PROPOSED

Species at Risk Act
Recovery Strategy Series

Recovery Strategy for the Eastern Ribbonsnake (*Thamnophis sauritus*), Atlantic Population in Canada

Eastern Ribbonsnake

October 2008

Parks Canada Parcs Canada

Canada

About the *Species at Risk Act* Recovery Strategy Series

What is the *Species at Risk Act* (SARA)?

SARA is the Act developed by the federal government as a key contribution to the common national effort to protect and conserve species at risk in Canada. SARA came into force in 2003, and one of its purposes is *"to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity."*

What is recovery?

In the context of species at risk conservation, **recovery** is the process by which the decline of an endangered, threatened, or extirpated species is arrested or reversed and threats are removed or reduced to improve the likelihood of the species' persistence in the wild. A species will be considered **recovered** when its long-term persistence in the wild has been secured.

What is a recovery strategy?

A recovery strategy is a planning document that identifies what needs to be done to arrest or reverse the decline of a species. It sets goals and objectives and identifies the main areas of activities to be undertaken. Detailed planning is done at the action plan stage.

Recovery strategy development is a commitment of all provinces and territories and of three federal agencies — Environment Canada, Parks Canada Agency, and Fisheries and Oceans Canada — under the Accord for the Protection of Species at Risk. Sections 37–46 of SARA (http://www.sararegistry.gc.ca/the_act/default_e.cfm) outline both the required content and the process for developing recovery strategies published in this series.

Depending on the status of the species and when it was assessed, a recovery strategy has to be developed within one to two years after the species is added to the List of Wildlife Species at Risk. Three to four years is allowed for those species that were automatically listed when SARA came into force.

What's next?

In most cases, one or more action plans will be developed to define and guide implementation of the recovery strategy. Nevertheless, directions set in the recovery strategy are sufficient to begin involving communities, land users, and conservationists in recovery implementation. Cost-effective measures to prevent the reduction or loss of the species should not be postponed for lack of full scientific certainty.

The series

This series presents the recovery strategies prepared or adopted by the federal government under SARA. New documents will be added regularly as species get listed and as strategies are updated.

To learn more

To learn more about the *Species at Risk Act* and recovery initiatives, please consult the SARA Public Registry (http://www.sararegistry.gc.ca/) and the Web site of the Recovery Secretariat (http://www.speciesatrisk.gc.ca/recovery/).

Recovery Strategy for the Eastern Ribbonsnake (*Thamnophis sauritus*), Atlantic Population (PROPOSED)

October 2008

Recommended citation:

McNeil, J. 2008. Recovery Strategy for the Eastern ribbonsnake (*Thamnophis sauritus*), Atlantic population in Canada. Species at Risk Act Recovery Strategy Series. Parks Canada Agency, Ottawa. x + 45 pp.

Additional copies:

Additional copies can be downloaded from the SARA Public Registry (http://www.sararegistry.gc.ca/)

Cover illustration: Eastern ribbonsnake at Grafton Lake, Nova Scotia © Tom Herman.

Également disponible en français sous le titre
« French document title »

ISBN *To come*
Cat. no. *To come*

DECLARATION

Under the *Accord for the Protection of Species at Risk* (1996), the federal, provincial, and territorial governments agreed to work together on legislation, programs, and policies to protect wildlife species at risk throughout Canada. The *Species at Risk Act* (S.C. 2002, c.29) (*SARA*) requires that federal competent ministers prepare recovery strategies for listed Extirpated, Endangered, and Threatened species.

The Minister of the Environment presents this document as the recovery strategy for the eastern ribbonsnake, Atlantic population, as required under *SARA*. It has been prepared in cooperation with the jurisdictions responsible for the species, as described in the Preface. The Minister invites other jurisdictions and organizations that may be involved in recovering the species to use this recovery strategy as advice to guide their actions.

The goals, objectives, and recovery approaches identified in the strategy are based on the best existing knowledge and are subject to modifications resulting from new findings and revised objectives.

This recovery strategy will be the basis for one or more action plans that will provide further details regarding measures to be taken to support protection and recovery of the species. Success in the recovery of this species depends on the commitment and cooperation of many different constituencies that will be involved in implementing the actions identified in this strategy. In the spirit of the Accord for the Protection of Species at Risk, all Canadians are invited to join in supporting and implementing this strategy for the benefit of the species and of Canadian society as a whole. The Minister of the Environment will report on progress within five years.

AUTHORS

This strategy was prepared by Jennifer McNeil, in collaboration with the Eastern Ribbonsnake Recovery Team.

ACKNOWLEDGEMENTS

Recovery team members continually contribute to the science and communications for the recovery of the eastern ribbonsnake. They also spent much time defining the strategic direction for this recovery strategy. The Recovery Team would like to acknowledge the contributions of Guillaume Bourque, James Brunt, Josianne Caron, Brennan Caverhill, Troy Frech, Tara Imlay, Jose Lefebvre, Robby Marrotte, JoAnne Phillips, Josie Todd, and Chris Wagner. Their field work and participation in recovery team meetings is much appreciated. The Recovery Team also acknowledges the assistance of Abbey Camaclang and Samara Eaton in finalizing this recovery strategy. Finally, the Recovery Team would like to thank the many volunteers who have reported sightings of ribbonsnakes and who have participated in research activities.

STRATEGIC ENVIRONMENTAL ASSESSMENT STATEMENT

In accordance with *The Cabinet Directive on the Environmental Assessment of Policy, Plan and Program Proposals (2004)*, a strategic environmental assessment (SEA) is conducted on all *Species at Risk Act* recovery strategies. The purpose of the SEA is to incorporate environmental considerations into the development of public policies, plans, and program proposals to support environmentally-sound decision making.

Recovery planning is intended to benefit species at risk and biodiversity in general. However, it is recognized that strategies may also inadvertently lead to environmental effects beyond their intended benefits. Environmental effects, including impacts to non-target species and the environment, were considered during recovery planning. The SEA is incorporated directly into the strategy and also summarized below.

Recovery objectives will focus primarily on addressing knowledge gaps (Section 4 of the recovery strategy). The need for further research into demography, habitat requirements, threats, and population trends was identified. This information will benefit eastern ribbonsnake (*Thamnophis sauritus*) recovery in Nova Scotia, and may also aid conservation of other ribbonsnake populations, including those in southern Ontario and southwestern Quebec. Increased knowledge and protection of habitat (Section 1.8 of the recovery strategy) will also benefit other species at risk (e.g., Blanding's turtle [*Emydoidea blandingii*] and Redroot [*Lachnanthes caroliana*]). To minimize overlap and maximize recovery efforts, this Recovery Team will work closely with the Blanding's turtle and Atlantic Coastal Plain Flora recovery teams. The recovery strategy also proposes collaboration with Fisheries and Oceans Canada (DFO) and the Provincial Fishery to monitor exotic and introduced fish (e.g., smallmouth bass [*Micropterus dolomieui*] and chain pickerel [*Esox niger*]). This will benefit competing native fish species (e.g., trout [*Salvelinus* sp.]) as well as trophic dynamics, including amphibian abundance. Actions aimed at stewardship and education may also benefit other snake species, in addition to commonly associated vegetation and other terrestrial and aquatic organisms. The potential impacts to other species as a result of eastern ribbonsnake management are provided in Section 6.6 of the recovery strategy. This recovery strategy will have several positive effects on other species and the environment, and no important negative effects are anticipated.

RESIDENCE

SARA defines residence as: *a dwelling-place, such as a den, nest or other similar area or place, that is occupied or habitually occupied by one or more individuals during all or part of their life cycles, including breeding, rearing, staging, wintering, feeding or hibernating* [Subsection 2(1)].

Residence descriptions, or the rationale for why the residence concept does not apply to a given species, are posted on the *SARA* public registry: http://www.sararegistry.gc.ca/plans/residence_e.cfm.

PREFACE

This recovery strategy addresses the recovery of the eastern ribbonsnake, Atlantic population. In Canada, this species is restricted to southern Ontario, the southwestern corner of Quebec, and the interior of southwestern Nova Scotia.

The Recovery Strategy for the Eastern Ribbonsnake, Atlantic Population meets the *Species at Risk Act* (S.C. 2002, c.29) (*SARA*) requirements in terms of content and process (Sections 39-41 and 48-49). This strategy also meets the particular requirements for recovery plans under the *Nova Scotia Endangered Species Act* (S.N.S. 1998, c.11) (*NS ESA*) (Section 15).

Section 37 of *SARA* requires the competent minister to prepare recovery strategies for listed extirpated, endangered, or threatened species, and Section 47 states that one or more action plans based on the recovery strategy must be prepared. The Eastern Ribbonsnake Recovery Team, Parks Canada Agency, and the Province of Nova Scotia led the development of this recovery strategy. This recovery strategy was developed in cooperation or consultation with numerous additional individuals and agencies, including Acadia University, Dalhousie University, L'sitkuk Department of Environment, environmental non-government organizations, industry stakeholders, Aboriginal groups, and private landowners.

EXECUTIVE SUMMARY

The eastern ribbonsnake (*Thamnophis sauritus*) is a small, slender, semi-aquatic snake typically found in slow flowing wetlands with abundant aquatic and terrestrial vegetation. Like several other species in the province, eastern ribbonsnakes occur near the northern limit of their range in Nova Scotia and are isolated from the species' main range. Within the province, eastern ribbonsnakes appear to have a limited distribution in the southwest interior and are only known to occur in scattered wetlands of three watersheds. The isolation, restricted distribution, and apparently small population size have resulted in the listing of the Atlantic population as Threatened under both the federal *Species At Risk Act* (S.C. 2002, c.29) and the Nova Scotia *Endangered Species Act* (S.N.S. 1998, c.11).

Since the formation of the Recovery Team in 2003, a number of projects have endeavoured to fill knowledge gaps and encourage public involvement through outreach and stewardship initiatives. However, efforts to obtain long-term data have been hampered by the lack of reliable marking and tracking techniques. Despite the existing knowledge gaps, a number of potential threats have been identified in this strategy. To assess these threats and to identify the scale(s) at which recovery should be initiated,

more information is needed on the population structure, habitat requirements, life history traits, limiting factors, and range extent of eastern ribbonsnakes in Nova Scotia.

The Recovery Team has also identified critical habitat based on known currently occupied areas with at least one recent, confirmed ribbonsnake sighting. Critical habitat is evaluated at two scales, the *location* scale and the *site* scale, although critical habitat will be identified and described only at the *site* scale. *Sites* are situated within the larger *location* (e.g., the entire lake, fen or bog, or selected portions of a river or stream), and will encompass all wetlands found within the *location* as well as the terrestrial and aquatic zones that extend 100 m around each wetland. Due to uncertainties surrounding the current extent and distribution of ribbonsnakes, only a partial identification of critical habitat is possible at this time. Other critical habitats may be identified in the future following additional surveys and studies on ribbonsnake movements and habitat use.

At the present time, recovery of the population is considered feasible. The long-term recovery goal is to ensure a self-sustaining population with a 95% probability of persistence across its range. In the absence of a quantitative population recovery target, the Recovery Team has identified two intermediate goals: 1) gain a sufficient understanding of distribution, demography, population structure, and habitat associations in order to conduct a realistic assessment of population viability; and 2) maintain populations of eastern ribbonsnake at known locations. A number of recovery objectives have been set to achieve these goals; these objectives are described in this strategy along with a list of recommended actions. At this time, it is believed that the recovery approaches outlined will have a beneficial impact on non-target species, ecological processes, and the environment. Where habitats overlap, efforts will be made to coordinate the recovery actions aimed at other species at risk to avoid potential conflict and ensure that actions are mutually beneficial. One or more action plan for the eastern ribbonsnake will be developed by June 2011.

TABLE OF CONTENTS

1. BACKGROUND

1.1 Species assessment information from COSEWIC[1]

Common name (population): Eastern ribbonsnake (Atlantic population)

Scientific Name: *Thamnophis sauritus*

Status: Threatened

Last examination and change: 2002

Canadian occurrence: In Canada, the eastern ribbonsnake occurs in Ontario, Quebec and Nova Scotia. The Atlantic population occurs only in Nova Scotia.

Reasons for designation: This ribbonsnake population is a small, isolated postglacial relict confined to a small area in Nova Scotia. As such, it is unique and susceptible to demographic and environmental fluctuations. In addition, shoreline development poses a threat. (COSEWIC 2002)

Status history: Designated Threatened in May 2002. Assessment based on a new status report.

1.2 Name and classification

The eastern ribbonsnake (*Thamnophis sauritus*) has four recognized subspecies: the eastern or common ribbonsnake (*T. s. sauritus*), the peninsula ribbonsnake (*T.s. sackinii*), the blue-striped ribbonsnake (*T.s. nitae*) and the northern ribbonsnake (*T.s. septentrionalis*). Of these, only the northern ribbonsnake, occurs in Canada (Smith 2002). Throughout this document the species will be referred to as eastern ribbonsnake or simply ribbonsnake, and to avoid confusion, use of sub-specific names will be avoided. Throughout this strategy it will be explicitly stated if knowledge presented is specific to the Nova Scotia population or was obtained elsewhere in the species' range, as populations may exhibit local and regional adaptations and display differences in habitat use and behaviour that will affect species recovery.

[1] COSEWIC - Committee on the Status of Endangered Wildlife in Canada

1.3 Species description

The eastern ribbonsnake (*Thamnophis sauritus*) is a small, slender, semi-aquatic snake. Like all snakes in Nova Scotia, it is not poisonous and completely harmless to people. Total adult length for the species throughout its range varies from 46 cm to 86.2 cm (Smith 2002). In Nova Scotia, the recorded maximum length is 75.8 cm, but most are considerably smaller (NS ribbonsnake database). The tail is long, accounting for almost one third of the total length (Gilhen 1984).

Figure 1. Distinctive yellow stripes on a ribbonsnake in Nova Scotia.

Eastern ribbonsnakes can be recognized by the three bright yellow stripes that run along the length of their dark body: one on each side and one along the back (Figure 1). The side stripes occur on the third and fourth scale rows up from the ventral (belly) scales, which are creamy white. In Nova Scotia populations, a caramel-brown stripe separates the side stripes and the ventral scales (Gilhen 1984) (Figure 2). The head is small and slender, and there is a small vertical white line in front of the eye (Logier 1967).

Eastern ribbonsnakes can be confused with eastern garter snakes (*Thamnophis sirtalis*), which also have three stripes along their bodies. However, the side stripes on garter snakes occur on the second and third scale rows, and there is no caramel-brown stripe below them (Gilhen 1984). In Nova Scotia, garter snake stripes tend to be less distinct than those of ribbonsnakes. Additionally, garter snakes lack the vertical white line in front of the eye and are typically thicker bodied and larger than ribbonsnakes.

Figure 2. Ribbonsnake in Nova Scotia showing the caramel-brown stripe below the side stripe.

1.4 Distribution

1.4.1 Global and Canadian range

The eastern ribbonsnake occurs east of the Mississippi River from Florida to southern Canada (Rossman 1970). In Canada, the ribbonsnake occurs in southern Ontario, southwestern Quebec, and Nova Scotia (Smith 2002). Ribbonsnakes in Nova Scotia are isolated from the species' main range and have been listed separately by COSEWIC (2002) as the "Atlantic population."

Although the eastern ribbonsnake is considered globally secure (G5[2]; NatureServe 2006) and is not listed under the United

Figure 3. Global range of the eastern ribbonsnake (*Thamnophis sauritus*). Adapted from Smith 2002 and Conant and Collins 1991.

[2] Global ranking (G): Overall status of the species across its entire range
Sub-national ranking (S): Status of the species in the provinces or territories in which it occurs (S1- critically imperiled, S2 -imperiled, S3 –vulnerable).

States *Endangered Species Act*, it is listed at some level of risk in 10 of the 28 (2 S1, 3 S2, 5 S3[2]) states and districts in which it occurs (NatureServe 2006).

1.4.3 Nova Scotia range

The "Atlantic population" of ribbonsnakes appears to be limited to the southwestern interior of Nova Scotia (Figure 4). Confirmed sightings remain confined to three watersheds: the Mersey, Medway, and LaHave Rivers (NS ribbonsnake database). Within these watersheds, several individual concentrations of ribbonsnakes have been identified (Appendix 1); the extent of movement between these sites is currently unknown.

The eastern ribbonsnake belongs to a suite of species at risk in southwest Nova Scotia that are geographically separated from their main ranges. Many of these species, including the eastern ribbonsnake, are believed to be climatic relicts that became isolated in Nova Scotia at the end of a warmer period 5000 years ago (Smith 2002).

Isolated populations may be significant, particularly if they occur at the edge of the species' range, as is the case of the Nova Scotia ribbonsnake population, because they may have diverged genetically from populations in the main range and may display local adaptations (Lesica and Allendorf 1995). The degree of genetic variability of ribbonsnakes in Nova Scotia remains unknown. There is no signal pattern of genetic variation within other isolated populations in Nova Scotia. Some species have diverged significantly from the main range and maintain high levels of genetic variation (Mockford *et al.* 1999) while others show little variation within the Nova Scotia or between the province and the main range. (Cody 2002).

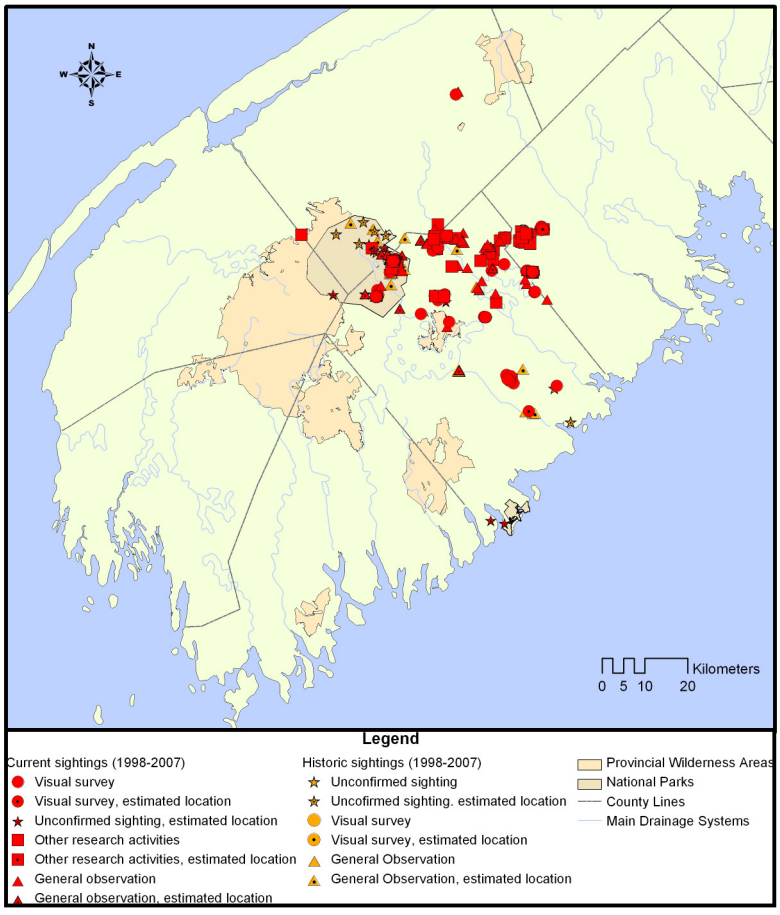

Figure 4: Currently known distribution of the eastern ribbonsnake in Nova Scotia.

1.5 Cultural significance of the Nova Scotia population

The known territory of the ribbonsnake in Nova Scotia is within the traditional territory of the local First Nation, the Mi'kmaq.

The Mi'kmaq call their traditional territory Mi'kma'ki, which encompasses what we now call Eastern Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and northern New England States, particularly Maine. The Mi'kmaq have lived upon these lands for millennia. The People lived a cyclical, semi-nomadic lifestyle, with seasonal migrations between the coast and inland camps.

The Mi'kmaq are known to be river people, having used rivers and streams as sources of transportation and encampment sites. Fishing weirs were built along rivers and were maintained trans-generationally. The People made camps along inland watersheds and used them as bases for hunting and fishing. The Mi'kmaq lived at the mercy of nature, learning the laws and characteristics of the surrounding ecosystems. This knowledge was passed from one generation to the next. Among many aspects of the natural world, information about eastern ribbonsnakes is held within the local Mi'kmaw communities.

Snakes have cultural significance for the Mi'kmaq. There are legends and dances pertaining to snakes as well as petroglyphs of snake beings. For these and other reasons, the Mi'kmaq are seen as important partners in the recovery of the eastern ribbonsnake.

1.6 Population size and trends

The size of the population of ribbonsnakes in Nova Scotia is not known, and data is lacking on abundance, distribution, and population trends. The current range appears to be limited to the southwest interior of the province, with confirmed sightings encompassing only three watersheds and approximately 2500 km^2 (Figure 4). While ribbonsnakes have been found at a number of locations within this range (Table 4), only a few sites are known to currently have high concentrations (Table 1). It is possible that these concentrations may be highly ephemeral and dependent on specific habitat conditions. Ribbonsnakes have apparently disappeared from one site (Colpton Pond), which in the 1980's contained the highest density of ribbonsnakes recorded in Nova Scotia (40+ snakes found in a single day). The habitat at this site has changed dramatically and the population may have either decreased and/or migrated to adjacent habitats. While ribbonsnakes are still known to occur in nearby habitats, such dense concentrations have not been recorded since.

The most reliable data on population size comes from a single site at Grafton Lake. While quantitative data are lacking, it is believed that ribbonsnakes at this site increased in numbers after the removal of a dam on the lake in the mid 1990's, which exposed the original lakeshore. A small area within this site has been the subject of an intensive mark-recapture study since 2004. Initial abundance calculations in 2004 estimated that there were approximately 100 individuals in the 4 ha study site (McNeil 2005). A reduction in the number of captures per unit effort in 2005 and 2006 suggests that this population may be declining; however, there is uncertainty in the reliability of these estimates. The marking technique (primarily scale clipping)

was not as permanent as hoped and was prone to identification errors. The habitat at this site is also changing rapidly as the shoreline vegetation regenerates following dam removal. This could affect both snake abundance and the detectability of ribbonsnakes within the habitat. In addition, the population within the study site is not closed and the rate of immigration from and emigration to adjacent habitats is not known. Furthermore, a three-year study period is too short a time to distinguish between real population trends and normal yearly fluctuations.

Table 1. Sites with 50 or more recent, confirmed sightings of ribbonsnakes in Nova Scotia (1997-2007).

Area	Total # of sightings	Sightings per total search effort	Year discovered	Other species at risk	Land ownership	Current habitat protection?	Research/ recovery efforts underway
Grafton Lake	1221	1098 sightings/ 2543.9 hrs	1955	Blanding's turtle	Federal crown (National Park)	Yes	Volunteer surveys; focus of intensive research
Cobrielle Brook	95	88 sightings/ 155.4 hrs	1998		Federal crown (National Park)	Yes	Surveys
Barren Meadow	65	41 sightings/ 125.2 hrs	2004	Blanding's turtle	Private and provincial crown	No	Surveys
Molega Lake /Hog Lake	231	194 sightings/ 323.7 hrs	1976	Redroot	Private (primarily cottage owners)	Partial (one land NSNT)	Nova Scotia Nature Trust; landowner contact; surveys
McGowan/ Deans Lake	82	46 sightings/ 117.7 hrs	1999	Blanding's turtle	Provincial crown; private (industry, individual landowners)	Provincial crown Integrated Resource Management Plan	Landowner contact; Surveys

1.7 Biological needs, ecological role, and limiting factors

1.7.1 Thermal biology

Ribbonsnakes must rely on heat from their surroundings to regulate their body temperatures. The need to maintain appropriate temperatures affects their behaviour and habitat use (Carpenter 1956, Rossman *et al.* 1996). Eastern ribbonsnakes in Michigan were found to be most active when their cloacal temperatures were between 20 and 30 degrees Celsius (Carpenter 1956). In cool weather, ribbonsnakes often bask in order to gain sufficient heat for movement and digestion (Carpenter 1952, Rossman *et al.* 1996). Because ribbonsnakes give birth to live young, maintaining appropriate temperatures may be particularly important to females while their young are developing (Charland and Gregory 1995, Rossman *et al.* 1996). In Nova Scotia, mean body temperatures of gravid female ribbonsnakes (i.e., those with developing young) implanted with temperature-sensitive radio transmitters during summer ranged from 25.3ºC to 31.98ºC (Bell

2003). Ribbonsnakes must also avoid overheating and may enter water, climb bushes, or take refuge under vegetation, rocks, or logs to cool off (Carpenter 1952, Carpenter 1956, Tinkle 1957). During the fall, ribbonsnakes move into their hibernacula, which must provide an environment that prevents both freezing and dehydration (Carpenter 1953, Costanzo 1989).

In Nova Scotia, ribbonsnakes occur near the northern limit of their range and may be constrained to the warmer southwest part of the province by temperature and climatic trends (Bleakney 1951).

1.7.2 Growth, maturity and reproduction

Ribbonsnakes are typically less than 25 cm in total length when born. Size and age at maturity in Nova Scotia are not known, but in Michigan, female eastern ribbonsnakes reach maturity in their second year of growth (Carpenter 1952) and most other species in the genus *Thamnophis* reach maturity during their second or third year of growth (Rossman *et al*. 1996). Reproductive frequency in Nova Scotia is also unknown. In general, female *Thamnophis* produce one clutch per year, although they may skip years, particularly in northern populations (Rossman *et al*. 1996). Carpenter (1952) found approximately 60 percent of the female ribbonsnakes in a Michigan population reproduced in a single year.

Mating has not been observed in Nova Scotia, although aggregations of adults observed in September suggest that mating may occur in fall. Spring mating has been reported in more southern populations of eastern ribbonsnake (Ernst and Barbour 1989).

Carpenter (1952) found that the greatest feeding in eastern ribbonsnakes in Michigan occurred from June through October, with feeding activity continuing until they move to their hibernacula (Carpenter 1952). In Nova Scotia, ribbonsnake with food bulges have been observed from April 9 to November 4. Most shed skins are found from June through September, suggesting that this is the period of greatest growth.

1.7.3 Ecological role

Throughout their range, adult ribbonsnakes feed primarily on amphibians and small fish (Bell *et al.,* 2007, Brown 1979, Carpenter 1952). Diet in young ribbonsnakes is largely unknown, although a small ribbonsnake in Nova Scotia regurgitated an earthworm on 21 May 2006 (NS ribbonsnake database, 2007). Additionally, in August 2006, a newborn ribbonsnake from the Nova Scotia population ate two earthworms while in captivity (Josie Todd, pers. comm.).

Although ribbonsnakes have many potential predators (e.g., raccoons, hawks, other snakes and fish), only one likely incident of predation has been documented in Nova Scotia. In spring 2007 a dead snake was found that appeared to have been preyed on by a bird (ribbonsnake database). Ribbonsnakes likely rely heavily on blending in with their environment (crypsis) and hiding under cover to avoid detection by predators (Scribner and Weatherhead 1995).

1.8 Habitat needs

1.8.1 General habitat

Ribbonsnakes are highly associated with wetlands, and most sightings in Nova Scotia occur within 5 m of water. They are typically found in slow flowing wetlands with abundant aquatic and terrestrial vegetation, including fens, along meadow streams, and in lake coves and shorelines. Many of these areas contain shallow pools and side channels. Ribbonsnakes have been found in a variety of vegetation, including sphagnum moss; grasses, sedges, and rushes; and emergent and shoreline shrubs. The occurrence and densities of ribbonsnakes in an area may be affected by disturbance regimes and stages of habitat succession, but the role of these factors is not yet understood. For instance, beaver activity occurs at many sites containing ribbonsnakes, and may play an important function in maintaining appropriate habitat.

The Recovery Team currently recognizes five important elements of life history for which habitat must be described: overwintering, basking, gestation and birthing, feeding, and mating. At this time, most knowledge of specific sites in Nova Scotia comes from the intensive study site at Grafton Lake (Table 2).

Table 2. Known ribbonsnake habitat in Nova Scotia.

Seasonal activity / (function)	Site description		Timing	Component of residence
	Grafton Lake intensive sites	Elsewhere		
Overwintering (allow survival through the winter)	• Suspected in the upper floodplain under ground in areas of fractured slate overlain with moss. Also suspected under a gravel walkway near the water's edge. Sites may be partially or fully submerged.	• Unknown	Oct. to Apr.	Yes
Basking (gain sufficient heat units for movement, digestion and gestation)	• Early spring/ late fall: Near suspected overwintering sites • Summer: Adjacent to feeding sites • Sunny locations associated with moss, matted sedge or grass clumps, rocks, logs, mudflats, and leaf litter	• Early spring / late fall: Unknown • Summer: Adjacent to feeding sites • Sunny locations similar to Grafton. Also includes sphagnum mats, mud flats, matted sedge or grass clumps, beaver lodges and dams, causeway	~Mar. to Nov.	Yes
Cover (avoid predators and prevent overheating)	• Includes moss, grasses and sedges, emergent vegetation, stumps, rock crevices	• Same as Grafton plus sphagnum mats, emergent and shoreline shrubs, hay bales	~Mar to Nov.	No
Feeding/ shedding	• Mostly near small pools and channels/shallows • Hunting has been observed in the main channel as well	• Snakes typically found near channels, streams and pools but feeding has not been documented. • Shed skins found near water on sphagnum mats and mud flats.	Apr. to Nov.	No
Gestation and birthing	• Birthing unknown • Gravid females found	• Gravid females found in hay pile and on causeway	Birth – Aug and Sept	Yes
Mating	• Unknown – concentrations of 10 adults in spike rush in mid-September suggest possible mating site	• Unknown – concentration of 43 snakes along road bank and sphagnum shore of pond in early September suggest possible mating site	Unknown	No

2. THREATS

2.1 Classification of known and potential threats

Like other aspects of ribbonsnake biology, threats are not well understood. Known and potential threats have been identified in Table 3 and ranked according to the level of concern in each category. The occurrence, frequency, certainty, and severity of most of these threats remain unknown and there may be additional threats to ribbonsnake populations that have not yet been identified.

Table 3. Classification of known and suspected threats to eastern ribbonsnake recovery in Nova Scotia.

General Threat	Specific Threat	Potential Stress	Extent	Occurrence	Frequency	Causal Certainty	Severity	Level of Concern
			Threat Information[+]					
A. THREAT CATEGORY: Changes in ecological dynamics or natural processes								
1. Lack of information	Inaction or inappropriate action (inability to recognize threats; delayed implementation of recovery actions; initiation of actions with unexpected detrimental effects)	↑ mortality; Degradation of habitat	WS	C	NA	H	U	H
2. Small, isolated population	Small population effects (inbreeding; genetic drift; increased susceptibility to stochastic events)	↑ mortality; ↓ fecundity	U	U	U	L	U	H
3. Cottage and residential development	Alteration of natural disturbance regimes and functional processes	Alteration of movement patterns; Alteration of genetic structure	U	U	U	L	U	M
B. THREAT CATEGORY: Habitat loss or degradation								
1. Dam construction or removal (human or beaver) *	Alteration of water level and seasonal water flow regimes; long-term cumulative habitat loss	Change in habitat availability; Winter mortality; Change in prey availability; Local extinction	L	C	U	L	U	H
2. Cottage and residential development	Habitat degradation, fragmentation, and loss; alteration of water level and seasonal water flow regimes; alteration of shorelines; long-term cumulative habitat loss	↓ Habitat availability; ↑ mortality; ↓ movement between concentrations; local extinction	WS	C	R	M	U	H
3. Road density and new road construction	Habitat fragmentation; long-term cumulative habitat loss	↑ mortality; isolation of concentrations;	WS	C	U	U	U	H
4. Climate change*	Alteration of water level and seasonal water flow regimes	Change in habitat availability	WS	A	C	L	U	M
5. Forest harvesting practices (i.e., clear cutting, harvesting in the	Alteration of water level and seasonal water flow; decrease in water quality; habitat degradation, fragmentation, and loss; long-term cumulative habitat loss; potential	↓ habitat availability; ↑ mortality; ↓ movement between	WS	C	U	L	U	M

General Threat	Specific Threat	Potential Stress	Extent	Occurrence	Frequency	Causal Certainty	Severity	Level of Concern
riparian zone, rotation times)	disruption of overwintering sites	concentrations						
6. Agricultural practices (i.e., tilling, crop production, cranberry growing)	Alteration of water level and seasonal water flow; decrease in water quality; habitat degradation, fragmentation, and loss; long-term cumulative habitat loss	↓ habitat availability; ↑ mortality; ↓ movement between concentrations	WS	U	U	L	U	M
7. Infilling/ draining wetlands	Habitat degradation, fragmentation, and loss; long-term cumulative habitat loss; loss of wetland function	↑ mortality; ↓ habitat availability; local extinction	L	C	M	M	H	H
8. Peat mining	Habitat degradation, fragmentation, and loss; long-term cumulative habitat loss	↑ mortality; ↓ habitat availability; local extinction	L	A	U	M	U	L
C. THREAT CATEGORY: Accidental mortality								
1. On and off road vehicles	Vehicular mortality; increased encounters with people	↑ mortality	WS	C	C	M	U	H
2. Cottage, residential and road development	Vehicular mortality; increased encounters with people; increased predation by pets	↑ mortality	WS	C	U	M	U	H
3. Agricultural and forestry equipment	Vehicular mortality	↑ mortality	L	C	U	L	U	L
D. THREAT CATEGORY: Disturbance and persecution								
1. Negative perception of snakes	Intentional killing by humans resulting from hatred or fear of snakes	↑ mortality	U	U	U	L	U	M
2. Cottage, residential and road development	Increased encounters with people, pets and machinery; disturbance to snakes and habitat features	↑ mortality; ↓ fecundity	WS	U	U	L	U	M
E. THREAT CATEGORY: Exotic or invasive species								
1. Exotic predatory fish	Introduction of small mouth bass and chain pickerel; changes to ecosystem function	↑ mortality; ↑ competition for prey; altered prey composition	U	C	U	L	U	H
F. THREAT CATEGORY: Climate change								
1. Climate change*	Shifts in seasonal temperatures (reduction of heat units for development of young; increased winter mortality); alteration of water level and seasonal water flow	Change in fecundity Change in prey availability Winter mortality*	WS	A	C	L	U	M
G. THREAT CATEGORY: Natural Processes or activities								
1. Human activities and development	Increase in natural predator populations	↑ mortality	U	U	U	L	U	L
H. THREAT CATEGORY: Pollution								
1. Pesticide use (i.e., landscaping,	Direct and long-term exposure	↑ mortality; ↓ prey	U	C	U	L	U	L

General Threat	Specific Threat	Potential Stress	Extent	Occurrence	Frequency	Causal Certainty	Severity	Level of Concern
crop and agricultural production, forestry)		availability; ↓ fecundity						
2. Air pollution	Accelerated effect of methylated mercury impacting the food chain	↑ mortality; ↓ prey availability	U	C	U	L	U	L

* These factors in particular could have a positive or negative effect on ribbonsnake populations.

\+ Extent: WS = widespread; L = localized; U= unknown
Occurrence: C = current; A = anticipated; U = unknown
Frequency: C= continuous; R = recurrent; U = unknown; NA = not applicable
Causal certainty: H = high; M = medium; L = low
Severity: U = unknown
Level of concern: H= high; M= medium; L=low

2.2 Description of "specific" threats

The following descriptions highlight the "specific" threats as outlined in Table 3, emphasizing key points and providing additional information on the threats. As there is little published literature outlining threats to ribbonsnakes, most information presented here deals with potential threats and effects, as assessed by the Recovery Team.

While the threats below and in the table are listed separately, an important concern is the long-term cumulative effect of a variety of threats on the ribbonsnake population. As human development increases, the overall impact of activities on the habitat becomes more serious at both the small and larger scales. At the landscape scale, incremental losses and multiple threats often complicate recovery efforts and confound understanding of population trends (Jensen *et al.* 1993).

2.2.1 Lack of information for decision making

The COSEWIC status report identified lack of information as the greatest current threat to ribbonsnake recovery (Smith 2002). Little is reported on eastern ribbonsnake ecology or threats anywhere in its range. What is reported elsewhere is not necessarily applicable to the Nova Scotia population. At this point, it is not known what factors limit ribbonsnakes in the province (geographically or demographically), how healthy the population is, or what level of population fluctuations are normal. This could prevent recovery managers from recognizing population decline or identifying significant threats. In fact, it is not known if the effect of many of the potential threats listed below will be positive or negative (especially water level and climate change). Lack of information could also result in the Recovery Team having to either delay recovery actions because of uncertainty of potential detrimental effects, or risk initiating actions that may have unanticipated negative effect(s).

2.2.2 Small population effects

The Nova Scotia ribbonsnake population is geographically isolated from the species' main range, which prevents any possibility of in-migration or a natural rescue effect. Although the full extent of the range within Nova Scotia remains unknown, it does appear to be restricted to a small number of watersheds in the southwest region of the province. This places the snakes at risk of small population effects such as inbreeding and genetic drift, and increases the population's susceptibility to stochastic events. These risks are further exacerbated if the Nova Scotia population actually consists of numerous isolated sub-populations with little or no movement between them.

2.2.3 Changes to water level and seasonal water flow

Changes to water level and seasonal water flow are anticipated to be among the most significant threats to ribbonsnake habitat. Hydrological changes can result from many activities, including installing or removing human-made dams, removing beaver dams, forestry, agriculture, infilling of wetlands, altering shorelines and climate change. Even a small change in flooding regimes could result in vegetation succession in previously wet meadows, or in preventing vegetation from establishing. While these changes to the terrestrial and aquatic habitat could affect all aspects of ribbonsnake life history, the impacts on feeding and overwintering sites are of particular concern.

Effects from either stabilizing or destabilizing water levels could be positive or negative for ribbonsnakes. We do not yet have sufficient understanding to be able to predict the type or scale of impact resulting from particular activities. Two of the sites containing the highest known densities in the province (Grafton Lake and Cobrielle Brook) have had human-made dams removed within the last decade. The destabilizing impact of natural beaver dam cycles may also be important for the local ribbonsnake population.

2.2.4 Habitat degradation, fragmentation, and loss

Habitat degradation, fragmentation, and loss can occur from many activities, including cottage and residential development, road construction, agriculture and forestry practices, and infilling wetlands. Cottage development is of particular concern as it could result in alteration of shorelines, destruction of habitat, and fragmentation. Expansion of the road network could also result in fragmentation as well as direct mortality from vehicles and increased encounters with people and pets. In turn, fragmentation could result in isolation of individual concentrations or increased risk to individuals as they travel between concentrations.

Changes to water quality (e.g., pollution, eutrophication, siltation) may also pose a threat to ribbonsnakes, particularly those that affect prey abundance. Based on limited data, adult ribbonsnakes in Nova Scotia appear to prey primarily on amphibians and small fish (Bell *et al.* 2007, NS ribbonsnake database 2007); the diet of neonate ribbonsnakes, however, is largely unknown. The extent to which prey availability limits population numbers, as well as the degree of dependence of ribbonsnakes on specific prey items, are also still unknown.

2.2.5 Vehicular mortality

Vehicular mortality is one of the few direct sources of mortality that has been documented in Nova Scotia. This includes mortality from both automobiles and all terrain vehicles. It could also include farm or forestry equipment and lawn mowers, although these are probably a lesser threat at the present time. Vehicular mortality may be particularly significant if snakes must cross roads to travel between overwintering and summering sites, or if they are drawn to roads to bask. Since 2004, nine incidences of vehicular mortality have been recorded in Nova Scotia (8 on roads, 1 on an ATV trail). Most of these reports have been incidental and not the result of targeted road surveys, so the true incidence of vehicular mortality may be considerably higher. This is particularly disturbing given the relatively low volume of traffic in the area. As development increases, vehicular mortality is also expected to increase.

2.2.6 Introduction of exotic predatory fish

The introduction of exotic predatory fish into areas containing ribbonsnakes is of particular concern. As a result of introductions, the ranges of both smallmouth bass and chain pickerel have been expanding in Nova Scotia, including the southwestern region of the province. These species can alter trophic dynamics, which could negatively impact ribbonsnakes through either direct predation or competition. Predatory fish have been shown to dramatically reduce populations of small fish and affect amphibian abundance (Vander Zanden *et al.* 2004, Jackson 2002). Both of these exotic fish species are more tolerant of higher water temperatures than many of the native fish, thus increasing their potential effect on ribbonsnake prey populations (Vander Zanden *et al.* 2004).

2.2.7 Shifts in seasonal temperatures associated with climate change

Climate change will undoubtedly affect ribbonsnakes in Nova Scotia, and the impact may vary according to the different aspects of their life history. It is not known whether the overall effect on ribbonsnake populations will be positive, negative, or neutral. In addition to affecting water level, prey abundance, and habitat as described above, climate change may also directly impact ribbonsnake physiology. Ribbonsnakes in Nova Scotia occur near the northern limit of the species range (Bleakney 1951). Each year they spend 5-6 months in overwintering sites and have only 6-7 active months to feed and reproduce. While it might appear that an increase in annual temperatures will benefit this southern species, this may not necessarily be the case. Changes in seasonal temperature and precipitation conditions may affect growth and development of young, particularly if it results in cooler, wetter weather during the active season.

Winterkill can be a significant source of mortality for other species of *Thamnophis* (Shine and Mason 2004). The significance of winterkill has not been documented in ribbonsnakes, although one dead eastern ribbonsnake was found at the top of a hibernaculum in Michigan (Carpenter 1953). Snakes are at risk of freezing and dehydration over the winter and may be dependent on specific conditions inside the hibernacula. Altered winter climates may directly impact the severity of winterkill.

2.2.8 Increased predation associated with human activities

Snakes are at risk of predation from both natural predators and domestic pets. Predation by domestic pets has been documented in Nova Scotia (one documented cat kill and several other anecdotal reports) and is expected to increase as cottage, residential, and road development increase. Natural predators and predation rates remain unknown and until these are determined, it is difficult to identify potential anthropogenic effects on these predators and their subsequent effect on snake predation.

2.2.9 Intentional killing and disturbance resulting from increased encounters between humans and snakes

Many people fear or dislike snakes and some people will kill any that they see, particularly if the snakes are found near or in their homes. While intentional killing has been a significant threat in other snake species at risk (Eastern Massasauga Recovery Team 2002), and may be the cause of death of one ribbonsnake found with extensive wounds in Nova Scotia in 2007, it is believed that the overall risk is relatively low for Nova Scotia ribbonsnakes at present. People rarely venture into wetlands where ribbonsnakes are typically found, and even when they do, these snakes are cryptic and difficult to catch. Because ribbonsnakes are strongly associated with wetlands, they are not as commonly encountered on lawns or in houses as some other species in Nova Scotia. However, with increasing development near wetlands, encounters by people will become more common and the threat may increase. It is not known how effective education will be in mitigating this threat.

3. ACTIONS ALREADY COMPLETED OR UNDERWAY

In 2003, the Eastern Ribbonsnake Recovery Team was formed, and several of the recovery actions outlined in the strategy have been underway since that time. Work to date has focused primarily on filling knowledge gaps and encouraging public involvement with the species through outreach and stewardship initiatives.

Extensive surveys to expand knowledge of the range of ribbonsnakes in Nova Scotia have been underway since 2004. The majority of surveys to date have been limited to the Mersey and Medway watersheds, focusing on sites with historical or reported sightings; large areas of potential habitat, particularly to the west of the known range, remain largely unexplored. These surveys have expanded the known range in the province to a third watershed (LaHave) and have confirmed a number of new sites within the known range. They have also resulted in the confirmation of relatively high densities (>20 sightings) at five sites (Table 1). Data on area searched, date, effort, and weather conditions are collected during each survey to refine survey protocols for greater efficiency. In coordination and collaboration with the Blanding's Turtle Recovery Team, many of the wetlands previously surveyed for the presence of ribbonsnakes have been characterized; the data will ultimately be used to try to develop models that may help predict where ribbonsnakes occur.

Researchers have been conducting intensive mark-recapture surveys in a defined area on Grafton Lake since 2004 to identify seasonal habitat use and to begin collecting long-term data on abundance, survivorship, and individual site fidelity. While researchers have been able to document some seasonal movement patterns and identify feeding areas and potential overwintering areas, efforts to date have been hampered by a lack of a reliable long-term marking technique, especially for young snakes, and a method to track snakes. Since 2004, snakes at this site have been marked by ventral scale clipping; however, using the current techniques, these marks often wear off within a single season. Beginning in 2006, some snakes were marked by PIT tagging; long-term success of this technique will be assessed in the coming years, although initial findings from 2007 reveal high rates of PIT tag loss. A study was initiated in 2007 to radio track adult females by externally attaching small radio transmitters; however, attempts to attach transmitters were largely unsuccessful, with transmitters only remaining on the snake up to four days. Fluorescent powder was also used to track ribbonsnakes in 2007 and was found to be useful in examining microhabitat use. Comparable studies at Molega Lake were also initiated in 2007.

No genetic analysis had been published on eastern ribbonsnakes anywhere in their range prior to 2004, when Harwood (2005) initiated a study to develop microsatellite primers and to conduct an initial analysis of population structure in Nova Scotia. No genetic structure was found in the initial analysis; however, both sample sizes (n=44) and number of loci (n=2) evaluated were small, and Harwood (2005) recommended the continued collection of DNA samples and the development of additional primers. The collection of DNA samples has been incorporated into the standard procedure for all extensive ribbonsnakes surveys and the number of samples collected has substantially increased since 2005. A second genetic study was initiated in 2007 to examine population structure based on the increased sample size (McLaughlin, in progress).

The Recovery Team has been engaging in outreach and in soliciting sightings from the public since 2004. A ribbonsnake pamphlet was developed and distributed to various nature and outdoor organizations in southwestern Nova Scotia. People have also been informed and engaged through a variety of other methods, including direct landowner contact, displays at community events, presentations at local schools and community groups, field trips, interpretive programs (KNPNHS), and media presentations. In addition, a toll-free reporting hotline has been set up at the Mersey Tobeatic Research Institute to provide a single number that people can call to report all sightings of species at risk. These efforts have already produced a number of credible sightings, mostly within the known range. Since 2004, volunteers have also participated in ribbonsnake surveys at Grafton Lake. This process was expanded beginning in 2006, when regular surveys led by Parks Canada Interpreters both informed Park visitors and allowed them to participate in meaningful research. Further expansion of outreach and public involvement occurred in 2007 with the creation of websites and the use of various online networking tools to reach new audiences and encourage greater volunteer participation, the development of a Species At Risk identification guides and business cards, and the pilot testing of “Steward Kits” designed to facilitate data collection by independent volunteers.

A best practices guide, designed to inform landowners and land users of ways to minimize the impacts of their activities on ribbonsnakes, Blanding's turtles, and Atlantic Coastal Plain Flora, is currently under development. The recovery teams of these species are collaborating on the development and distribution of this guide. It is hoped that this guide will help alleviate fears about critical habitat designation and result in concrete benefits to wetland species at risk in Nova Scotia.

4. KNOWLEDGE GAPS

Currently, there are knowledge gaps on all aspects of the life history of ribbonsnakes, including demography and current population trends, historical status, habitat requirements at specific life stages, and severity of threats. At the present time, the three most important questions are as follows:

1) What is the current status of the Nova Scotia population of ribbonsnakes?

We need to identify the current range of the population and the spatial distribution within that range. We do not know at what spatial scale genetic structure is evident, if snakes from neighbouring sites interact with one another, and what factors constrain movements between concentrations of ribbonsnakes. If individual concentrations are isolated, we need to determine if it is historical or the result of recent anthropogenic events. We also lack crucial information on basic life history traits such as abundance, survivorship and longevity required to determine population if populations are increasing, decreasing or table. We currently do not understand if high density concentrations are short-lived.

2) What are the critical features of the habitat, and are they limiting?

We do not currently know why ribbonsnakes occur in some wetlands and not in others and we have not yet identified a suit of habitat features that would predict which habitats are suitable for ribbonsnakes We need to understand the how habitat disturbance, connectivity and long-term habitat trends affect persistence of ribbonsnake populations.

Much remains unknown about overwintering. We need to know where ribbonsnakes of all life stages spend the winter, identify the important characteristics of those sites, determine if sites are used communally or singly and if fidelity is shown to specific sites. We do not know if overwintering mortality is a significant threat to the population and have not identified how factors, such as water level fluctuations, affect winter survival. We also do not know if ribbonsnakes have specific requirements for other activity sites, (including feeding basking, mating and gestation/birthing), if there are particular characteristics of these sites, if sites are used repeatedly over time, or if snakes aggregate at certain sites. We do not understand the relationship between ribbonsnakes and their prey, if there are temporal shifts in prey and feeding locations throughout the season and how significant side pools are as feeding sites.

3) What are the threats limiting the recovery of this population?

We need to understand which threats are the most significant and identify the appropriate scale to manage these threats. We do not know how changes in water level, habitat fragmentation, development or climate will affect populations or why the range is limited in the province. We need to know if individual concentrations are currently experiencing deleterious effects from small population size (inbreeding, genetic drift, reduced fitness). Answering these questions requires basic information on all life stages including basic demography (longevity, stage specific survivorship, population trends, predator and prey relationships), habitat use (sites used for specific life stages, large scale range, habitat characteristics, current movement patterns), and genetic structure (assessment of population structure, evaluation of inbreeding depression, estimate of genetic variation, identification of past events that may have influenced patterns seen today).

5. CRITICAL HABITAT

5.1 Rationale for partial critical habitat designation

Critical habitat is defined in the *Species at Risk Act* (S.C. 2002, c.29) as "…the habitat that is necessary for the survival or recovery of a listed wildlife species and that is identified as the species' critical habitat in the recovery strategy or in an action plan for the species" (s. 2(1)). Describing critical habitat for the eastern ribbonsnake is challenging since little is known about the distribution, population trends, densities or habitat requirements in Nova Scotia. Additionally, the detectability of ribbonsnakes is low and may be influenced by season, weather, and habitat conditions. This may confound the interpretation of visual survey results; ribbonsnakes present in significant numbers in an area could be missed by occasional surveys. Despite fairly high search effort over the last several years (>4000 person hours over 40+ waterbodies), only five sites with a high density of ribbonsnake sightings (>50 sightings) have been identified. For most of the remaining areas there are less than ten sightings per waterbody (Table 6). There are many possible interpretations for this observed distribution pattern, including: 1) snake densities may fluctuate greatly over time at all sites; 2) snakes may exist in high densities in these areas but were not seen due to little or no search effort, effort in the wrong place, effort under sub-optimal conditions (weather, season), or lower detectability due to the habitat; 3) snakes may naturally exist in low densities in these habitats; 4) snakes may be declining at these sites due to unidentified threats.

Despite the challenges, the Ribbonsnake Recovery Team believes there is sufficient information to partially describe critical habitat for the species based on an occupancy approach and the precautionary principle. Although little is known about ribbonsnakes in Nova Scotia, their occurrence has been confirmed at a number of locations on three watersheds in the province (Table 4). Location points are based on historic sightings (1950-1997), current unconfirmed sighting reports (1998-2007), current general observations (1998-2007), sightings from snake specific search efforts (2004-2007), and sightings incidental to Blanding's turtle research (1999-2007). The majority of the sightings, particularly those resulting from snake specific search effort and Blanding's turtle research, can be pinpointed to specific locations (within 50 m or less). Only the

general locality is known for some sightings, particularly the unconfirmed reports and historical sightings.

Critical habitat designation will be based on known currently occupied waterbodies (within the last 10 years). Because ribbonsnakes are difficult to locate, the Recovery Team feels that a single recent, confirmed sighting is enough to suggest that a concentration of ribbonsnakes likely exists at that location.

5.2 Identification of critical habitat

Critical habitat will encompass all wetlands falling within an identified *location* as well as terrestrial and aquatic zone that extend 100 m around each wetland. The *location* is the geographical place where ribbonsnakes occur (e.g., the entire lake, fen or bog, or selected portions of a river or stream). Although *locations* in their entirety are not identified as critical habitat, they are both functional ecological units and recognized political units; identifying these *locations* will facilitate management and recovery. All wetlands within the *location* will be included in critical habitat designation based on the precautionary principle and the reasonable inference that ribbonsnakes, if found in one wetland, are also likely to be found in nearby wetlands.

In this strategy, wetlands are defined according to the accepted legal definition in the Nova Scotia *Environment Act* (S.N.S. 1994-95, c. 1) which states that "'wetland' means land commonly referred to as a marsh, swamp, fen or bog that either periodically or permanently has a water table at, near or above the land's surface or that is saturated with water, and sustains aquatic processes as indicated by the presence of poorly drained soils, hydrophytic vegetation and biological activities adapted to wet conditions" (s. 3(bg)). At this time, it is not feasible to identify key habitat requirements beyond the broad definition of wetland; ribbonsnakes have been found in a variety of wetland types and very little is currently known about their ecology. Some of the more typical wetland habitats in which ribbonsnakes have been found are described in Section 1.8 above, and include, but are not limited to, slow flowing water, abundant aquatic and terrestrial vegetation, and the presence of shallow pools and side channels.

The zone extending 100 m out from the edges of the wetlands is included as part of the critical habitat to incorporate adjacent habitat use by ribbonsnakes. This zone allows the incorporation of difficult to define wetland edges, seasonal flooding zones, vernal pools, beaver channels, and other areas that may not fit into the traditional definition of wetlands but do, on occasion, provide seasonal habitat for ribbonsnakes. It also recognizes occasional use of terrestrial habitats by ribbonsnakes. Ribbonsnakes have been recorded up to 104 m inland from the edge of the wetland (ribbonsnake database). Several recent upland sightings in late spring and early fall have suggested that snakes may use upland habitats either as hibernacula or as travel corridors between summer sites and hibernacula. This 100 m zone is also consistent with the critical habitat definition for Blanding's turtles, simplifying critical habitat designation in wetlands where the two species' distributions overlap.

5.2.1 Guidelines for delineating critical habitat

To identify critical habitat, each *location* was first mapped, using the guidelines in Table 4. Maps show the approximate boundaries of the *location*, the search effort to date, and all ribbonsnake sightings (as of 2007). A summary of locations is presented in Table 5.

Table 4. Guidelines for mapping ribbonsnake *locations.*

Mapping guidelines
Only include locations with current confirmed sightings occurring near a waterbody: • Sightings were considered confirmed if reported by a knowledgeable observer (e.g., researcher, park interpreter, experienced volunteer) or if supporting evidence was provided (e.g., photograph, specimen). • Current sightings are those that occurred within the last ten years (1998-2007). • Sightings >100m from a waterbody were not incorporated at this time due to lack of knowledge of upland habitat requirements. • *Locations* with only unconfirmed reports and/or historical sightings were added to the list of priority sites for future surveys (Appendix 1). Additional critical habitat will be identified in the future as sightings are confirmed (Section 5.3).
Use official Nova Scotia place names to identify locations: • *Locations* will be identified using official Nova Scotia Place Names, as documented in the Nova Scotia Atlas, and the description will include the 'NS Atlas Square Reference' (Province of Nova Scotia, 2001). • In instances where a *location* does not have an official place name, the name used by the Recovery Team will be noted in Table 1 along with UTM (NAD 83) coordinates (Table 4). • In places where two or more named waterbodies form a single functional ecological unit, it will be considered as one *location*, but both official names will be included in the *location* description (e.g., McGowan-Deans Lake).
Lake locations include the entire lake: • For sightings that occur on a lake, the entire lake will be included as the *location*. This will also include all wetlands on the lake, including those along stream inlets and outlets that are within 100 m of the lake.
River or stream locations include only the occupied portion of the river/stream: • For sightings occurring on a stream or river, the *location* will be named separately from the associated lake. • The *location* will include the extent of the sightings along the brook/stream or river as well as an additional 200 m linear area downstream and upstream of the outermost sightings. • Where portions of adjacent wetlands occur within the extent of the sightings and the 200 m zones downstream or upstream, the entire wetland will be included in the *location.* This definition uses the precautionary principle, and is justified by field observations of individual snakes moving up to a maximum of 391 m along waterways (Imlay, in progress).

C*ritical habitat* was then identified based on existing wetland spatial GIS data provided by the Nova Scotia Department of Natural Resources (Figures 5 and 6). The recovery team recognizes that this dataset does not necessarily contain all wetlands that fall within the above wetland definition (e.g. vernal pools, treed bogs and other small wetlands may not by identified as such on the existing spatial data) and that the extent of wetlands varies seasonally. In this context, these maps were prepared as general guidelines for landowners to enable them to identify large areas of critical habitat on or near their properties. Current ribbonsnake sightings within a *location* that did not fall within a wetland polygon in the spatial dataset, are indicated with a 200m buffer.

All maps will be retained by the Ribbonsnake Recovery Team and used to guide management and recovery actions.

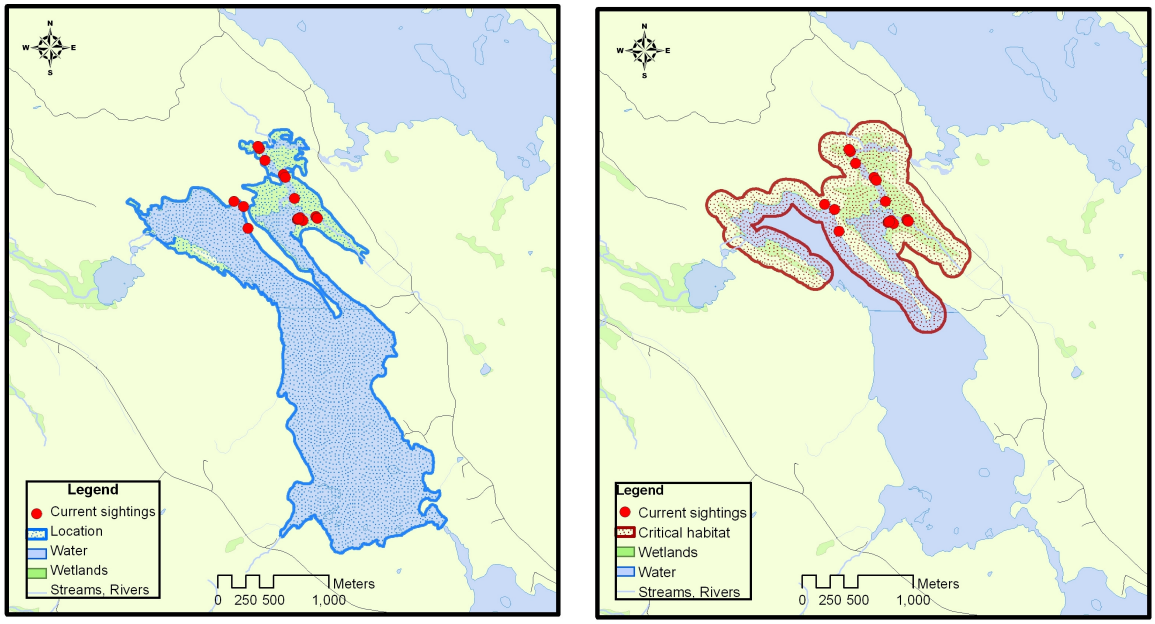

Figure 5. Example of critical habitat identification on a lake*. The left map shows the outline of the *location*, which includes the entire waterbody. The right map shows the identified critical habitat. Critical habitat includes all wetlands that fall within the outlined location and a 100 m zone around each wetland.

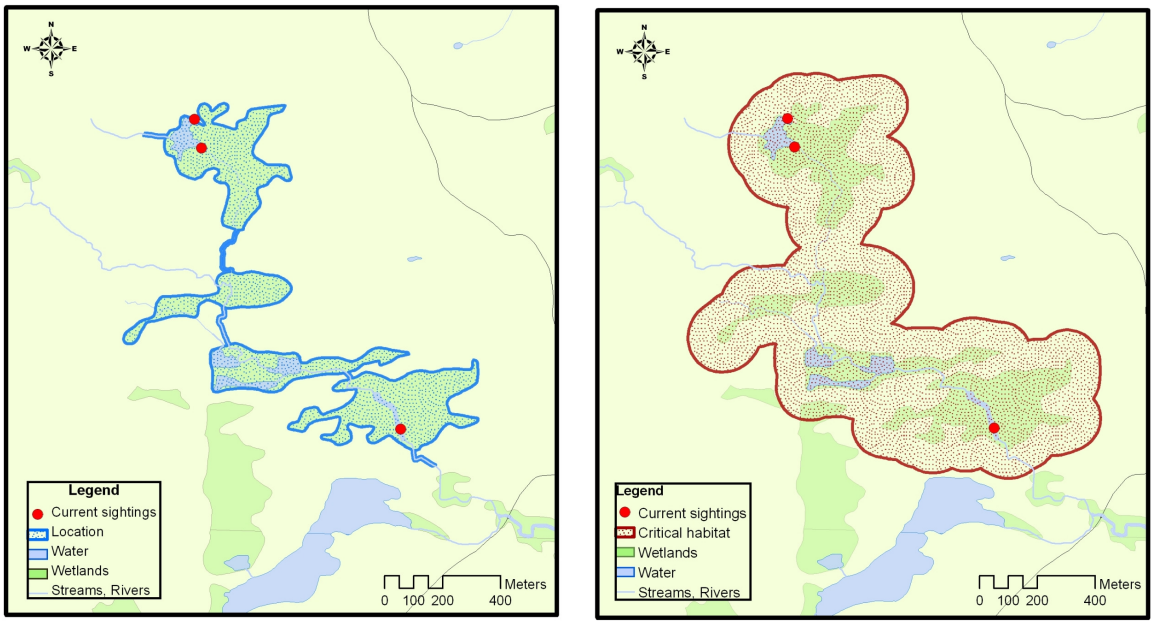

Figure 6. Example of critical habitat identification along a stream*. The left map shows the outline of the *location*, which includes the extent of the brook and associated wetlands 200m upstream and downstream of the outermost sightings. The right map shows the identified critical habitat. Critical habitat includes all wetlands that fall within the outlined location and a 100 m zone around each wetland.

*These maps are included is for illustration purposes only and are not official critical habitat designations for gazetting.

Table 5. List of locations with current, confirmed ribbonsnake sightings. All sightings are listed with official Nova Scotia place names (Province of Nova Scotia 2001), unless otherwise indicated with an asterisk.

Location	Water-shed	County	Map book square	Current (1998-2007)			Historical (< 1998)			Total sightings	Land ownership
				Survey effort (person/ hrs)	Sightings from survey effort	Other sightings	Survey effort (person/ hrs)**	Sightings from survey effort	Other sightings		
Barren Meadow Brook	Medway	Lunenburg	73W2	125.2	41	24	N/A	0	0	65	Provincial / Private
Beaver Brook	Medway	Queens	73V3	0.0	0	1	N/A	0	0	1	Private
Beavertail Lake	Medway	Queens	73X4	11.7	2	0	N/A	0	0	2	Private
Bradley Lake	Medway	Queens	72Z4	5.8	1	0	N/A	0	0	1	Private
Bull Moose Brook	Medway	Queens	73V2	12.6	0	1	N/A	0	0	1	Provincial / Private
Cameron Lake	Medway	Queens	73V4	4.7	0	2	UNK	0	2	4	Private / Provincial
Charlotte Lake	Medway	Queens	72Z3	0.0	0	1	N/A	0	0	1	Private/ Provincial
Cobrielle Brook	Mersey	Queens	72X4	154.5	88	7	N/A	0	0	95	Federal
Cobrielle Lake	Mersey	Queens	72X4	5.8	*2*	0	N/A	0	0	*2*	Federal
Deep Brook	Medway	Queens	73W2	44.7	2	4	N/A	0	0	6	Private
East Lake	Medway	Annapolis	55Z1	4.3	1	2	N/A	0	0	3	Private/ Provincial
Eighteen Mile Brook	Medway	Queens	73V5	28.5	8	0	N/A	0	0	8	Private/ Provincial
Faulkenham Brook	Medway	Queens	73V3	0.0	0	1	N/A	0	0	1	Private
Fox Lake	Medway	Lunenburg	73X2	0.0	0	3	N/A	0	0	3	Provincial/ Private
Grafton Brook	Mersey	Queens	72X3	9.1	6	9	UNK	0	8	23	Federal
Grafton Lake	Mersey	Queens	72Y3	2543.9	1098	72	UNK	0	51	1221	Federal
Harmony Lake	Medway	Queens	72Y3	3.1	2	0	N/A	0	1	3	Private/ Provincial
Hen Lake	Medway	Queens	72Z2	0.0	0	2	N/A	0	0	2	Private
Herring Cove Lake	Mersey	Queens	79X3	11.6	1	0	N/A	0	1*	2	Private

Location	Water-shed	County	Map book square	Current (1998-2007)			Historical (< 1998)			Total sightings	Land ownership
				Survey effort (person/ hrs)	Sightings from survey effort	Other sightings	Survey effort (person/ hrs)**	Sightings from survey effort	Other sightings		
Hog Lake Lake * (UTM 347356 4918566)	Medway	Queens	73V2	15.7	9	1	N/A	0	0	10	Provincial
Hog Lake offshoot* (UTM 348117 4917065)	Medway	Queens	73V3	3.0	0	1	N/A	0	0	1	Private
Horseshoe Lake	Mersey	Annapolis / Digby	72V2	0.0	0	1	N/A	0	0	1	Private/ Provincial
Joe Tom Brook	Medway	Queens	72Z2	3.3	4	2	N/A	0	0	6	Provincial
Keddy Brook	Medway	Lunenburg	73W2	1.3	1	4	N/A	0	0	5	Provincial / Private
Kejimkujik Lake-George Lake	Mersey	Annapolis. /Queens	72X3	18.3	1	15	N/A	0	12	28	Federal
Lake Rossignol	Mersey	Queens	78Y2	32.7	1	1	N/A	0	5	7	Provincial / Private / First Nations
Little Kempton Lake	Mersey	Queens	72Y3	3.3	0	5	N/A	0	2	7	Federal
Little Rocky Lake	Medway	Queens	72Z5	0.0	0	1	N/A	0	0	1	Provincial / Private
Long Lake	Medway	Lunenburg	73X4	0.0	0	1	N/A	0	0	1	Private/ Provincial
Lower Great Brook	Mersey	Queens	79W3	36.8	3	2	N/A	0	0	5	Private
Mary Lake	Medway	Queens	72Z3	3.9	0	1	UNK	0	1	2	Private/ Provincial
McBride Brook	Medway	Queens	72Z4	24.4	2	1	N/A	0	0	3	Provincial/ Private
McGowan Lake / Deans Lake	Medway	Annapolis / Queens	72Z2	117.4	46	35	N/A	0	0	95	Provincial/ Private
McGuire Lake	Medway	Queens	72Z4	1.0	0	1	N/A	0	0	1	Provincial/ Private
McKay's Pond * (UTM 354700 4923630)	Medway	Lunenburg	73W2	0.0	0	2	N/A	0	0	2	Private
Medway River (upstream of Ponhook Lake)	Medway	Queens	73V4	0.0	0	1	N/A	0	0	1	Private

Location	Water-shed	County	Map book square	Current (1998-2007)			Historical (< 1998)			Total sightings	Land ownership
				Survey effort (person/ hrs)	Sightings from survey effort	Other sightings	Survey effort (person/ hrs)**	Sightings from survey effort	Other sightings		
Mersey River (upstream of Lake Rossignol)	Mersey	Queens	72Y5	0.0	0	1	N/A	0	0	1	Provincial/ Private
Mersey River (at Big Guzzle Island)	Mersey	Queens	79W4	26.5	1	0	N/A	0	3	4	Private
Moccasin Lake Brook	Medway	Queens	72Z5	0.0	0	1	N/A	0	0	1	Provincial/ Private
Molega Lake - Hog Lake	Medway	Queens	73W3	323.7	194	24	UNK	0	13	231	Private / Provincial / First Nations
North Brookfield Pond (UTM 346195 4919955)	Medway	Queens	73V2	1.7	0	2	N/A	0	0	2	Private
North Cranberry Lake	Mersey	Queens	72X4	0.0	0	1	N/A	0	0	1	Federal
Peskowesk Lake	Mersey	Annapolis. /Queens	72W4	13.0	0	3	N/A	0	0	3	Federal
Ponhook Lake	Medway	Queens	73W4	0.0	0	2	N/A	0	0	2	Private/ Provincial
Schroder's Swamp* (UTM 335284 4925305)	Medway	Annapolis	72Z1	0.3	0	1	N/A	0	0	1	Provincial
Seven Mile Lake	Lahave	Lunenburg	73X2	91.0	14	3	N/A	0	0	17	Private/ Provincial
Shinglemill Brook	Medway	Queens	73W2	21.3	0	2	N/A	0	0	2	Private
Snake Lake	Mersey	Queens	72X3	25.2	2	0	UNK	0	9	11	Federal
Sweeney Brook - McGinty Bog	Mersey	Queens	72Y3	0.0	0	2	N/A	0	3	5	Federal
Ten Mile Lake - Little Ten Mile Lake	Mersey	Queens	79W2	42.4	7	0	N/A	0	0	7	Private/ Provincial
Tupper Lake	Medway	Queens	73V2	0*	0	9	N/A	0	0	9	Private
Westfield Bog* (UTM 339469 4921991)	Medway	Queens	72Z2	1.7	0	4	N/A	0	0	4	Private

Location	Water-shed	County	Map book square	Current (1998-2007)			Historical (< 1998)			Total sightings	Land ownership
				Survey effort (person/ hrs)	Sightings from survey effort	Other sightings	Survey effort (person/ hrs)**	Sightings from survey effort	Other sightings		

** Does not have an official NS place name. For reference, a UTM of the location is given in NAD 83 Zone 20 N datum.*
*** UNK - there may have been historical effort but it was not recorded; all sightings were reported as "other sightings".*
N/A - there is not believed to have been any historical effort.

5.3 Schedule of studies to identify critical habitat

At this time, only a partial designation of critical habitat is possible; more information about the basic biology, distribution, movement patterns, and habitat requirements of ribbonsnakes at all life stages is necessary for a full designation. In particular, this recovery strategy does not incorporate habitat over 100m away from wetlands that may be used by ribbonsnakes and could be important in maintaining connections between sites. A number of priority sites have been identified for future surveys to confirm the presence of ribbonsnakes (Appendix 1). Critical habitat designation will be reviewed on a regular basis as more information becomes available. A schedule of studies for identifying further critical habitats is listed in Table 6.

Table 6. Schedule of studies to identify further critical habitat for the eastern ribbonsnake, *Thamnophis sauritus*, Atlantic population.

Study to be undertaken	Recovery Objective	Timeline
Determine appropriate survey protocols to increase confidence in presence/absence decisions.	Objective 2	2014
Survey priority sites outlined in Appendix 1 to confirm the presence of ribbonsnakes.	Objective 3	2014
Survey additional sites within and beyond the currently known range to determine the distribution of ribbonsnakes.	Objective 3	Ongoing
Determine location and habitat characteristics of overwintering sites.	Objective 4	Ongoing
Determine location and habitat characteristics of gestation and birthing sites.	Objective 4	Ongoing
Identify and describe specific critical habitat features at the wetland scale to predict occurrence of ribbonsnakes.	Objective 4	2014
Determine extent of overland movements.	Objective 3	Ongoing
Examine the connectedness between concentration sites.	Objective 3	Ongoing
Determine the population genetic structure to refine the spatial scale at which critical is identified and described.	Objective 3	Ongoing
Assess population abundance and trends to determine a quantitative population target for rationalizing critical habitat designation.	Objective 3	Ongoing

5.4 Examples of activities likely to result in destruction of critical habitat

The *Species at Risk Act* (S.C. 2002, c. 29) contains prohibitions against the destruction of critical habitat on federal lands (s. 58(1)). Destruction, in this context, is currently defined as "any alteration to the topography, geology, soil conditions, vegetation, chemical composition of air/water, surface or groundwater hydrology, micro-climate, or sound environment of such a magnitude, intensity, or duration which significantly reduces the capacity of the critical habitat to contribute to the survival or recovery of the species at risk" (Environment Canada 2004). Any

activity that may result in the destruction of critical habitat as described above must therefore be managed, mitigated, or prohibited to ensure the continued protection of critical habitat.

Activities may have impacts on critical habitat at the *site* scale, *location* scale, or both. It is important to identify the scale(s) at which various activities may have an impact to ensure the protection of critical habitat. Activities that may result in the destruction of critical habitat include, but are not limited to, the examples listed in Table 7.

Table 7. Examples of activities likely to result in the destruction of the critical habitat for the eastern ribbonsnake, along with the scale at which these activities may impact critical habitat.

Activities	Impact Scale	
	Entire location	Critical habitat
Road and trail development	✓	✓
Causeway development	✓	✓
Off-highway vehicle use		✓
Cottage and residential development		✓
Shoreline alterations, including mowing and raking, construction of breakwaters	✓	✓
Draining and infilling of wetlands or other direct removal of vegetation	✓	✓
Hydroelectric dam operations that impact shoreline and wetland vegetation	✓	✓
Crop and animal production resulting in alteration of water quality or the hydrologic regime	✓	✓
Forest harvesting practices resulting in alteration of water quality or the hydrologic regime	✓	✓
Industrial development resulting in alteration of water quality or the hydrologic regime	✓	✓
Extensive trapping of beavers or removal of beaver dams that result in significant changes in the hydrological regime.	✓	✓
Peat mining		✓
Use of pesticides	✓	✓

5.5 Existing and recommended approaches to habitat protection

5.5.1 Critical habitat protection on federal lands

Critical habitats for the eastern ribbonsnake on federal lands occur specifically in Kejimkujik National Park and National Historic Site of Canada (KNPNHS). The eastern ribbonsnake and its critical habitat are protected under the *Canada National Parks Act* (S.C. 2000, c.32) and the *Species at Risk Act* (S.C. 2002, c.29). Parks Canada is the federal authority responsible for ensuring the continued survival and existence of this species. Given that Kejimkujik is both a national park and a national historic site, critical habitat protection will be achieved by fully integrating both commemorative and ecological integrity objectives. The following conditions will be applied to activities involving the eastern ribbonsnake:

- Every effort will be made to consider activities and solutions that enhance both ecological and commemorative integrity objectives;
- All reasonable alternatives to the activity that would reduce the impact on the eastern ribbonsnake are considered and the best solution is adopted;
- All feasible measures are taken to minimize the impact of the activity on the eastern ribbonsnake; and
- The activity does not jeopardize the survival or recovery of the species.

5.5.2 Critical habitat protection on provincial and private lands

Legal protection for critical habitats located outside KNPNHS may be provided by a number of provincial legislation that apply to provincial Crown land, or, in some cases, private lands:

- *Endangered Species Act* (S.N.S. 1998, c. 11) – provides protection for listed threatened and endangered species, their dwelling places, and core habitats in NS (s.13(1)).
- *Wildlife Act* (R.S.N.S. 1989, c. 504) – regulates activities related to wildlife and conservation (s. 6), and allows for the creation of wildlife sanctuaries, management areas, and parks (ss. 14 – 16).
- *Provincial Parks Act* (R.S.N.S. 1989, c. 367), *Wilderness Areas Protection Act* (S.N.S. 1998, c. 27), and *Special Places Protection Act* (R.S.N.S. 1989, c. 438) – protects habitats through creation and management of parks, wilderness areas, and special places.
- *Environment Act* (S.N.S. 1994-95, c. 1) – includes the preservation and prevention of loss of biodiversity as part of its purpose (s. 2(b)(i)), specifies the requirements for the environmental assessment process (ss. 31-41), and prohibits the alteration and release of substances into water courses and wetlands (s. 105(3)(a)).
- *Environmental Goals and Sustainable Prosperity Act* (S.N.S. 2007, c. 7) – commits the provincial government to protecting 12% of provincial land mass by 2015 (s. 4(2)).
- *Crown Lands Act* (R.S.N.S. 1989, c. 114) – protects the integrity of water-supply watersheds, wildlife habitats, special places, and ecological reserves (s. 25(2)).
- *Forests Act* (R.S.N.S. 1989, c. 179) – ensures that wildlife conservation requirements and ecological impacts of forestry practices are considered (s. 8(1)(b)) and that wildlife and wildlife habitats and forest ecosystem diversity are managed (s. 10).
- *Conservation Easements Act* (S.N.S. 2001, c. 28) – sets out the regulations governing conservation easements, which, among other reasons, may be made for the purpose of protecting, restoring or enhancing land that constitutes the habitat of rare, threatened, or endangered plant or animal species (s. 4(c)(i)).

Critical habitat protection can also be achieved through a variety of non-legislative means. For instance, protection of critical habitats can be incorporated into the provincial Integrated Resource Management (IRM) planning process (Department of Natural Resources, Province of Nova Scotia 2007). The IRM coordinates resource use by assigning provincial Crown lands into one of three land use categories; designation as C2 or C3 lands provides for the restriction of activities to ensure protection of habitats. Similarly, critical habitats may also be protected at the municipal level by incorporating species at risk habitat considerations into municipal land use planning and permitting. Direct purchase of lands by individuals, governments or other organizations is also an effective means of protecting critical habitats

Stewardship is an important component of critical habitat protection and can take a variety of forms. Stewardship can be performed by individual landowners or community groups wishing to maintain and protect critical habitats on their properties or in surrounding areas, special interest groups concerned with monitoring or managing particular species or locations, or corporations willing to set aside portions of their land as protected areas and to alter their practices to minimize their impact on critical habitats. The flexibility in the format and manner in which it can occur makes stewardship an effective approach to protecting critical habitats. Encouraging stewardship through awareness and education initiatives, the development of a guide for living with species at risk, and various grants and subsidies for habitat protection can contribute greatly to the protection of critical habitats.

6. RECOVERY

6.1 Feasibility of species recovery

At this time, recovery of the eastern ribbonsnake in Nova Scotia is considered to be feasible according to the criteria outlined in the Policy on the Feasibility of Recovery (Government of Canada 2005). The population contains individuals capable of reproduction, and the Recovery Team feels that sufficient habitat is available or can be made available through habitat management or restoration. The severity of threats, best methods to avoid or mitigate those threats, and effectiveness of recovery techniques are unknown road blocks to recovery. Limited knowledge prevents significant analysis of recovery feasibility. Feasibility will be re-examined when further knowledge of distribution, abundance, population genetic structure, and habitat associations is gained.

6.2 Recovery goals

The long-term recovery goal is to: *ensure a self-sustaining population of eastern ribbonsnakes with a 95% probability of persistence across its current range*.

A self-sustaining population is necessary for the full recovery of any species; however, at this time, the stability and size of the ribbonsnake population in Nova Scotia is unknown. The distribution in Nova Scotia is already limited and the species would likely be further jeopardized by loss of range. The current lack of knowledge of present and historical status prevents any quantitative assessment to determine a precise recovery target. Consequently, the Recovery Team has identified two intermediate goals, over the next 5-10 years that are designed to prevent the species from declining and to acquire the knowledge necessary to determine appropriate recovery targets.

The intermediate goals are to:

1. *gain a sufficient understanding of distribution, demography, population structure, and habitat associations to conduct a realistic assessment of population viability; and*
2. *maintain populations of eastern ribbonsnake at known locations.*

6.3 Recovery objectives

The following are recovery objectives for the eastern ribbonsnake that the Recovery Team will begin to address over the next five years. Specific steps to achieve these objectives are identified in Table 7, and the rationale for each is outlined in the narrative following the table.

1. Achieve conservation of currently known critical habitats and new habitats as they are identified through stewardship, land acquisition, and protection measures.
2. Overcome challenges in conducting research on this small, cryptic species to gain a better understanding of population dynamics and habitat use.
3. Determine the extent of the range in Nova Scotia and the population structure, abundance, and trends within that range in order to identify the appropriate scales for recovery.
4. Identify critical habitat features used for each life stage and activity, and determine if they are limiting.
5. Identify population threats and evaluate their significance.
6. Develop long-term monitoring protocols and techniques to evaluate the success of recovery actions.

6.4 Actions recommended to meet recovery objectives

6.4.1 Recovery planning

The goals and objectives can be addressed through four broad, interrelated strategies: Communication and Stewardship, Research, Habitat Protection, and Monitoring. These broad strategies provide a framework for the development of species recovery actions, help participants identify their role in the recovery process, and can increase efficiency and cost-effectiveness of recovery actions. Table 7 provides a summary, organized according to the six recovery objectives, of the recommended actions required to meet the objectives and address threats. Section 6.4.2 provides the rationale for each recovery action outlined in Table 8.

Table 8. Recovery planning table for the eastern ribbonsnake (*Thamnophis sauritus*) in Nova Scotia.

Recommended action to meet objective	Priority	Broad strategy	Threats addressed	Outcomes	Timeline
Objective 1. Achieve conservation of currently known critical habitats and new habitats as they are identified through stewardship, land acquisition, and protection measures.					
1.1 Continue public education campaign. • Target approach to people who will be living or working on the land. • Improve species at risk awareness in schools and promote inclusion in the curriculum.	U	C	• Negative perception of snakes	• Informed public • Promotion of activities that minimize impact to snakes and their habitat	Ongoing
1.2 Support Mi'kmaw participation in all aspects of ribbonsnake recovery. • Continue to assist with the facilitation of Mi'kmaq-organized cultural events that celebrate the ribbonsnake.	U	C, R	• Negative perception of snakes • Lack of information	• Meaningful participation of local Mi'kmaq • Increased public awareness • Promotion of activities that minimize impact to snakes and their habitat	Ongoing
1.3 Continue to develop volunteer opportunities and promote public involvement in research and recovery.	U	C, R	• Lack of information • Negative perception of snakes	• Network of knowledgeable stewards dedicated to ribbonsnake recovery	Ongoing
1.4 Work with landowners, industry, recreational groups, and developers to minimize impact on snakes and their habitat. • Continue to participate in the development and distribution of a Best Practices guide. • Work directly with stakeholders to minimize impacts at specific sites.	U	C, P	• Habitat degradation and fragmentation • Changes to water level and seasonal water flow • Vehicular mortality	• Promotion of activities that minimize impact to snakes and their habitat • Discourage activities that negatively impact snakes and their habitat	Ongoing
1.5 Continue to develop and error-proof a central database for all ribbonsnake information in Nova Scotia to provide high quality information and maps to recovery planners.	U	C, R	• Lack of information	• Database available for identifying and planning recovery actions and for identifying knowledge gaps	Ongoing
1.6 Continue to work with other recovery teams and organizations to prevent overlap. • Coordinate stewardship activities. • Identify and protect priority sites containing more than one species at risk.	U	C, P	• Habitat degradation and fragmentation	• Network of organizations that work toward species at risk recovery in SW Nova Scotia • Focused resources on high priority sites	Ongoing
1.7 Collaborate with private landowners, industry, and government to formally protect habitat and develop management plans. • Work with landowners to protect habitat at high priority ribbonsnake sites through formal and informal agreements. • Identify additional critical habitat (see Table 5 for steps to identify critical habitat). • Consult with landowners and industry to develop site-specific management plans for critical habitat as it is delineated.	N	C, P	• Habitat degradation and fragmentation • Changes to water level and seasonal water flow	• Habitat protected • Critical habitat delineated and management plans developed • Fears of property owners alleviated	Ongoing

Recommended action to meet objective	Priority	Broad strategy	Threats addressed	Outcomes	Timeline
Objective 2. Overcome challenges in conducting research on this small, cryptic species to permit better understanding of population dynamics and habitat use.					
2.1 Identify the best technique to mark individuals that is permanent, minimizes risk to snakes, and reduces identification error. • Continue assessment of PIT tags as a permanent marking technique and refine protocols for inserting PIT tags. • Investigate alternative technology to mark snakes, especially neonates.	U	R	• Lack of information	• Ability to assess abundance, estimate age survivorship, and document individual movements	2009-2014
2.2 Refine visual survey techniques and evaluate the influence of habitat structure, weather, season, and search effort on detectability. • Conduct analysis to determine the amount of effort needed to reliably determine if ribbonsnakes are present in an area and under what conditions to maximize search efficiency. • Develop protocols to ensure sufficient effort is put into searching new areas for the presence of ribbonsnakes. • Evaluate the effect of detectability on population estimates.	U	R	• Lack of information	• More accurate population estimates • Refined search protocol that maximizes efficiency	2009-2014
2.3 Explore alternative means of capturing snakes. • Explore the potential of artificial cover (e.g., boards, tarps, sheet metal, landscape fabric) in attracting snakes. • Investigate the use of drift fences, particularly around known or suspected hibernacula, to monitor population and locate new individuals. • Contact other scientists working on small, cryptic herpetofauna to discover what techniques have been successful.	N	R	• Lack of information	• Improved ability to assess an area for the presence of snakes • Development of efficient, standardized techniques that can be incorporated into the volunteer program	2009-2014
2.4 Explore technology to track individuals to allow us to assess movement and habitat use. • Investigate the potential of using harmonic radar to locate snakes • Explore other low invasive technological means to track snakes. • Continue to explore the most efficient ways to observe snakes and document behaviour.	N	R	• Lack of information	• Ability to document movement patterns and habitat use • Identification of critical habitat	2009-2014
Objective 3. Determine the extent of the range in Nova Scotia and identify population structure, abundance, and trends within that range in order to identify the appropriate scales and priorities for recovery.					
3.1 Conduct surveys and solicit public sightings to determine the extent of the range in Nova Scotia. • Continue to solicit sightings from the public and follow up credible sightings with systematic surveys • Conduct systematic surveys of priority sites (Appendix 1) and around the periphery of the known range. • Solicit and train volunteers in the region to help conduct surveys.	U	C, S	• Lack of information • Negative perception of snakes	• Determination of the extent of the range • Identification of new concentrations of ribbonsnakes • Development of a network of trained, local volunteers dedicated to ribbonsnake recovery	Ongoing

Recommended action to meet objective	Priority	Broad strategy	Threats addressed	Outcomes	Timeline
• Investigate local and aboriginal knowledge to determine the availability of information on current or historical range.					
3.2 Design and implement a Mi'kmaw knowledge acquisition project. • Work with the Mi'kmaw community to develop a culturally appropriate Mi'kmaw knowledge acquisition project and submit to the Mi'kmaw Ethics Board for approval. • Work with a Mi'kmaw researcher to acquire and interpret appropriate results that would benefit ribbonsnake recovery.	U	C, R	• Lack of information	• More diverse information relating to ribbonsnakes gained	2009-2014
3.3 Identify the spatial scale of population genetic structure. • Continue to collect genetic samples from known sites throughout the range to obtain a sufficient sample size. • Continue to develop primers for a suite of microsatellite loci for the eastern ribbonsnake. • Conduct genetic analysis to determine population structure. • If overwintering concentrations are found, conduct genetic analysis to determine if they play a role in genetic structure.	U	R	• Lack of information • Small population effects	• Assessment of population genetic structure and identification of the appropriate scale for management	Ongoing
3.4 Evaluate current movement patterns and identify travel routes between concentration sites. • Conduct surveys around the perimeter of intensively surveyed sites and in adjacent habitats to explore how far individual snakes move. • Estimate home ranges based on mark-recapture studies.	U	R	• Lack of information • Habitat degradation and fragmentation	• Assessment of movement between sites and the effect of habitat configuration on that movement • Identification of travel routes to be used in critical habitat designation	2009-2014
3.5 Evaluate abundance and population trends. • Continue to mark and re-capture snakes at specific study sites to acquire a sufficient dataset to determine abundance, survivorship, longevity, and growth.	N	R,M	• Lack of information • Small population effects	• Estimates of population abundance and trends • Collection of data necessary for development of PVA	Ongoing
Objective 4. Identify critical habitat features used for each life stage and activity, and determine if they are limiting.					
4.1 Locate and characterize habitat features used for each life stage and activity. • Locate and characterize overwintering sites. • Locate feeding sites and identify prey and timing of feeding. • Locate other sites used for specific activities (e.g. mating, birthing).	U	R	• Lack of information	• Identification of sites to be used in critical habitat designation • Identification of important characteristics of these sites and assessment of how limiting they are	Ongoing
4.2 Characterize habitat used at the wetland scale and develop models to predict occurrence and identify critical habitat features.	B	R	• Lack of information	• Assessment of potentially limiting features at the wetland scale that could explain the current distribution • Development of models to refine the search for additional concentrations	2012-2014
4.3 Document the response of ribbonsnakes to dam removal in KNPNHS (if applicable).	B	R	• Lack of information • Dam construction or removal	• Assessment of the effect of dam removal on snake distribution and abundance	As applicable

Recommended action to meet objective	Priority	Broad strategy	Threats addressed	Outcomes	Timeline
Objective 5. Identify population threats and evaluate their significance.					
5.1 Document current development in and around critical habitats and evaluate its effect on the species.	U	R	• Lack of information	• Assessment of threats and development of a strategy to address those threats	Ongoing
5.2 Evaluate susceptibility to inbreeding	N	R	• Small population effects	• Assessment of the current genetic variability in local concentrations	2009-2014
5.3 Assess the attitude of people toward snakes.	B	R	• Negative perception of snakes	• Assessment of level of intentional killing of snakes • Development of best techniques to approach landowners and encourage participation in snake recovery	2009-2014
5.4 Collaborate with DFO, NS DNR, and other fisheries and research agencies to monitor exotic fish and assess their impact. • Collaborate with the Mersey Tobeatic Research Institute's current campaign to inform the public about the dangers of introducing these fish.	N	R	• Exotic predatory fish	• Development of a system to monitor watersheds containing ribbonsnakes for the presence of exotic fish • Assessment of potential impact of these fish on prey abundance and composition	Ongoing
5.5 Conduct Population Viability Analysis (long-term objective).	B	R	• Lack of information	• Assessment of the current health of the population	>2014
Objective 6. Develop long-term monitoring protocols and techniques to evaluate the success of recovery actions.					
6.1 Develop and implement protocols for long-term monitoring of populations and their habitats. • Identify the appropriate temporal and spatial scales for monitoring populations and their habitats. • Monitor populations over the long-term to assess changes in abundance in relation to changes in habitat and/or threats. • Monitor sites over time to document changes in habitat, water level, and climate. • Model potential impact of water level, water temperature, and climate change (long-term objective).	U	M	• Lack of information • Climate change • Changes to water level and seasonal water flow	• Development of efficient protocols that allow long-term monitoring of populations and their habitats • Allow for assessment of how population trends vary with changes in habitat, water level, and climate • Potentially, assessment of threats that are not immediately apparent from short-term studies	Ongoing
6.2 Evaluate the success of educational initiatives in affecting knowledge and attitudes; develop a protocol outlining the best methods to approach landowners.	B	M	• Negative perception of snakes	• Development of best techniques to approach landowners and encourage participation in snake recovery	2009-2014
6.3 Evaluate recovery actions as they are undertaken.	N	M	• Lack of information	• Assessment of the effect of recovery actions	Ongoing

Broad strategy: C =communication and stewardship; R=research; P = habitat protection; M=monitoring
Priority: U = urgent; N= necessary; B= beneficial

6.4.2 Rationale to support recovery planning table

The ribbonsnake recovery team has developed rationale to support the recovery planning table (The eastern ribbonsnake recovery team, 2008). A copy of this document is available from the recovery team.

6.5 Evaluation

Recovery efforts must be evaluated to assess their success. Preliminary performance measures are outlined in Table 9. Additional evaluation tools will be identified in future action plans.

Table 9. Recovery objective performance measures

Objective	Performance measures
1. Achieve conservation of currently known significant habitats and new important habitats as they are identified through stewardship, land acquisition, and protection measures.	• Increased public awareness of ribbonsnakes and the threats in the known range (*Action 1.1*) • Increased collaboration and involvement of local Mi'kmaq communities on recovery initiatives (*Action 1.2*) • Increased involvement of landowners and other volunteers in recovery activities, including active participation in hands-on science and recovery projects (*Actions 1.4, 1.5*) • Integrated resource management plan developed for Barren Meadow area by 2011 (*Action 1.5*) • Record of cottage owners contacted and mitigation measures suggested and implemented by 2014 (*Action 1.5*) • Central database developed and error-proofed on an annual basis(*Action 1.6*) • Priority sites containing multiple species at risk identified; collaborative plan developed by 2012 (*Action 1.7*) • Increased number of sites under formal habitat protection (*Action 1.8*) • No net loss of known habitats (*Action 1.8*) • One or more site-specific management plans developed by 2014(*Action 1.8*)
2. Overcome challenges in conducting research on this small, cryptic species to permit better understanding of population dynamics and habitat use.	• Standard protocols for effectively locating, capturing, marking, and tracking ribbonsnakes developed and integrated into recovery programs by 2014(*Actions 2.1, 2.2, 2.3, 2.4*) • The effect of detectability on visual survey results analyzed by 2014 (*Action 2.2*) • Formal evaluation of alternative techniques to capture ribbonsnakes by 2014(*Action 2.3*) • Formal evaluation of the technology used to assess movement patterns and habitat use by 2014 (*Action 2.4*)
3. Determine the extent of the range in Nova Scotia and identify population structure, abundance, and trends within that range in order to identify the appropriate scales for recovery.	• Increased knowledge of the extent of ribbonsnake range in Nova Scotia and the connectedness between concentration sites within that range (*Action 3.1, 3.2, 3.3*) • Mi'kmaw knowledge acquisition protocol designed and approved (*Action 3.2*) • Increased awareness of traditional knowledge of ribbonsnakes and their habitat (*Action 3.2*) • Report written on areas surveyed and newly identified ribbonsnake concentrations by 2014 (*Action 3.1, 3.3*) • Appropriate management scales identified (*Action 3.1, 3.2, 3.3*) • Abundance assessed at select study sites (*Action 3.4*) • Collection of long-term demography data commenced at 3 or more sites to allow future assessment of the effectiveness of recovery activities (*Action 3.4*) • Assessment of movement patterns, travel routes, and population genetic structure used in additional critical habitat identification (Action 3.1, 3.2, 3.3)

Objective	Performance measures
4. Identify critical habitat features used for each life stage and activity and determine if they are limiting.	• Overwintering, feeding, and other activity sites identified and characterized (*Action 4.1*) • Long-term habitat, water level, and climate monitoring protocols identified and initiated (*Action 4.2, 4.4*) • Models developed to predict occurrence and identify critical habitat features (*Action 4.3*) • Response of ribbonsnakes to dam removal documented (*Action 4.5*; *dependent on dam removal schedule in KNPNHS*)
5. Identify population threats and evaluate their significance.	• Formal evaluation of threats and potential management strategies to mitigate those threats by 2014(*Action 5.2*) • Susceptibility to inbreeding evaluated by 2014 (*Action 5.3*) • Assessment of public attitudes toward snakes by 2014 (*Action 5.5*) • Data collected toward eventual PVA and habitat models by 2014 (*Action 5.1, 5.4*) • Exotic fish monitoring protocol developed and implemented by 2014 (*Action 5.6*)
6. Develop long-term monitoring protocols and techniques to evaluate the success of recovery actions.	• Success of education initiatives evaluated (*Action 6.1*) • Success of recovery activities evaluated (*Action 6.2*) • Protocols developed and initiated for long-term monitoring of populations and their habitats (*Action 6.3*)

6.6 Effects on other species

Overall, it is anticipated that the approaches outlined in this recovery strategy will have a beneficial impact on non-target species (other species at risk and those not at risk), ecological processes, and the environment.

Management is likely to include protection of wetland habitat. This has the potential to benefit many wetland species, including some that are at risk. In Nova Scotia, the distribution and habitats of ribbonsnakes overlap considerably with that of the Endangered Blanding's turtle (COSEWIC 2005). There are also a number of Atlantic Coastal Plain Flora species at risk that occur in similar wetlands. There are examples, such as the red root, where the habitats of Atlantic Coastal Plain Flora species overlap with those of eastern ribbonsnakes. Where other species at risk coexist with ribbonsnakes, recovery and conservation initiatives outlined in this strategy will be coordinated with other recovery teams. This will help to avoid potential conflicts with other recovery actions planned or underway. It will also ensure that actions are mutually beneficial and not detrimental to other species at risk.

Stewardship actions, educational programs and awareness initiatives with landowners and the general public, all levels of government, industry, and other audiences, will lead to increased understanding, appreciation of, and concrete action towards the conservation of wetlands and the recovery of species at risk in general. In particular, the development of a best practices guide for landowners with species at risk on their property will help encourage stewardship of species at risk on private lands and inform landowners of ways to minimize their impacts on these species.

6.7 Statement on action plans

One or more action plans will be developed by Jun, 2011. Some activities detailed in the recovery planning table (Table 7) will be undertaken concurrently with the creation of the action plan.

REFERENCES CITED

Accord for the Protection of Species at Risk. 1996.

Bell, S. 2003. Ecology of northern ribbon snake, *Thamnophis sauritus septentrionalis*, in Kejimkujik National Park, Nova Scotia. BScH Thesis. Dalhousie University, Halifax, NS.

Bell, S., T. Herman, R. Wassersug. 2007. Ecology of *Thamnophis sauritus* (Eastern Ribbon Snake) at the Northern Limit of its Range. Northeast Naturalist. 297-292.

Bleakney, J.S. 1951. A new snake record for Nova Scotia. The Canadian-Field Naturalist 65: 118-119.

Brown, W.S., W.S. Parker. 1976. A ventral scale clipping system for permanently marking snakes (Reptilia, Serpentes). Journal of Herpetology 10:247-249.

Brown, E.E. 1979. Stray food records from New York and Michigan snakes. The American Midland Naturalist 102:200-203.

Carpenter, C.C. 1952. Comparative ecology of the Common gartersnake (*Thamnophis s. sirtalis*), the Ribbonsnake (*Thamnophis s. sauritus*) and Butler's gartersnakes (*Thamnophis butleri*) in mixed populations. Ecological Monographs 22:235-258.

Carpenter, C.C. 1953. A study of hibernacula and hibernating associations of snakes and amphibians in Michigan. Ecology 34:74-80.

Carpenter, C.C. 1956. Body temperatures of three species of *Thamnophis*. Ecology 37:732-735.

Charland, M. B., P.T. Gregory. 1995. Movements and habitat use in gravid and non-gravid female garter snakes (Colubridae, Thamnophis). Canadian Journal of Zoology 236:543-561.

Cody, N. 2002. Genetic variation of the thread-leaf sundew in Nova Scotia. Honours Thesis. Acadia University, Wolfville, NS.

Conant, R., J.T. Collins. 1991. Reptiles and Amphibians: Eastern and Central North America (3rd edition). New York: Houghton Mifflin Company. 450 pgs.

COSEWIC. 2002. COSEWIC assessment and status report on the eastern ribbonsnake *Thamnophis sauritus.* Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 24 pp.

COSEWIC 2005. COSEWIC assessment and update status report on the Blanding's Turtle Emydoidea blandingii in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. viii + 40 pp. (www.sararegistry.gc.ca/status/status_e.cfm).\

Costanzo, J.P. 1989. Effects of humidity, temperature, and submergence behavior on survivorship and energy use in hibernating garter snakes *Thamnophis sirtalis*. Canadian Journal of Zoology 67:2486-2492

Department of Natural Resources, Province of Nova Scotia. 2007. Integrated Resource Management. Department of Natural Resources, Nova Scotia. Available http://www.gov.ns.ca/natr/irm/default.htm. (Accessed: Feb 14, 2008)

Eastern Massasauga Recovery Team. 2002. National Massasauga Recovery Strategy – February 2003.

Engelstoft, C., K. Ovaska, N. Honkanen. 1999. The harmonic direction finder: a new method for tracking movements of small snakes. Herpetological Review 30:84-87.

Environment Canada. 2004. Federal Policy Discussion Paper: Critical Habitat. Species at Risk Recovery Program, Environment Canada.

Ernst, C.H., R.W. Barbour. 1989. Snakes of Eastern North America. Fairfax, Virginia: George Mason University Press. 282 pp.

Gilhen, J. 1984. The Amphibians and Reptiles of Nova Scotia. Halifax, Nova Scotia: Nova Scotia Museum of Natural History.

Government of Canada. 2005. Policy on the feasibility of recovery. Draft document, April 15, 2005.

Harwood, B.N. 2005. Microsatellite primers for studying structure of the Eastern ribbonsnake (*Thamnophis sauritus*): a species at risk in Nova Scotia. BScH Thesis. Acadia University, Wolfville, NS.

Imlay, T. In progress. Examining ecology at multi-scales: implications for Eastern Ribbonsnake (Thamnophis sauritus) recovery in Nova Scotia. MSc Thesis. Acadia University, Wolfville, NS.

Jackson, D.A. 2002. Ecological effects of *Micropterus* introductions: the dark side of black bass. American Fisheries Society Symposium, 31:221-232.

Jensen, D.B., M.S. Torn, J. Harte. 1993. In Our Own Hands: A Strategy for Conserving California's Biological Diversity. Berkeley: University of California Press. http://ark.cdlib.org/ark:/13030/ft6k4007vz.

Langkilde, T., R.A. Alford. 2002. The tail wags the frog: harmonic radar transponders affect movement behaviour in *Litoria lesueuri*. Journal of Herpetology 36:711-715.

Lesica, P., F.W. Allendorf. 1995. When are peripheral populations valuable for conservation? Conservation Biology 9:753-760.

Logier, E.B.S. 1967. The snakes of Ontario. Royal Ontario Museum of Zoology, Handbook No. 4. Toronto, Ontario: University of Toronto Press. 63 pp.

MacCartney, J.M., K.W. Larsen, P.T. Gregory. 1989. Body temperatures and movements of hibernating snakes *Crotalus* and *Thamnophis* and thermal gradients of natural hibernacula. Canadian Journal of Zoology 67:108-114.

McLaughlin, C. In progress. Microsatellite analysis of population structure in the eastern ribbonsnake, *Thamnophis sauritus*. BScH Thesis. Acadia University, Wolfville, NS.

McNeil, J. 2002. Distribution, movements, morphology and reproduction in a population of Blanding's turtle (*Emydoidea blandingii*) in an unprotected landscape in southwestern Nova Scotia. MSc Thesis. Acadia University, Wolfville, NS.

McNeil, J. 2005. Seasonal ranging characteristics of the eastern ribbonsnake at Grafton Lake, Kejimkujik National Park and National Historic Site of Canada. Report to Parks Canada. 10 pp.

Mockford, S.W., M. Snyder, T.B. Herman. 1999. A preliminary examination of genetic variation in a peripheral population of Blanding's Turtle, *Emydoidea blandingii*. Molecular Ecology 8: 323-327.

Nature Serve. 2006. An Online Encyclopedia of Life [web application]. Version 6.1. NatureServe, Arlington, Virginia. Available http://www.natureserve.org/explorer. (Accessed: May 15, 2007)

Northwest Marine Technology. 2007. Visible Implant Elastomer Tags (VIE). Northwest Marine Technology, Shaw Island, Washington. Available http://www.nmt.us/products/vie/vie.htm. (Accessed: Jan 26, 2008)

Nova Scotia Endangered Species Act S.N.S. 1998, c. 11. List amended 2003.

Nova Scotia ribbonsnake database. 2007. Eastern ribbonsnake recovery team. (Accessed: December 31, 2007).

Province of Nova Scotia. 2001. The Nova Scotia Atlas, 5th Edition. Formac Publishing Company and the Province of Nova Scotia. Halifax, Nova Scotia.

Reinert, H.K., D. Cundall. 1982. An improved surgical implantation method for radio-tracking snakes. Copeia 1982:702-705.

Rossman, D.A. 1970. *Thamnophis sauritus*. IN Catalogue of American amphibians and reptiles: 99.

Rossman, D. A., N.B. Ford, R.A. Siegel. 1996. The Garter Snakes: Evolution and Ecology. Norman, Oklahoma: University of Oklahoma Press. 332 pp.

Scribner, S.J., P.J. Weatherhead. 1995. Locomotion and antipredator behaviour in three species of semi-aquatic snakes. Canadian Journal of Zoology 73:321-329.

Shine, R., R.T. Mason. 2004. Patterns of mortality in a cold-climate population of garter snakes (*Thamnophis sirtalis parietalis*). Biological Conservation 120:205-214.

Smith, K. 2002. COSEWIC status report on the eastern ribbonsnake, *Thamnophis sauritus*. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi+24 pp.

Species at Risk Act S.C. 2002, c.29

The Atlantic Whitefish Conservation and Recovery Team. 2006. Recovery Strategy for the Atlantic Whitefish (Coregonus huntsmani) in Canada. Nova Scotia, Canada.

The Blanding's Turtle Recovery Team. 2003. National Recovery Plan for the Blanding's turtle (*Emydoidea blandingii*) Nova Scotia Population (draft strategy). Nova Scotia, Canada.

The Eastern Ribbonsnake Recovery Team.2008. Rationale to support the recovery planning table. Unpublished document.

Tinkle, D.W. 1957. Ecology, maturation and reproduction of *Thamnophis sauritus proximus*. Ecology 38:69-77.

Todd, B.D., C.T. Winne, J.D. Willson, J.W. Gibbons. 2007. Getting the drift: examining the effects of timing, trap type and taxon on herpetofaunal drift fence surveys. The American Midland Naturalist 158:292-305.

Vander Zanden, M.J., J.D. Olden, J.H. Thorne, N.E. Mandrakc. 2004. Predicting occurrences and impacts of smallmouth bass introductions in north temperate lakes. Ecological Applications 14:132-148.

Webb, J.K., R. Shine. 1997. A field study of spatial ecology and movements of a threatened snake species, *Hoplocephalus bungaroides*. Biological Conservation 82:203-217.

RECOVERY TEAM MEMBERS

Mark Elderkin (Co-Chair)	Nova Scotia Department of Natural Resources, Wildlife Division
Stephen Flemming (Co-Chair)	Parks Canada, Atlantic Service Centre
Steve Mockford (Co-Chair)	Biology Department, Acadia University
Sarah Bell	Department of Anatomy and Neurobiology, Dalhousie University
John Gilhen	Nova Scotia Museum of Natural History
Tom Herman	Biology Department, Acadia University
Shalan Joudry	L'sitkuk Department of Environment, Bear River First Nation
Chris McCarthy	Parks Canada, Kejimkujik National Park and National Historic Site
Joshua McNeely	Maritime Aboriginal Peoples Council
Jeffie McNeil	Parks Canada, Atlantic Service Centre
Jonathan Shepard	Parks Canada, Kejimkujik National Park and National Historic Site
Duncan Smith	Parks Canada, Atlantic Service Centre
Richard Wassersug	Department of Anatomy and Neurobiology, Dalhousie University

APPENDIX 1

Table 1. Priority sites to survey to confirm the presence of eastern ribbonsnakes.

Location	Watershed	County	Map Book Square	Total visual survey effort to date (person hrs)	Number historical sightings	Number current unconfirmed sighting	Comments
Big Dam Lake	Mersey	Annapolis	72X1	0	3	0	
Brooklyn (near Liverpool)	Mersey	Queens	79Y5	0	1	0	Unconfirmed report - no detailed location given.
Eel Lake	Medway	Queens	72Z2	0	0	0	Between 2 CH polygons
Eight Mile Lake	Medway	Queens	79W2	0	1	0	Near 10 Mile Lake, which has confirmed sightings
Heber Meadow Brook (Kejimkujik L)	Mersey	Annapolis	72X2	0.3	0	1	Sighting in the upper meadow of the brook
Innis Brook (Frozen Ocean)	Mersey	Annapolis	72W2	0	1	0	
J-Line Bog	Mersey	Annapolis	72X2	0	1	0	
Kejimkujik Seaside Adjunct		Queens	84W3	0.7	0	1	
Little River	Mersey	Annapolis	72X2	0	1	0	
Mersey River in KNPNHS	Mersey	Annapolis	72X2	6.9	2	1	
Minard Lake	Mersey	Queens	72Y2	7.7	1	0	Confirmed historical sighting (snake collected)
Moose Pit Brook	Medway	Queens / Annapolis	72Z1	0	1	0	Unconfirmed report of ~30 snakes in 1983
Pebbleloggitch Lake	Shelburne	Digby	72W4	0	0	0	Sighting on road, could have come from Peskawa or Pebbleloggitch Lake
Peskowa Lake	Mersey	Digby	72W4	0	0	1	Sighting on road, could have come from Peskawa or Pebbleloggitch Lake
Puzzle Lake	Mersey	Queens	72X4	0	0	0	Between 2 CH polygons
Telfer Lake	Medway	Queens	72Z5	0	0	1	
Thomas Radall Park		Queens	84W4	0			One sighting - unsure of date
Torment Brook (Frozen Ocean)	Mersey	Annapolis	72W1	0	1	0	