the fifth and sixth scale rows. The belly is pale yellow with four dark longitudinal stripes.

Distribution

The US distribution of the queen snake ranges throughout the eastern states from Michigan to northern Florida. In Canada, the queen snake is limited to southwestern Ontario, specifically, west of the Niagara escarpment and south of Georgian Bay.

Habitat

The queen snake requires a highly specific habitat with a permanent body of water (preferably with a moderate current), an abundance of crayfish as prey and an adequate supply of rocks and vegetation to provide cover.

Biology

The diet of the queen snake is extremely specialized, comprised almost exclusively of newly molted crayfish. Female queen snakes give birth to live young in late summer and early fall, and litter size commonly ranges from five to eighteen snakelings. Young queen snakes almost double their size in the first year; growth rates decrease as the snakes age. The normal period of activity in Ontario is from May to October. Large groups of queen snakes congregating in preparation for hibernation have been reported in the United States. Queen snakes are also commonly reported in the company of other snake species. Home range size is fairly small.

Population sizes and trends

In two recent surveys of known queen snake habitat, 30 and 38 specimens were located. Accurate estimates of population size cannot be developed on the basis of

these surveys as a result of the queen snake's generally aquatic and cryptic behaviour. Nevertheless, it is widely accepted that the queen snake is rare in Canada.

Limiting factors and threats

Queen snakes are vulnerable to many human activities, such as habitat destruction by construction of dams or erosion controls. In addition, pollution of streams may result in the contamination of the queen snakes' food supply or accumulation of toxicants in the queen snakes themselves.

Special significance of the species

In Canada, the queen snake reaches the northern limits of its range. The Ontario population may show specific adaptations (genetic, physiological, behavioural) to the colder climate.

Existing protection or other status designations

The queen snake is legally protected under the Ontario Game and Fish Act, which prohibits the collection, hunting, possession or sale of native reptiles, except under authority of a license. Several queen snake populations receive additional protection as a consequence of their location falling within conservation areas or provincial parks. The queen snake is the least reported snake species in Ontario, with only 163 records in the Ontario Herpetofaunal Summary. Several populations in Ontario appear to have been extirpated.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) determines the national status of wild species, subspecies, varieties, and nationally significant populations that are considered to be at risk in Canada. Designations are made on all native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fish, lepidopterans, molluscs, vascular plants, lichens, and mosses.

COSEWIC MEMBERSHIP

COSEWIC comprises representatives from each provincial and territorial government wildlife agency, four federal agencies (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biosystematic Partnership), three nonjurisdictional members and the co-chairs of the species specialist groups. The committee meets to consider status reports on candidate species.

DEFINITIONS

Species	Any indigenous species, subspecies, variety, or geographically defined population of wild fauna and flora.
Extinct (X)	A species that no longer exists.
Extirpated (XT)	A species no longer existing in the wild in Canada, but occurring elsewhere.
Endangered (E)	A species facing imminent extirpation or extinction.
Threatened (T)	A species likely to become endangered if limiting factors are not reversed.
Special Concern (SC)*	A species of special concern because of characteristics that make it particularly sensitive to human activities or natural events.
Not at Risk (NAR)**	A species that has been evaluated and found to be not at risk.
Data Deficient (DD)***	A species for which there is insufficient scientific information to support status designation.

* 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.

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.

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Canada

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

COSEWIC Status Report

on the

Queen Snake

Regina septemvittata

in Canada

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1999

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SPECIES INFORMATION

The queen snake (*Regina septemvittata*) is a moderately sized, brown, semi-aquatic snake. The species inhabits widely separated habitat areas, restricted to the region of Southern Ontario west of the Niagara Escarpment and south of Georgian Bay. It could feasibly be considered a species-at-risk solely by virtue of its ecological characteristics; extreme food and habitat specialization render it particularly sensitive to human activities or natural events. In addition, habitat loss has contributed to the extirpation of queen snake populations both in Canada and in the United States, despite existing legislation to protect the species. The potential for further habitat loss in Ontario is significant, given the density of the existing human population and the apparent trend toward expansion into more rural areas.

Name and classification

The queen snake has many aliases. Among its various common names are crayfish snake (Campbell and Perrin, 1979), moon snake (Mills, 1948), seven-banded snake (Wright and Wright, 1957), striped water snake (Mills, 1948), willow snake (Wright and Wright, 1957; Logier, 1958; Froom, 1981), water snake (Minton, 1972) and leather snake (Nash, 1908; Conant and Collins, 1991).

The scientific nomenclature of the queen snake is equally complicated. From 1766 until 1917, most authors referred to the queen snake as Coluber leberis, Linnaeus (Smith and Huheey, 1960). In 1853, however, Baird and Girard (1853) created the new genus Regina, and designated *Regina leberis* as the type representative of the genus; thus, during the period from 1853 until 1917, the queen snake was known by two names. In 1917, scepticism arose with regard to Linnaeus' description of the queen snake. Closer examination of the characteristics attributed to Coluber leberis revealed that Linnaeus could not possibly have been describing a queen snake (Stejneger and Barbour, 1917; as cited by Smith and Huheey, 1960). The characteristics he described are actually those of the red-bellied snake, *Storeria occipitomaculata* (Smith and Huheey, 1960). The earliest (accurate) description of the queen snake *was Coluber septemvittata* (Say, 1825), and this, therefore, came to replace Linnaeus' earlier inaccuracy. Although the genus name *Regina* was initially slow to gain acceptance, it is now firmly established as the accepted Latin name for the queen snake.

Further confusion arose in the 1960's with regard to the potential existence of a subspecies. Based on seven individuals collected from Alabama, Neill (1963) described the subspecies *Natrix [Regina] septemvittata mabila*, which he considered significantly different from *Natrix [Regina] septemvittata (auctorum)* with respect to colour and markings, dorsal scale carination, relative tail length and scale counts of ventrals and subcaudals. Spangler and Mount (1969) reexamined the taxonomic status of the queen snake after encountering difficulty in allocating newly discovered individuals to one or the other subspecies. Ninety-three queen snakes were examined (including the holotype of *N. s. mabila*) and several key features of the subspecies were found to be within the range of variation for *N. s. septemvittata*, both in Alabama and in other

localities. Unfortunately, the misconception of the existence of a distinct subspecies persisted for some time (Cochran and Goin, 1970; Campbell and Perrin, 1979).

Description

Despite its regal name, the queen snake is rather plain in appearance. Its dorsal ground colour has been variously described as light brownish olive, olive brown or grayish olive (Wright and Wright, 1957), to chocolate brown or chestnut (Schmidt and Davis, 1941). The specific name, *septemvittata*, is from the Latin *sept*, meaning seven and vittatus, meaning striped, in reference to the seven longitudinal stripes running along the body (Johnson, 1989). There is a narrow, dark stripe down the midline of the back and along each side on the fifth and sixth scale rows (Minton, 1972). These stripes are most apparent in juveniles and are often indistinct or lacking completely in adults (Martof et al., 1980). The remaining four stripes are brown and run along the pale yellow underside; two laterally and two medially (Cochran and Goin, 1970). These stripes are an important identifying feature, since no other snake in Ontario has a striped underside (Oldham, 1986). The scales are keeled (Morris, 1974) and the anal plate is divided (Behler and King, 1996). The iris is dark brown with brassy flecks and the tongue is dark reddish-brown (Minton, 1972).

The queen snake is slender (Ditmars, 1907), with a relatively small head for its body size (Baird and Girard, 1853). It is a moderately sized snake, with an average total length ranging from 38-61 cm (Conant and Collins, 1991). The number of scale rows is usually 19 at midbody, decreasing to 17 posteriorly (Anderson, 1965). Ventrals range in number from 133-154 (Wright and Wright, 1957). In Ohio, Wood and Duellman (1950) reported partial (i.e.- overlapping) sexual dimorphism with regard to caudal scute counts, whereas in Kentucky, Branson and Baker (1973) observed complete sexual dimorphism with regard to the number of caudal scutes.

History of the Queen Snake in Canada

The reported first queen snake in Ontario was in Toronto in 1858 (Ure, 1858; cited by Campbell and Perrin, 1979). Other early records include Mitchell's Bay, Lake St. Clair, 1880; Chatham, 1882; Thames River near London, 1882 and Lake St. Clair, 1883 (Le Ray, 1928).

There is no species of amphibian or reptile that is unique to Canada (Cook, 1977). Like most Canadian reptiles, queen snakes have been studied in greater detail in the United States than in Canada (Logier and Toner, 1942), which may be partly due to the fact that they are found in much larger numbers in the more southern parts of their range. The most complete examination of the queen snake in Ontario was a series of field studies by Craig Campbell and D.W. Perrin in the late 1970's (Campbell, 1977; Campbell and Perrin, 1979). Other Ontario herpetologists contributing significant information on Ontario queen snakes include Michael J. Oldham (Oldham, 1986, 1988a and 1988b), R.H. Spurr and D.C. Smith (Spurr, 1978; Spurr and Smith, 1979), W.J. Le Ray (Le Ray, 1928) and W.W. Judd (Judd, 1955, 1962).

DISTRIBUTION

North America

The queen snake's North American range is generally east of the Mississippi River, from Ontario south as far as Florida (Figure 1). It is found contiguously through Michigan, Wisconsin, Indiana, Illinois, Ohio, Pennsylvania, New York, Maryland, Delaware, New Jersey, Virginia, West Virginia, the District of Columbia, Kentucky, Tennessee, North Carolina, South Carolina, Mississippi, Alabama, Georgia and Florida. There are also disjunct populations in Arkansas, northern Michigan and southwestern Mississippi. Three specimens were collected in Missouri in 1927 (Anderson, 1965), however none have been reported since this time, and many authorities believe this population to be extirpated (Ashton, 1976; Campbell and Perrin, 1979; Weller, 1982). The queen snake populations in Ontario, Arkansas, Mississippi and Wisconsin are considered peripheral (Ashton, 1976). The Canadian population represents the northern extreme of the species' range (Cook, 1970), as is the case with the majority of Ontario's reptiles (Oldham 1988b).

Canada

The Canadian range of the queen snake is entirely restricted to southwestern Ontario (Figure 2), west of the Niagara Escarpment and south of Georgian Bay. Historically, the queen snake's range extended east to Toronto, but none have been found in this area since the mid 1800's (Lamond, 1994). The absence of queen snakes on the Niagara Peninsula creates a gap between the Ontario and western New York ranges, even though apparently suitable habitat exists in the Niagara region (Campbell and Perrin, 1979).

HABITAT

Habitat Definition

The habitat requirements of the queen snake are highly specialized. It is a highly aquatic species, seldom found more than 3 m from water (Campbell and Perrin, 1979; pers. obs.). Wood (1949) summarized habitat preferences in a study of queen snakes in Ohio. He found the following three conditions necessary to support a population of queen snakes:

1. a permanent area of water, flowing or still, with a temperature remaining at or above 18.3^{o}C throughout most of the active season;
2. abundant cover, such as flat rocks submerged and/or on the bank;
3. an abundance of crayfish.

Figure 1. Distribution of the queen snake (*Regina septemvittata*) in North America. Adapted from Conant and Collins, 1991.

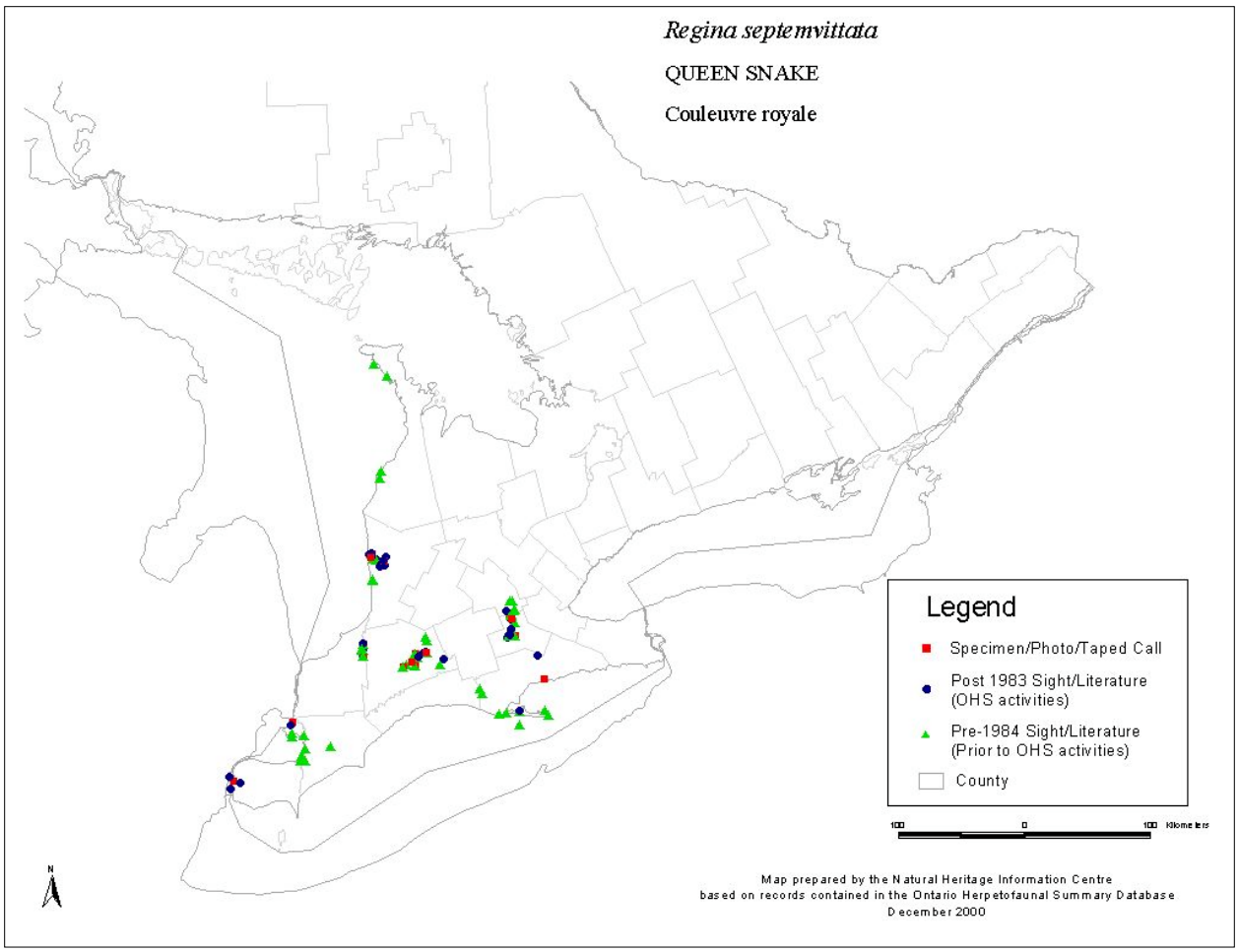

Figure 2. Distribution of the queen snake (*Regina septemvittata*) in Ontario
Note that the 1858 Toronto sighting is not shown. From Oldham and Weller, 2000.

Many authors have also cited a rocky or gravelly bottom as an indicator of optimal queen snake habitat (Conant, 1960; Duellman, 1951; Oldham, 1986; Johnson, 1989). Conant (1960) noted that queen snakes prefer woodland surroundings. Limestone (Wood, 1949; Minton, 1972) and slate (Triplehorn, 1949) have been cited as preferred streambed substrates. Although the vast majority of queen snake sightings occur along rocky streams with a swift to moderate current, the species has been known to utilize marshes (Conant, 1960), ponds (Wood and Duellman, 1947), lakes (Duellman, 1947) and quarries (Mattison, 1995) as occasional habitats. The queen snake has been referred to as the "stream counterpart" of Graham's water snake, *Regina grahami* (Smith, 1961). The two species are closely related and similar in appearance and food habits, but *Regina grahami* prefers swamp waterways (Hebrard and Mushinsky, 1978) and ponds (Hall, 1969).

Campbell and Perrin (1979) surveyed the vegetation associated with queen snake habitats in Ontario in great detail. Among trees, *Salix* (willows) and *Populus deltoides* (cottonwood) were the best indicators. The most commonly associated native

herbaceous plants were *Eupatorium maculatum* and *E. purpureum* (Joe-pye weeds), *Scirpus* spp. (bulrushes) and *Solidago* spp. (goldenrods).

Habitat Trends

Unfortunately, the queen snake's southern Ontario range coincides with the most densely populated area in Canada. In order to accommodate human needs, alteration to some queen snake habitat has been unavoidable. Other habitat areas were not developed; a result of their being unsuitable for development (e.g. river or creek valleys with bedrock outcrops)(Campbell and Perrin, 1979).

Dams, such as those on the Thames River, Whiteman's Creek and Otter Creek, may pose a threat to queen snakes by altering stream flow and rendering habitat conditions unfavourable (Campbell, 1977). Queen snakes have not been sighted on Otter Creek since 1979, leading to the conclusion that the population may have been extirpated. Similarly, queen snakes were extirpated from Missouri as a result of habitat lost through the construction of dams (Anderson, 1965; Ashton, 1976; Conant, 1960).

In 1979, Campbell and Perrin (1979) observed bulldozing along the flood plain and in the riverbed of the Bayfield River, a former locality for queen snakes. Almost twenty years later, queen snakes still are not found on this river.

In Kent County near Lake St. Clair, agriculture and drainage developments have altered creeks and marshes to such an extent that queen snakes can no longer survive there (Campbell and Perrin, 1979). The last queen snake sighting in this area was in 1973, from Bradley's Marsh at the mouth of the Thames River.

Erosion and flood control are important considerations for municipalities throughout the queen snake's range. In cities such as London, the installation of gabions and storm drains has altered queen snake habitat along the Thames River (pers. obs.). Such actions may eliminate sources of cover for queen snakes and alter features of the waterway such as temperature, turbidity and flow rates.

Habitat Protection

Although the majority of queen snake habitat in Ontario is under private ownership, a few populations are afforded extra protection as a result of their location falling within protected areas. Significant queen snake populations are found within the Rock Glen Conservation Area in Arkona (Judd, 1962; Spurr and Smith, 1979) and the Fanshawe Conservation Area in London (pers. obs.). One queen snake was found in 1997 in Komoka Provincial Park (pers. obs.). There are also populations protected within the Big Creek/ Long Point National Wildlife Area and the Apps' Mill Conservation Area (Mike Oldham, pers. comm.). Under the Official Policies Plan of the Regional Municipality of Waterloo, a second queen snake locality on the Grand River near Cambridge has been designated an environmentally sensitive area (Campbell and Perrin, 1979).

BIOLOGY

Food Habits

The most distinguishing characteristic of queen snake ecology is certainly their extreme food specialization. Examination of 45 queen snakes in western New York revealed that crayfish had been consumed by all but one, representing 99.4% of total food volume (Raney and Roecker, 1947). Branson and Baker (1974) dissected 120 queen snakes in Kentucky, and found that crayfish accounted for 98.6% of the diet. Reports of alternate prey taken by queen snakes are scarce, but include single occurrences of a mud minnow and a snail (Adler and Tilley, 1960), two dragonfly naiads (Raney and Roecker, 1947) and a toad (Surface 1906, as cited by Wood, 1949).

This specialization is true of Ontario queen snakes as well. Judd (1955) found only crayfish in the guts of two queen snakes captured in London. Campbell and Perrin (1979) found crayfish at all localities where queen snakes occur.

Conant (1960) showed the remarkably similar distribution patterns of queen snakes and crayfish of the genus Cambarus (with the exception of members of the burrowing Diogenes section of the genus), particularly toward the southern extent of their ranges. He concluded that crayfish of this genus form the bulk of the queen snake diet, an observation supported by Wood (1949) in Ohio, and Raney and Roecker (1947) in New York. However, in Kentucky (Branson and Baker, 1974), the queen snake diet comprises almost exclusively (93.2%) a single species of a different genus*, Orconectes juvenilis*. Penn (1950) reached a similar conclusion with queen snakes in New York, Pennsylvania and Virginia, reporting that 94% of the food volume consisted of *Orconectes obscurus*. Branson and Baker (1974) determined that the ratio of *Orconectes:Cambarus* at their study site was approximately 9:1; thus it seems likely that queen snakes will consume whichever genus is more abundant in a given region. Because crayfish of the genus *Cambarus* are not widely distributed throughout the queen snake's northern range (Guiasu et. al., 1996), populations in Ontario probably consume mostly *Orconectes propinquus*, the most commonly collected species at queen snake localities surveyed by Campbell and Perrin (1979). Crocker and Barr (1968) and Judd (1968) also reported on the abundance of this species in habitats known to support queen snake populations. Recently, *O. propinquus* has disappeared from numerous watersheds in Ontario, possibly from competition with the larger, more aggressive *Orconectes rusticus*, and from air and water pollution (Hamr, 1998).

An additional element to the fastidious dietary habits of the queen snake is the preference for newly molted crayfish. Burghardt (1968) conducted chemical preference studies on newborn queen snakes and found that they responded most strongly to extracts prepared from newly molted crayfish. They responded to fish and frog extracts with more tongue-flicks than when presented with controls, but only crayfish extracts produced a significant response. The fact that the snakes responded to non-crayfish food items provides support to the scattered reports of queen snakes consuming prey other than crayfish. Burghardt (1968) hypothesized that this response could be either a

vestigial character or a mechanism guarding against the ecological hazards of specializing on a single food source.

A possible explanation for the queen snake's preference for newly molted crayfish is that it would eliminate the chances of injury to the snake while ingesting its prey. Newly molted crayfish are quite helpless until their exoskeletons harden (Wood, 1949). Although large crayfish have been found in the stomach contents of queen snakes (Raney and Roecker, 1947; Branson and Baker, 1974), these specimens were likely either dead or newly molted at the time they were swallowed (Wood, 1949). Branson and Baker (1974) watched a queen snake approach a hard-shelled *Orconectes*, which immediately attacked the snake and drove it away. Although it is likely that small crayfish can be consumed in any state, Wood (1949) determined that crayfish ecdysis occurs frequently enough that large queen snake populations could be sustained strictly on newly molted prey.

Feeding behaviour has seldom been observed in the field (Wood, 1949). Raney and Roecker (1947) observed queen snakes foraging among stones and detritus in shallow, relatively fast-moving water, or alternatively, lying motionless in quiet pools with only the head protruding. LeRay (1928) also commented on the bottom-feeding habits of the queen snake, and Wood (1949) watched a female queen snake swallow a dead crayfish, telson-first. During June, July and August, queen snakes feed most heavily during early morning (8-10 AM) and late afternoon (4-6 PM), (Raney and Roecker, 1947). A well-known trait of queen snakes is their refusal to feed in captivity (LeRay, 1928; Logier, 1958; Ernst and Barbour, 1989).

Reproduction

The queen snake is viviparous, a condition which may be advantageous given its aquatic habitat (Hall, 1969). Females give birth to live young between July and early September in Ontario (Froom, 1981). In Ontario, litter size ranges from 5 to 19 but usually numbers no more than 12 (Logier, 1958; Triplehorn, 1949). Two females captured by Campbell (1977) gave birth to 10 and 15 young on 13 and 24-25 September, respectively. Other reported litter sizes are nine, born 15 August to a queen snake in South Carolina (Arndt, 1994), and 14 near-full-term young in the body cavity of a road-killed Tennessee specimen (Scott and Zirkle, 1992). Litter size is positively correlated with female body length (Campbell, 1977). The record number of young produced by a single female is 23, from a very large (922 mm total length) specimen from Ohio (Triplehorn, 1949). Barbour (1971, as cited by Campbell and Perrin, 1979) reported that queen snakes give birth under stones near water.

Branson and Baker (1974) studied the reproductive cycle of Kentucky queen snakes in detail. They determined that females normally do not reproduce until their third year, although immature eggs may be found early in the second year, possibly having been produced the previous (first) fall. Males mature earlier, during their second year. Mating probably takes place in both spring and fall. The courtship behaviour of queen snakes is described explicitly in Ford (1982). Briefly, it involves a series of

vertical oscillations of the first 6 to 20 cm of the neck of the male while aligned on the female's dorsum, followed by tail-search copulatory attempts. These vertical oscillations are presumably a substitute for the caudal-cephalic waves typical of other natricine snakes.

There is little information on reproductive success in queen snakes. Conant and Downs (1940) reported a Pennsylvania queen snake which produced two living young, two dead embryos and two infertile ova. The first of the two living young, measuring only 168 mm and weighing 1.4 g, was deformed. In a litter of 20, one stillbirth was reported (Burghardt, 1968). Branson and Baker (1974) described a male queen snake born with a fused body loop.

Physiology

Butler et al. (1980) studied queen snake feeding habits in the colder weather of spring. They examined the stomach contents of Ohio queen snakes to determine whether there was any dietary shift from crayfish to more terrestrial prey, which would allow the snakes to avoid foraging in cold water. As 94.1% of the stomachs with food contained crayfish, there was no indication that a dietary shift occurred in colder weather. However, only 56.6% of stomachs examined contained food, significantly less than the proportion (91.7%) found by Branson and Baker (1974) during the summer. Because the Ohio investigators could find no physiological or biochemical adaptations for feeding in cold weather, they concluded that queen snakes simply do not feed as frequently in spring as they do in summer.

Branson and Baker (1974) investigated body temperature and critical thermal maxima (CTM) in Kentucky queen snakes. They concluded that queen snakes are able to exert some regulation of their body temperature, as cloacal temperatures were up to 6.2°C above ambient (water or air, as applicable). Body temperatures ranged from 12.2°C to 30.4°C, with an average of 25.6°C. Smaller snakes generally exhibited higher temperatures than larger snakes. In adult queen snakes, CTM ranged from 43.4°C to 44.5°C, with a mean of 43.9°C, and there was no correlation between body mass or length and CTM. For juveniles, the average CTM was 40.3°C, with a range from 39.5°C to 41.5°C. Critical thermal maximum in juveniles appeared to be directly proportional to body mass and length.

Queen snakes have the most water-permeable skin of any snake, a feature attributed to their highly aquatic existence (Stokes and Dunson, 1982).

Growth and Survivorship

The total lengths of newborn Ontario queen snakes range from 181-203 mm (Campbell, 1977). The mass of newborn Kentucky queen snakes ranged from 2.4 g to 4.2 g (mean = 3.3 g) and total length varied between 172-265 mm, with an average of 227 mm (Branson and Baker, 1974). The recorded maximum size for an adult queen snake is 933 mm (Behler and King, 1996). Female queen snakes have a greater annual

length increment and reach a larger maximum size than males (Wood and Duellman, 1950; Branson and Baker, 1974)

Although growth rates have not been examined in Ontario queen snakes, several American studies provide excellent information on the subject. Branson and Baker (1974) compared the mean total length of newborns with the size of yearlings, and found an average growth increment of 171 mm, or 75%. Similarly, Raney and Roecker (1947) determined an average growth of 173 mm, or 79% in the first year. Second-year size increased an average of 44.8% in Kentucky (Branson and Baker, 1974) and 50% in Ohio (Wood and Duellman, 1950). Age-specific size classes for queen snakes older than two years were not clearly apparent in either study; therefore annual increments in snakes beyond this age could not be calculated.

Branson and Baker (1974) were able to calculate the growth of adult queen snakes over shorter intervals of time by capture-release-recapture. A 615 mm specimen increased in size by 15% over a period of 38 weeks, and another 738 mm female grew 14% in 42 weeks. One large (850 mm) female grew only 5 mm (0.6%) over a period of 42 weeks.

No information is available with regard to survivorship. Campbell and Perrin (1979) determined the population structure of Ontario queen snakes. The adult sex ratio was 1.3:1.0 (males to females) during their 1979 survey. They speculated that the slight skewing in favour of males could be because males show greater activity than females, as is the case with some other snakes such as the blue racer (*Coluber constrictor foxii*). The ratio of adults to juveniles was 1.9:1.0. Breaking this down further, they found a ratio of 1.0:0.7:1.2 (one year olds: two year olds: individuals three or more years old), although they cautioned that their data were inconclusive given the small sample size and the possible differences among populations.

The recorded maximum life span of a queen snake is 11 years, 1 month and 3 days, attained by a wild-caught male at the Fort Worth Zoo in Texas (Snider and Bowler, 1992). A captive queen snake lived over 19 years (Harding, 1997).

Hibernation

In Ontario, the recorded extremes of queen snake activity are from 9 May to 16 October (Mike Oldham, unpubl. data, OHS). This is considerably shorter than the range of 20 March to 7 November given for Indiana queen snakes (Wright and Wright, 1957). One Ohio queen snake was discovered in January, lying on top of the ice on a creek (Conant, 1938a), although the normal period of activity in this state is from April through September (Conant, 1938b).

Several papers describe late fall aggregations which are believed to occur prior to communal hibernation. Wood (1944) reported a group of 47 queen snakes on 27 October that were gathered in saplings overhanging the Miami River in Ohio. Neill (1948) described a November aggregation of "dozens upon dozens" of queen snakes in Georgia. As queen snakes were considered scarce in this particular locale, he believed the aggregation to

represent the entire queen snake population of the creek. The most striking queen snake assemblage on record was discovered in Ohio by W.E. Duellman, D.E. Ladd and R.E. Riecken on 22 September, 1946 (Wood and Duellman, 1950): over 125 specimens were collected in less than an hour from a 100-m section of creek. Wood (1949) reports one occasion where 24 individuals were collected from beneath a single rock.

Reports of aggregations associated with hibernation are not as common in Ontario, although there is no evidence to suggest that queen snakes do not exhibit similar behaviour. On 28 August 1977, Spurr and Smith (1979) found 16 queen snakes that had all taken cover in the crevices around a large limestone rock in the middle of the Ausable River. However, since the weather that day was "extremely hot" with "intensive sun", it is doubtful that this particular aggregation was formed for the immediate purpose of communal hibernation. A possible post-hibernation group of queen snakes was discovered on 31 May, 1997 by Glenn Gallagher (pers. comm.): ten individuals were captured on the Thames River in London within a 6-m section of riverbank, possibly representing a group which had recently emerged from hibernation and had not yet disbanded.

Although the literature on hibernacula is scant, Campbell and Perrin (1979) listed a number of structures that they believed might serve this purpose for queen snakes. Abutments of old bridges were found at queen snake localities on Whiteman's Creek, Mitchell's Bay, the Thames River and Baptiste Creek. Suitable bedrock outcrops were found on the Grand River, Bayfield River, Mitchell's Bay, Mud Creek (St. Clair River), the Thames River and Baptiste Creek. In addition, they postulated that crayfish burrows were also possible hibernation sites.

Behaviour

Queen snakes have been described as "alert and shy" (Logier, 1958), "timid" (Schmidt and Davis, 1941) and "very wary" (Johnson, 1989). The docility of queen snakes clearly separates them from other natricines, such as the northern water snake (*Nerodia sipedon*) (pers. obs.). The queen snake will typically thrash around and give off a foul smelling musk upon capture, but it will rarely attempt to bite, regardless of how roughly it is handled (Raney and Roecker, 1947; Campbell, 1977; Martof et. al, 1980; Ernst and Barbour, 1989). Nakamura and Smith (1960) attribute the submissive behaviour of the queen snake to its relatively narrow head, which is not capable of inflicting as much damage as the broader, well-muscled head of water snakes.

Another interesting aspect of queen snake behaviour is its gregarious nature, previously mentioned in the above section on hibernation. In addition to pre-hibernation aggregations with conspecifics, queen snakes are often found under rocks in the company of northern watersnakes (*Nerodia sipedon*) (Raney and Roecker, 1947; Branson and Baker, 1974).

Layne and Ford (1984) studied flight distance — the nearest distance an individual will allow a predator to approach before attempting escape — in Ohio queen snakes.

They found a direct relationship between body temperature and flight distance, with cooler snakes allowing predators to approach more closely than would warmer snakes. They concluded that queen snakes rely more heavily on crypsis at low body temperatures, since they would not be able to move as quickly and would likely be overtaken by predators if they drew attention to themselves during an escape attempt.

Movement and Migration

There is very little information on the home ranges and movements of queen snakes in Ontario. Branson and Baker (1974) studied home range and homing in Kentucky queen snakes. Using mark-recapture, they determined that queen snakes have a relatively small home range size, but show some tendency for dispersal. Eleven of thirteen recaptured snakes were within 30 m of the original point of capture. The greatest distance traveled upon release was 122 m, over a period of two weeks. During the homing experiment, 49 snakes were moved to a different location; none were recaptured in the same season. Although this indicated that the snakes had likely dispersed, it was unknown where they had gone. Some evidence for homing was demonstrated by the fact that two snakes were recaptured close to their release points after having overwintered, indicating that the snakes had found their way back to the same area upon their return from a hibernaculum. However, since Branson and Baker were also unable to locate a hibernation site, this does not preclude the possibility that the hibernaculum was nearby, and that the snakes had never migrated away.

Newcomer et al. (1974) determined that queen snakes are able to use the sun for orientation. The Ohio queen snakes in their study exhibited a bi-polar escape response along the Y-axis to which they were trained. This response was attributed to the fact that queen snakes are normally found on the banks of streams, and from such a position they can escape either into the water or onto land. An alternative explanation offered was that the response toward land could be restricted to gravid females shifting their location toward land prior to giving birth. However, since the sex of snakes in the study was not determined, and the time of year in which the experiment was conducted was not stated, this hypothesis is impossible to evaluate. It is supported, however, by the observations of Campbell and Perrin (1979): the only queen snake that was found far from water (3.1 m) was a gravid female.

Vulnerability

Queen snakes are vulnerable to local extinctions because their extremely specialized habitat requirements tend to create high concentrations in certain areas, with large gaps of unfavourable habitat between populations (pers. obs.). Thus, any detrimental change in a small, yet densely populated, section of stream could wipe out an entire population. Branson and Baker (1974) showed that the home ranges of queen snakes are fairly small, a feature that would greatly delay recolonization. The gregarious nature of the queen snake and its mild temperament render it susceptible to mass collection; individuals sheltering together under choice rocks are easily captured with little chance of harm coming to the collector.

Like many snake species, queen snakes are vulnerable to humans. Spurr and Smith (1979) found one dead queen snake at Hungry Hollow which they concluded had been clubbed to death by a human, and another specimen dead of an undetermined cause. Campbell and Perrin (1979) found a large, mutilated female, probably stoned to death, at the Benmiller Inn on the Maitland River. In Pennsylvania, Carl H. Ernst observed the disappearance of about 100 queen snakes from a rock dam, which were apparently shot by local teenage boys (Ernst and Barbour, 1989). Swanson (1952) offered the advice that queen snakes are "more difficult to hit with a .22 calibre rifle [than water snakes]". Such cases of wanton killing by humans are proof of the fearful and ignorant attitude towards snakes that persists despite efforts of public education.

Predation and Interspecific Interactions

Ironically, crayfish are among the known predators of queen snakes. Juvenile and hibernating snakes are vulnerable to crayfish (Branson and Baker, 1974). Mice also prey upon hibernating queen snakes (Branson and Baker, 1974; Wood, 1949). Possible queen snake predators in Ontario include great blue herons, black-crowned night herons, belted kingfishers, American kestrels, herring gulls, raccoons and dogs (Campbell and Perrin, 1979). Branson and Baker (1974) found young snakes in the gut of the hellbender, *Cryptobranchus alleganiensis*. In Ontario, it is possible that small queen snakes are eaten by the mudpuppy, *Necturus maculosus*, as one was found in the Maitland River in close proximity to the capture site of several queen snakes (Scott Gillingwater, pers. comm.).

Queen snakes host several known parasites, but because they do not feed on amphibians, they are normally free of the trematode parasites that plague almost all other water snakes (Goodman, 1951). All West Virginia queen snakes examined by Chu (1936) contained the nematode *Rhabdias fuscovenosa* in the lungs, with an average burden of 2.2 worms per snake. Upton et al. (1991) recovered coccidian oocysts of the species *Emeria septemvittata* from queen snake feces. Branson and Baker (1974) found two types of ectoparasites on their Kentucky specimens: a fungus of the genus *Verticellium* and a leech, *Placobdella rugosa*. Unfortunately, there are no accounts of the effects these parasites have on their hosts. No parasites were noted in the Ontario specimens examined by Campbell and Perrin (1979), although the snakes were not specifically examined for this purpose. Of the 29 queen snakes examined in their study, three showed evidence of tail rot, three had incomplete tails (probably caused by tail rot) and six specimens had noticeable scars other than incomplete tails (op. cit.).

POPULATION SIZES AND TRENDS

Population Size

There are only 163 records of the queen snake currently in the Ontario Herpetofaunal Summary (OHS) making it the least reported snake species in Ontario (Oldham, unpubl. data, OHS). There have been no attempts in Ontario to determine

absolute population size. Surveys were conducted in 1979 (Craig Campbell and D.W. Perrin) and 1997 (Michelle Fletcher, Lucas Foerster, Glenn Gallagher, Scott Gillingwater, Phil James and Kim Smith) to determine how closely the current distribution matched the historic distribution.

In the 1979 study, Campbell and Perrin (1979) examined 16 of the 25 known queen snake sites in Ontario. Their survey took place over 10 field days from mid-August to early September, and encompassed the municipalities of Middlesex, Kent, Lambton, Brant, Huron and Waterloo. A total of 30 queen snakes were found (including one dead specimen), of which 19 were from Middlesex County. Queen snakes were notably absent from Bayfield River, Baptiste Creek and Bradley's Marsh.

The 1997 survey included casual observation throughout May, June and July (mostly within the London area) as well as more intensive searching during August (Middlesex, Brant, Huron, Essex, Bruce, Waterloo, Lambton and Kent Counties). Sightings were confirmed in Middlesex, Brant, Huron and Essex, and a total of 37 live specimens and one dead specimen (Phil James, pers. comm.) were found.

The total number of queen snakes in Ontario is extremely difficult to estimate for two reasons. Many authors have noted the queen snake's tendency to be present in very large numbers at certain locations, yet completely absent from other, seemingly suitable habitats (Spurr, 1978; pers. obs.). This pattern of local occurrence could result in either a gross over- or under-estimation of total population size, depending on sampling techniques and precise locations chosen for enumeration. The second reason for the difficulty in estimating numbers is the amphibious nature of this snake. Depending on whether snakes are resting under rocks on land or foraging in the water at the time a census is conducted, there will be a large margin of error until a reliable sampling protocol is developed. These obstacles partly explain the disparity that has existed in Ontario with regard to the status of the queen snake, as demonstrated by the following:

1908 - Nash: "Very rare"
1928 - LeRay: "...may be more generally distributed than we have thought, although it does not appear to be at all common"
1948 - Mills: "Not common"
1958 - Logier: "It is not common"
1967 - McBride: "...not as rare as formerly thought"
1970 - Cook: "...Of scattered occurrence but possibly fairly common where it occurs. It is a stream and river edge snake and could be in danger due to this restricted habitat."
1972 - Froom: "...has not been considered common and is possibly an endangered species...however...not as rare as it was previously thought to be"; "The queen snake is rare in Canada."
1974 - Stewart: "...a prime candidate for extinction in Canada"
1977 - Campbell: "Threatened"
1977 - Gregory: "Threatened"

1978 - Spurr: "It is considered scarce in southwestern Ontario but the point is in some doubt as, because of its striped appearance, it has often been mistaken for the eastern garter snake, *Thamnophis sirtalis sirtalis*"
1979 - Campbell and Perrin: "...threatened and vulnerable reptile in Ontario/ Canada"; "...may be potentially endangered"
1986 - Oldham: "...very rare and local"
1988b - Oldham: "...generally considered to be one of Ontario's rare reptiles"
1989 - Johnson: "...uncommon species"
1994 - Lamond: "...a very scarce snake in Ontario, being of very local occurrence due to its specialized habitat requirements"

Population Distribution, Persistence and Trends

Although there have been no studies in Ontario estimating population size, sightings from the Ontario Herpetofaunal Summary (Oldham, 1988a; Oldham and Sutherland, 1986; Oldham and Weller, 1989) provide a reasonable means of describing distribution and estimating trends in queen snake populations. The following information on queen snake sightings has been taken from this database (provided by Mike Oldham), unless otherwise stated.

It appears as though a number of Ontario queen snake populations have been extirpated, while relatively few new colonies have recently been discovered. The first queen snake reported in this province was in Toronto in 1858 (Ure, 1858, as cited by Campbell, 1977). There have been no records of queen snake sightings in Toronto since this time. Other early records include several specimens from Mud Creek and Mitchell's Bay, Lake St. Clair, found by J.H. Garnier in the early 1880's. As there have been no queen snake sightings in this area since 1973, this population is presumably extirpated. Several populations on the Bruce Peninsula have disappeared: queen snakes have not been reported since 1927 at Lake Scugog, and since 1969 at Baie du Dore. Queen snakes have not been reported since the late 1970's at Rattlesnake Creek and Bayfield River. Conditions on Bayfield River appear ideal (pers. obs.; Lucas Foerster, pers. comm.), but no snakes were found during a four-day search in 1997, and none were seen over a ten-year period of casual observation in the area during the 1980's (Josh Feltham, pers. comm.). Other possibly extirpated populations include those on Walpole Island and Nanticoke Creek, with no reported sightings since the mid 1980's. Queen snakes were reported near the lighthouse at Long Point in 1961 and 1962; none have been seen since this time, even with the constant presence of naturalists in the area. More study is needed in order to ascertain whether the aforementioned populations have indeed been extirpated, or if they are merely very difficult to find: Francis and Campbell (1983) discovered queen snakes in the Waterloo Region at sites where they had not been reported for over 50 years.

Consistent queen snake sightings are reported for only a few rivers: the Thames, Maitland, Grand and Ausable, and some of their tributaries. The complete absence of queen snakes from Oxford County (Milnes, 1946; Oldham, unpubl. data, OHS) is

noteworthy, as these snakes have been found in three adjacent counties (Brant, Waterloo and Middlesex).

LIMITING FACTORS

It is widely agreed that the most significant threat to queen snakes in both Canada and the United States is habitat loss (Ashton, 1976; Campbell, 1977; Cook, 1970; Froom, 1972; Johnson, 1989; Weller, 1983). Because of the highly specific nature of the habitat required by queen snakes, the number of suitable locations in Ontario is finite, and declining rapidly because of urban encroachment. Streams are physically altered by the construction of dams, erosion control measures and various other structures designed to improve the living conditions of humans. Although the queen snake is legally protected in Missouri, it has been extirpated from that state as a result of habitat loss through the construction of dams (Anderson, 1965; Ashton, 1976; Conant, 1960). It is not difficult to foresee a similar fate awaiting queen snake populations in the more heavily settled regions of southern Ontario, where the construction of new bridges, drainage systems and gabions pose a constant threat.

Pollution of Ontario streams which provide habitat for queen snakes is also a potential limiting factor (Stewart, 1974). Because of their extreme food specialization, any threat to crayfish populations is also a direct threat to queen snake populations. Queen snakes have disappeared from many localities in Pennsylvania because the local crayfish populations have been extirpated (McCoy, 1982). Some Ontario populations face the same fate, as the increased runoff and siltation in many southern Ontario streams has reached the point where crayfish can no longer survive therein (Johnson, 1989). The species that likely forms the bulk of the queen snake diet in Ontario, *Orconectes propinquus*, is more sensitive to stream acidification than crayfish of the genus *Cambarus* (Berrill et. al, 1985; Hamr, 1998). Crayfish also accumulate mercury (Vermeer, 1972), therefore, queen snakes could be vulnerable to mercury toxicity (Froom, 1972). In addition to a contaminated food supply, queen snakes might be especially susceptible to other pollutants because of their highly permeable skin (Stokes and Dunson, 1982) and aquatic habit.

Queen snakes are often be mistaken for garter snakes because of their striped appearance (Froom, 1981). However, since almost all queen snakes are found only under the cover of rocks along streams (Branson and Baker, 1974; pers. obs.), most people would not come across a queen snake unless they were deliberately searching for one. This aspect of queen snake ecology, combined with its cryptic colouration and mild temperament, offers it some degree of protection against human persecution. Nevertheless, queen snakes are often encountered and killed by fishermen who believe the snake eats game fish (Harding, 1997).

SPECIAL SIGNIFICANCE OF THE SPECIES

The queen snake reaches the northern limits of its range in Canada, like all other native reptiles (Weller, 1982). Because peripheral populations are often genetically divergent from central populations (Lesica and Allendorf, 1995), Canadian queen snakes might represent a significant proportion of the genetic variation of the species, a trait well worth conserving. In adapting to the colder climate of Canada, these populations may even have speciated, an event that is likely far more common than we realize (Hunter and Hutchinson, 1994). Although queen snakes are globally common, Hunter and Hutchinson (1994) recognize the importance of protecting locally rare species as an important function in conserving ecosystem integrity at smaller scales. Queen snakes could be of some value as an indicator species because they consume crayfish, which have been used in previous studies as indicators of mercury contamination (Vermeer, 1972).

EXISTING PROTECTION

The queen snake is legally protected under the Ontario Game and Fish Act, which prohibits the collection, hunting, possession or sale of reptiles except under authority of a license (Revised Statutes of Ontario 1990, Chapter G.1, Sections 76, 77 and 78). Because of the aquatic habitats frequented by queen snakes, they also receive incidental protection from flood plain regulations (Campbell and Perrin, 1979). The ABI ranking of the queen snake in Ontario is “S2”; nationally, it is ranked “N2” and globally, “G5” (Alvo and Oldham, 2000).

The snake receives varying levels of protection throughout its range in the United States. It is considered “special concern” by the Arkansas Game and Fish Commission and “endangered” by the Wisconsin Department of Natural Resources (Frank and Ramus, 1994). Notable IUCN rankings of this species are “S1” in Arkansas, Delaware, New York and Wisconsin, and “S3” in Mississippi (Mike Oldham, pers. comm.).

EVALUATION AND PROPOSED STATUS

The queen snake should be designated a threatened species for the following reasons, which are discussed in greater detail in the relevant sections of this paper.

1. The queen snake's distribution in Canada is limited to a small portion of a single province. Much of its range overlaps with one of the most densely populated areas in the country.
2. It is the least reported of any of the 14 snake species native to Ontario.
3. The diet of the queen snake is extremely specialized. Over 90% of prey taken may be of a single species of crayfish.
4. As aquatic organisms, crayfish are susceptible to acidification and mercury toxicity. Acidification kills crayfish outright, while mercury may be accumulated

in the tissues and passed on to predators such as queen snakes. Increased runoff and siltation have extirpated crayfish populations in many southern Ontario streams.

5. Queen snakes inhabit very specialized aquatic habitats that are vulnerable to alteration by damming, channelization and other construction practices associated with urban expansion. Habitat alteration has contributed to the extirpation of queen snake populations both in Canada and in the United States, despite existing legislation to protect the species.
6. Home range size is small, which delays recolonization and range expansion.
7. Snakes are still misunderstood by many people and harassed or killed as a consequence.
8. This species has apparently disappeared from many areas that it once occupied in Ontario, particularly in the northern parts of its previous distribution.
9. Although sometimes abundant in very restricted areas, the queen snake is only found in a few such areas scattered across southwest Ontario. These populations may be extremely isolated from each other. This isolation, the snakes' specialized feeding and habitat requirements, and encroaching habitat modification by people make the populations highly vulnerable to extirpation.

TECHNICAL SUMMARY

Regina septemvittata
Queen Snake — Couleuvre royale
Ontario

Extent and Area information	
• *extent of occurrence (km²)*	<< 20,000 km^2
• *specify trend (decline, stable, increasing, unknown)*	decline
• *are there extreme fluctuations in extreme occurrence (> 1 order of magnitude)?*	no
• *area of occupancy (km²)*	< 1,500 km^2
• *specify trend (decline, stable, increasing, unknown)*	decline
• *are there extreme fluctuations in area of occupancy (> 1 order magnitude)?*	no
• *number of extant locations*	about 10
• *specify trend in # locations (decline, stable, increasing, unknown)*	decline
• *are there extreme fluctuations in # locations (>1 order of magnitude)?*	no
• *habitat trend: specify declining, stable, increasing or unknown trend in area, extent or quality of habitat*	decline
Population information	
• *generation time (average age of parents in the population) (indicate years, months, days, etc.)*	>2 yrs (male) >3 yrs (female)
• *number of mature individuals (capable of reproduction) in the Canadian population (or, specify a range of plausible values)*	unknown
• *total population trend: specify declining, stable, increasing or unknown trend in number of mature individuals*	decline
• *if decline, % decline over the last/next 10 years or 3 generations, whichever is greater (or specify if for shorter time period)*	40 % based on the number of areas from which the species has disappeared
• *are there extreme fluctuations in number of mature individuals (> 1 order of magnitude)?*	no

• *is the total population severely fragmented (most individuals found within small and relatively isolated (geographically or otherwise) populations between which there is little exchange, i.e., ≤ 1 successful migrant / year)?*	yes
• *list each population and the number of mature individuals in each*	< 5 populations # individuals unknown
• *specify trend in number of populations (decline, stable, increasing, unknown)*	unknown likely declining
• *are there extreme fluctuations in number of populations (>1 order of magnitude)?*	no
Threats (actual or imminent threats to populations or habitats) [add rows as needed]	
-habitat loss – urban encroachment, dam construction, erosion control -increased runoff and siltation, stream acidification, mercury and other pollutants -loss of prey species to pollutants and habitat loss -humans' fearful and ignorant attitude towards snakes	
Rescue Effect (immigration from an outside source)	
• *does species exist elsewhere (in Canada or outside)?*	yes in US
• *status of the outside population(s)?*	most populations considered not at risk, others at risk or endangered
• *is immigration known or possible?*	no
• *would immigrants be adapted to survive here?*	probably
• *is there sufficient habitat for immigrants here?*	no
Quantitative Analysis	**no**

Ron Brooks, August 2001

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Although there is no authority currently conducting research on the queen snake in Ontario, Mike Oldham and Craig Campbell have extensive experience with this species.

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