COSEWIC
Assessment and Status Report

on the

Spring Salamander
Gyrinophilus porphyriticus

Adirondack / Appalachian population
Carolinian population

in Canada

Adirondack / Appalachian population – THREATENED
Carolinian population - EXTIRPATED
2011

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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COSEWIC
Assessment Summary

Assessment Summary – May 2011

Common name
Spring Salamander - Adirondack / Appalachian population

Scientific name
Gyrinophilus porphyriticus

Status
Threatened

Reason for designation
This species occurs in clear, cool headwater streams in the Appalachians and Adirondacks of southeastern Quebec. The species' habitat is threatened by several kinds of development, including ski resorts, windfarms and golf courses that may alter water availability in the streams. Similarly, forestry activities affect the salamander's habitat by reducing shade, altering stream temperatures and increasing silt. Introduction of predatory game fish is also a severe threat to the species' larvae and adults.

Occurrence
Quebec

Status history
The species was considered a single unit and designated Special Concern in April 1999 and May 2002. Split into two populations in May 2011. The Adirondack / Appalachian population was designated Threatened in May 2011.

Assessment Summary – May 2011

Common name
Spring Salamander - Carolinian population

Scientific name
Gyrinophilus porphyriticus

Status
Extirpated

Reason for designation
No valid records in more than 50 years.

Occurrence
Ontario

Status history
The species was considered a single unit and designated Special Concern in April 1999 and May 2002. Split into two populations in May 2011. The Carolinian population was designated Extirpated in May 2011.

COSEWIC
Executive Summary

Spring Salamander
Gyrinophilus porphyriticus

Adirondack / Appalachian population
Carolinian population

Wildlife species description and significance

The Spring Salamander (*Gyrinophilus porphyriticus*) is among the largest species in the family Plethodontidae (lungless salamanders), reaching 23 cm in total length. Adults are usually pink or orange and possess dark and diffused reticulations, spots or streaks. The aquatic larvae have reddish gills, lack reticulations and become brightly coloured at metamorphosis. Both adults and larvae are characterized by a pale line from eye to snout, a pale belly, and a laterally compressed tail that forms a fin. In Canada, the species is represented by the most widely distributed subspecies, the Northern Spring Salamander (*G. p. porphyriticus*).

Distribution

The Spring Salamander has a patchy distribution in high-elevation streams along the Appalachian uplift of eastern North America. The species' Canadian range extends from the US border to Kinnear's Mills in Quebec. The Canadian distribution includes between 0.7% and 8.6% of the global range and is limited to elevations above 100 m on the outskirts of the Appalachian Mountains. Quebec populations occur within two areas: the Adirondack Piedmont and the Appalachian Mountains. The species has also been recorded from Niagara Regional Municipality in southern Ontario, but this population is considered extirpated. The species' extent of occurrence (EO) in Canada is 17 237 km^2, of which the Adirondack Piedmont accounts for 50 km^2.

Habitat

The species is mainly associated with headwater mountain streams with cool, well-oxygenated water, abundant rocky or gravelly substrates, and few predatory fish. Both adults and juveniles take refuge in interstitial spaces among rocks in the streambed. Adults may venture onto the stream bank to forage, whereas the strictly aquatic larvae remain in the stream. Eggs are laid under large rocks or other protective cover, submerged or partially embedded in the stream bank. The salamanders spend winter on the stream bottom or hidden under the stream bank, protected from freezing. Abundant forest cover is required to maintain essential habitat features.

Biology

The Spring Salamander has a two-phase life cycle characterized by a long larval period lasting 3 to 6 years. Sexual maturity is generally attained within 1 year after metamorphosis, though maturation may be delayed at higher elevations. Mating occurs in summer or autumn and females oviposit annually. Fecundity increases with body size, and clutch size varies between 9 and 132 eggs across the species' range. Hatching occurs in late summer or early autumn. Longevity is about 10 years.

The Spring Salamander's small size, permeable skin and aquatic life stage also make them susceptible to dehydration and water acidification. The species is territorial and nocturnal. Terrestrial and aquatic invertebrates are most commonly consumed, but Spring Salamanders may prey upon smaller salamanders including conspecifics.

Dispersal occurs primarily upstream along stream corridors. Downstream movements are infrequent and relatively short (rarely more than 10 m). Terrestrial movements of adults are generally restricted to within 2 m from the stream edge.

Population sizes and trends

The size of Canadian populations remains unknown. The species is naturally rare and local densities are usually low. Higher abundances are observed in streams where predatory fish are absent. Occasionally, up to 25 salamanders have been recorded in a single area, but usually smaller numbers are encountered.

Fluctuations and trends for Canadian populations have not been recorded. Numerous surveys in the past decade led to the discovery of nine new populations. Accordingly, the extent of occurrence has increased, likely reflecting greater search effort rather than population growth or the establishment of new populations. Failure to confirm the species' persistence at historical sites suggests that some populations might have disappeared.

Threats and limiting factors

Over the past 20 years, residential development and recreational infrastructure (e.g., ski resorts, golf courses) have significantly increased in the Appalachians, resulting in habitat loss throughout the species' range. Housing developments and wind farms also threaten and degrade the species' habitat.

Alteration or reduction of water quality and water flow remain the principal threats to the Spring Salamander. Because of a long, strictly aquatic life stage, larvae are vulnerable to acidification and other changes in water conditions. The Spring Salamander is also vulnerable to contamination of water by pesticides and herbicides.

Timber harvesting has negative effects on the species by altering water chemistry, temperature, quality or supply. Another important negative effect of timber harvesting on Spring Salamanders is that it increases silt which then fills the interstitial spaces used for foraging and shelter. An indirect effect is reduction of oxygen levels.

Another threat, particularly to larvae, is predation by fish, especially introduced Brook Trout. The impact of Brook Trout increases when interstitial refuges become scarce from increased silt.

Protection, status, and ranks

At the federal level, the Spring Salamander is listed under the *Species at Risk Act* (SARA) in Schedule 1 as Special Concern.

In 2009, the Spring Salamander was designated Vulnerable in Quebec by the provincial government, under the *Act Respecting Threatened or Vulnerable Species*. Consequently, the species is protected by the provincial *Act Respecting Conservation and Development of Wildlife* (R.S.Q, c. C-61.1) which prohibits collecting, buying, selling or keeping specimens in captivity.

In Ontario, the Spring Salamander is listed as Extirpated in Ontario under *Endangered Species Act* 2007 (ESA).

In Quebec, protective measures for stream salamanders, regarding silvicultural practices on public provincial lands, have been recently adopted and implemented. However, most of the Spring Salamander's range in southern Quebec is located on private lands. Article 22 of the provincial *Environment Quality Act* offers protection against unregulated degradation of environmental quality

Globally, the species is ranked secure (G5) by NatureServe (2009). In Canada, the Spring Salamander is considered Vulnerable (N3), and in Quebec, it is ranked vulnerable (S3).

At the present time, nearly a quarter of the species' observations occur in three protected areas and areas covered by 12 ownership agreements, representing overall about 25% (127 km^2) of total habitat occupied in Quebec.

TECHNICAL SUMMARY – Appalachian population

Gyrinophilus porphyriticus
Spring Salamander
Adirondack / Appalachian population
Range of occurrence in Canada: Quebec

Salamandre pourpre
Population des Adirondack/Appalaches

Demographic Information

Generation time *Following IUCN guidelines (2008), generation time was estimated by assuming that generation time is greater than the age at first breeding (i.e., average 5 years) and less than the age of the oldest known breeding individual (10 years)*.	7 yrs
Is there a continuing decline in number of mature individuals? *Five populations probably have disappeared (Cassville, Mount Brome, Mount Foster, Mount Smith and Mount Yamaska), indicating a decline in number of mature individuals*.	Yes
Estimated percent of continuing decline in total number of mature individuals within 5 years or two generation.	Unknown
Estimated percent change in total number of mature individuals over the last 10 years.	Unknown
Percent reduction in total number of mature individuals over the next 10 years. *Developments (residential, recreational, windfarms) are ongoing or planned in Arthabaska, Kinnear's Mills, Mount Brome and Mount Orford. A reduction in the number of mature individuals from these populations in the next 10 years is likely*.	Unquantified reduction
Percent reduction in total number of mature individuals over any 10 years period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible and understood and ceased? Possibly understood, but not ceased nor reversible	No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence *The total EO value in Canada was calculated using a minimum convex polygon (COSEWIC 2009) around all extant occurrences, minus a large area of unsuitable habitat, separating the Adirondack Piedmont and the Appalachian Mountains areas.*	<17 237 km² Note that the record near Portneuf is unconfirmed and if it were omitted the EO would be reduced by 15-20%.
Index of area of occupancy (IAO) *Calculated by superimposing a grid with 2 km x 2 km cells over the species' range*	1 416 km²
Is the total population severely fragmented? *Populations are isolated among headwater streams on isolated areas of uplift and have limited or no gene flow given their poor dispersal ability and lack of connecting habitat between watersheds. Connecting habitat has undoubtedly been greatly reduced by anthropogenic activities over the past two centuries. Most populations likely have fewer than 5000 adults, making them vulnerable to stochastic effects of small population size*.	Yes
Number of "locations∗" 14, *See Table 1 and text under Canadian Range.*	14
Is there an observed continuing decline in extent of occurrence?	No

∗ See definition of location.

Is there a continuing decline in index of area of occupancy? *Five populations probably have disappeared recently (Cassville, Mount Brome, Mount Foster, Mount Smith and Mount Yamaska)*	Probably
Is there an inferred continuing decline in number of populations?	Yes
Is there a projected continuing decline in number of locations? Please refer to **Habitat Trends** section for details.	Yes
Is there an observed continuing decline in extent and/or quality of habitat? Please refer to **Habitat Trends** section for details.	Yes
Are there extreme fluctuations in number of populations?	No
Are there extreme fluctuations in number of locations*?	No
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

Number of Mature Individuals (in each population)

Total	Unknown

Quantitative Analysis

Probability of extinction in the wild is unknown	NA

Threats (actual or imminent, to populations or habitats)

- Deforestation for agricultural and urban developments that reduces habitat quality and connectivity and alters water quality through siltation and modification of hydrological regime.
- Habitat loss due to development and expansion of existing recreational sites (ski resorts, golf courses) or creation of windfarms.
- Alteration of water quality (acidification, pollution) or supply (extraction of ground and surface water), by human activities.
- Brook Trout introduction
- Stochastic events, because of the small size and isolation of many populations

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? *US:* The Spring Salamander has a large and continuous distribution throughout the eastern US. Populations adjacent to Canadian populations (i.e., New York, Vermont and New Hampshire) are secure or apparently secure, except in Maine where the species is Vulnerable. Among the 20 states where the species occurs, it is at risk in four of them.	
Is immigration known or possible? Immigration is possible at Covey Hill, White Mountains, and Sixtynine Mountain, provided that distances from US populations are small and that connectivity of habitat and watershed exists. Please refer to **Dispersal and Migration** and **Rescue Effect** sections of the report.	Possible
Would immigrants be adapted to survive in Canada?	Likely
Is there sufficient habitat for immigrants in Canada?	Unknown, but is already limited
Is rescue from outside populations likely?	Unlikely, there are few situations, if any, where the conditions would allow rescue.

Current Status

COSEWIC: DU not assessed by COSEWIC

* See definition of location.

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Threatened	B1ab(ii,iii,iv,v)+2ab(ii,iii,iv,v)
Reasons for designation: This species occurs in clear, cool headwater streams in the Appalachians and Adirondacks of southeastern Quebec. The species' habitat is threatened by several kinds of development, including ski resorts, windfarms and golf courses that may alter water availability in the streams. Similarly, forestry activities affect the salamander's habitat by reducing shade, altering stream temperatures and increasing silt. Introduction of predatory game fish is also a severe threat to the species' larvae and adults.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Although there has probably been decline, there are no quantitative data, and it is unlikely that the size of the decline would meet the criteria.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Threatened under B1ab(ii,iii,iv,v)+2ab(ii,iii,iv,v) as both the EO and IAO values are lower than the thresholds for Threatened, the species' habitat is estimated to be severely fragmented, and there is an observed and inferred continuing decline in area of occupancy, habitat area and quality, number of populations, and number of mature individuals.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable as the total number of mature individuals is unknown.
Criterion D (Very Small or Restricted Total Population): Not applicable as the number of mature individuals is unknown, IAO is larger than 20km^2 and there are more than 5 locations.
Criterion E (Quantitative Analysis): Not performed.

TECHNICAL SUMMARY – Carolinian population

Gyrinophilus porphyriticus
Spring Salamander — salamandre pourpre
Carolinian population — Population carolinienne
Range of occurrence in Canada: Ontario

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines(2008) is being used)	7 yrs
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	It is extirpated having no valid records in over 100 years
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	NA
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	NA
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	NA
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 years, or 3 generations] period, over a time period including both the past and the future.	NA
Are the causes of the decline clearly reversible and understood and ceased?	No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence	0 km²
Index of area of occupancy (IAO)	0 km²
Is the total population severely fragmented?	NA
Number of "locations*"	0
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	NA
Is there an [observed, inferred, or projected] continuing decline in index of area of occupancy?	NA
Is there an [observed, inferred, or projected] continuing decline in number of populations?	NA
Is there an [observed, inferred, or projected] continuing decline in number of locations?	NA
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	NA
Are there extreme fluctuations in number of populations?	NA
Are there extreme fluctuations in number of locations*?	NA
Are there extreme fluctuations in extent of occurrence?	NA
Are there extreme fluctuations in index of area of occupancy?	NA

* See definition of location.

Number of Mature Individuals (in each population)

Population	N Mature Individuals
Total	0

Quantitative Analysis

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

Threats (actual or imminent, to populations or habitats)

Loss of habitat, zero population

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? Declining	
Is immigration known or possible?	Not possible
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Not likely
Is rescue from outside populations likely?	No

Current Status

COSEWIC: DU not assessed by COSEWIC

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Extirpated	N/A
Reasons for designation: No valid records in more than 50 years.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small or Restricted Total Population): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

PREFACE

The Spring Salamander (*Gyrinophilus porphyriticus*) was assessed Special Concern in Canada by COSEWIC based on a status report by Bonin (1999), but Ontario was not listed as a range jurisdiction by COSEWIC (2001) even though Bonin (1999) and other authors (e.g., Dunn, 1926; Brandon 1966, 1967; Cook 1984) mentioned two Ontario records and the identification of *G. porphyriticus* was confirmed for both records. However, subsequent surveys have not found the species at these or any other Ontario localities (Cook 1970, 1977; F.R. Cook pers comm. Nov. 2009). The most recent of the two known records was a larva collected at Britannia near Ottawa in 1934. It was definitely *G. porphyriticus* (F.R. Cook pers. comm. Nov. 2009), but apparently was either an introduction or, more likely, an incorrect locality (Bleakney 1958; F.R. Cook, pers. comm. Nov. 2009). An earlier record (1877) was of three larvae collected from "opposite to Buffalo, New York", which corresponds currently to the Niagara Regional Municipality. At least one of these larval specimens still exists. It is deposited in the Museum of Comparative Zoology, Harvard University. Currently, the species is assessed Extirpated in Ontario under the *Endangered Species Act* 2007 (ESA).

Over the past decade, considerable fieldwork has been carried out in Quebec, along the Appalachian Mountains and in the Adirondack Piedmont area. This increase in search effort confirmed the Spring Salamander's persistence in some historical sites, but also uncovered new areas occupied by the species in Quebec. Since the species' last assessment in 1998, over 300 observations were added to the distribution in Quebec. Accordingly, the species' extent of occurrence has increased somewhat. However, some Quebec populations may have disappeared because of habitat destruction associated with human activities. Also, the extent of occurrence was increased by about 15% by including an unconfirmed record from the south shore of the St. Lawrence River opposite Portneuf (see Fig. 5). Probably, this record should not be accepted at this time.

The lack of knowledge of the species' ecology in Canada made previous estimation of the area of occupancy difficult. Recent studies of the species' dispersal and degree of genetic isolation in the US have allowed some inference regarding Canadian populations with respect to genetic distinctiveness and index of area of occupancy. Still, population sizes, fluctuations and trends in the number of individuals remain unknown.

COSEWIC HISTORY

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list. On June 5, 2003, the *Species at Risk Act* (SARA) was proclaimed. SARA establishes COSEWIC as an advisory body ensuring that species will continue to be assessed under a rigorous and independent scientific process.

COSEWIC MANDATE

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assesses the national status of wild species, subspecies, varieties, or other designatable units that are considered to be at risk in Canada. Designations are made on native species for the following taxonomic groups: mammals, birds, reptiles, amphibians, fishes, arthropods, molluscs, vascular plants, mosses, and lichens.

COSEWIC MEMBERSHIP

COSEWIC comprises members from each provincial and territorial government wildlife agency, four federal entities (Canadian Wildlife Service, Parks Canada Agency, Department of Fisheries and Oceans, and the Federal Biodiversity Information Partnership, chaired by the Canadian Museum of Nature), three non-government science members and the co-chairs of the species specialist subcommittees and the Aboriginal Traditional Knowledge subcommittee. The Committee meets to consider status reports on candidate species.

DEFINITIONS
(2011)

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

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

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

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

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

COSEWIC Status Report

on the

Spring Salamander
Gyrinophilus porphyriticus

Adirondack / Appalachian population
Carolinian population

in Canada

2011

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and classification

The Spring Salamander (*Gyrinophilus porphyriticus*; Green 1827*)* is a member of the family Plethodontidae, also referred to as lungless salamanders (*sensu* Gray 1850). This highly diverse family is the largest among salamanders, with 394 species and 28 genera (AmphibiaWeb 2009).

Phylogenetic relationships among plethodontid subfamilies and tribes remain ambiguous (see Frost *et al*. 2004 for a review of phylogenetic studies prior to 2004, also see Macey 2005 and Vieites *et al.* 2007). The phylogenetic incongruence among studies is probably dependent upon which species were sampled as well as on character types analysed, e.g., combined morphological and molecular characters (Chippindale *et al.* 2004), complete mtDNA genomes (Mueller *et al.* 2004, Macey 2005), and nuclear genes (Vieites *et al.* 2007). Regardless of discrepancies within the current plethodontid phylogenies, it is generally accepted that *Gyrinophilus porphyriticus* belongs to the Spelerpinae subfamily (*sensu* Cope 1869) and Hemidactyliini tribe (Chippindale *et al.* 2004) or to the Hemidactyliinae subfamily, Spelerpini tribe (*sensu* Vieites *et al*. 2007).

The genus *Gyrinophilus* is represented by four species: *G. gulolineatus*, *G. palleucus*, *G. porphyriticus*, and *G. subterraneus* (Crother 2008, Frost 2008, NatureServe 2009). The last has been considered as a variant of *G. porphyriticus* (Blaney and Blaney 1978, Frost 1985), but limited electrophoretic data provide evidence for its specific distinctiveness (Green and Pauley 1987). It is considered a full species by some authors, although further study is warranted (Beshare and Holsinger 1977, Petranka 1998, Collins and Taggart 2002).

Considerable variability occurs in *G. porphyriticus*, for which four subspecies are currently recognized: *G. p. danielsi*, *G. p. dunni*, *G. p. duryi* and *G. p. porphyriticus* (Brandon 1966, Crother 2008, NatureServe 2009). Only the last subspecies occurs in Canada, under the common name of Northern Spring Salamander (Crother 2008). *Gyrinophilus p. porphyriticus* is by far the most widely distributed subspecies covering the whole northern part of the species' range south to West Virginia and Kentucky plus parts of the range south of these states.

Brandon (1967) listed scientific names previously given to the species: *Salamandra porphyritica, S. salmonea* (Green 1827, Storer 1838); *Pseudotriton salmoneus* (Baird 1850); *Spelerpes salmonea, S. porphyritica, S. salmoneus* (Gray 1850, Cope 1866); *Ambystoma salmoneum* (Duméril 1854); *Geotriton porphyritica* (Garman 1884); *Pseudotriton prophyriticus* (Organ 1961). Bishop (1947) used the English name *Purple Salamander*. A large number of additional synonyms have been reviewed by Frost (2008) and include: *Triturus lutescens* (Rafinesque 1832), *Triton porphyriticus* (Holbrook 1842), *Gyrinophilus danielsi* (Fowler and Dunn 1917) and *Gyrinophilus danielsi duryi* (King 1939). In French, the Spring Salamander is known as the *salamandre pourpre* (Cook 1984, Bider and Matte 1994, Desroches and Rodrigue 2004).

Morphological description

The Spring Salamander is among the largest of the plethodontid salamanders, reaching 23 cm total length (Desroches and Rodrigue 2004). The species is characterized by a light line from each eye to the tip of the snout, which is relatively square, and a tail laterally compressed to form a fin (Figure 1). Its colour varies from salmon to pinkish orange overlaid by dark and diffused reticulations, spots or streaks. The belly is a lighter shade, commonly cream (Petranka 1998, Desroches and Rodrigue 2004). Colour varies geographically and with age. There is no evident sexual dimorphism and males lack a well-defined mental gland (Petranka 1998). Albinism has been reported only twice (Brandon and Rutherford 1967, Ferriero *et al*. 1998).

Figure 1. *Gyrinophilus porphyriticus*: (A) adult, photo by David Green; (B) larva, photo by Mathieu Ouellette.

Larvae of the Spring Salamander are pale and often without reticulations, which are acquired later in development. At metamorphosis, the salamanders become more brightly coloured (Brandon 1967, Petranka 1998, Desroches and Rodrigue 2004). Larvae have well-developed reddish gills, small eyes, and a variable ground colour (beige, light pink, light grey, lavender) (Figure 1). These features make them similar to the Mudpuppy (*Necturus maculosus*); however, the latter lacks the pale line between the eye and the nostrils, is covered by black spots, and has four toes instead of five. Albino forms of the Northern Dusky Salamander (*Desmognathus fuscus*) could also be misidentified as the Spring Salamander because of their orange colour, but the uncompressed tail and the absence of reticulations on the body of the Northern Dusky Salamander distinguish it from the Spring Salamander (Desroches and Rodrigue 2004).

Population spatial structure and variability

No genetic studies have been done on Canadian populations of the Spring Salamander, and hence isolation by geographic, ecological, or behavioural barriers remains somewhat hypothetical. Furthermore, the extent to which Spring Salamander populations in Canada differ from United States' populations is unknown. However, inferences can be made from work conducted on US populations.

Various studies report significant variation in life history, phenotype, and morphology of *G. porphyriticus* (Bruce 1972, 1978, Adams and Beachy 2001), all suggesting the presence of regional differentiation. Also, some parapatrically distributed variants of the species are sexually incompatible, confirming the presence of ethological barriers among populations of the species (Beachy 1996). Based on amplified DNA fragment length polymorphism (AFLP), phenotypic divergence in the species is believed to have a genetic basis (Lowe *et al*. 2008).

Because large-scale movements of Spring Salamanders only occur along linear networks of stream and riparian habitat, gene flow in *G. porphyriticus* is restricted to this pathway (Lowe *et al.* 2008). Additionally, gene flow occurs primarily along the main, perennial channel and not between the main channel and temporary tributaries. Within the stream network, slope has a direct effect on dispersal and should be examined as a possible mechanism leading to population differentiation (Lowe *et al*. 2006b, Lowe *et al*. 2008). Amplified DNA fragment length polymorphism (AFLP) revealed that genetic divergence increases with slope such that genetic distances between downstream and upstream sites are positively correlated with changes in elevation, even over very short distances ($\leq$1 km) (Lowe *et al*. 2006b, 2008).

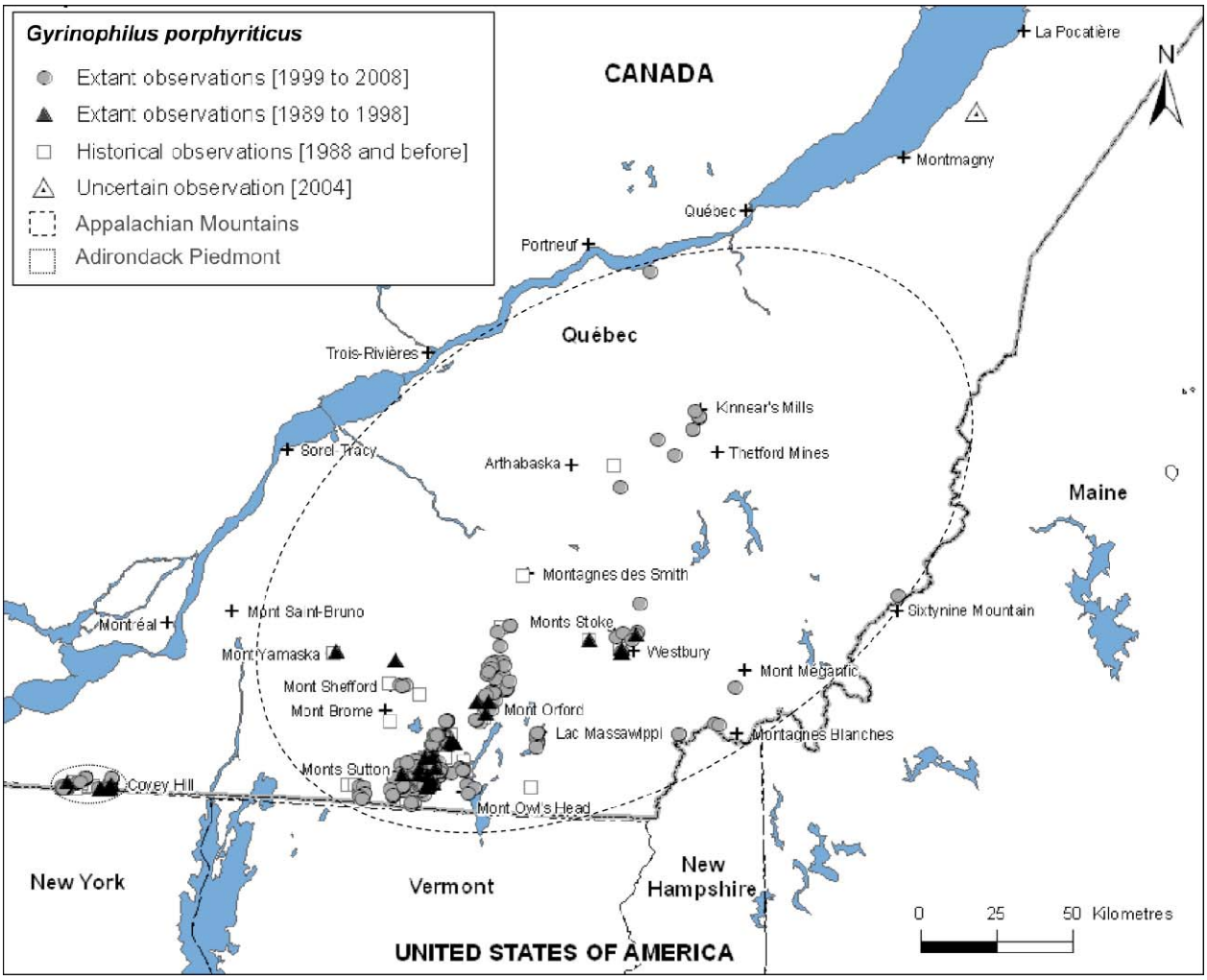
Landscape-scale patterns of dispersal and gene flow are closely related to the species' movement (Lowe *et al.* 2008). Both adults and larvae move significantly more frequently and over longer distances upstream than downstream (Lowe 2003, Lowe *et al.* 2006b), refuting the common hypothesis that downstream movement or drift is an important mechanism of gene flow in the species.

Other elements of the landscape affect population structure. Adams and Beachy (2001) suggested that large rivers act as geographical barriers to dispersal and gene flow in *G. porphyriticus*. Their findings support the idea that drainage history is a primary factor influencing the phylogenetic history of *G. porphyriticus*. Niemiller *et al*. (2008) tested the effects of watershed and drainage structure on the genetic variation of the species. They found a significant relationship between nuclear DNA variation and major drainage inhabited, independent of distance.

Designatable units (DU)

Applachian population (DU 1)

Most Spring Salamander populations in Quebec occur within the Appalachian / Atlantic Coast Faunal Province (aka Appalachian Faunal Province) of the Amphibians and Reptiles Faunal Provinces (COSEWIC 2010). Spring Salamanders are found in two main areas of Quebec: 1) the Adirondack Piedmont, and 2) the Appalachian Mountains (Figure 2).



Data sources
Centre de données sur le patrimoine naturel du Québec (CDPNQ)
Atlas des Amphibiens et des Reptiles du Canada (AARQ)
Anaïs Boutin
Appalachian Corridor Appalachien (ACA)
Agence régionale de mise en valeur des forêts privées de la Chaudière (ARFPC)
Gallois and Ouellet 2005
Mathieu Wéra-Bussière
Société de conservation du corridor naturel de la rivière au Saumon (SCCNRS)
Weller 1977
Weller and Cebek 1991

Figure 2. Canadian range of *Gyrinophilus porphyriticus* adapted from Environment Canada (*in preparation*), including extant observations from the past decade until now, and historical observations.

The Adirondack Piedmont, or Covey Hill area, is separated from the Appalachian Mountains by over 75 km of lowlands, and by significant geographical barriers including the Richelieu River and Lake Champlain. Based on the COSEWIC Terrestrial Amphibians, Reptiles Faunal Provinces map (Figure 3 in COSEWIC 2009) the Covey Hill (Adirondack Piedmont) portion of the Quebec range is actually within the Great Lakes / St. Lawrence Faunal Province, whereas the remainder of the Quebec range is within the Appalachian / Atlantic Faunal Province. The Allegheny Mountain Dusky Salamander (*Desmognathus ochrophaeus*) also occurs in the Covey Hill area and the COSEWIC DU for that population is called the Great Lakes / St. Lawrence population.

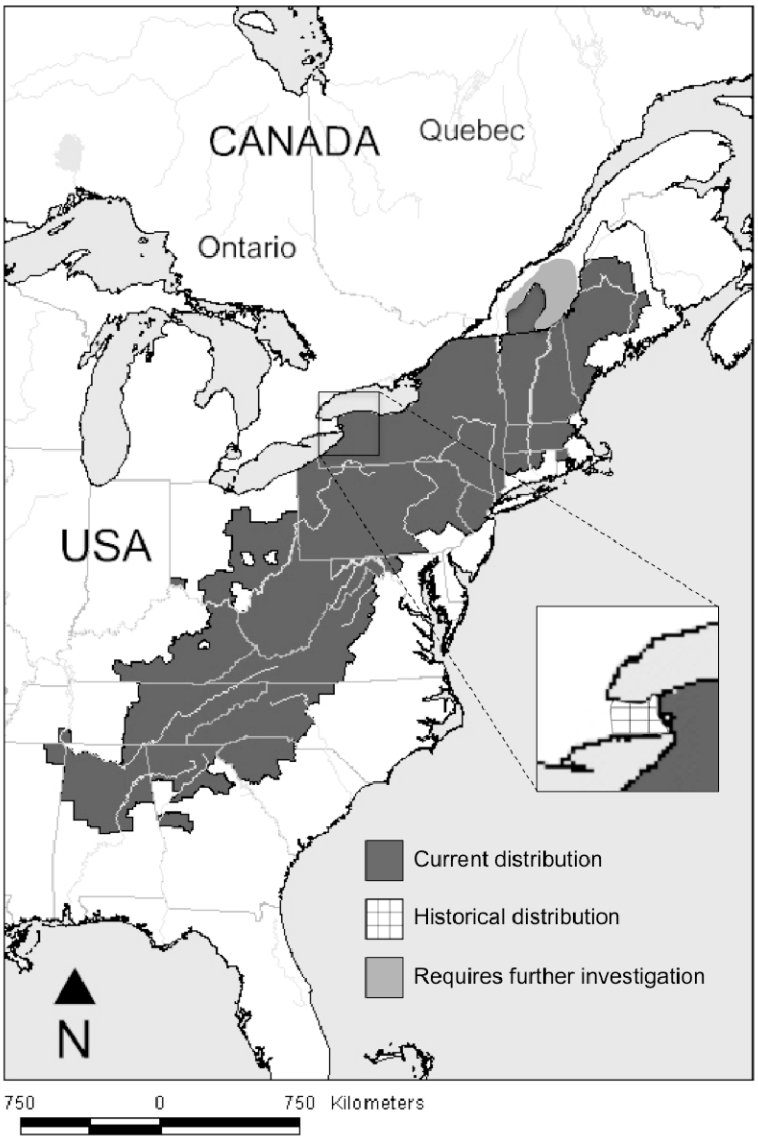


Figure 3. Global range of *Gyrinophilus porphyriticus* adapted from NatureServe (2009), with historical distribution in Ontario and areas where further investigation is needed.

Genetic isolation between the Adirondack Piedmont and the Appalachian Mountains is highly probable and would be consistent with morphological distinctions seen between salamanders from the same two geological formations in New England. Because small-scale factors such as slope, watershed and drainage history significantly affect gene flow and genetic distances in *G. porphyriticus*, defining populations and conservation units should be done at watershed levels. Currently, however, there is insufficient evidence for more than one DU in Quebec, and this single DU is called the Appalachian DU.

Carolinian population (DU 2)

There are only two records (four specimens) of Spring Salamander from Ontario. All specimens were larvae and there has been some dispute as to their authenticity. However, to quote from a recent email (Nov. 2009) to R. J. Brooks from F. R. Cook Curator Emeritus of the Canadian Museum of Nature, "their (the larvae) identification is NOT in question. The Britannia larva is in the Canadian Museum of Nature collection and has been examined by Bleakney and again by me several times. It is without question *Gyrinophilus*. The same for the Harvard specimen from 'opposite Buffalo' which has been confirmed by Dunn, Brandon, and myself as I outlined earlier". However, he goes on to say, "The Britannia locality (Britannia Creek) was examined by Bleakney and myself in the early 1950s the same year we also examined *Gyrinophilus* localities in Quebec where we collected both adults and larvae so we were familiar with both the species and its habitat. We concluded that due to habitat modification, the Britannia locality was no longer suitable for the species, if it ever had been. Today the creek is even further modified. If I recall correctly, Bleakney managed to contact the collector 20 years after he supposedly took it in Britannia Creek and Bleakney was not convinced that the specimen had actually come from there. But the specimen exists and there is no doubt of its identification, just the authenticity of the locality data. This record can be written off due to doubt of the accuracy of the data not of the identification".

There is another larva deposited in the Museum of Comparative Zoology, Harvard University. The Harvard specimen is catalogued as 1370 and labeled "Canada: Ontario: A.R. Grote don. 1877". The Harvard larva was examined 13 February 1972 and measured on 21 July 1975 by F. R. Cook. It measured 42.2 mm snout to mid-vent and 15.7 mid-vent to tail tip (total length 57.9 mm). It had a costal groove count of 18-19 which is in the *Gyrinophilus* range (and well above the 14 normally reported for *Desmognathus*). It was x-rayed 18 July 1975 and had 20 trunk vertebrae - one more than the costal count which is a normal relationship, and its hind legs are not enlarged. Confusion with *Desmognathus* is virtually impossible (F.R. Cook pers. comm. Nov 2009); see **Preface** for other details). Earlier, Brandon (1966) and Dunn (1926) had made the same identification of this specimen.

In Nov. 2009, W. Weller sent an email to R. J. Brooks regarding the possibility that Spring Salamanders once occupied the Niagara Gorge in Ontario (W. Weller pers. comm. Nov. 2009). He stated that in June 2008, he and the A. Boutin spent about a half day in the Niagara Gorge with several others (including MNR personnel) searching for

dusky salamanders at their two known locations in Ontario. They didn't find any Alleghany Mountain Dusky Salamanders, but they did find several Northern Dusky Salamanders. Weller indicated that there is one location in the Niagara Gorge, called Smeaton Creek, that requires more searching for all three species of stream salamanders. Sampling is treacherous there and this stream has been overlooked. The Northern Dusky Salamander and Alleghany Mountain Dusky Salamander are still in the Niagara Gorge and for a long time their presence, particularly the former, in Ontario was based on similarly vague records as that of the Spring Salamander, so Weller sees “no reason to doubt that *Gyrinophilus* could have been there in the 1800s. Bishop (1941) maps it from three sites in Erie County, NY, which borders the Niagara River, so it is or was nearby in New York State. Based on my relatively brief visits to the Queenston and Whirlpool sites, and talking to the MNR people based on their dozens of visits to these locations, my opinion is that *Gyrinophilus* does not now occur in these areas”.

To summarize: there is no reason to doubt the Niagara record, despite its vague locality data. The identification has been confirmed by several experts, there is and was suitable, although limited, stream habitat, and the comparatively recent discovery of two species of stream dwelling *Desmognathus* salamanders in Niagara peninsula all suggest that Spring Salamanders could have persisted many years without being detected. The Spring Salamander specimens were larvae indicating that a breeding population existed in the Niagara region. Also, the species occurs nearby on the New York side of the border and its distribution pattern is similar to those of the two *Desmognathus* species found in the Niagara region. Although no genetic comparisons have been done on Canadian specimens, the Ontario occurrence qualifies as a separate DU because it was completely isolated from the Quebec populations, occurred in a separate ecoregion and it would likely be a different evolutionary entity if it still existed.

Special significance

Gyrinophilus porphyriticus is the largest plethodontid in Canada and a prevalent predator of low-order streams (Resetarits 1995).The species reaches its northernmost limit in Canada (NatureServe 2009). Some populations are geographically isolated and may possess unique traits. Cave salamanders (*Gyrinophilus palleucus* and *G. necturoides* complex) probably arose from *G. porphyriticus* forms (Niemiller *et al*. 2010).

DISTRIBUTION

Global range

The Spring Salamander is distributed between 100 and 2000 m of elevation along the Appalachian uplift of the eastern portion of North America from southern Maine and adjacent Quebec to central Alabama (Petranka 1998, Frost 2008). Its range covers part of southern Quebec, western Maine, most of New England, New York and Pennsylvania, portions of Ohio, West Virginia, Virginia, Kentucky, Tennessee and North and South Carolina. It extends to northern Georgia and Alabama, and reaches the northwestern corner of Mississippi (Conant and Collins 1991, AmphibiaWeb 2009). The distribution is disjunct in southwestern Ohio where an isolated population occurs near Cincinnati (Figure 3).

The current global range of the Spring Salamander covers between 200 000 km^2 and 250 000 km^2 (NatureServe 2009) and is similar to previous range estimates (Conant and Collins 1991, Brandon 1967, Petranka 1998). It resembles the original distribution provided by Dunn (1926), though there have been refinements over the years (Appendix 1).

Canadian range

The species is known from Ontario and Quebec. The historical distribution in Ontario is based on two records only one of which appears valid (Cook 1970, 1977; OHS 1996; Figure 3). The valid record consists of three larvae collected in 1877 from an unnamed stream in the former Welland County in Niagara Regional Municipality (Cook 1984, Bonin 1999). Given that the species has not been reported in the province since then, as of June 30, 2010, it is considered Extirpated according to Ontario Regulation 230/08 under the Ontario *Endangered Species Act,* 2007. It is treated as Extirpated in this report (see further discussion in section on **Designatable units**). F.R. Cook examined it and concluded that it is *Gryrinophilus* supporting a similar conclusion by Dunn (1926) and Brandon (1966) (F.R. Cook pers. comm. Nov. 2009). In Cook (1984), he stated (page 48): “A locality that yielded larvae in 1877 “opposite Buffalo” in southwestern Ontario has never been rediscovered, and no other valid Ontario records are known”. Earlier, Logier and G.C. Toner (1955; p. 41) gave the locality as “Welland Co., opposite Buffalo, New York”, apparently based on Dunn 1926 (F.R. Cook pers. comm. Nov. 2010). There were originally three larvae according to Dunn (1926), but only one remained when Cook examined it Feb. 13, 1972

In Canada, the present distribution of the Spring Salamander is limited to the outskirts of the Appalachian Mountains of southern Quebec, at an average altitude of 329 m (SD=115 m, n=421 observational data in 2009). This distribution currently represents between 0.7% and 8.6% of the estimated global range (NatureServe 2009) (Figures 2, 3, 4, 5).

Gyrinophilus porphyriticus reaches its western limit in the Covey Hill region of the Adirondack Piedmont area. Within this area, more than one population may be present, as some occurrences are separated by nearly 10 km and occur in different drainages. The Covey Hill population may also be disjunct from adjacent New York populations because of hydrological discontinuities and changes in topography.

The species occurs throughout the formations of the Appalachian Mountains, such as Mounts Le Pinacle, Sutton, Orford, Owl's Head, Elephant, and Stoke, as well as in isolated areas bordering this mountain system, including the Monteregian Hills (Figure 2). The range spreads out near Lake Memphremagog, and the surroundings of Lake Massawippi and Lake Brompton. The eastern limit of the species' range in Canada corresponds to the White Mountains and Sixtynine Mountain, near the US border. The species has been observed near Westburry and further north, between Arthabaska and Kinnear's Mills.The northernmost observation is from Saint-Aubert, south of Montmagny, near Portneuf. However, this record should be regarded with caution as no recent fieldwork has confirmed the species' presence in the area (S. Rioux, pers. comm. 2008).

The Appalachian Mountains area probably includes numerous populations which cannot be defined unambiguously in the absence of genetic information. Because of the isolated topography of the Monteregian Hills, occurrences at Mounts Yamaska, Shefford, Brome and Mégantic probably represent distinct populations (Table 1, Figure 4). The Sutton Mounts (including Mount Echo), the Bolton area, and the surroundings of Mount Orford may be considered as three populations. Other mountaintops (Le Pinacle, Foster, Stoke, Smith, Montagne du Cinq, etc.) and remote occurrences (Westburry, Arthabaska, and Cassville) could also be treated as distinct populations, especially when the surrounding habitat is inhospitable. Mount Elephant and Owl's Head conceivably consist of two distinct populations; they are separated by Lake Memphremagog and are cut off from other Canadian occurrences by distance, and roads (Table 1, Figure 4).

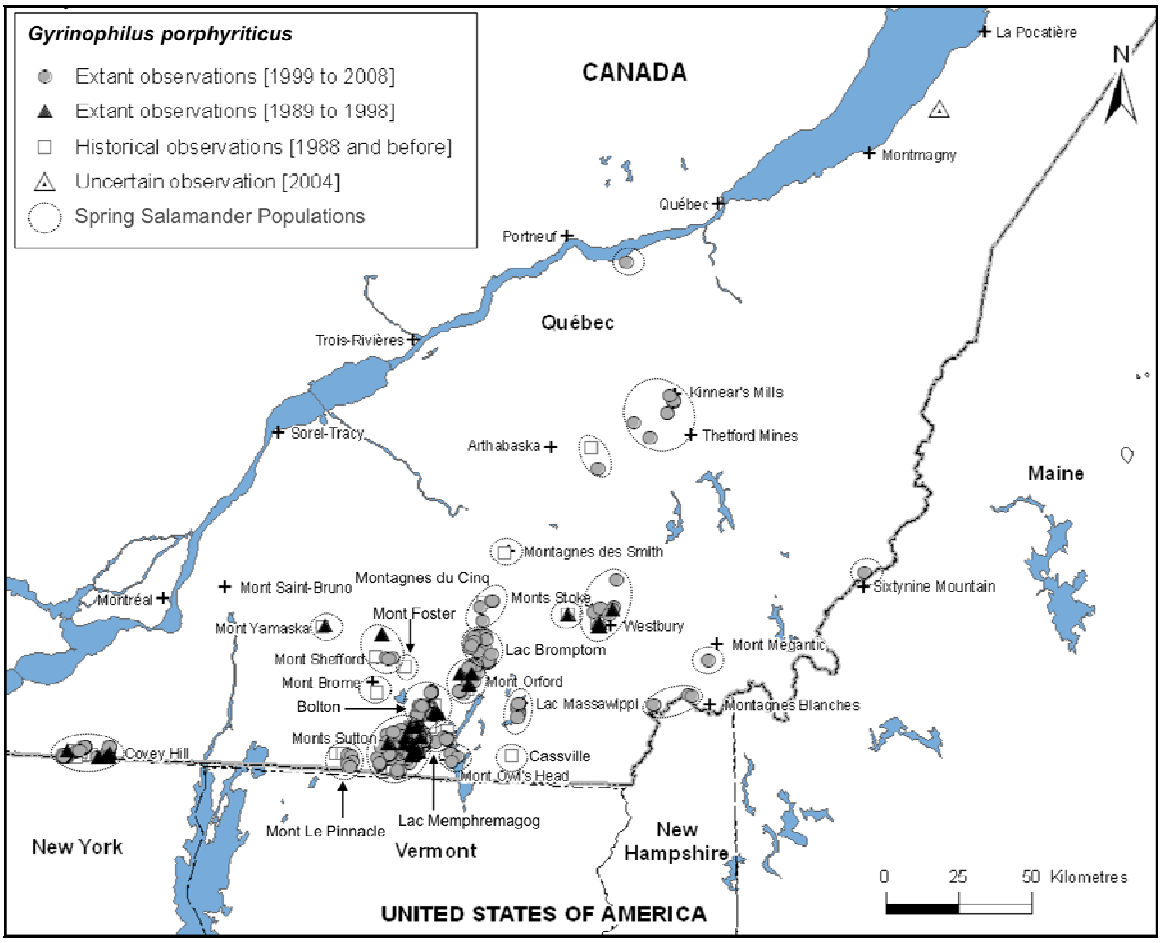


Figure 4. Canadian "populations" of the Spring Salamander.

Table 1. Numbers of specimens observed, index of area of occupancy (IAO) and percent of IAO protected for all Spring Salamander populations in Canada.

Population or Location ( )	Observation period	Number Adult	Number Larvae	Number of specimens observed *	Number of adults observed **	IAO grids	IAO (km^2)	IAO in protected habitats (grids)	% of IAO protected	% of occ. in protected areas
Covey Hill	Historical 1989-1998 1999-2008	8 4 66	1 - 30	15 16 111	70	29	116	4	13.8	0
Arthabaska	Historical 1989-1998	- -	- -	1 1	-	8	32	0	0	0
Bolton	Historical 1989-1998 1999-2008	- 4 30	- - 39	5 6 76	34	24	96	5	20.8	0
Brompton Lake	1989-1998	48	94	144	48	26	104	4	15.4	0
Cassville	Historical	-	-	1	-	-	-	-	-	-
Kinnear's Mills	1989-1998	12	1	16	12	29	116	0	0	0
Massawippi Lake	1999-2008	-	-	8	-	6	24	0	0	0

Population or Location ( )	Observation period	Number Adult	Number Larvae	Number of specimens observed *	Number of adults observed **	IAO grids	IAO (km^2)	IAO in protected habitats (grids)	% of IAO protected	% of occ. in protected areas
Memphrmagog Lake	1989-1998 1999-2008	27 1	3 3	32 8	28	13	52	3	5.8	
Montagne du Cinq	Historical 1999-2008	- 4	- 17	1 21	4	22	88	0	0	0
Montmagny [x]	1999-2008	-	-	1	-	-	-	-	-	-
Mount Brome	Historical	-	-	2	-	-	-	-	-	-
Mount Foster	Historical	-	-	1	-	-	-	-	-	-
Mount Le Pinnacle	Historical 1989-1998 1999-2008	3 - 13	2 - 3	9 2 18	13	12	48	3	6.3	
Mount Mégnatic	1999-2008	1	0	1	1	2	8	1	0	0
Mount Orford	Historical 1989-1998 1999-2008	- 213 4	- 305 16	2 521 25	217	29	116	18	62.1	40
Mount Owl's Head and Mount Elephant	1999-2008	2	2	4	2	11	44	0	0	0
Mount Shefford	Historical 1989-1998 1999-2008	- - 0	- - 1	1 3 1	-	12	48	3	25	0
Mount Smith	Historical	-	-	1	-	-	-	-	-	-
Mount Stoke	Historical 1989-1998	- -	- -	1 1	-	8	32	0	0	0
Mount Yamaska	Historical 1989-1998	- -	- -	1 1	-	4	16	0	0	0
Portneuf	1999-2008	-	-	1	-	1	4	0	0	0
Sutton Mounts	Historical 1989-1998 1999-2008	1 12 117	- 3 128	6 26 294	129	80	320	32	40	60
Sixtynine Mountains	1999-2008	2	0	2	2	4	16	0	0	0
Westburry	Historical 1989-1998 1999-2008	- - 16	- - 33	1 4 50	16	27	108	0	0	0
White Mountains	1989-1998	8	-	8	8	7	28	0	0	0
TOTAL		518	650	1308	584	354	1416	69	19.49	100

[x] Uncertain observation.

* For occurrences were the number of individuals observed is unavailable, a value of 1 was accounted, providing that 1 observation = at least 1 individual. Hence, the total number of individuals may be underestimated.

** Estimation based on the number of mature individuals observed in extant observations (ie. from 1989 to 2008). Note: Historical observations not considered in IAO calculations

The Montagnes blanches population is separated from the nearest Canadian population by at least 30 km including unsuitable lowlands habitat, and the Magog River which may be a barrier to the salamanders. As for the Sixtynine Mountain population, it is separated from other Canadian populations by at least 75 km. It is possible that these two units receive migrants from neighbouring populations in New Hampshire and Maine because these mountains extend beyond the US-Canada border; however, the suitability of the habitats between them is unknown.

As the species is affiliated with mountaintops, occurrences in lowlands of the Appalachian Mountains are unlikely, except in isolated geological formations of at least 100 m height. Surveys in the western Monteregian Hills (Mount-Royal, Saint-Bruno, Saint-Hilaire, Saint-Grégoire, and Rougemont) failed to locate the species (Ouellet *et al*. 2004, Gallois and Ouellet 2005), indicating that *G. porphyriticus* may not be present beyond Covey Hill and Yamaska. On the other side of the distribution, the species has been found in the Montagnes Blanches, but not on Mount Notre-Dame (Available data in 2009). The St. Lawrence lowlands represent the northwestern limit of the species' range in Canada (Bleakney 1958, Bonin 1991). However, additional search efforts should be oriented towards the northeastern part of the species' distribution, between Thetford Mines and La Pocatière. Also, a large area of apparently suitable habitat, east of Thetford Mines, has never been investigated and could possibly be occupied by the species (S. Rioux, pers. comm.). Current data suggest the species may have disappeared from Mounts Foster and Smith. Observations near Cassville and Arthabaska (Weller and Cebek 1991) are considered historical. The species was last observed on Mount Yamaska in 1995 (Coté and Cormier 2007); since then, habitat loss has occurred in the area, and the species may have disappeared (S. Rioux pers. comm.). On Mount Brome, the species was observed in 2004 in an area now altered by a ski station (Frenette 2007); the species' persistence there is uncertain.

Information available in 2009 suggests an extent of occurrence (EO) of 17 237 km^2, of which the Adirondack Piedmont accounts for 50 km^2. The total EO value in Canada was calculated using a minimum convex polygon (COSEWIC 2009) around all extant occurrences, minus a large area of unsuitable habitat, separating the Adirondack Piedmont and the Appalachian Mountains areas. The size of the EO has increased over the past 10 years because of the discovery of previously undocumented occurrences northeast of Arthabaska and east of Mount Stoke (Figure 5).

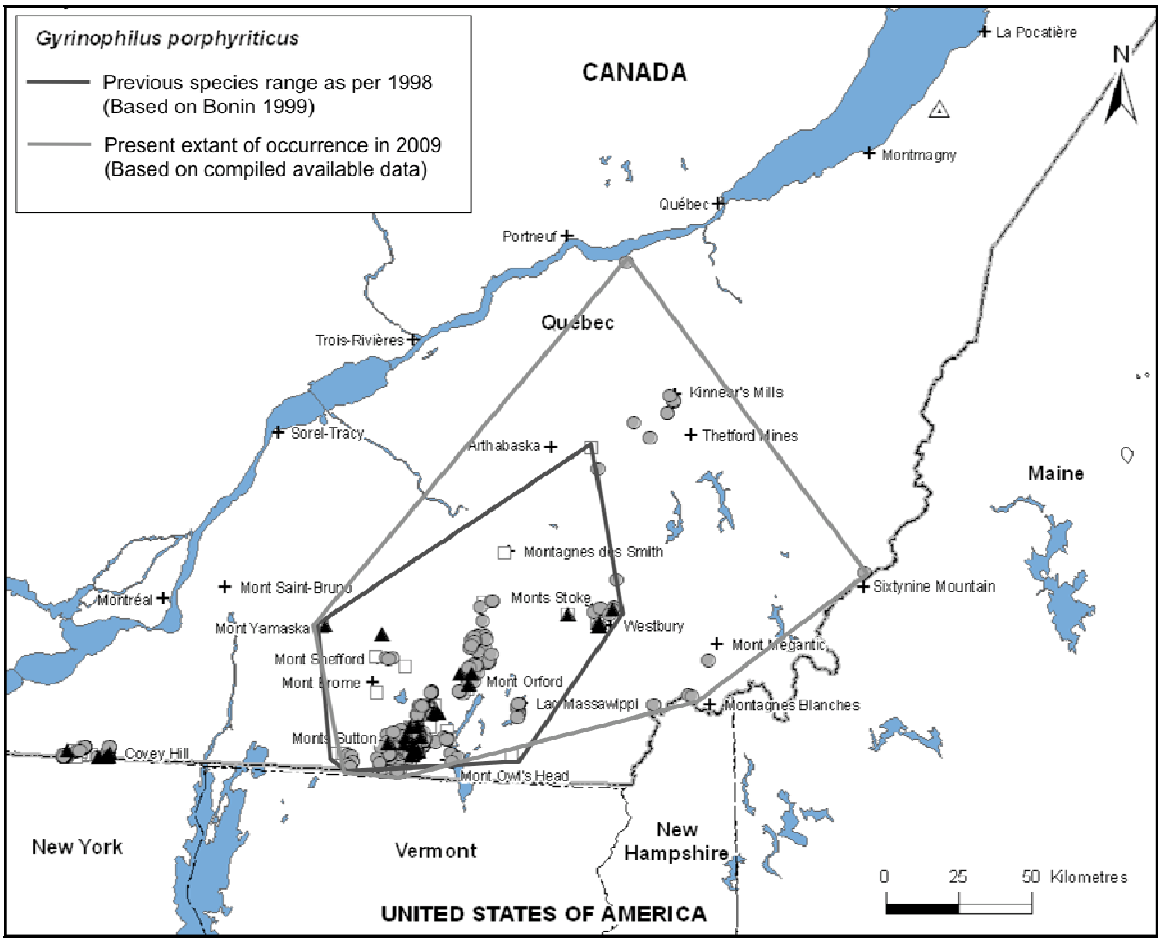


Figure 5. Change in the extent of occurrence of *G. porphyriticus* in Canada prior to 1998 compared to 2009. Note: the northernmost record (near Portneuf) may not be valid and therefore the extent of occurrence is likely somewhat less than shown).

Within the EO, the Spring Salamander occurs patchily in forested, high elevation low-order streams, in forest habitat, at altitudes 100 m above sea level. This area of occupancy is assumed to provide essential habitat (for food, shelter, reproduction and wintering) for the species. The index of area of occupancy (IAO) is 1 416 km^2, calculated by superimposing a grid with 2 km x 2 km cells over the species' range, and subtracting all grids overlying altitudes below 100 m. Because the species' dispersal is achieved through stream networks and riparian habitats, IAO was determined accordingly, along the streams where the species occurs. As *G. porphyriticus* movements can occasionally reach nearly 500 m, over a 3-year period (Lowe 2003), a maximum dispersal of 2 km was assumed in IAO calculations. Therefore, an extra grid of 4 km^2 around each extant occurrence was added. Also, grids connecting two extant occurrences of the species along a stream were kept in calculations, except in the presence of significant dispersal barriers (e.g., roads, lakes) (Appendix 2).

In terms of the number of locations *sensu* IUCN, Covey Hill can be considered a single location as a single threat to the drainage system could wipe out this entire area. Because it's difficult to determine which sites belong to which watershed (many of them overlap) over other parts of the species' distribution in Quebec, it was decided that each site at which mature individuals were observed be considered a separate location. Given this approach, there would be 14 locations (based on Table 1, column 6).

Search effort

Appalachian DU.

The majority of available data on the distribution of *G. porphyriticus* is from herpetological fieldwork from the late 1950s (Bleakney 1958) until the present, although additional observations from various sources need to be verified (Bonin 1999). Since 1998, the number of amphibian surveys in southern Quebec has increased considerably resulting in new Spring Salamander occurrences and better delineation of its range (Frenette 2007). Accordingly, over 300 observations have been added to the species' distribution in the past decade (S. Rioux *unpublished data*); however, population sizes remain unknown.

At Covey Hill, 399 stream sections of 25 m were searched systematically in 2002 and 2003 (Frenette 2007). The following year, 63 additional stream sections were investigated in the same area (Boutin 2004).

In the Appalachian Mountains area, Appalachian Corridor Appalachien (ACA) has been performing yearly surveys along streams of the Sutton Mounts and their surroundings since 2001. In 2001, MRNF also conducted inventories of seven streams on Mount Stoke and of streams near Lake Massawippi (Frenette 2007).

Numerous field surveys took place on seven Monteregian Hills between 1997 and 2004, in the Gulf Valley in 2001 and in the hydrological basin of the Saumon River (Ouellet *et al*. 2005, Frenette 2007). In addition, 35 old forests of Beauce, Estrie, and Montérégie have been investigated for amphibian diversity (Bonin *et al*. 1999).

Carolinian DU.

Most recently, the Niagara Natural Areas Inventory (NAI) project compiled information on 14,770 amphibian and reptile records from the Niagara Region, including 8,708 records collected between 2006 and 2008 (Yagi *et al*. 2009). No Spring Salamanders were located and Yagi *et al*. (2009) and COSSARO (Oldham 2001, Anonymous 2010) concluded that the species was extirpated from Niagara (see also **Preface, Designatable units** and **Canadian range).**

HABITAT

Habitat requirements

Gyrinophilus porphyriticus is an epigean (surface-dwelling) species associated with cool, well-oxygenated, low-order (*i.e*., headwater), perennial mountain streams (Bishop 1941, Petranka 1998, Lowe 2003). The species has a predilection for springs, seepages, and small tributaries of headwater streams lacking predatory fish (Bishop 1941, Bruce 1972) and is absent from large fast-flowing streams (Bruce 1972, 2003). In the Covey Hill area (Adirondack Piedmont), more individuals were found in intermittent streams (35) than in permanent streams (19). However, the most captures per site occurred in a permanent stream with a water flow varying between 9 and 167 litres/second (Rutherford *et al*. 2004, Boutin *unpublished data*). In this type of stream, salamanders were found under submerged rocks, swimming, or on land close to the water's edge, whereas in intermittent streams, they were found on land under cover objects (Rutherford *et al*. 2004). At all stages, the species depends on sufficient water quantity and quality and is therefore vulnerable when the stream dries up or becomes acidic (Green and Peloquin 2008).

Oviposition occurs in underground depressions within streams or seeps, and thus nests are rarely observed (Organ 1961, Petranka 1998). Females lay their eggs in a monolayer under large rocks, or other objects either submerged or partially embedded in the stream bank (Bruce 1978, Petranka 1998, Desroches and Rodrigue 2004).

Larvae of *G. porphyriticus* are strictly aquatic and survival depends on a number of stream conditions. They take refuge in the interstitial spaces in the streambed substrate (Resetarits 1991, 1995). They require gravel beds, rocks or logs under which they can hide, sometimes at a depth of several centimetres (Bishop 1941, Bruce 1980, 2003). They emerge from these refuges at night to forage on the streambed surface (Resetarits 1991).

Adult Spring Salamanders use terrestrial habitats, usually within 2 m of the stream edge, reflecting their requirements for moisture (Bruce 1978, Lowe *et al.* 2006a). They are found under cover objects (Bishop 1941) or foraging on the forest floor (Deban and Marks 2002). Presence of large rocks or other protective cover on stream banks is important for the species (Bonin 1991) and becomes essential in adverse conditions such as drought (Bishop 1941). Because of their size, adults require large interstitial spaces in the streambed for refuge and foraging (Resetarits 1991, 1995).

Spring Salamanders probably winter in the stream bottom or in refuges under the stream bank that are protected from freezing (Bishop 1941, J. Bonin, pers. obs.). Abundant rocky substrate on the streambed probably prevents young individuals from freezing by providing underwater refuges (Bider and Matte 1994). Maintenance of water flow to these streams is important to ensure availability of wintering habitat (Bonin 1999).

Spring Salamanders require forest cover (Bonin 1991), but occur in a wide range of forest types (Bruce 2003). Gibbs (1998) suggested that some woodland amphibian populations (*Notophthalmus v. viridescens*) do not persist under a forest cover below 50%. Salamander densities are known to increase with the area of remaining forest in a landscape and decline with fragmentation (Gibbs 1998). Vegetation cover keeps water cool and well oxygenated, reduces drought and maintains soil moisture and temperature levels adequate for salamander survival and foraging (Thorson and Svihla 1943, Shealy 1975, Krzysik 1979, Petranka 1998, Grover 2000, Jung *et al*. 2000). Forest also plays a role in water quality and refuge availability as it prevents siltation (Hawkins *et al*. 1983, Waters 1995, Shannon 2000).

Habitat trends

The landscape of the St. Lawrence lowlands has been extensively altered by human use since European settlement; forest has disappeared from large parts of southern Quebec and watersheds have been modified for agricultural purposes. These trends undoubtedly have reduced habitat available for the Spring Salamander and are expected to continue. For example, the species has probably disappeared from Mount Yamaska in the past decade due to habitat loss (S. Rioux pers. comm.). In the mountain regions where the species occurs, timber harvesting is the main cause of habitat loss. Forestry affects water quality (i.e., through siltation) and results in fragmentation of the natural landscape, over wide areas.

Over the past 20 years, residential development and recreational infrastructure (i.e., skiing stations, golf courses) have significantly increased in the Appalachian region. Mounts Shefford, Brome, Orford, and Sutton have been targeted by developers. Therefore, habitat loss, alteration, and fragmentation have occurred to varying degrees in these locations. After an environmental impact assessment conducted in 2004, work to enlarge the Bromont ski station began in areas where the species is abundant (Frenette 2007, M. Frenette pers.comm.). Plans to enlarge the Mount Orford ski area were considered in 2002 and included the creation of a village comprising housing units, hotels, numerous commercial establishments and a water park along a brook inhabited by the Spring Salamander (Memphrémagog Conservation Inc. 2005).The project has not yet been initiated however.

On the upper portion of Covey Hill (Adirondack Piedmont), the soil type in areas occupied by the species discouraged agricultural development. Also, probably, because of topography, the hill has not been subjected to substantial timber harvesting; hence, the area retains old forest stands, unique in the province (Laroque *et al*. 2006). Nevertheless, the hill is now isolated in a highly fragmented landscape where agriculture, tourism developments, and increasing water demands are important pressures on natural habitats (Laroque *et al*. 2006, Frenette unpub. data).

In May 2009, the Des Moulins wind farm was under study by SNC-Lavalin Environnement Inc. The project consists of the installation and operation of 78 turbines (SNC-Lavalin Environnement Inc. 2009). Located between Thetford Mines and

Kinnear's Mills, the study area of 132 km^2 completely overlaps the three northernmost extant occurrences of the Spring Salamander. This development would require upgrading and construction of access roads. A second project, the *Des Érables* wind farm south of Kinnear's Mills, has been approved and should be operational by 2011. The Des Érables windfarm covers 50 km^2 on a total study site of 153 km^2, located in Spring Salamander habitat (Éoliennes de l'Érable Inc. 2009).

In the southern Appalachians (United States), 40% of mountain streams exhibit signs of acidification, mainly caused by atmospheric deposition of pollutants. This acidification has severely affected stream water chemistry in the area, and analyses predict it will continue to increase (Sullivan *et al*. 2004). The levels of stream acidification within the species' Canadian range are unknown, but it is known that acidification of their habitat is detrimental to Stream Salamanders (see **Physiology**). Because headwater streams may have little acid-neutralizing capacity and may fluctuate with rainfall beyond the acidity levels tolerated by the species (Green and Peloquin 2008), this should be regarded as a threat throughout the species' range. Extreme incidents may significantly impact habitat quality, as shown by a stream salamander community that was eliminated by acidic runoff from pyritic gravel from a construction accident 7-8 km upstream. The effects of this incident are still noticeable 30 years later and some species have not yet completely recovered (Green and Peloquin 2008).

BIOLOGY

Life cycle and reproduction

The Spring Salamander has a two-phase life cycle (Bruce 1972). Its larval period is the longest among plethodontid species (Hairston 1987, Beachy and Bruce 1992), lasting 3 to 6 years, but most commonly 4 years (Bruce 1980, Resetarits 1991). Larvae attain large sizes before metamorphosing (Bruce 1972) and their development is influenced by habitat quality, predation pressure (Bruce 1978, Resetarits 1995), and sex, with males generally developing faster (Bruce 1978). Metamorphosis happens in late spring or summer (Bruce 1980). At low elevations, most larvae transform when they reach 55-65 mm snout-vent length (SVL), whereas in populations at altitudes above 1200 m, transformation occurs at a SVL of 61-82 mm (Bruce 1972, 1978, 1979, 1980). Sexual maturity is generally attained within one year after metamorphosis, though maturation may be delayed at higher elevations (Bishop 1941, Bruce 1972, 1980). Considering that breeding first occurs at an average age of 5 years, and that the oldest breeding individuals can attain 10 years of age (Tilley 1977, Lowe 2003), generation length for the Spring Salamander is estimated at 7 years.

Mating occurs in summer or autumn (Bishop 1941, Bruce 1969). Courtship is complex with individuals engaging in a tail-straddle walk, in which success is variable and may be lower in smaller individuals (Beachy 1996). Although variation exists between high and low elevation populations, females oviposit annually, generally in

summer, a year after mating (Bruce 1972, 1978, 1980). Clutch size and egg diameter are relatively large for a plethodontid (Collazo and Marks 1994). Fecundity increases with body size, but for similar-sized females, egg production is greater at low elevations (Bruce 1969, 1972). Throughout the species' range, clutches of between 9 and 132 eggs have been reported (Bishop 1941, Bruce 1972), but tend to be smaller in southern regions (Bruce 1972, Organ 1961). Egg diameter averages 3.5 to 4.0 mm (Bishop 1941, Bruce 1972). Some nests are found with attending females (Petranka 1998), a behaviour that is known to increase reproductive success in plethodontids (Forester 1979). Hatching occurs in late summer or early autumn (Bruce 1978, 1980).Early development stages were described by Collazo and Marks (1994).

Demographic attributes of Canadian populations have not been documented. Sex ratios of 1:1 have been observed in populations in South and North Carolina (Bruce 1972). Studies conducted in New Hampshire suggest that larvae to adult ratios are variable (0.67 - 1.5 : 1; Lowe *et al*. 2006b).

Because of the species' tendency for upstream dispersal, population growth in upstream sections is directly influenced by immigration from downstream section (Lowe 2003). Accordingly, local reproduction and mean body condition are higher in downstream sections (Lowe 2003, Lowe *et al* 2006a).

Physiology and adaptability

Because they lack lungs, keeping the skin moist to facilitate respiratory gas exchange is critical to all plethodontid salamanders (Feder and Burggren 1985). Both metamorphosed and larval individuals are extremely vulnerable to water loss by evaporation when exposed to air (Spotila 1972, Feder 1983). Their skin has a low resistance to water loss by evaporation (Spight 1967, 1968, Spotila 1972, Spotila and Berman 1976). This vulnerability affects habitat use, dispersal, and daily activity (Heatwole 1962), and also suggests a strong sensitivity to chemicals. Spring Salamander larvae are critically sensitive to acidification; pH values under 3.5 are lethal (Green and Peloquin 2008). Adults however, tolerate pH 3.75 (Green and Peloquin 2008). Effects include lethargic movements, reduced swimming speed, and a reduced sensitivity of the tail to stimulus; all of these responses affect salamanders' ability to escape predators and/or to capture prey (Green and Peloquin 2008).

The long trunk, short limbs, relatively broad and flat snout of *G. porphyriticus* are considered adaptations to burrowing. This morphology allows the salamanders to use subsurface habitats in the interstitial zone of streambeds (Brandon 1966, Bruce 2003), allowing escape from predators and adverse conditions (Bishop 1941, Bruce 1980).

Stream salamanders are distributed along a moisture gradient. Their distribution is mainly determined by avoidance of predation and competition (Hairston 1987, Grover 2000, Grover and Wilbur 2002, Petranka and Smith 2005). *Gyrinophilus porphyriticus* is usually the most aquatic species along this spectrum. It successfully displaces other salamander species towards drier environments (Hairston 1949, Smith and Pough

1994, Grover 2000). Aggressive interactions between adults suggest that they are territorial (Bishop 1941), whereas larvae may be tolerant to proximity of other Spring Salamanders.

Spring Salamanders are nocturnal and adults forage during rainy nights (Burton and Likens 1975, Burton 1976). This strategy reduces dehydration and predation, while increasing foraging success (Jaeger 1972, Fraser 1976). With a predilection for large prey consumed at long intervals, the species tolerates short-term food deprivation in adverse conditions (Bruce 1972, Resetarits 1991).

Because of the physiological limits of lunglessness (Spotila 1972, Feder 1983), Spring Salamanders are sensitive to habitat modifications, especially those affecting moisture conditions. As environmental stressors such as warming and drying are thought to have greater effects on metamorphosed individuals, the retention of a long larval period seems to be an adaptive strategy (Bruce 1978). However, throughout this long stage, survival is highly compromised by predators, larger conspecifics (Resetarits 1995), and habitat alteration. The particular secretiveness of vulnerable stages (brooding females, eggs, hatchlings and metamorphosing individuals) and their tendency to burrow in the substrate, and to hide in refuges on the stream bottom (Bruce 1980) may allow them to circumvent some of these threats. Overall, the species' long life expectancy and high fecundity may compensate for the high mortality pressures on larvae (Resetarits 1995).

Dispersal and migration

Dispersal of *G. porphyriticus* occurs primarily along the stream corridor following a model of simple diffusion (Lowe 2003). The species exhibits a strong upstream bias for movements in both adults and larvae, independently of stream chemistry, physical structure, or abundances of prey and predators (Lowe 2003, Lowe *et al*. 2005, 2006a). Downstream movements (drift) are infrequent and occur on small spatial scales. Over a 3-year interval, one monitored individual travelled a maximum of 484 m upstream, whereas the maximum downstream distance moved was less than 85 m (n=118, Lowe 2003). The distance travelled is not correlated with individual size (Lowe 2003). For individuals that move more than 1 m over a 3-year period, average distance moved is 9.1 m $\pm$ 2.8 m ($\pm$1 SE, n=21) m, with the majority of movements not exceeding 50 m (Lowe 2003). Terrestrial movements of adults are generally restricted to within a 2-m distance from the stream edge (Lowe *et al*. 2006a). Occasionally, adults are found on the forest floor at night, far from running water (Petranka 1998). These longer terrestrial movements are usually achieved in moist habitat (Bonin 1991, 1999, Desroches and Rodrigue 2004).

Interspecific interactions

Gyrinophilus porphyriticus feeds on terrestrial and aquatic invertebrates and smaller salamanders (Bishop 1941, Bruce 1979), including conspecifics (Bruce 1972, Burton 1976). The extent of this behaviour varies geographically; in North and South Carolina, nearly half of the diet consists of salamanders (Bruce 1972), whereas in northern populations, salamanders represent only a small fraction of the diet (Burton 1967, Bruce 1979, Lowe *et al*. 2005). Adult *G. porphyriticus* inhibit the development of small conspecifics, through competition or threat of predation (Gustafson 1994).

The main predators of the species are fish, especially Brook Trout (*Salvelinus fontinalis*) (Resetarits 1991, 1995). Survival of larval *G. porphyriticus* is reduced by over 50% in the presence of fingerling Brook Trout and reduced even more in the presence of adults. Growth in mass is reduced by over 90% where Spring Salamanders co-occur with Brook Trout (Resetarits 1995). This reduced growth may result in later metamorphosis or smaller size at metamorphosis, both affecting fecundity and population dynamics (Bruce 1972, 1980). The presence of fish also causes the salamanders to shift habitat towards shallow waters, which are perhaps less suitable (Resetarits 1995, Lowe 2003). Spring Salamanders are occasionally eaten by Eastern Gartersnakes (*Thamnophis sirtalis*) (Uhler *et al.* 1939). When attacked, individuals take a defensive posture with the head tucked beneath the body and the tail raised and undulated (Petranka 1998). Adults produce skin secretions that are noxious and repel shrews (Brodie *et al*. 1979). The bright colour and noxious secretions may be part of a Müllerian mimicry with the Red-spotted Newt (*Notophthalmus viridescens*) (Petranka 1998).

In Canada, the Spring Salamander co-occurs with other stream salamander species, such as the Northern Dusky Salamander, Allegheny Mountain Dusky Salamander and Two-lined Salamander (*Eurycea bislineata*). It will occasionally be found with the Mudpuppy (*Necturus maculosus*) and larvae of some terrestrial species (Boutin 2006).

POPULATION SIZES AND TRENDS

Sampling effort and methods

In Canada, some parts of the species' range have experienced considerable sampling effort, whereas others need further investigation.In Covey Hill, 399 stream sections were systematically searched in 2002 and 2003. Sections were 25 m in length and extended up to 2 m from the water's edge. Sections were searched for 1 hour each (i.e., 15 minutes of search by a group of four people), resulting in a total search effort of 90 person-days for 2002 and 2003 (Frenette 2007). The following year, the same area was surveyed, using the same search method, for a total effort of 64 person-days (Boutin 2004).

Annual salamander surveys were conducted along streams of the Sutton Mounts and their surroundings over 5 years between 2001 and 2005. Search effort consisted of 41, 20, 30, 30, and 60 person-days, respectively (Frenette 2007). In 2001, seven streams on Mount Stoke (15 person-days) and a few streams near Lake Massawippi were inventoried (Frenette 2007).

In 2004, a herpetological survey was conducted on Mount Brome as part of an impact assessment study. A total of 4.7 km in stream length was investigated in a portion of this mountain, which had not yet been exploited by the ski resort. Stream salamanders, including *G. porphyriticus* were then found in large numbers, prior to the beginning of the work to enlarge the ski resort (Frenette 2007). These observations do not appear on the distribution maps because they were not transmitted to the AARQ or CDPNQ.

Abundance

The number of Spring Salamanders in Canada is unknown. Over the length of a single stream, as many as 71 adults and 64 larvae have been observed in Quebec (CDPNQ 2008), indicating the species may be locally abundant.

In the Adirondack Piedmont (Covey Hill), time-constrained searches of 1 hour (four persons searching 15 minutes) covering a stream section of 25 m in length, and extending up to 2 m from the water's edge, yielded a maximum of four adults and two larvae per section (Boutin unpublished data). However, up to 25 individuals over this sampling scale have occasionally been reported in Canada (J. Bonin, pers. obs.).

Over its global range, *G. porphyriticus* is difficult to collect in large numbers, especially in the adult stage (Beachy 1996, Adams and Beachy 2001). In Canada, the species is considered to be rare (Cook 1970, Bider and Matte 1994). The Spring Salamander is usually the least abundant among sympatric plethodontid salamanders (Bruce 1972). This relative rarity was also observed in the Covey Hill region where the Spring Salamander was the least abundant of five species (i.e. Northern Dusky Salamander, Allegheny Mountain Dusky Salamander, Two-lined Salamander and Eastern Red-backed Salamander (*Plethodon cinereus*); Boutin 2003, 2004). Spring Salamanders accounted for only 2.2 % and 4.5 % of the total captures (n=1319 and 1207 respectively) of salamanders from 2 different years (Boutin 2003, 2004).

Fluctuations and trends

Fluctuations and trends in Canadian populations have not been documented. The species' cryptic behaviour and the lack of search effort in some parts of the range may be responsible for observation gaps. A comparison of historic and current records (as of 2008) shows that populations have persisted for as long as 36 years after their initial discovery. Numerous observations made in the past decade led to discovery of nine new populations and an increase in extent of occurrence, likely reflecting greater search effort rather than population growth or the establishment of new populations (Table 1).

In some areas, the species is known only from historical records, suggesting these populations might have disappeared (Table 1). In 1993, 15 historical sites were investigated to verify persistence of some populations; Spring Salamanders were observed at only five of these sites (Bonin 1994). The low rate of site occupancy was suspected to be due, in part, to lack of precision in the locality information associated with earlier records (Bonin 1999). In 1993, one of the historical sites was destroyed by the development of a ski facility (Bonin 1994).

Rescue effect

Throughout its range in the US, *G. porphyriticus* is mostly secure (NatureServe 2009), but declines have been reported in New Jersey, Maine, and Massachusetts. Populations in Connecticut and Mississippi are currently considered imperiled and critically imperiled, respectively (Cromatie 1982, DeGraaf and Rudis 1983, NatureServe 2009). Adjacent to Canada, populations in New York, Vermont and New Hampshire are all secure or apparently secure, and could offer a rescue potential as long as suitable habitats provide connectivity between the populations. Because of their geographic proximity, only three populations in Canada (i.e., Covey Hill, White Mountains, Sixtynine Mountain) would possibly receive migrants from the United States (respectively, New York, New Hampshire, Maine). However, hydrological discontinuities, changes in topography, and the limited dispersal abilities of the species reduce the potential for natural immigration. Also, the genetic differentiation and sexual incompatibility that is known to occur at local scales in the US could be significant impediments to a rescue effect (Beachy 1996, Lowe *et al*. 2008).

THREATS AND LIMITING FACTORS

The principal threat to the Spring Salamander is alteration or reduction of water quality and water flow by human activities (Jutras 2003). Modification of hydrological systems has negatively affected survival of the species in New Jersey and Mississippi (Ashton 1976). These modifications are especially critical if they reduce water flow, converting permanent streams into temporary ones. Such an event has been observed after intensive water pumping in residential areas (Medina 1990).

Water pollution, spreading via both underground water channels and connecting surface streams, has been suggested to compromise survival of the species (Bury 1980). The longevity and high trophic position of the Spring Salamander make the species, particularly the larvae, vulnerable to contamination and pollution (Bonin 1999). However, the extent of this threat has not been assessed in Canada. Water acidification can be lethal (Green and Peloquin 2008).

In collaboration with the Quebec stream salamander recovery team, University of Montreal and Nature Conservancy of Canada are developing a monitoring protocol for stream salamanders at Covey Hill. Once implemented, this program will provide long-term monitoring of hydrological processes on the hill (Laroque *et al.* 2006). This should provide information on water resources and threats to this essential element of the Spring Salamander (S. Giguère and M. Frenette pers. comm.).

Water chemistry, quality or supply may be diminished by many factors (e.g., water exploitation, agriculture, residential or recreational development, contamination). Timber harvesting is an imminent and severe threat to salamanders (Corn and Burry 1989, Petranka 1991,Gibbs 1998). Canopy removal affects moisture and temperature conditions crucial for plethodontid survival, and also reduces water quality (Shealy 1975, Krzysik 1979, Jung *et al*. 2000) by increasing silt in streams which fills in interstitial spaces in the streambed that are used for foraging and shelter (Hawkins *et al*. 1983, Waters 1995, Shannon 2000). Adults seem to be primarily affected, because they require larger interstices (Lowe *et al.* 2004). Increase in organic matter caused by erosion reduces oxygen levels which has negative impacts on larvae (Bider et Matte 1994). Recruitment may also be impaired if sediments are deposited on eggs (Bruce 1978). Even though these impacts may be temporary (Martin *et al*. 1984), they can have long-term outcomes on population survival (Stiven and Bruce 1988) and may increase vulnerability to natural disturbances (Lowe and Bolger 2002).

The most important threat to larvae is predation by fish, especially Brook Trout, sometimes the only predator present in these high-elevation streams (Burton and Odum 1945). Brook Trout introduction into streams or upstream lakes compromises populations of Spring Salamanders (Resetarits 1991, 1995; Jutras 2003), especially when interstitial refuges become scarce (Lowe *et al.* 2004). Hence, predation should be considered as a severe threat particularly in the presence of timber harvesting. There is little quantitative information on trends or patterns of introduction and spread of Brook Trout relative to distribution of Spring Salamanders.

PROTECTION, STATUS, AND RANKS

Legal protection and status

At the federal level, the Spring Salamander has been assessed as Special Concern (2002) by COSEWIC and therefore falls under the *Species at Risk Act* (SARA) and has been listed as such in the Schedule 1 of this Act.

In fall 2009, the Spring Salamander was listed Vulnerable in Quebec by the provincial government under the *Act Respecting Threatened or Vulnerable Species* (R.S.Q., c. E-12.01). Therefore, the species is protected by the provincial *Act respecting conservation and development of wildlife* (R.S.Q, c. C-61.1) that prohibits collecting, buying, selling or keeping specimens in captivity.

In Ontario, the species is considered extirpated under Ontario Regulation 230/08, Schedule 1 of the *Endangered Species Act*, 2007 (S.O. 2007, c.6).

Non-legal status and ranks

Protection measures for stream salamanders relating to silvicultural practices on public provincial lands have been recently adopted and implemented in Quebec (MRNF 2008a). However, about 75% of the Spring Salamander's range in southern Quebec is on private lands that lack habitat protection. Landowners have been encouraged to apply these protection measures on a voluntary basis (D. Banville, J. Jutras pers. comm. 2009). Therefore, a certificate of authorization from the Minister must be obtained prior to undertaking any construction or industrial activity that negatively affects a river, a brook (permanent or intermittent), a lake, a pond, a marsh, or a peat bog. Typically, however, people do not obtain authorization and are not asked for it afterward (S. Nadeau pers. comm. Nov. 2010).

Globally, the species is ranked G5 by NatureServe indicating that it is widespread and globally secure (NatureServe, 2009). In the United States, it is also nationally secure (N5), whereas in Canada it is considered vulnerable (N3). In Quebec, the Spring Salamander is ranked S3, vulnerable (NatureServe 2009).The IUCN Red List considers the species Least Concern (IUCN 2008), and it does not appear on the Convention on International Trade in Endangered Species (CITES).

Habitat protection and ownership

Of the total of 425 Spring Salamander records in Canada, 26 are in protected areas and 84 occur on properties of the Nature Conservancy of Canada (NCC). Accordingly, nearly a quarter of the species' records occur in three protected areas and 12 ownership agreements (Table 2), representing 127.56 km^2 of total habitat (M-M. Rousseau-Clair, pers. comm.). The protected areas cover roughly 19.5 % of the species' area of occupancy.

Table 2. Protected areas in which Spring Salamander occur in Canada (provided by Nature Conservancy Canada)

Type of protection	Responsible authority or owner	Name	Area protected (km^2) Area protected (km^2)	Year of protection
Ecological reserve	MDDEP	Vallée-du-Ruiter Ecological Reserve	1.2	Updated in 2008
Quebec national park	MDDEP	Yamaska national park	12.8	Updated in 2008
Quebec national park	MDDEP	Mount Orford national park	54.9	Updated in 2008
Ownership	NCQ	-	1.4	2007
	NCQ	-	3.9	2004
	NCQ	-	4.1	unknown
	NCC	-	0.4	2006
	NCC	-	1.2	2008
	NCC	-	3.0	2002
	NCC	-	4.8	2001
	NCC	-	36.7	2004
	Ruiter Valley Land Trust	Ruiter Valley Land Trust Conservation Servitude	2.1	unknown
	Private	Elisabeth and Victor Frank Allistone Conservation Servitude	0.4	unknown
	Private	Philippe Tatarachef Conservation Servitude	0.02	unknown
	Private	Vicki Tansey and Richard Sommer Land Donation	0.4	unknown
TOTAL			127.6	

NCC: Nature Conservancy Canada
NCQ: Nature Conservancy Québec
MDDEP: Ministère du Développement durable, de l'Environnement et des Parcs du Québec

In the Appalachian Mountains, the species' habitat is protected in Quebec national parks, which fall under provincial jurisdiction, including: Mount Orford Park (54.90 km^2), and Mount Mégantic Park (54.86 km^2). In Haut-Saint-François County, the Ecological Reserve of Samuel-Brisson was created, providing protection for 7.9 km^2 of habitat adjacent to Mount Mégantic. Records confirmed the species' presence at Mount Yamaska National Park (12.89 km^2) in 1975 and 1995 (Weller 1977, Coté and Cormier 2007); however, very little suitable habitat remains inside the park's limits (Bonin 1999, Rioux pers. comm.).

The Mount Sutton Range, protected by NCC in partnership with the forest company Domtar Inc., is the largest private protected area in Quebec, currently covering 63.94 km^2 (Frenette 2007, NCC 2008). The acquisition of this land doubled the area protected within the Spring Salamander's Canadian distribution (Frenette 2007). Ultimately, NCC wishes to protect a total of 101.17 km^2 in the centre of these mountains and establish a surrounding buffer zone of 303.51 km^2 (NCC 2008). The south slope of Mount Sutton is also protected as part of the Ruiter Valley Ecological Reserve (1.17 km^2), a piece of land found near some known occurrences of the species.

As a non-profit conservation organization, ACA works to help preserve wildlife habitats along the Appalachia. Since 2001, conservation plans for the Spring Salamander have been produced for landowners and conservation agreements have been signed with them (Frenette 2007).

Since 2000, the Société de conservation du corridor naturel de la rivière au Saumon has also been active in the conservation of a region north of Mount Orford. This non-profit organization has bought over 0.65 km^2 of land and oversees the management of an additional 1.27 km^2 of adequate habitat for the Spring Salamander (Frenette 2007). The Société de conservation et d'aménagement du bassin de la rivière Châteauguay promotes public awareness on private properties in the hydrological basin of the Chateauguay River (Frenette 2007). Collectively, these initiatives help the species on private land.

Mount Saint-Hilaire is a Migratory Bird Sanctuary managed by the Canadian Wildlife Service. It covers 4 km^2 of which 0.13 km^2 are aquatic habitats (CWS 2008). This Spring Salamander habitat is further protected through the Gault Natural Reserve, owned by the McGill University (S. Giguère pers. comm.). On Mount Shefford, the sites where the species occurs are not directly secured; however, some are located in a protected area surrounding the Boivin Lake water reservoir exploited by the Granby municipality (Bonin 1999, J. Jutras pers. comm.).

The establishment of the Réserve écologique de la Serpentine-de-Coleraine in 2003 may help protect the species near Thetford Mines. It comprises two of the three Coleraine Mounts over an area of 3.96 km^2 (MDDEP 2008a). However, as opposed to other nature reserves on private land, public access is allowed in this reserve.

At the western limit of the species' range, NCC bought 1.24 km^2 of lands as part of its Covey Hill Natural Laboratory initiative, protecting half of the hilltop bog that feeds the streams of the hill (Laroque *et al*. 2006). The protection of the bog does not guarantee the ecological and hydrological integrity of the habitat because it is very susceptible to external disturbances (Pellerin and Lavoie 2003). South of the US border in New York State, a similar area, "The Gulf Unique Area", is protected and represents 2.16 km^2 (Laroque *et al*. 2006). On the east side of the species' range, a territory of 958.2 km^2 in the White Mountains is to be protected eventually as a Biodiversity Reserve in the Quebec strategy for protected areas (MDDEP 2008b).

At a smaller scale, measures to mitigate adverse effects on stream salamanders, including *G. porphyriticus,* have been developed with regard to silvicultural operations in public forests (MRNF 2008a). The measures protect a riparian area that includes 60 m from either side of a record of a Spring Salamander over a distance of 500 m downstream and upstream, along the hydrological network concerned. The guidelines prohibit construction of logging roads and installation of bridges or culverts in riparian zones. Depending on severity of forest harvest in adjacent areas, some forest operations are allowed in the protected zone (MRNF 2008a). For species observations that are not along a stream (e.g*.,* springs, resurgence, seepage area), the protection zone is considered as a circle of 150 m diameter around the occurrence.

Unfortunately, most of the species' range in Canada is located on private lands, which do not fall under any type of protection. As much as 75% of the species' occurrences remain in unprotected habitat, which represents 80.5% of the area of occupancy (Appendix 2). However, initiatives to protect the species' habitat have increased over the past decade.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Anaïs Boutin obtained her Master's degree in biology at l'Université de Montréal in 2006. Her thesis focused on determining the habitat selection of a community of stream salamanders from Covey Hill (Quebec) comprising five species and *Desmognathus fuscus* x *D. ochrophaeus* hybrids. Her work also focused on the development of molecular methods for identifying these hybrids and their parental species. She acts as a member of the National Recovery Team for the Mountain Dusky Salamander and has written the recovery plan for that species in Canada. She remains involved in the conservation of endangered wildlife and works as a biologist under the Habitat Stewardship Program for Species at Risk.

COLLECTIONS EXAMINED

No collections were examined for this update of the Spring Salamander status report.

DATA SOURCES

This report is based on available data in 2009, provided from:

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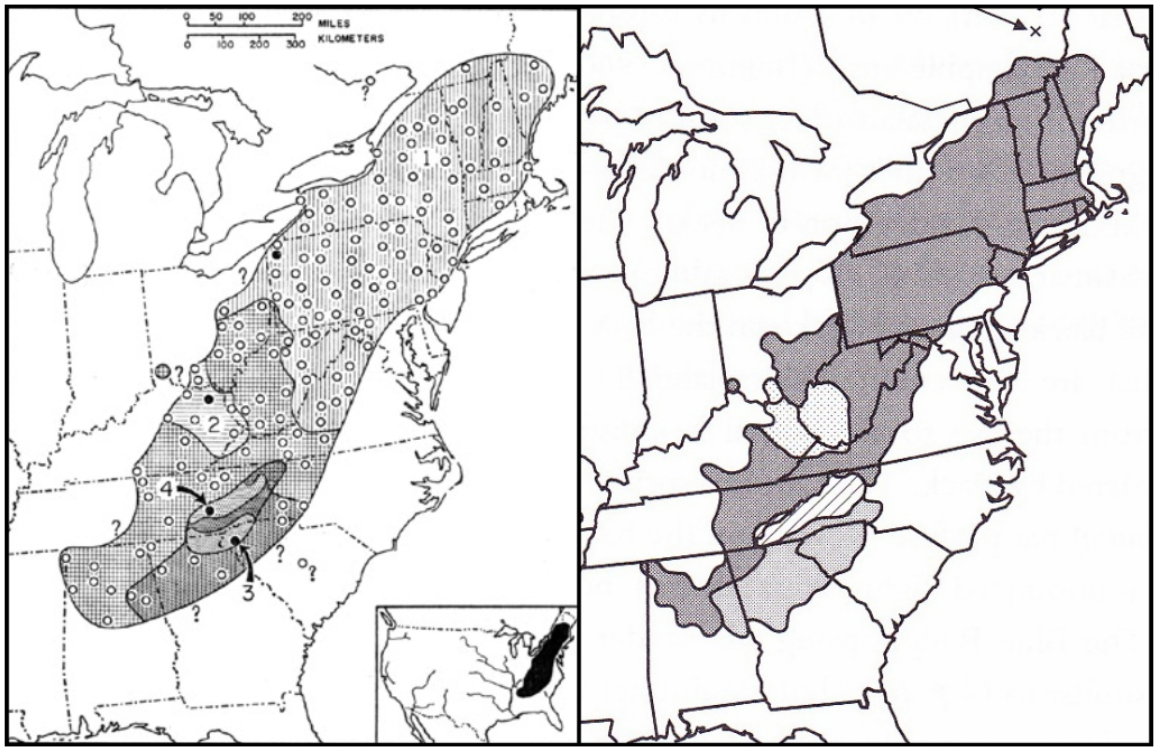
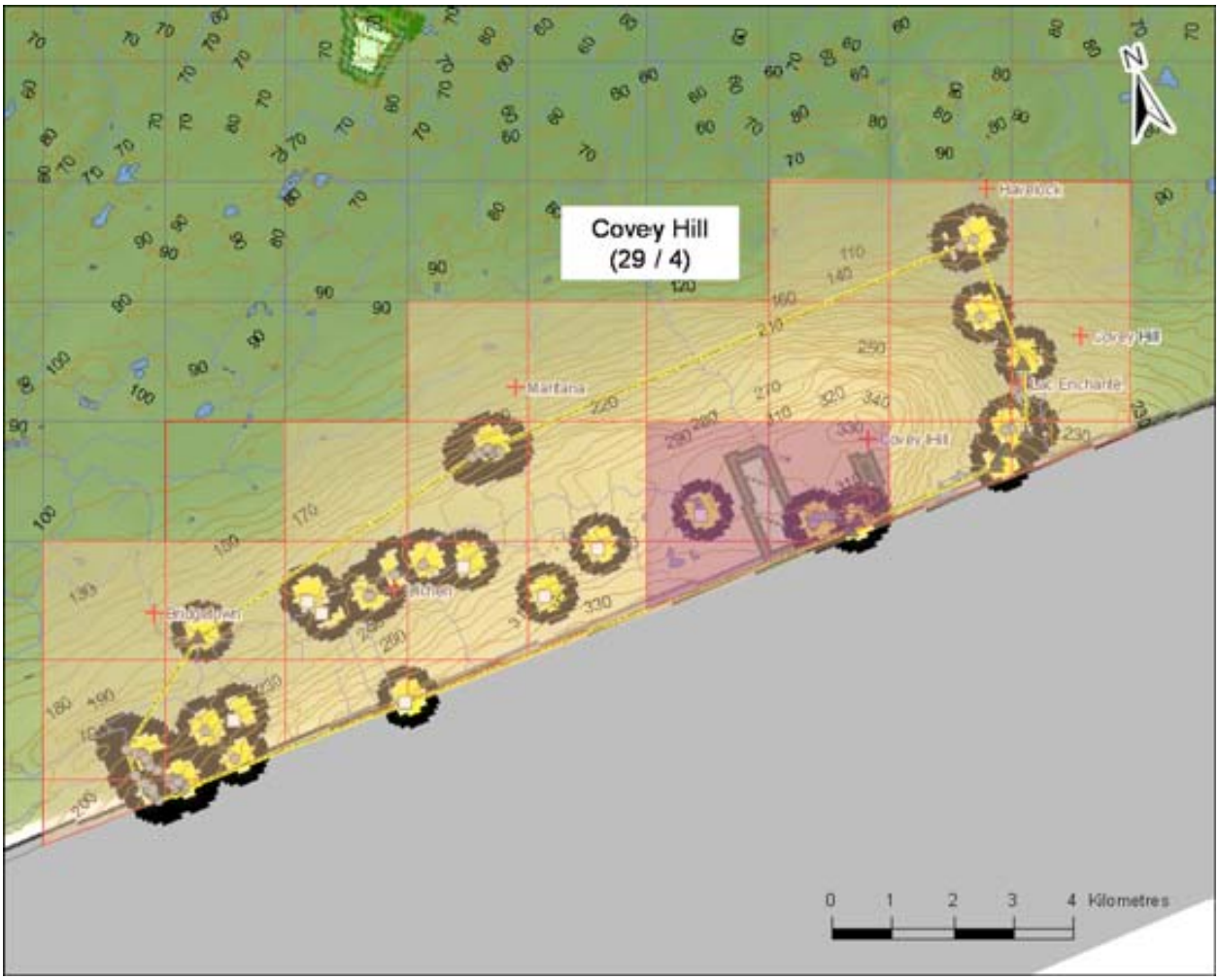
Atlas des Amphibiens et Reptiles du Canada (AARQ)

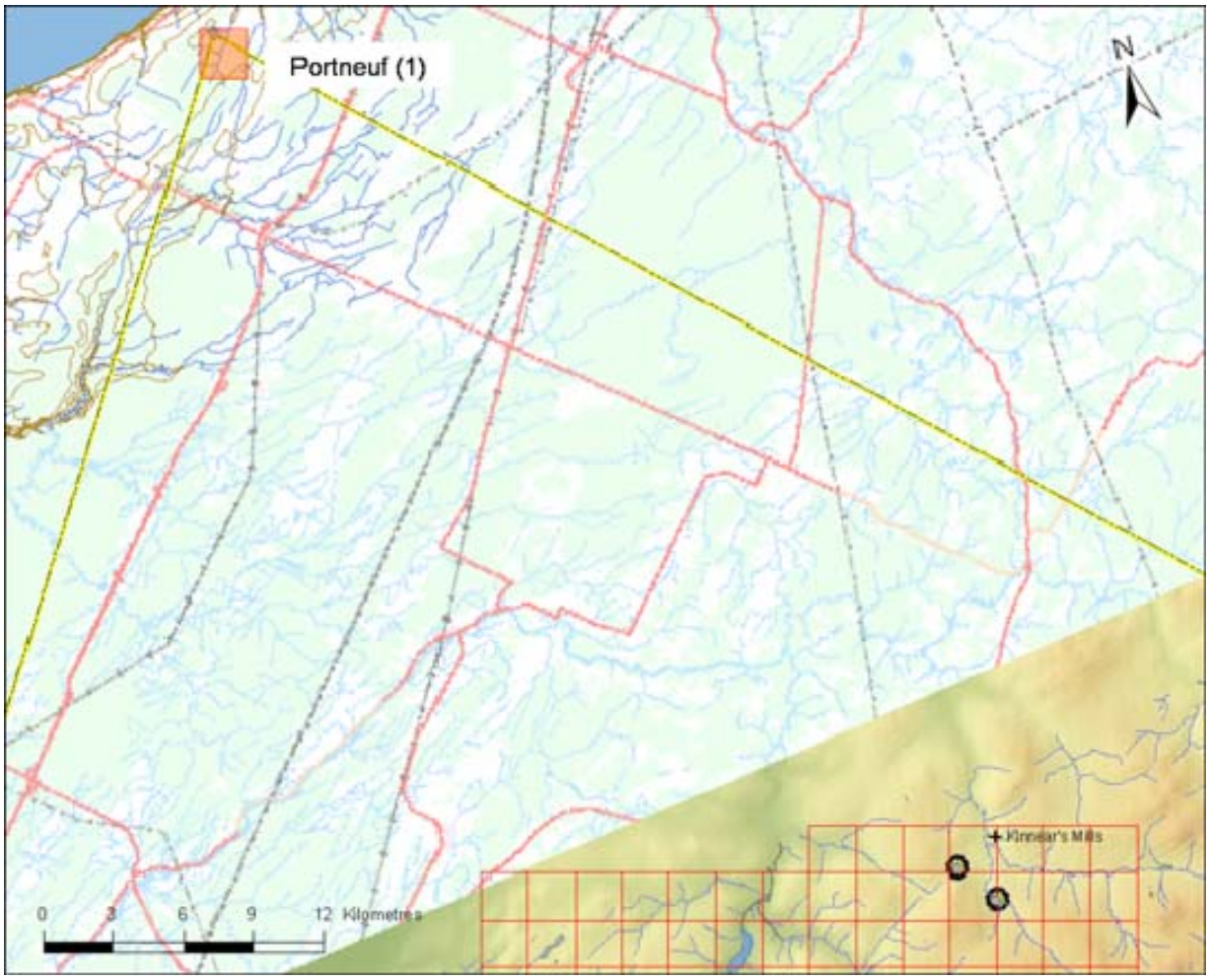
Anaïs Boutin, unpublished data
Appalachian Corridor Appalachien (ACA)
Agence régionale de mise en valeur des forêts privées de la Chaudière (ARFPC)
Gallois and Ouellet 2005
Mathieu Wéra-Bussière, unpublished data
Société de conservation du corridor naturel de la rivière au Saumon (SCCNRS)
Weller 1977
Weller and Cebek 1991

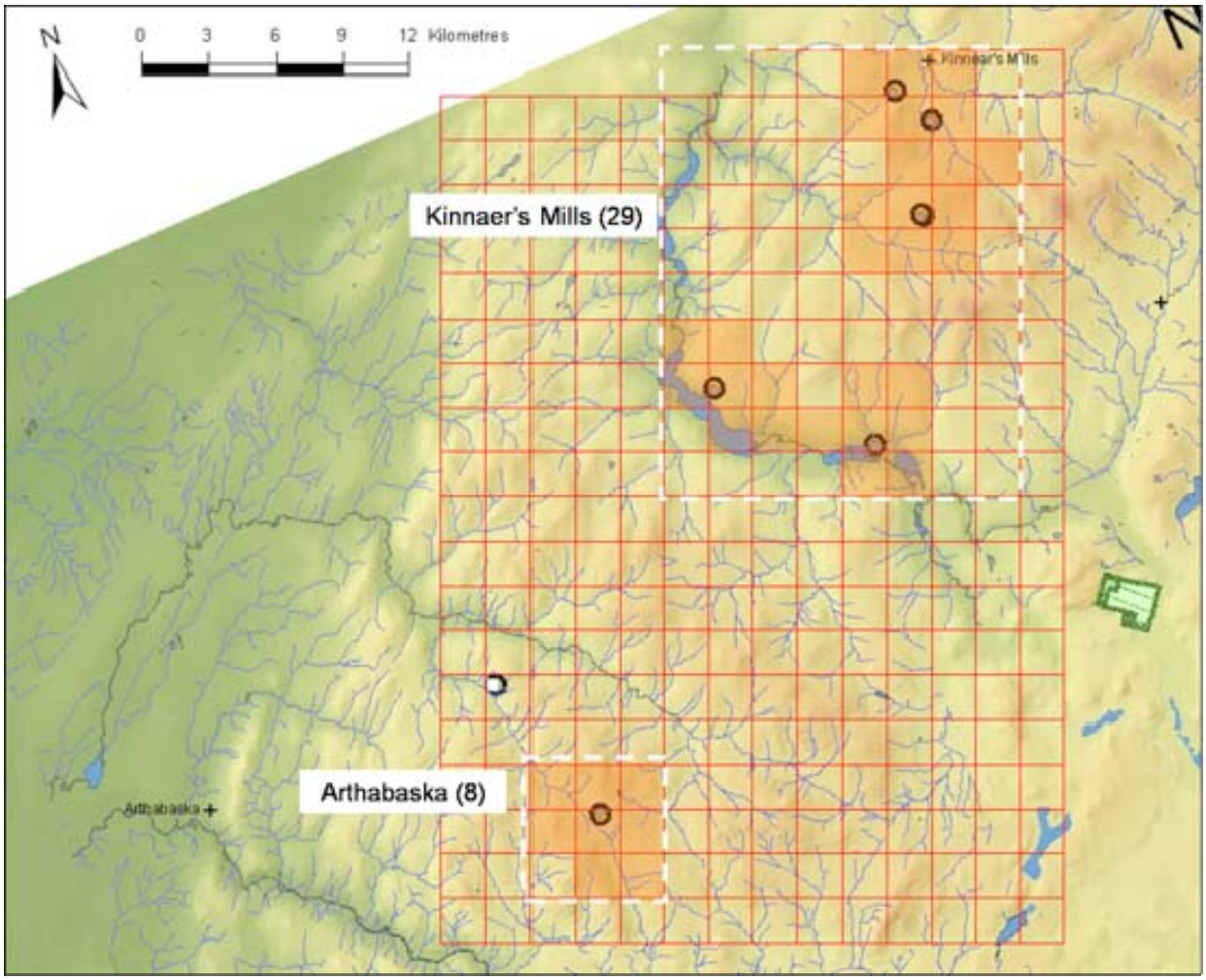
Appendix 1. Earlier global range of *G. porphyriticus* provided by Brandon (1967) compared to later species distribution described by Petranka (1998). The later map shows a more accurate presentation of the distribution. The darkest colour (includes Canada) represents the range of the subspecies *G.p porphyriticus*).

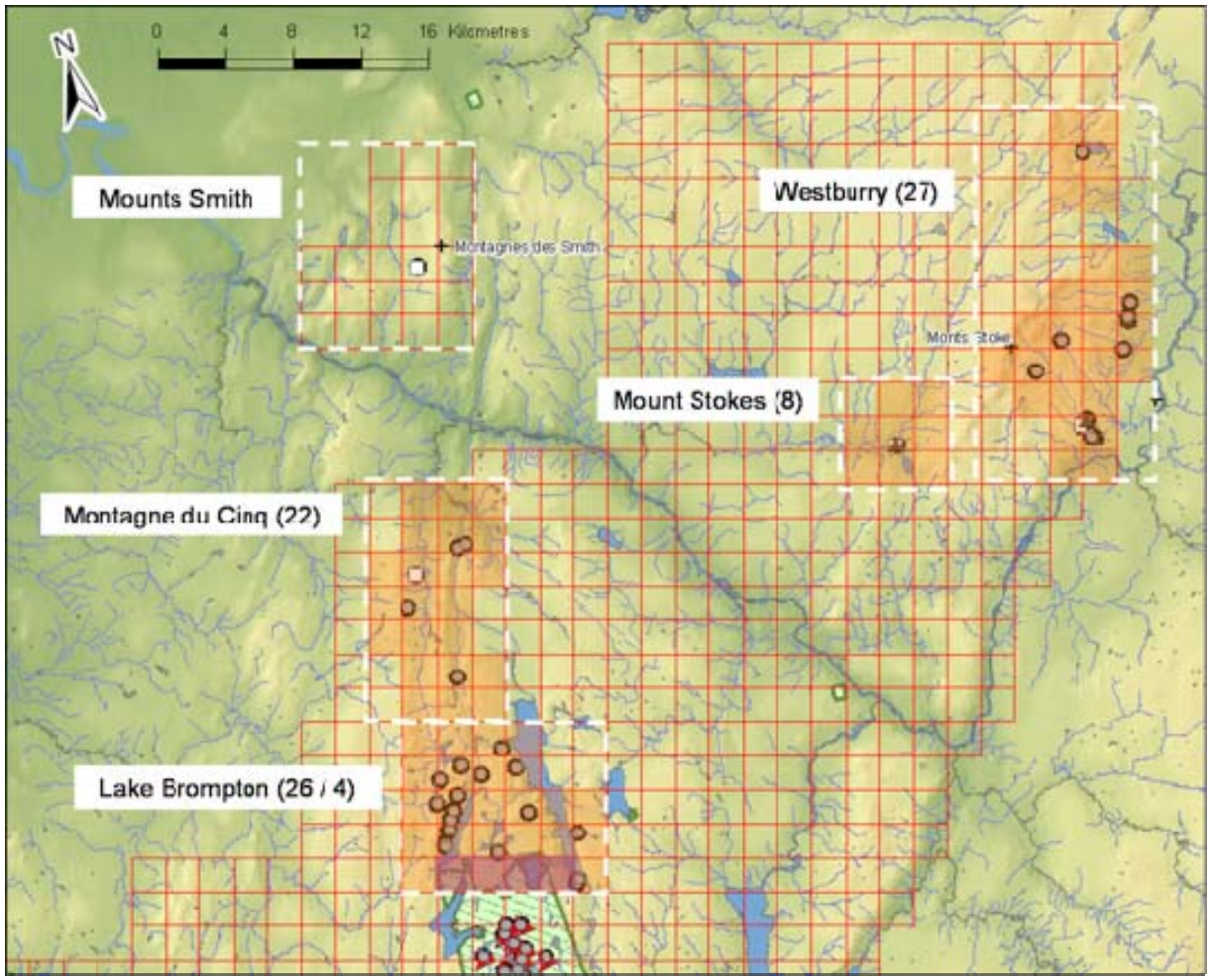


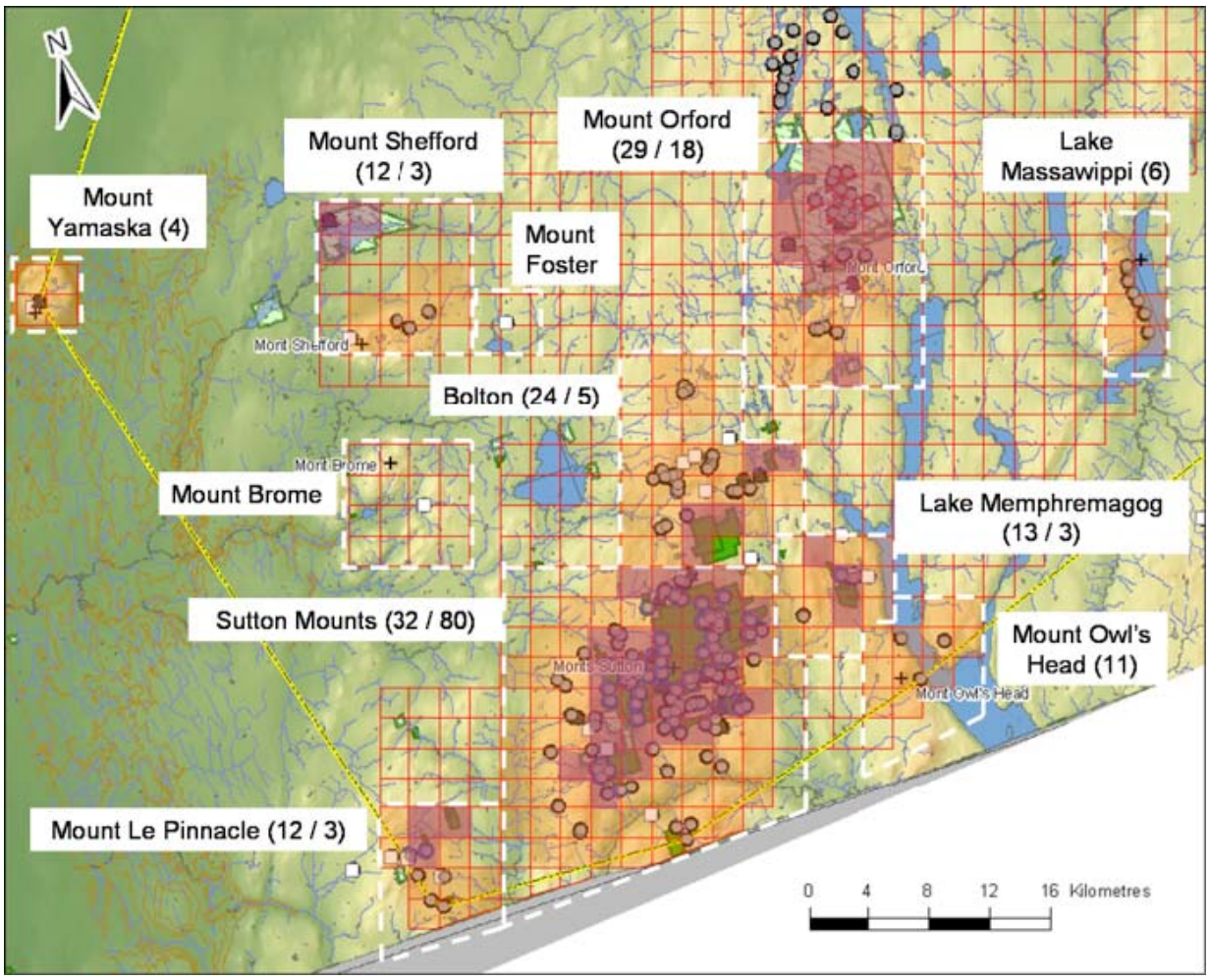
Appendix 2. Details on estimation of the index of area of occupancy (IAO). Coloured grids (orange and purple) are considered in the IAO calculations, in which purple indicate protected habitats. White dotted lines delineate populations. Values in parenthesis represent the total number of grids accounted for the IAO, and the number of grids in protected habitat, respectively.

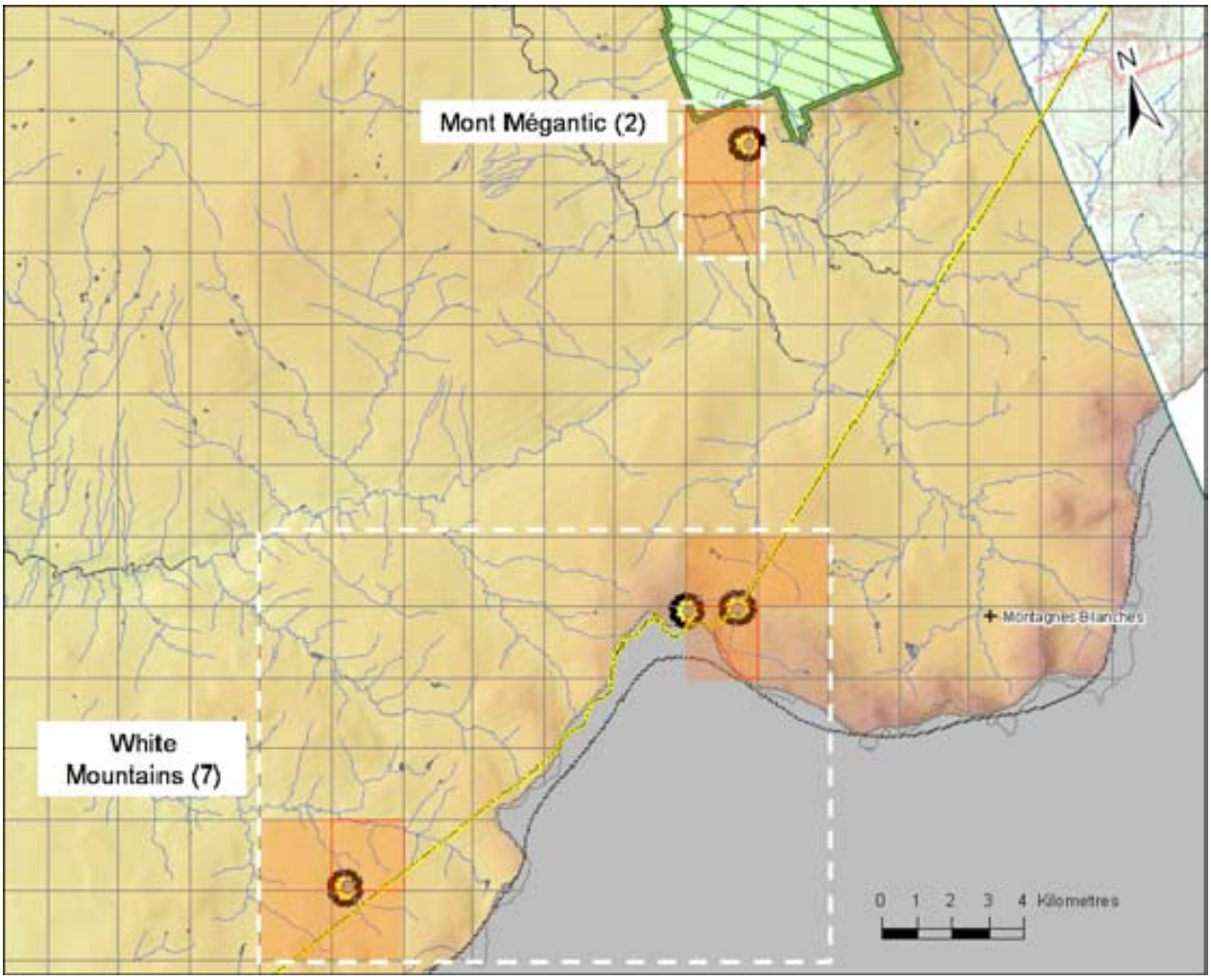


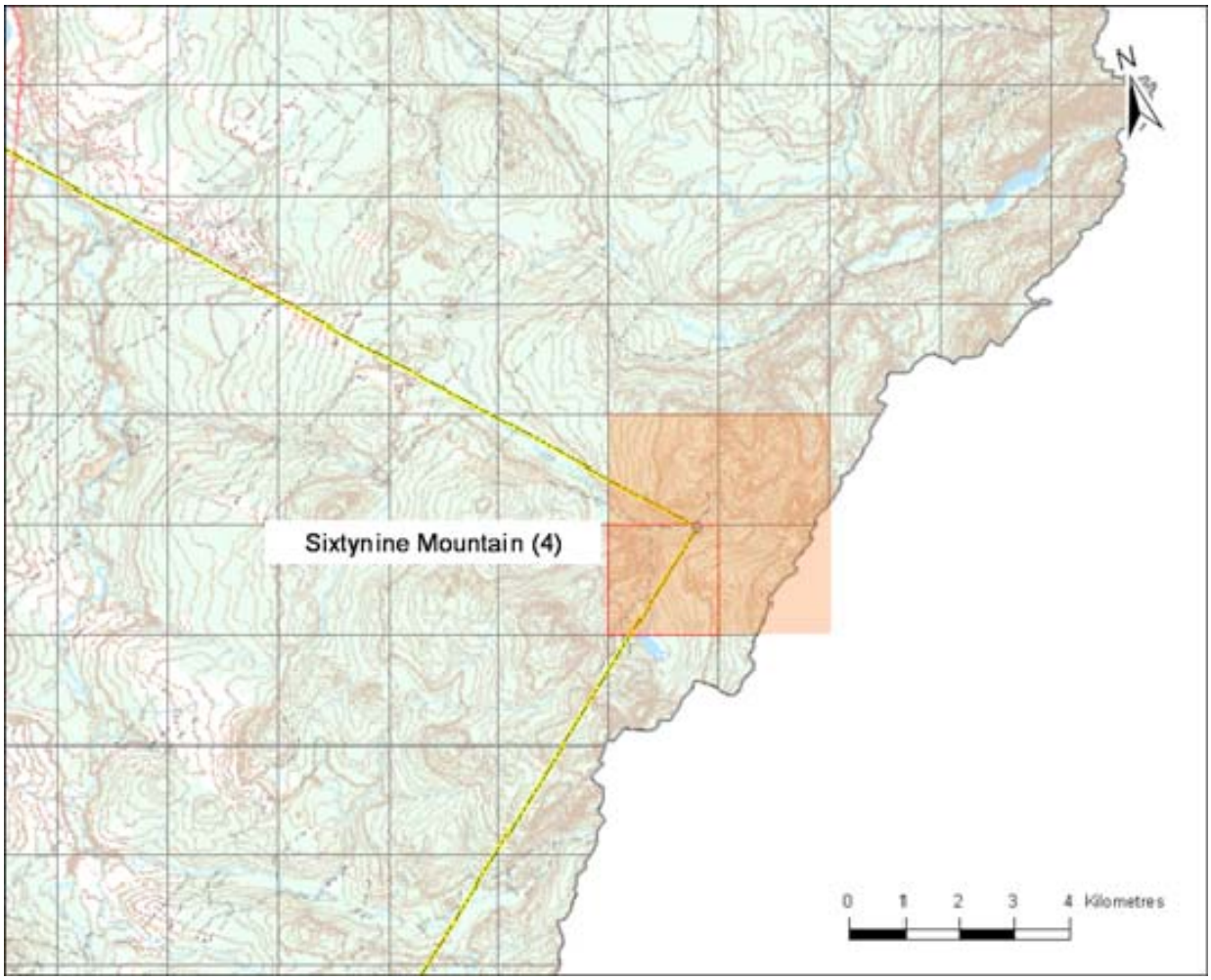

Portneuf (1)
N
Kinnear's Mills
0
3
6
9
12 Kilometres


N
0 3 6 9 12 Kilometres
Kinnaer's Mills
Kinnaer's Mills (29)
Arthabaska (8)
Arthabaska


N
0 4 8 12 16 Kilometres
Mounts Smith
Montagnes des Smith
Westburry (27)
Monts Stoke
Mount Stokes (8)
Montagne du Cinq (22)
Lake Brompton (26 / 4)


N
Mount Yamaska (4)
Mount Shefford (12 / 3)
Mount Orford (29 / 18)
Lake Massawippi (6)
Mount Foster
Mont Orford
Mont Shefford
Bolton (24 / 5)
Mont Brome
Mount Brome
Lake Memphremagog (13 / 3)
Sutton Mounts (32 / 80)
Mont Sutton
Mount Owl's Head (11)
Mont Owl's Head
Mount Le Pinnacle (12 / 3)
0 4 8 12 16 Kilometres


Mont Mégantic (2)
White Mountains (7)
N
Montagnes Blanches
0 1 2 3 4 Kilometres


Sixtynine Mountain (4)
N
0 1 2 3 4 Kilometres