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May 19, 2021

The Honourable Mike Holland
Minister of Natural Resources and Energy Development
Hugh John Flemming Forestry Centre
P.O. Box 6000
Fredericton, NB E3B 5H1
Mike.Holland@gnb.ca

Dear Minister Holland,

Re: Violations of New Brunswick's *Species at Risk Act*, RSNB 2012, c 6

We are counsel for the Maliseet Nation Conservation Council, the Conservation Council of New Brunswick, Nature Trust of New Brunswick, Nature New Brunswick, and WWF-Canada. We write further to our clients' letter to you of November 4, 2020. We reiterate our clients' concern over the Minister's continued failure to implement the New Brunswick *Species at Risk Act*[1] ("***SARA***" or the "**Act**") meaningfully and comprehensively. The many, longstanding violations of the Act detailed in our clients' letter and the report by East Coast Environmental Law[2] have not been remedied or addressed since their correspondence of six months ago. The East Coast Environmental Law report demonstrates that for many species at risk listed under the Act, even simple, preliminary steps towards protection have not been taken. In the context of the current global biodiversity crisis, outlined below, and the unique and culturally significant species at risk within this province, there is no time to waste.

Given this urgent situation, we write to demand that you take immediate steps to come into compliance with the Act. Specifically, we ask that:

[1] *Species at Risk Act*, RSNB 2012, c 6 [*SARA*].
[2] East Coast Environmental Law, *Protected on Paper Only: An Evaluation of New Brunswick's Legal Obligations under the Species at Risk Act* (September 15, 2020). Available online at https://www.ecelaw.ca/media/k2/attachments/NB_SARA_Report_-_Final__Sept_2020.pdf.

1) The required dates for production of management plans and recovery strategies be posted to the public registry within 90 days for all listed species for which these documents have not already been produced;

2) Management plans be prepared and posted to the public registry for the Eastern Wood-Pewee, Atlantic Salmon (Gaspé-Southern Gulf of St Lawrence Population) and Horned Grebe within 180 days;

3) Feasibility of recovery assessments be prepared and posted to the public registry for the Canada Lynx, Barn Swallow and Atlantic Salmon (Outer Bay of Fundy Population) within 180 days;

4) Dates for the production of protection assessments for the Roseate Tern, Butternut, and Van Brunt's Jacob's-Ladder be posted on the public registry within 90 days; and

5) Protection assessments for the Roseate Tern, Butternut, and Van Brunt's Jacob's-Ladder be prepared and posted to the public registry within 180 days.

We have chosen to focus the majority of the above demands on species that are representative of particular violations of the Act. This choice should not be interpreted as acceptance of the many other failures to comply with the Act's statutory duties regarding the many other species and statutory provisions not specifically mentioned. Our clients continue to expect full compliance with the Act's requirements.

I. Background

a) The participating organizations

The Maliseet Nation Conservation Council (MNCC) works with and supports the Wolastoqey First Nations of New Brunswick. The MNCC promotes and advances Wolastoqiyik co-management of the Saint John River (Wolastoq) watershed and ecosystem through conservation, and stewardship, education and respect for the traditional knowledge of their communities and ancestors, for present and future generations. MNCC works to improve the fate of those we need to take care of - the 4 legged, the finned, the winged, the crawlers, the plants, trees and waters. MNCC seeks to honor their role as caretakers, stewards and helpers to the environment and with this action, to reaffirm their goal of restoring health and balance.

The Conservation Council of New Brunswick, established in 1969, is among the province's leading public advocates for environmental protection, working to find practical solutions to protect the air we breathe, the water we drink, the precious marine ecosystem and the land, including the forest, that support us. The Conservation Council's work on species at risk has included the Endangered Spaces Campaign of over 25 years ago, publishing critical works on the state of the Acadian forest and, more recently, pressing for more action to protect the endangered North Atlantic right whale.

The Nature Trust of New Brunswick (the Nature Trust) conserves land needed by at-risk species and helps private landowners do their part for the conservation effort. Since 1987, the Nature Trust has conserved over 9,000 acres (3,600 hectares) of ecologically significant land in more than 60 beautiful and diverse nature preserves throughout the province. The Nature Trust also carries out and supports on-the-ground projects to protect habitat for species at risk outside our nature preserves, including species at risk recovery planning, working with private landowners to help them preserve species at risk habitat on their land, and increasing public awareness of the presence of at-risk species.

Nature NB has been a leader in species at risk conservation and education throughout New Brunswick since it was founded in 1972. The Piper Project, our Piping Plover conservation program has actively monitored and protected Piping Plovers and their critical habitat in the Acadian Peninsula for over 30 years. We also support species at risk conservation through our many citizen science initiatives and partnerships.

WWF-Canada works to conserve species at risk, protect threatened habitats and address global threats like climate change. Since 1967, WWF-Canada has worked to safeguard wild places and the species that live in them. From protecting southern resident killer whales in the Pacific Ocean and caribou calving grounds in Nunavut to supporting the establishment of the federal Species at Risk Act and the Last Ice Area, WWF-Canada works to help nature.

b) The global biodiversity crisis

As detailed in our clients' earlier letter, we are in the midst of a biodiversity crisis which is happening across our planet, our country and within the Province of New Brunswick.

The biodiversity crisis threatens not only species at risk, but implicates the foundations of all cultures, economies and societies. The ongoing decline and destruction of Canadian biodiversity is particularly concerning given its impact on Indigenous languages, cultures and traditions.

Although the biodiversity crisis occurs globally, it demands local action. The United Nations' Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services states:

> The global environment can be safeguarded through enhanced international cooperation and linked, locally relevant measures… Such widespread adoption implies advancing and aligning local, national and international sustainability efforts and mainstreaming biodiversity and sustainability across all extractive and productive sectors, including mining, fisheries, forestry and agriculture, so that together, individual and collective actions result in a reversal of the deterioration of ecosystem services at the global level [emphasis added].[3]

II. Ongoing violations of the New Brunswick *Species at Risk Act*

On behalf of our clients, we demand that you take immediate steps to implement the *SARA* for the benefit of New Brunswick's most vulnerable species. In particular, we ask that you ensure compliance with the following provisions:

[3] IPBES (2019): Summary for policymakers of the global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. S. Díaz, J. Settele, et. al. (eds.). IPBES secretariat, Bonn, Germany, at page 17.

Section 18(3)

Section 18(3) requires the Minister to post in the public registry dates by which they will publish management plans for species of special concern and recovery strategies for threatened, endangered and extirpated species.[4] The public registry is essential to the Act's transparency, yet it has not been updated in 8 years. This seriously undermines the public's ability to stay informed and engaged on species at risk in New Brunswick.

Currently there are no dates listed in the public registry pursuant to this provision. In other words, there are no dates posted for any species that does not already have a management plan or a recovery strategy. By failing to publish dates by which these documents will be prepared, the Minister has eliminated one of the few metrics by which they might demonstrate that a concrete plan has been formulated to meet the Act's requirements.

We respectfully request that the required dates be posted for all listed species that do not already have management plans or recovery strategies within 90 days from the date of this letter.

Section 20(1)

Section 20(1) requires the preparation of management plans for species of special concern.[5] These management plans are the only protection available to species of special concern under the Act and are essential to ensuring that the populations of these species do not decline further to the point that they must be classified as threatened, endangered or extirpated. Many species of special concern have no management plans posted in the public registry, in breach of this requirement.

The Eastern Wood-Pewee,[6] Atlantic Salmon (Gaspé-Southern Gulf of St Lawrence Population)[7] and the Horned Grebe[8] have been listed under the *SARA* since 2013 as a result of earlier COSEWIC assessments.[9] The Minister has had eight years to prepare management plans for these species and has unreasonably delayed doing so.

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[4] *SARA* at s 18(3).
[5] *Ibid* at s 20(1).
[6] "Eastern Wood-pewee" (April 29, 2013) online: *Species at Risk Public Registry* https://www1.gnb.ca/0078/speciesatrisk/details-e.asp?ID=14.
[7] "Atlantic Salmon Gaspé-Southern Gulf of St Lawrence Population" (April 29, 2013) online: *Species at Risk Public Registry* https://www1.gnb.ca/0078/speciesatrisk/details-e.asp?ID=40.
[8] "Horned Grebe" (April 29, 2013) online: *Species at Risk Public Registry* https://www1.gnb.ca/0078/speciesatrisk/details-e.asp?ID=15.
[9] COSEWIC, *COSEWIC Assessment and Status Report on the Eastern Wood-pewee Contopus virens in Canada* (Ottawa, Committee on the Status of Endangered Wildlife in Canada, 2012) online: https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/cosewic/sr_Eastern%20Wood-pewee_2013_e.pdf [**Appendix A**]; COSEWIC, *COSEWIC Assessment and Status Report on the Atlantic Salmon Salmo salar … Gaspé-Southern Gulf of St. Lawrence population … in Canada* (Ottawa, Committee on the Status of Endangered Wildlife in Canada, 2010) online: https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/cosewic/sr_Atlantic_Salmon_2011a_e.pdf [**Appendix B**]; COSEWIC, *COSEWIC Assessment and Status Report on the Horned Grebe Podiceps auritus Western population Magdalen Islands population in Canada* (Ottawa, Committee on the Status of Endangered Wildlife in Canada, 2009) online: https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/cosewic/sr_horned_grebe_0809_e.pdf [**Appendix C**].

We request that the Minister rectify this non-compliance with the Act and that management plans be prepared and published for the Eastern Wood-Pewee, Atlantic Salmon (Gaspé-Southern Gulf of St Lawrence Population) and Horned Grebe within 180 days from the date of this letter.

Section 21(1)

The Minister is required by section 21(1) to ensure that an assessment is conducted as to whether the recovery of a wildlife species that is listed as an extirpated species, an endangered species or a threatened species is feasible. Feasibility of recovery assessments ("**FRAs**") play a vital threshold role under the Act in determining whether a recovery strategy will be prepared and later whether a protection assessment will be conducted. FRAs have not yet been prepared for many listed threatened, endangered, and extirpated species. These species include, but are not limited to, the Canada Lynx, Barn Swallow and Atlantic Salmon (Outer Bay of Fundy Population).

The Canada Lynx[10] is listed as endangered under the *SARA* as a result of previous listing under the former New Brunswick *Endangered Species Act*.[11] The Lynx has been listed under the current Act for 8 years, yet there is no indication that an FRA has been prepared for this species.

The Barn Swallow[12] and the Atlantic Salmon (Outer Bay of Fundy Population)[13] have been listed as threatened and endangered respectively under the *SARA* since 2013 as a result of earlier COSEWIC assessments.[14] There is no mention of an FRA for either species on the public registry.

We request that FRAs be prepared and posted to the public registry for the Canada Lynx, Barn Swallow, and Atlantic Salmon (Outer Bay of Fundy Population) within 180 days from the date of this letter.

Sections 24 and 25(1)

Sections 24 requires the Minister to post a date for the preparation of a protection assessment within 90 days of posting a recovery strategy.[15] Section 25(1) requires the Minister to prepare protection assessments for these species.[16] A protection assessment determines whether protection measures under section 28 or 29 should be applied in respect of the wildlife species. If

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[10] "Canada Lynx" (April 29, 2013) online: *Species at Risk Public Registry* https://www1.gnb.ca/0078/speciesatrisk/details-e.asp?ID=60 .

[11] *Endangered Species Act*, SNB 1996, c E-9.101.

[12] "Barn Swallow" (April 29, 2013) online: *Species at Risk Public Registry* https://www1.gnb.ca/0078/speciesatrisk/details-e.asp?ID=19.

[13] "Atlantic Salmon Outer Bay of Fundy Population" online: *Species at Risk Public Registry* https://www1.gnb.ca/0078/speciesatrisk/details-e.asp?ID=34 .

[14] COSEWIC, *COSEWIC Assessment and Status Report on the Barn Swallow Hirundo Rustica in Canada* (Ottawa: Committee on the Status of Endangered Wildlife in Canada, 2011) online: https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/cosewic/sr_barn_swallow_0911_eng.pdf [**Appendix D**]; *COSEWIC Assessment and Status Report on the Atlantic Salmon Salmo salar … Outer Bay of Fundy population … in Canada* (Ottawa, Committee on the Status of Endangered Wildlife in Canada, 2010) online: https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/cosewic/sr_Atlantic_Salmon_2011a_e.pdf [**Appendix B**].

[15] *SARA*, *supra* at s 24.

[16] *Ibid* at s 25(1).

applied, section 28 prohibits killing, harming, harassing, taking, possessing, buying, selling or trading species. [17] Section 29 allows the Minister to designate survival habitat and recovery habitat for species. [18] These measures offer the most direct legal protections available to species under the Act. Protection assessments have not been completed for a number of species with recovery strategies, including the three species listed below.

The Roseate Tern,[19] the Butternut,[20] and the Van Brunt's Jacob's-Ladder[21] have been listed as endangered under the New Brunswick *SARA* since 2013 as a result of previous COSEWIC assessments.[22] Federal recovery strategies were completed for the Roseate Tern and Butternut species in 2010, and adopted in New Brunswick with New Brunswick addenda.[23] A federal recovery strategy for the Van Brunt's Jacob's-Ladder was completed in 2012 and adopted in New Brunswick with a New Brunswick addendum.[24] No date has been posted in the public registry for the preparation of protection assessments for the above species and no protection assessments have been completed.

We request that the dates by which protection assessments will be completed for the Roseate Tern, Butternut and Van Brunt's Jacob's-Ladder be posted in the public registry within 90 days. We also require that these protection assessments be prepared and posted in the public registry within 180 days from the date of this letter.

III. Conclusion

Given the urgent and catastrophic nature of the ongoing biodiversity crisis and consecutive Ministers' chronic and systemic failures to implement and administer the *SARA*, our clients demand that you do the following and, where appropriate, direct the Department of Natural Resources and Energy Development to:

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[17] *Ibid* at s 28.
[18] *Ibid* at s 29.
[19] "Roseate Tern" (May 6, 2013) online: *Species at Risk Public Registry* https://www1.gnb.ca/0078/speciesatrisk/details-e.asp?ID=12.
[20] "Butternut" (May 6, 2013) online: *Species at Risk Public Registry* https://www1.gnb.ca/0078/speciesatrisk/details-e.asp?ID=80.
[21] "Van Brunt's Jacob's-ladder" (May 6, 2013) online: *Species at Risk Public Registry* https://www1.gnb.ca/0078/speciesatrisk/details-e.asp?ID=88.
[22] COSEWIC, *COSEWIC Assessment and Update Status Report on the Roseate Tern Sterna dougallii in Canada* (Ottawa: Committee on the Status of Endangered Wildlife in Canada, 2009) online: https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/cosewic/sr_roseate_Tern_0809_e.pdf [**Appendix E**]; COSEWIC, *COSEWIC Assessment and Status Report on the Butternut Juglans cinerea in Canada* (Ottawa: Committee on the Status of Endangered Wildlife in Canada, 2003) online: https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/cosewic/sr_Butternut_2017_e.pdf [**Appendix F**]; COSEWIC, *COSEWIC Assessment and Update Status Report on the Van Brunt's Jacob's-ladder Polemonium vanbruntiae in Canada* (Ottawa: Committee on the Status of Endangered Wildlife in Canada, 2002) online: https://wildlife-species.canada.ca/species-risk-registry/virtual_sara/files/cosewic/sr_van_brunt_jacob_ladder_e.pdf [**Appendix G**].
[23] "Roseate Tern," online: *Species at Risk Public Registry*; "Butternut," online: *Species at Risk Public Registry*.
[24] "Van Brunt's Jacob's-ladder," online: *Species at Risk Public Registry*.

(1) Within 90 days, post dates to the public registry by which management plans and recovery strategies will be prepared for all listed species that do not yet have a management plan or recovery strategy, as required by section 18(3);

(2) Prepare and post to the public registry management plans for the Eastern Wood-Pewee, Atlantic Salmon (Gaspé-Southern Gulf of St Lawrence Population) and Horned Grebe as required by section 20(1) within 180 days;

(3) Prepare and post to the public registry feasibility of recovery assessments for the Canada Lynx, Barn Swallow and Atlantic Salmon (Outer Bay of Fundy Population) as required by section 21(1) within 180 days; and

(4) Within 90 days, post on the public registry the dates by which protection assessments will be completed for the Roseate Tern, Butternut and Van Brunt's Jacob's-Ladder as required by section 24.

(5) Prepare protection assessments for the Roseate Tern, Butternut, and Van Brunt Jacob's-Ladder and post the assessments to the public registry as required by section 25(1) within 180 days.

We look forward to hearing from you on this matter. Our clients are prepared to meet with you in the presence of counsel to further discuss the resolution of their concerns.

If we do not hear from you, or if any of these requirements are not implemented in full by the stated deadlines, we are prepared to commence proceedings to enforce such obligations in the New Brunswick Court of Queen's Bench, without further notice to the Province. We expect and look forward to the Minister taking timely and appropriate action to protect species at risk in New Brunswick, as legally mandated by the *SARA.*

Best regards,

James Gunvaldsen Klaassen

Sarah McDonald

cc: Lisa Mitchell and Kostantina Northrup, East Coast Environmental Law

COSEWIC
Assessment and Status Report

on the

Eastern Wood-pewee
Contopus virens

in Canada

Photo: courtesy Carl Savignac

SPECIAL CONCERN
2012

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

COSEWIC. 2012. COSEWIC assessment and status report on the Eastern Wood-pewee *Contopus virens* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. x + 39 pp. (www.registrelep-sararegistry.gc.ca/default_e.cfm).

Production note:
COSEWIC would like to acknowledge Carl Savignac for writing the status report on the Eastern Wood-pewee, *Contopus virens,* in Canada*,* prepared under contract with Environment Canada. The report was overseen and edited by Jon McCracken, COSEWIC Birds Specialist Subcommittee Co-chair.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur le Pioui de l'Est (*Contopus virens*) au Canada.

Cover illustration/photo:
Eastern Wood-pewee — Photo: courtesy Carl Savignac.

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COSEWIC
Assessment Summary

Assessment Summary – November 2012

Common name
Eastern Wood-pewee

Scientific name
Contopus virens

Status
Special Concern

Reason for designation
This species is one of the most common and widespread songbirds associated with North America's eastern forests. While the species is apparently resilient to many kinds of habitat changes, like most other long-distance migrants that specialize on a diet of flying insects, it has experienced persistent declines over the past 40 years both in Canada and the United States. The 10-year rate of decline (25%) comes close to satisfying the criteria for Threatened. The causes of the decline are not understood, but might be linked to habitat loss or degradation on its wintering grounds in South America or changes in availability of insect prey. If the population declines continue to persist, the species may become Threatened in the foreseeable future.

Occurrence
Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Prince Edward Island, Nova Scotia

Status history
Designated Special Concern in November 2012.

COSEWIC
Executive Summary

Eastern Wood-pewee
Contopus virens

Wildlife Species Description and Significance

The Eastern Wood-pewee is a small forest bird about the same size as a House Sparrow. Both sexes have similar plumage, being generally greyish-olive on the upperparts and pale on the underparts. This species is often observed perched in an upright position typical of flycatchers. It is distinguished from its 'confusing' *Empidonax* flycatcher cousins by its larger size, lack of an eye-ring, and longer and more pointed wings. During the breeding season, the most reliable way to detect and identify the Eastern Wood-pewee is by hearing its distinctive, clear, three-phrased whistled song, often paraphrased as "*pee-ah-wee.*"

Distribution

The breeding range of the Eastern Wood-pewee covers much of south-central and eastern North America. It breeds from southeastern Saskatchewan to the Maritime provinces, south to southeastern Texas and east to the U.S. Atlantic coast. About 11% of its global breeding range is in Canada, which accounts for about 8% of the breeding population.

It winters primarily in northern South America, mainly from northwestern Colombia and northeastern Venezuela south to southern Peru, northern Bolivia and Amazonian Brazil.

Habitat

In Canada, the Eastern Wood-pewee is mostly associated with the mid-canopy layer of forest clearings and edges of deciduous and mixed forests. It is most abundant in forest stands of intermediate age and in mature stands with little understory vegetation.

During migration, a variety of habitats are used, including forest edges, early successional clearings, and primary and secondary lowland (and submontane) tropical forest, as well as cloud forest. In South America in the winter, the species primarily uses open forest, shrubby habitats, and edges of primary forest. It also occurs in interior forests where tree-fall gaps are present.

Biology

The Eastern Wood-pewee is considered monogamous, but polygyny sometimes occurs. In Canada, adults arrive on the breeding grounds mostly from mid-May to the end of May. Pair formation and nest building start soon after arrival. Nests are usually located on top of a horizontal limb in a living tree at heights between 2 and 21 m. Clutch size averages 3 eggs. Incubation lasts about 12 to 13 days, and nestlings fledge after about 16 to 18 days. Up to two broods can be produced per year. Generation time is estimated to be 2-3 years.

Population Sizes and Trends

In Canada, the current Eastern Wood-pewee population is estimated to be about 217,500 breeding pairs or 435,000 mature individuals. Breeding Bird Survey (BBS) data for Canada indicate a significant population decline of 2.9% per year for the period 1970-2011, which yields an overall decline of 70% over the last 42 years. In the most recent 10-year period (2001 to 2011), BBS data show a significant decline of about 2.8% per year, which represents a 25% decline over the period. Populations declined significantly in Manitoba, Ontario, Québec, New Brunswick, and Nova Scotia/Prince Edward Island for the period of 1970-2011, with pronounced declines in Québec and New Brunswick. A pattern of widespread decline is also apparent for much of the United States.

The BBS trend generally conforms to the direction of results from two other monitoring programs (Study of Québec Bird Populations and Ontario Forest Bird Monitoring Program), but contrasts with those from other monitoring programs in Ontario (Ontario Breeding Bird Atlas and Long Point Bird Observatory migration monitoring), which suggest stable or increasing populations. Despite discrepancies across monitoring programs, the BBS is judged to represent the most reliable trend estimate at this time.

Threats and Limiting Factors

Threats and limiting factors affecting Eastern Wood-pewees have not been clearly identified and are poorly known, largely because of a lack of research. Possible threats and limiting factors have been suggested as including: 1) loss and degradation of habitat quality on the breeding grounds due to urban development and/or changes in forest management; 2) loss and/or degradation of habitat on the wintering grounds; 3) large-scale changes in the availability of flying-insect prey due to unknown causes; 4) high rates of mortality during migration and/or on the wintering grounds); 5) high rates of nest predation from increasing numbers of avian predators; and 6) changes in forest structure due to White-tailed Deer over-browsing.

Protection, Status, and Ranks

The Eastern Wood-pewee was ranked as ‘globally secure’ (G5) in 1996 by NatureServe and is considered ‘Least concern’ according to the IUCN Red List. In Canada, its nests and eggs are protected under the *Migratory Birds Convention Act*. Similar protection is afforded under various kinds of provincial legislation. It is considered ‘secure and common’ nationally; ‘apparently secure’ in Saskatchewan, Manitoba, Ontario, and Prince Edward Island; ‘secure’ in New Brunswick; and ‘vulnerable’ to ‘apparently secure’ in Québec.

TECHNICAL SUMMARY

Contopus virens
Eastern Wood-pewee Pioui de l'Est
Range of Occurrence in Canada: Saskatchewan, Manitoba, Ontario, Québec, New Brunswick, Nova Scotia, Prince Edward Island

Demographic Information

Generation time	2 to 3 yrs
Is there an observed, continuing decline in number of mature individuals?	Yes
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations] - Trend estimates for short time frames (2 generations) do not provide robust information	Not estimated
Estimated percent reduction in total number of mature individuals over the last 10 years, or 3 generations. - Based on BBS data for 2001-2011 showing a significant decline of 2.81.% per year (95% CI: -3.65, -1.93).	25%
[Projected or suspected] percent reduction in total number of mature individuals over the next 10 years, or 3 generations.	Not estimated, but long-term decline is expected to continue
[Observed, estimated, inferred, or suspected] percent reduction 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.	Not estimated, but long-term patterns indicate a log-linear decline
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 - Based on a minimum convex polygon of the species' range map from NatureServe 2012, version 3, provided by Alain Filion	2,090,000 km^2
Index of area of occupancy (IAO) - IAO based upon the 2x2 km grid cell method cannot be calculated at this time because precise locations of nesting individuals have not been mapped. However, the estimated IAO would be far greater than COSEWIC's minimum threshold of 2000 km^2	Unknown but >2000 km^2
Is the total population severely fragmented?	No
Number of "locations"	Unknown; definitely >10
Is there an observed continuing decline in extent of occurrence?	No
Is there an observed continuing decline in index of area of occupancy?	Unknown (yes in Maritimes, but apparently not elsewhere)
Is there an observed continuing decline in number of populations?	No
Is there an observed continuing decline in number of locations?	Unknown
Is there an observed, inferred or projected continuing decline in area and/or quality of habitat? - Habitat supply (forest cover) trends vary in different regions of Canada and are unknown on the wintering range; trend in habitat quality is unknown.	Unknown
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

Population	N Mature Individuals
Total (217,500 breeding pairs)	435,000

Quantitative Analysis

Ex.: % chance of extinction in 50 years	Not done

Threats (actual or imminent, to populations or habitats)

Threats are not understood, but are thought to include: 1) degradation of habitat quality on the breeding grounds due to urban development and reduced levels of forest management; 2) loss and/or degradation of habitat on the wintering grounds; 3) large-scale changes in the availability of flying-insect prey due to unknown causes; 4) high rates of mortality during migration and/or on the wintering grounds; 5) high rates of nest predation from increasing numbers of avian predators; and 6) changes in forest structure due to White-tailed Deer over-browsing.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? USA: statistically significant decline of 1.2% per year (1966-2010); significant declines are present for many northeastern states bordering Canada	
Is immigration known or possible?	Yes (highly likely)
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	Possibly; tempered by current species decline in north-eastern US, especially in states bordering Canada

Current Status

COSEWIC: not assessed previously

Recommended Status and Reasons for Designation

Recommended Status: Special Concern	**Alpha-numeric code:** not applicable
Reasons for designation: This species is one of the most common and widespread songbirds associated with North America's eastern forests. While the species is apparently resilient to many kinds of habitat changes, like most other long-distance migrants that specialize on a diet of flying insects, it has experienced persistent declines over the past 40 years both in Canada and the United States. The 10-year rate of decline (25%) comes close to satisfying the criteria for Threatened. The causes of the decline are not understood, but might be linked to habitat loss or degradation on its wintering grounds in South America or changes in availability of insect prey. If the population declines continue to persist, the species may become Threatened in the foreseeable future.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criterion; the recent 10-year decline (25%) does not meet the 30% threshold for Threatened A2b.
Criterion B (Small Distribution Range and Decline or Fluctuation): Does not meet criterion; exceeds thresholds for extent of occurrence and area of occupancy.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable; exceeds thresholds for population size
Criterion D (Very Small or Restricted Total Population): Not applicable; exceeds thresholds for population size, area of occupancy and number of locations.
Criterion E (Quantitative Analysis): Not done

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
(2012)

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

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

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

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

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

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

COSEWIC Status Report

on the

Eastern Wood-pewee
Contopus virens

in Canada

2012

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Contopus virens (Linnaeus, 1766) is commonly called the Eastern Wood-pewee. The French name is '*Pioui de l'Est*'. The taxonomy is as follows:

Class:	Aves
Order:	Passeriformes
Family:	Tyrannidae
Genus:	*Contopus*
Species:	*Contopus virens*

Morphological description

The Eastern Wood-pewee is a small forest bird (15 cm, 14 g; McCarty 1996). Both sexes have similar plumage. Adults have pale wing-bars, and are greyish-olive above and pale below, with a slightly darker greenish-wash on the breast and sides. This species is often observed in an upright position typical of flycatchers, and 'hawks' flying insects from perches (McCarty 1996).

In the field, the Eastern Wood-pewee is virtually indistinguishable in appearance from the Western Wood-pewee (*C. sordidulus*), which has a darker and browner chest and sides and has no tinge of green on the chest (McCarty 1996). Apart from notable differences in their breeding ranges, the Eastern Wood-pewee is best distinguished from its western counterpart by its clear, three-phrased song, often paraphrased as a whistled "*pee-ah-wee*". It is generally distinguished from similar-looking *Empidonax* flycatchers by its larger size, lack of an eye-ring, and longer and more pointed wings. The Eastern Wood-pewee also resembles the Eastern Phoebe (*Sayornis phoebe*), but is slightly smaller, has distinctive wing-bars, has a pale lower mandible, and lacks the phoebe's tail-wagging behaviour (McCarty 1996).

Population Genetic Structure and Variability

No research has been conducted on the population genetic structure of the Eastern Wood-pewee in Canada or the United States (McCarty 1996).

Designatable Units

No subspecies have been recognized or are currently known for the Eastern Wood-pewee (McCarty 1996; American Ornithologists' Union 1998) and there are no other distinctions that warrant assessment below the species level. This report deals with a single designable unit.

Special Significance

No particular aspect of the Eastern Wood-pewee's ecology appears to give it particular significance. No published Aboriginal traditional knowledge is currently available for this species in Canada.

DISTRIBUTION

Global Range

From west to east, the breeding range of the Eastern Wood-pewee extends from southeastern Saskatchewan, through southern Manitoba, Ontario and Québec, to the Canadian Maritimes. From the Canadian border with the U.S., it breeds south to southern Texas and east to the Atlantic coast (McCarty 1996; Figure 1).

Eastern Wood-pewees winter primarily in northern South America, from northwestern Colombia and northeastern Venezuela, south to southern Peru, northern Bolivia and Amazonian Brazil (McCarty 1996; Figure 1).

Canadian Range

About 11% of the Eastern Wood-pewee's global breeding range is in Canada, which accounts for about 8% of the global breeding population (Blancher *et al.* 2007; Table 1). It breeds in south-central and southeastern Canada, from New Brunswick, Prince Edward Island and Nova Scotia (BSC 2012), west through southern Québec north to Haute Cote-Nord, Gaspé peninsula and Îles-de-la-Madeleine (Cyr and Larivée 1995; Gauthier and Aubry 1995), though it has apparently not been recently recorded on Îles-de-la-Madeleine (Gauthier pers. comm. 2012). It occurs across most of southern Ontario north to Slate Falls to the west and Moose River to the east (Cadman *et al.* 2007). In the prairies, it breeds in southern Manitoba north to Duck Mountain Provincial Park (BSC 2011b), and southeastern Saskatchewan (Government of Saskatchewan 2011; Figure 2).

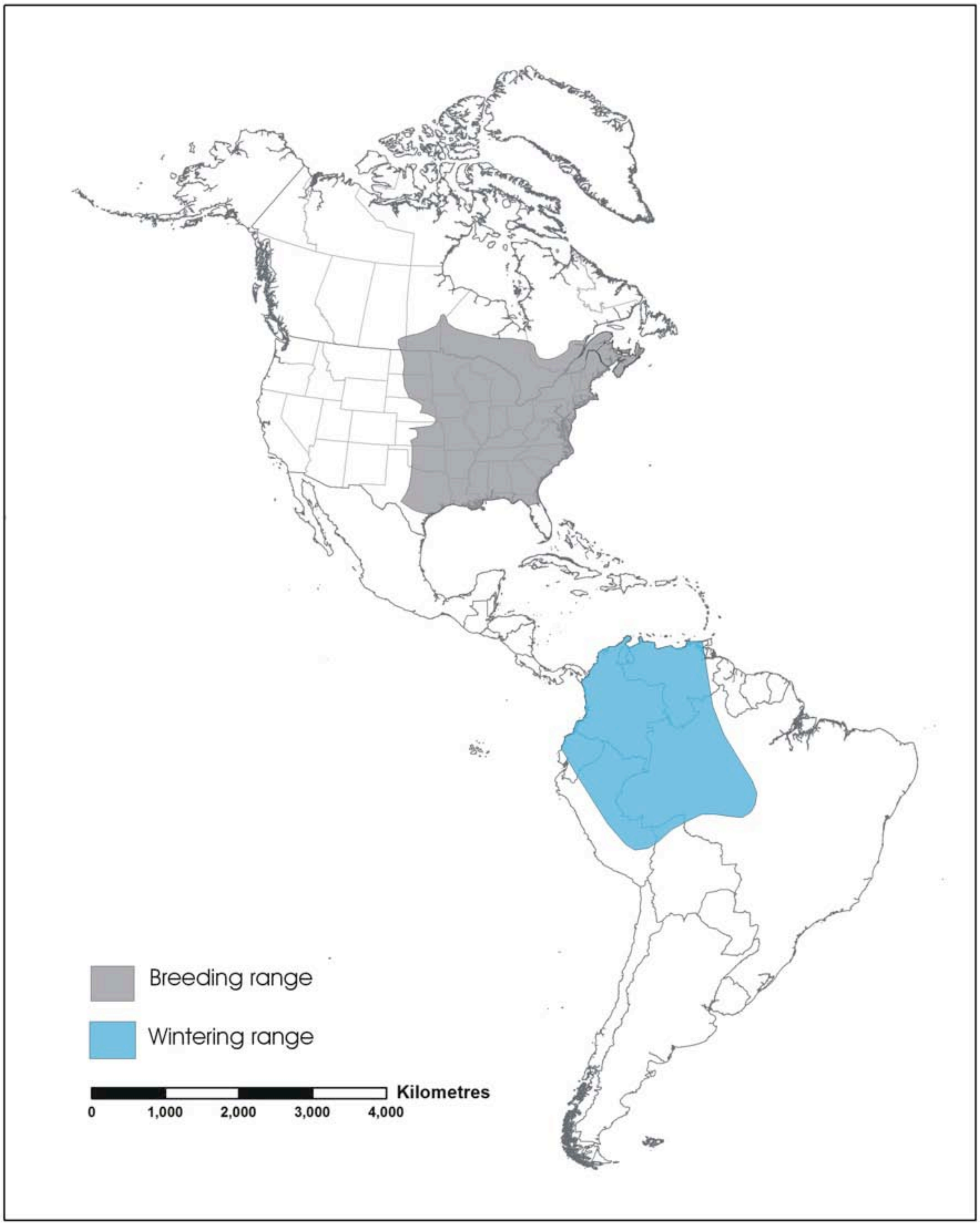

Figure 1. Global range of the Eastern Wood-pewee (based on Gauthier and Aubry 1995; Ridgely *et al.* 2003; Cadman *et al.* 2007; Bird Studies Canada [BSC] 2011a, b).

Figure 2. Canadian breeding range of the Eastern Wood-pewee (based on Gauthier and Aubry 1995; Cadman *et al.* 2007; BSC 2011a, b; Government of Saskatchewan 2011; BSC 2012).

The extent of occurrence in Canada is 2,090,000 km^2, as measured by a minimum convex polygon based on the NatureServe range map (Ridgely *et al.* 2003). The estimated index of area of occupancy (IAO) based on a 2 km x 2 km grid intersecting known areas of occupancy for the species cannot be calculated due to a lack of detailed information on the locations of all breeding sites, but it undoubtedly exceeds COSEWIC's minimum threshold of 2000 km^2.

Search Effort

Distributional data for the Eastern Wood-pewee in Canada mainly come from breeding bird atlas work conducted in the 1980s and in the 2000s in Ontario (Cadman *et al.* 1987; 2007), Québec (Gauthier and Aubry 1995, BSC 2011a), and the Maritimes (Erskine 1992; BSC 2012). Recent atlas projects have also been initiated in Manitoba (BSC 2011b). The Québec checklist program (Cyr et Larivée 1995) and the Breeding Bird Survey (BBS) in Canada also provide insight into the species' distribution in Canada.

HABITAT

Habitat Requirements

Breeding season

In Canada, the Eastern Wood-pewee breeds mostly in mature and intermediate-age deciduous and mixed forests (less often in coniferous forest) having an open understory (Ouellet 1974; Godfrey 1986; Peck and James 1987; Gauthier and Aubry 1995; Falconer 2010; Burke *et al*. 2011). It is often associated with forests dominated by Sugar Maple (*Acer saccharum*), elm (*Ulmus* sp.) and oak (*Quercus* sp.; Graber *et al.* 1974). It is usually associated with forest clearings and edges within the vicinity of its nest (Hespenheide 1971; Peck and James 1987).

A comparison of habitat use by the Eastern Wood-pewee in deciduous forest and conifer plantations in one study in southern Ontario found that in each habitat, territories had lower tree basal area, tree species diversity, and fewer pines than non-territory sites (Falconer 2010). Pewees were apparently selecting for fewer trees and greater openness in the forest—a structure that would favour bouts of aerial foraging activities.

In the Maritimes, an analysis of breeding bird atlas point count data suggests that pewees are strongly associated with mature poplar and hardwood forest, with weaker associations with older pine, hemlock and other forest types (M. Campbell unpubl. data). At the landscape scale in the Maritimes, pewees are associated with the presence of marshes, lakes, ponds and rivers, and negatively associated with harvested forest, human-occupied areas and roads (M. Campbell unpubl. data).

In West Virginia, the Eastern Wood-pewee selects habitat based on forest stand-level characteristics (elevation, size of stand, age, and ecological land type) and at the microhabitat level (tree stem density and tree species diversity; McDermott *et al.* 2010). The species can become abundant in pure hemlock stands that have experienced >60% mortality of trees resulting from chronic Hemlock Woolly Adelgid (*Adelges tsugae*) infestations (Tingley *et al.* 2002).

In Iowa, habitat suitability for this species increased rapidly with tree density, before levelling off or declining when densities approached 1600 trees/ha (Best and Stauffer 1986). In Virginia, the Eastern Wood-pewee was most abundant in forest stands of intermediate age with little understory vegetation (Crawford *et al.* 1981).

In some regions at least, the pewee reaches higher breeding densities in dry upland sites than in lowland forest (Peck and James 1987; Robbins *et al.* 1989; McCarty 1996; Newell and Rodewald 2011). Nesting in wet forests probably just reflects a preference for open space near the nest tree (Peck and James 1987).

Generally, size of forest fragments does not appear to be an important factor in habitat selection (Stauffer and Best 1980; Blake and Karr 1987, Robbins *et al.* 1989, Freemark and Collins 1992; Desrochers *et al.* 2010). However, the species is known to occur less frequently in woodlots with surrounding residential development than in those without houses (Friesen *et al.* 1995; Keller and Yahner 2007).

More than most other eastern flycatcher species, the Eastern Wood-pewee uses dead branches as hunting perches (Via 1970), which may be an additional habitat need.

Non-breeding season

During migration, various forested habitats are used, including woodland edges, early successional clearings, and primary and secondary lowland (and submontane) tropical forest, as well as cloud forest (Ridgely and Gwynne 1989; Stiles and Skutch 1989; Arendt 1992; Vidal-Rodriguez 1992). In Costa Rica, the species is reported from clearings and young second-growth, but not old second-growth or primary forest (Blake and Loiselle 1992; Powell *et al.* 1992). It is found in both dry and moist forest in Panama (Hespenheide 1980), and is reported from coastal and urban areas, farmland, forest edge, and dry and wet forests in the Caribbean (Amos 1991; Arendt 1992). It is reportedly most common from lowlands to elevations of 1500 m (Stiles and Skutch 1989; Howell and Webb 1995), but may be found as high as 2850 m (Fjeldså and Krabbe 1990; Vidal-Rodriguez 1992).

There is little information available on the habitat types occupied on the South American wintering grounds. It reportedly uses open forest (e.g., flooded riparian stands), shrubby habitats, edges of primary forest, but also occurs in interior forests where tree-fall gaps are present (Fitzpatrick 1980; Pearson 1980; Fjeldså and Krappe 1990; Stotz *et al.* 1992; Ridgely and Tudor 1994).

Habitat Trends

The current amount of suitable breeding habitat in Canada is much less than it was prior to European colonization. For example, in eastern Ontario, 70-80% of the original deciduous forest cover had been removed by the 1880s (OMNR 1997; Zhang and Guindin 2005). Similar historical perspectives are also apparent in southern Québec (Ouellet 1974; Li and Ducruc 1999; Gratton 2010).

Since European settlement, the overall extent of forest habitat in eastern Canada has mostly been increasing in recent decades, because of the regrowth of secondary forest on abandoned farmland, particularly in eastern Ontario (Larson *et al*. 1999) and parts of southern Québec outside the St. Lawrence Lowlands (Latendresse *et al*. 2008). Within the St. Lawrence Lowlands, however, habitat loss is still occurring (Jobin *et al.* 2007). In New Brunswick, a preliminary analysis of forest inventory data comparing the area of mature deciduous forest habitat, which is the type favoured by Eastern Wood-pewees, indicates a decline of about 18% between the 1980s and the 2000s (New Brunswick Department of Natural Resources unpubl. data 2012). Declines in mature mixed forest habitat were greater, ranging from 34-68%, but such habitat is less favoured by pewees. The declines noted above reflect changes in the age structure of the forest community as a result of forest management planning favouring shorter rotation periods that are increasingly replacing mature forest with young forest (S. Makepeace *fide* Sabine pers. comm. 2012).

Large tracts of homogenous deciduous forests with little broken canopy probably reduce habitat suitability for pewees (Ahlering and Faaborg 2006; Friesen pers. comm. 2012). Hence, as second-growth forests mature to a climax successional stage, it is possible that the quality of pewee habitat naturally declines somewhat, especially in the absence of forest management. However, little is known about how much unmanaged habitat in Canada might be returning to a climax condition, nor the extent to which this might be affecting pewee populations or demographics.

On the wintering grounds, the Eastern Wood-pewee uses forest patches and second growth, and may be less affected by loss of contiguous tropical forest than some other species (McCarty 1996). However, virtually nothing is known about the species' wintering habitat requirements. A recent study, which examined change in forest area in Latin America between 2001 and 2010, found that deforestation rates were particularly severe in South America, especially within the moist forest biome (Aide *et al.* 2012).

BIOLOGY

Few studies have been conducted specifically on the Eastern Wood-pewee. McCarty (1996) is the general source of information for North America. While limited to rather specialized situations in Ontario, the most complete source of information on breeding biology, productivity, and habitat associations in Canada is provided by Falconer (2010).

Reproduction

Age of first reproduction is unknown but individuals probably breed at 1 year (McCarty 1996). The Eastern Wood-pewee is generally monogamous (McCarty 1996), but polygyny also occurs (11% of 53 nests in southern Ontario; Falconer 2010). Breeding activity extends from late May through August and occasionally September (McCarty 1996; Falconer 2010). Double broods are not infrequent (Falconer 2010).

In southern Ontario, nests tend to be built in large, mature trees (Falconer 2010). Nests are well camouflaged and located on top of a horizontal limb (often a dead limb) in a living tree, well out from the trunk, at heights ranging from 2 to 21 m (Peck and James 1987), and usually at the higher end of this range.

In Ontario, clutch size ranges up to 4 eggs but generally averages 3 eggs (62% of 103 nests; Peck and James 1987). In Ontario, egg dates for 94 nests ranged from 3 June to 14 August (Peck and James 1987). In Manitoba, pewees initiate clutches between 11 June and 6 July, with an average initiation date of 23 June (Underwood *et al.* 2004). The incubation period lasts about 12-13 days (Bendire 1895 in McCarty 1996; Knight 1908 in McCarty 1996; Bent 1942). Nestlings fledge after about 16-18 days (Bendire 1895 in McCarty 1996; Knight 1908 in McCarty 1996; Bent 1942; Sandusky 1977).

In his study in southern Ontario, Falconer (2010) found that nest success increased later in the breeding season, and nests in deciduous forest were twice as likely to be successful as those in pine plantations owing to differences in predation rates. Data from Minnesota, Wisconsin, and Iowa indicate that nesting success in fragmented landscape is 43% (Daily Survival Rate = 0.974 ± 0.006; n=90 nests; n=1605 observation days; Knutson *et al.* 2004).

Survival

The maximum recorded life-span is about 7 years (Clapp *et al.* 1983), and the species' age at first breeding is 1 year (McCarty 1996). Generation time for the Eastern Wood-pewee, which corresponds to the average breeding age in the population, is estimated at 2 to 3 years.

Movements/dispersal

Little research has been carried out on the Eastern Wood-pewee's fidelity to breeding sites (McCarty 1996). Of nine adults banded on their breeding sites in Illinois, two returned the following year (Robinson 1992). No information exists on local movements on the breeding grounds and/or dispersal after the nesting season.

About 95% of spring migration into southern Canada extends from about 10 May to about 10 June (Long Point Bird Observatory unpubl. data). Fall migration extends from about 20 August to 20 October. The species is generally solitary during migration (Stiles and Skutch 1989; Ridgely and Tudor 1994). Migration probably occurs mostly at night (McCarty 1996).

The Eastern Wood-pewee migrates primarily through the eastern and central U.S., south through the Gulf lowlands of Mexico, on both slopes from Chiapas south through Central America (Binford 1989; Ridgely and Gwynne 1989; Stiles and Skutch 1989; Howell and Webb 1995). It is also known to cross the Caribbean, passing through the West Indies (McCarty 1996).

Diet and Foraging Behaviour

No studies on feeding behaviour or diet have been conducted in Canada and most studies come from the United States (McCarty 1996). The pewee's diet consists primarily of small, flying insects that are 'hawked' in short flights from a perch in the subcanopy (Via 1979; McCarty 1996).

During the breeding season, the Eastern Wood-pewee feeds on a variety of small (mostly <15 mm) flying insects, including Diptera, Homoptera, Lepidoptera, Hymenoptera, Coleoptera, Orthoptera, Plecoptera and Ephemeroptera (Johnston 1971; Gray 1993; Sample *et al.* 1993). Foraging habits and diet during migration and in winter appear to be similar to those on the breeding grounds (Fitzpatrick 1980).

Interspecific Interactions

Few direct observations of predation on adults or nests of the Eastern Wood-pewee are available (McCarty 1996). In southern Ontario, Falconer (2010) reported an observation of a Blue Jay (*Cyanocitta cristata*) taking nestlings from a nest. He also suggested that Red Squirrels (*Tamiasciurus hudsonicus)* and flying squirrels (*Glaucomys* sp.) were potential predators. In Ohio, Blue Jays, American Crows (*Corvus brachyrhynchos*), owls, Eastern Chipmunks (*Tamias striatus*), Grey Squirrels (*Sciurus carolinensis*), and Raccoons (*Procyon lotor*) were regarded as potential predators (Newell and Rodewald 2011). During the breeding season, male pewees also show aggression towards Red-winged Blackbirds (*Agelaius phoeniceus*) and Common Grackles (*Quiscalus quiscula*) within their territories, suggesting that these species could depredate eggs or nestlings (Bent 1942; Nice 1961 in Graber *et al.* 1974).

The Eastern Wood-pewee is a rare host for the Brown-headed Cowbird (*Molothrus ater*; McCarty 1996), with low parasitism rates in Ontario (5.1%, n=117 nests; Peck and James 1987) and Manitoba (0%, n = 20 nests; Underwood *et al.* 2004).

Home Range and Territory

In a study in southern Ontario, Eastern Wood-pewee territories averaged 1.70 ± 0.33 ha (n=26 pairs) in deciduous forests and 1.83 ± 0.36 ha (n= 27 pairs) in pine plantations; there was no significant difference between habitat types (Falconer 2010). When both habitats were combined, territory size averaged 1.76 ± 0.24 ha (Falconer 2010).

Behaviour and Adaptability

On the breeding grounds, Eastern Wood-pewees can benefit from forest management practices such as selective harvest, which creates small openings in the canopy (Clark *et al.* 1983; Wilson *et al.* 1995; Artman *et al.* 2001; Campbell *et al.* 2007; Greenberg *et al.* 2007; Burke *et al.* 2011). A positive response may be due to higher levels of flying insect prey and/or their greater visibility in forest gaps. A study conducted in the southeastern U.S. (Arkansas, South Carolina and West Virginia) suggested that populations of Eastern Wood-pewees remained relatively stable over a 40-year scenario in landscapes managed under different forest management treatments (i.e., unmanaged, 60,120, and 180-acre cut size, and no-limit cut size; Mitchell *et al.* 2008). This suggests that the species shows some flexibility in its response to forest habitat management.

In southern Ontario, Falconer (2010) found that the presence of mature trees was important for nest-site selection. He suggested that maintaining large, mature trees (> 40 cm diameter at breast height in deciduous forest and > 32 cm in pine plantation), along with basal areas of 23 - 24 m^2 ha^{-1} (in both habitats), should provide adequate nesting requirements for wood-pewees.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

North American Breeding Bird Survey (BBS)

The BBS is designed to monitor North American breeding bird populations (Environment Canada 2010; Sauer *et al.* 2011). Breeding bird abundance data are collected by volunteers at 50, 400-m radius stops spaced at 0.8 km intervals along permanent 39.2 km routes on roadsides (Sauer *et al.* 2011). In Canada, the surveys are mostly conducted in June (i.e., during the height of the breeding period of most bird species). Surveys start one half hour before sunrise.

The main strengths of the BBS are that data from across much of North America have been collected according to a single standardized method, and surveys employ random start points and directions, thus enhancing regional representation of the avifauna (roadside bias notwithstanding; Blancher *et al.* 2007). Analysis of BBS data are now based on a hierarchical Bayesian model (see Sauer and Link 2011 and Environment Canada 2012). In the case of the Eastern Wood-pewee, the BBS covers most of the species' breeding range, and short- and long-term trends should correspond closely to actual population changes. Moreover, due to its highly recognizable song, the Eastern Wood-pewee should be readily detected wherever it occurs along BBS routes.

Étude des populations des oiseaux du Québec (ÉPOQ)/ Study of Québec Bird Populations (SQBP)

In Québec, the ÉPOQ (SQBP) database, which has been managing bird checklists submitted by thousands of volunteers since 1955 (accumulating more than 500,000 checklists), is another reference for determining Eastern Wood-pewee population trends (Cyr and Larivée 1995; Larivée 2011). The ÉPOQ database covers all regions south of the 52nd parallel, especially the St. Lawrence Lowlands, where the species is most abundant (Cyr and Larivée 1995). The abundance index is one of two abundance measures produced by ÉPOQ and is a measure of the number of birds observed based on the number of checklists submitted.

The strength of this survey lies in the fact that it covers the entire breeding range of the species in Québec (Cyr and Larivée 1995). However, the current analysis method does not take observation effort (i.e., the number of observers per checklist) into account, nor weather conditions, nor spatial variation in observation effort, but simply the number of hours of observation (Cyr and Larivée 1995). Nonetheless, the trends produced by the ÉPOQ database are correlated with those of the BBS and generate adequate trend assessments (Cyr and Larivée 1995; Dunn *et al.* 1996).

Ontario Breeding Bird Atlas (OBBA)

The Ontario Breeding Bird Atlas compared the distribution of breeding birds between 1981-1985 and 2001-2005, and is an important source of information on the status of the Eastern Wood-pewee in Ontario (Cadman *et al.* 2007). The data were gathered by volunteers who visited representative habitats within 10 km x 10 km squares for at least 20 hours during the breeding period (Cadman *et al.* 2007). The percent change in the distribution of the Eastern Wood-pewee in Ontario over a period of 20 years was calculated by comparing the percentage of the squares occupied in the first atlas period to the percentage occupied in the second atlas period, adjusting for observation effort (Blancher *et al.* 2007; Cadman *et al.* 2007).

The main limitation of this method is that the analysis comparing occupancy rates between the two atlas periods underestimates the change in actual population size for common, widespread species like the Eastern Wood-pewee (Francis *et al.* 2009). Differences in effort between the two atlases may also have led to some biases in estimating change (Blancher *et al.* 2007), because effort was not standardized between the two periods, and there can be important differences in efficiency of effort that cannot be captured by adjusting for quantity of effort. A major limitation of atlases is that they are typically repeated only at 20-year intervals, which means they cannot detect changes in population status during intervening periods (Francis *et al.* 2009).

Breeding Bird Atlases in other provinces

Using the same methodology as for the OBBA, data collection for a second atlas has been completed for the Maritimes for the period 2006-2010, which provides comparison with the first atlas, conducted from 1986-1990 (BSC 2012). In Québec, a second breeding bird atlas was started in 2010, but comparisons of results with the previous atlas conducted 20 years earlier (Gauthier and Aubry 1995) will not be available until 2014 (BSC 2011a). A first atlas project was also initiated in 2010 in Manitoba, which will provide results in 2014 (BSC 2011b).

A breeding bird atlas for Saskatchewan began in the 1970s and was completed in 1996 (Smith 1996). It employed a different methodology than was adopted by other provinces. Rather than engage in a massive field effort, it drew mostly upon several existing databases, including the Breeding Bird Survey, bird banding data from the Canadian Wildlife Service, and nest records from the Prairie Nest Records Scheme (Smith 1996).

Ontario Forest Bird Monitoring Program (FBMP)

Coordinated by the Canadian Wildlife Service, the Forest Bird Monitoring Program (FBMP) began in Ontario in 1987 to provide information on population trends and habitat associations of birds that breed in the forest interior (Ontario Forest Bird Monitoring 2006). Each year, between 50 and 150 sites are surveyed by volunteers, who make two 10-minute visits to five point count stations per site. The program was designed to investigate spatial and temporal patterns for forest birds, with monitoring sites selected in off-road sites in core areas of large, mature forests that are typically protected from active forest management. Because other kinds of forest habitat are not sampled and because of limited geographical coverage, the program's results are not representative of the overall landscape (Francis *et al.* 2009). Hence, for the Eastern Wood-pewee, which prefers intermediate-age forests, the FBMP may provide a biased sample. Trend analysis for Eastern Wood-pewee is currently available for the period 1987-2010 (R. Russell unpubl. data 2011).

Migration Monitoring

Several field stations associated with the Canadian Migration Monitoring Network provide counts of Eastern Wood-pewees during spring and/or fall migration. The longest-running station is Long Point Bird Observatory (LPBO), located on the north shore of Lake Erie, which has been in operation since 1961 and precedes the BBS by a decade. In addition to banding, volunteers also carry out a standardized daily count of all migrating birds, and keep track of all other migrants they observe throughout the day. Spring and fall population indices for the Eastern Wood-pewee for LPBO are calculated annually (BSC 2011c). Population indices are also available for other stations, but none span more than two decades. A major weakness of migration monitoring is that relatively little is currently known about the breeding origins of the birds being sampled.

Abundance

Based on BBS data from 1987-2006, the Eastern Wood-pewee reaches its highest Canadian abundance in southern Ontario (Figure 3). Based on all available information, there are roughly 435,000 breeding adults (217,500 mated pairs) in Canada (see Table 1). These birds are concentrated in Ontario (69%), Québec (10%) and Manitoba (9%); the rest are distributed at lower densities in other provinces (Table 1).

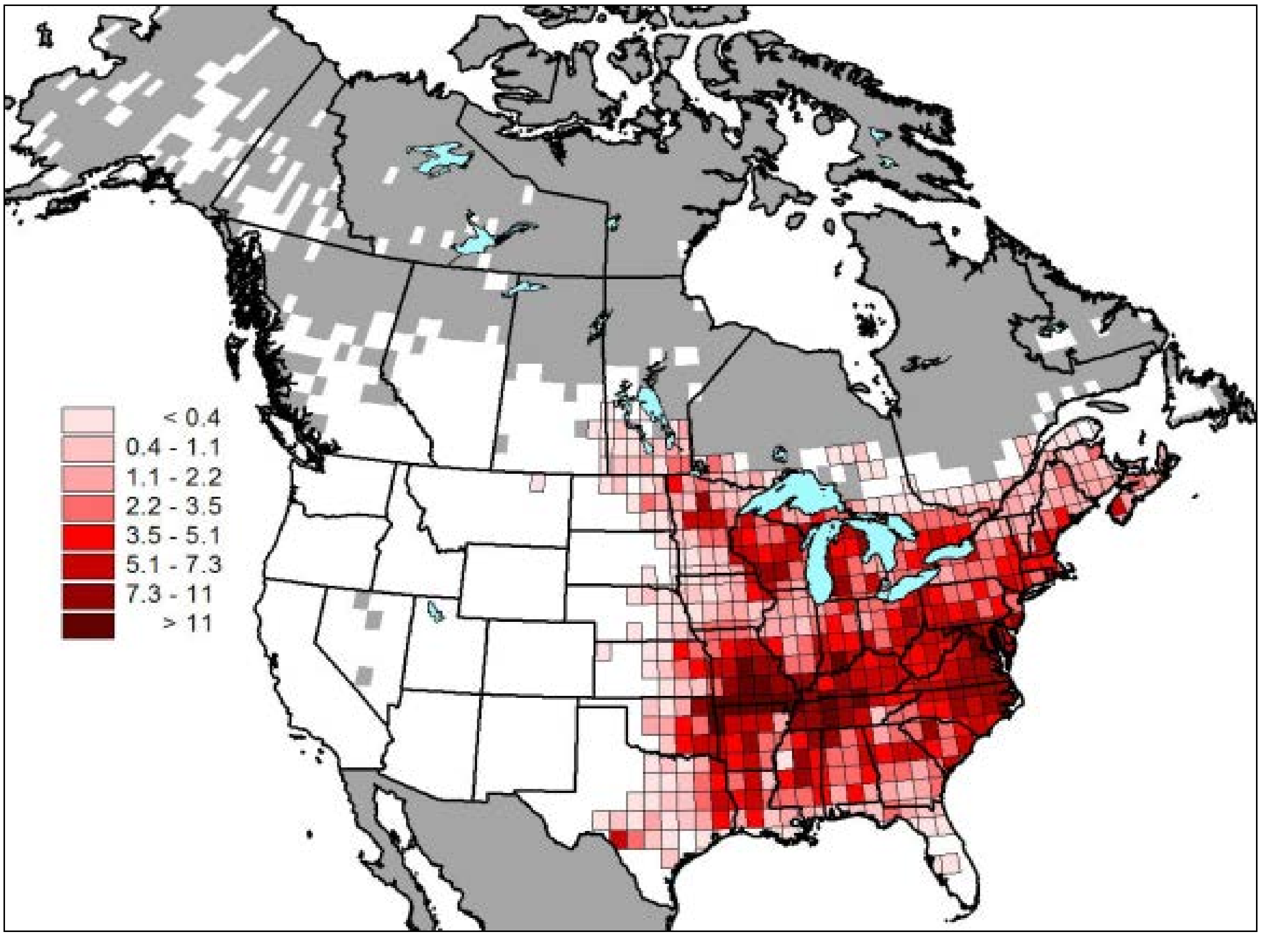

Figure 3. Relative abundance of Eastern Wood-pewees breeding in North America, based on BBS data calculated for each latitude and longitude degree block from 1987-2006, in relation to the proportion of the breeding range surveyed by the BBS. Grey areas = not surveyed by BBS; white areas = surveyed, but no Eastern Wood-pewees detected (Environment Canada 2011).

Table 1. Population size estimates of the numbers of Eastern Wood-pewees breeding in Canada based primarily on Breeding Bird Survey data (Blancher *et al.* 2007, updated by P. Blancher unpubl. data 2011).

Province[1]	Population Size (adults)	% of Global Population
ON[2]	300,000	5.3
QC	45,000	0.8
MB	40,000	0.7
NS	30,000	0.5
NB	18,000	0.3
PE	2,700	0.05
Total	**435,000**	**7.7**

[1] Too few birds were recorded on BBS routes in Saskatchewan to provide a population estimate.
[2] Ontario estimate is based on breeding bird atlas point counts (2001-2005). The atlas estimate is based on a far greater number of point counts (including off-road counts) than the BBS, which increases the reliability of the atlas estimate.

Fluctuations and Trends

The Eastern Wood-pewee has probably always been fairly common and widespread within its current range in Canada (Wintle 1896; Dionne 1906; Ouellet 1974; Godfrey 1986; Gauthier and Aubry 1995; Cadman *et al.* 2007). Population trends are, however, only available since the 1970s.

<u>North American Breeding Bird Survey</u>

In Canada, long-term BBS data show a significant decline of about 2.9% per year (95% CI: -3.4, -2.5) between 1970 and 2011, which corresponds to an overall decline of 70% over the last 40 years (Figure 4, Table 2; Environment Canada unpubl. data). In the most recent 10-year period (2001 to 2011, or roughly three generations), BBS data show a significant decline of about 2.8% per year (95% CI: -3.7, -1.9; Table 2), which represents a 25% decline over the last 10 years in Canada (95% CI: -31.4%, -17.5%). Populations declined significantly in Manitoba, Ontario, Québec, New Brunswick and Nova Scotia/Prince Edward Island for the period 1970-2011, with a more pronounced decline in Québec and New Brunswick (Table 2). For the more recent period (2001-2011), short-term declines are also apparent, and again tend to be more pronounced in the eastern part of the country (Table 2).

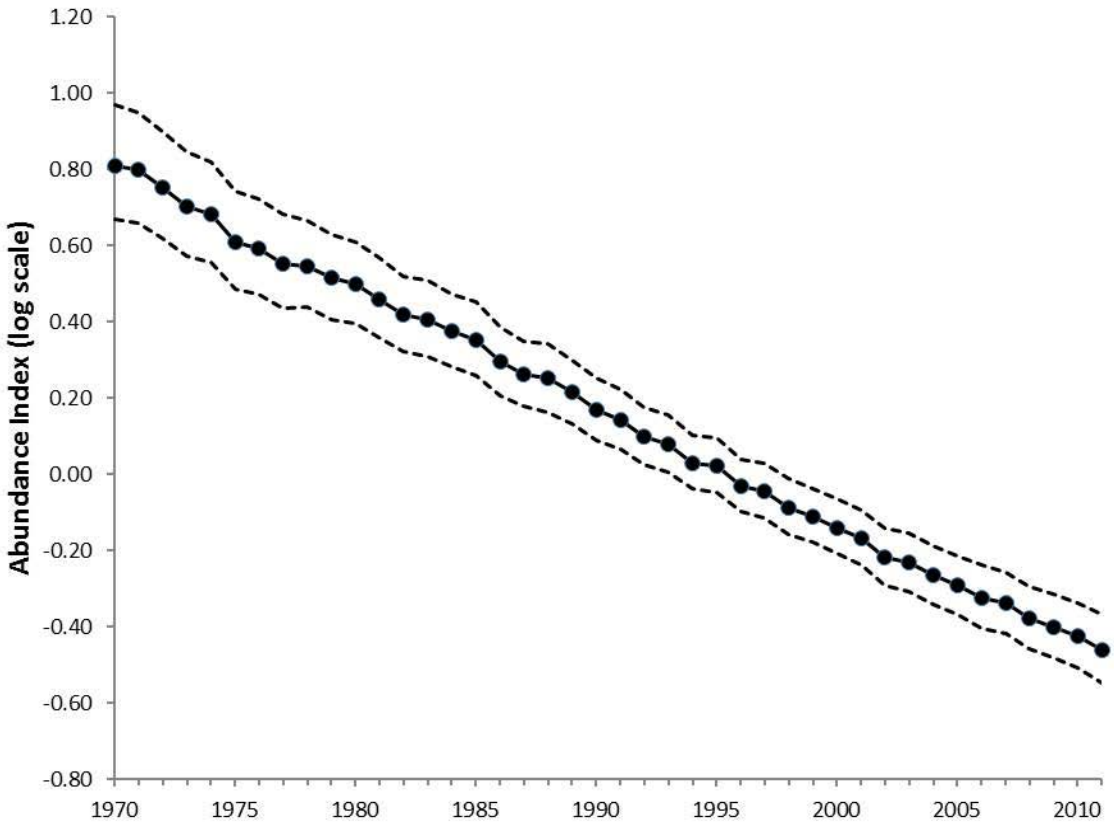

Figure 4. Eastern Wood-pewee annual abundance indices for Canada between 1970 and 2011, based on a hierarchical Bayesian model of Breeding Bird Survey data, plotted on a log-scale (Environment Canada unpubl. data 2012). Dotted lines correspond to the 95% upper and lower credible intervals.

Table 2. Average annual population trends (and 95% lower [lcl] and upper [ucl] credible intervals) for the Eastern Wood-pewee in the long- and short-term based on BBS surveys (Environment Canada unpubl. data 2012). Results in bold are statistically significant.

	1970-2011			**2001-2011**		
Region	**Annual Rate of Change (%/yr)**	**lcl**	**ucl**	**Annual Rate of Change (%/yr)**	**lcl**	**Ucl**
Canada	**-2.93**	-3.39	-2.48	**-2.81**	-3.65	-1.93
Manitoba	**-1.85**	-3.83	-0.03	-1.97	-6.02	1.22
Ontario	**-2.59**	-3.25	-1.97	**-2.51**	-3.54	-1.43
Québec	**-4.43**	-5.49	-3.40	**-4.37**	-6.33	-2.32
New Brunswick	**-3.84**	-4.92	-2.63	**-4.32**	-8.33	-0.40
Nova Scotia & Prince Edward Island	**-1.85**	-2.99	-0.76	-1.96	-4.88	0.50

Ontario Breeding Bird Atlas (OBBA)

A comparison of the species' probability of observation in Ontario from the first (1981-1985) to the second (2001-2005) atlas period showed no statistically significant change across the province as a whole (Cadman *et al.* 2007). Indeed, there was an overall, non-significant, increase of 9%. This result contrasts with the significant negative trend obtained from the BBS data. However, by region the probability of observation decreased significantly in the Lake Simcoe-Rideau area (-6%) and in the Southern Shield (-15%) and decreased non-significantly in the Carolinian region (-6%) (Cadman *et al.* 2007; Figure 5). These declines could have been balanced somewhat by a shift in the species' distribution from the Southern Shield region northward into the adjacent Northern Shield region where the Eastern Wood-pewee showed a 75% increase in probability of observation (Cadman *et al.* 2007).

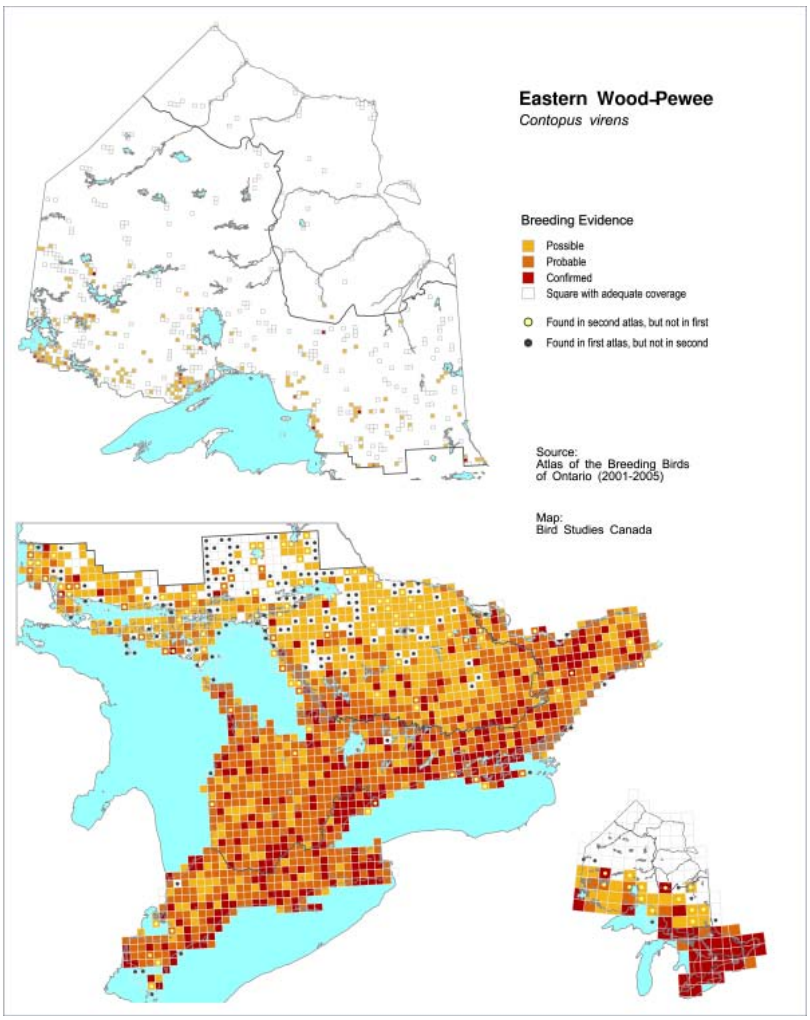

Figure 5. Ontario distribution of the Eastern Wood-pewee during the period 2001-2005, based upon atlas data (reproduced with permission from Cadman *et al.* 2007). Squares with black dots are those in which the species was found in the first atlas period (1980-1985), but not in the second (2001-2005). Squares with yellow dots correspond to those where the species was found only in the second atlas.

Maritimes Breeding Bird Atlas (MBBA)

Preliminary analyses comparing the probability of observation of Eastern Wood-pewees within their Maritime range after 20 hours of observation in the first and second Atlas periods indicate significant declines over the last 20 years (Figure 6). The probability of observation declined from 0.50 to 0.40, which yields a statistically significant average annual decline of 1.02% over the 20-year period (or roughly a 10% decline over 10 years). The decline was driven mainly by New Brunswick (-1.6% per year; M. Campbell unpubl. data; S. Makepeace *fide* Sabine pers. comm. 2012).

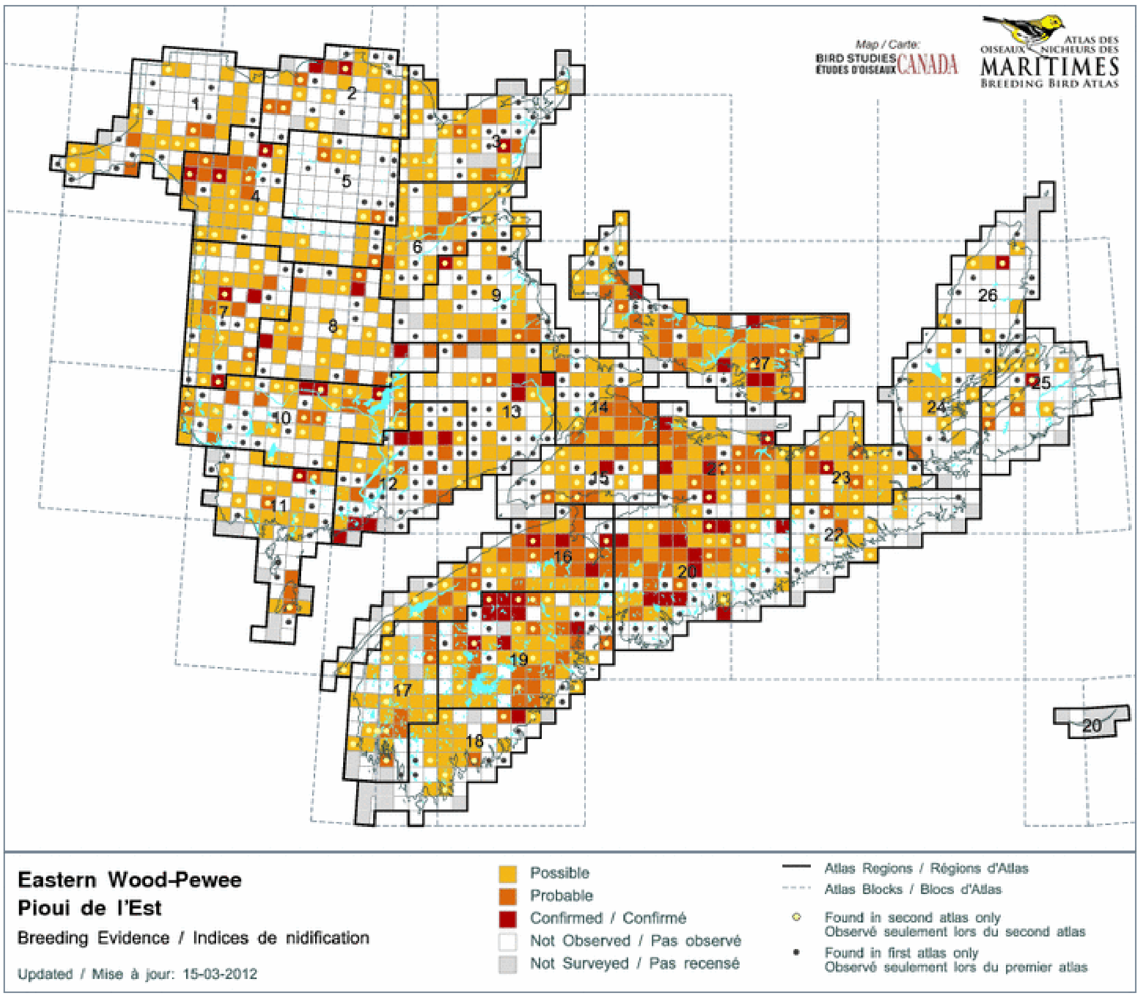

Figure 6. Distribution of the Eastern Wood-pewee in the Maritimes during the period 2006-2010 (reproduced with permission from BSC 2012). Squares with black dots are those in which the species was found in the first atlas period (1986-1990), but not in the second (2006-2010). Squares with yellow dots are those in which the species was found in the second atlas period but not in the first.

Étude des populations des oiseaux du Québec (ÉPOQ)/ Study of Québec Bird Populations (SQBP)

The ÉPOQ database shows a significant long-term decline in Eastern Wood-pewee abundance in Québec of 0.5% per year (R^2= 0.62; P ≤ 0.001; Figure 7) between 1970 and 2009, representing a 17% decline over 39 years. For the 10-year period from 2000-2009, the short-term trend was stable, with a non-significant decline of 0.06% per year (R^2= 0.006; P ≥ 0.05).

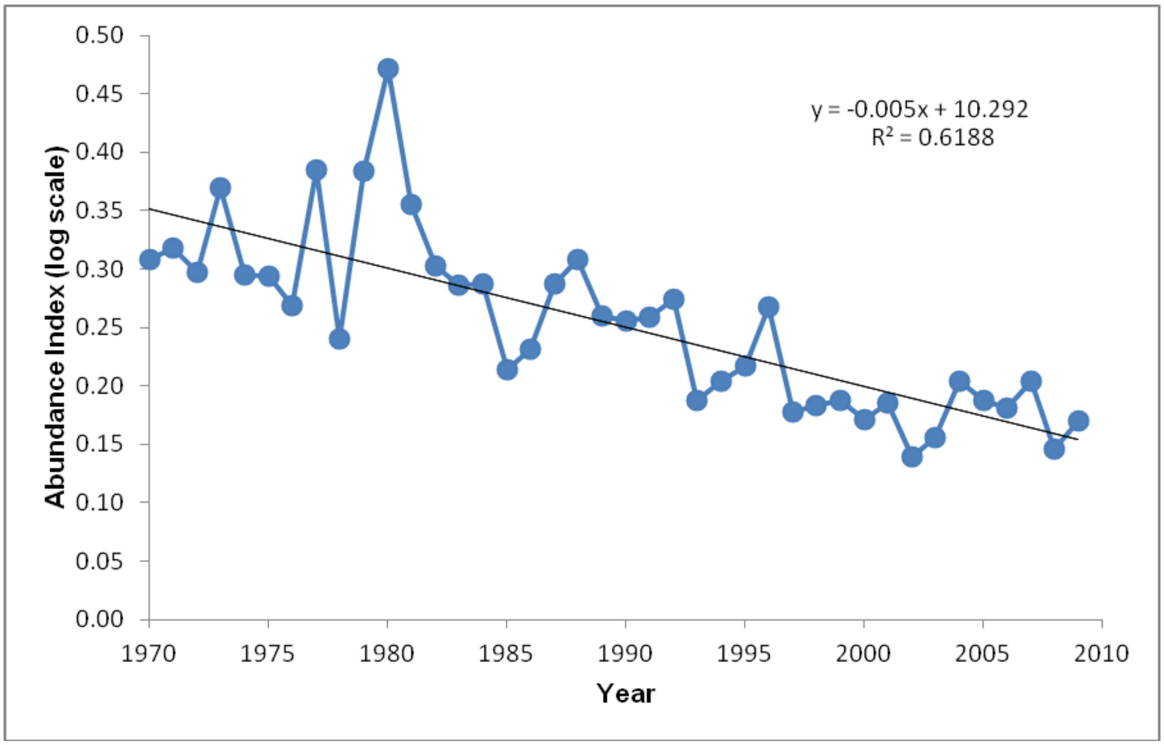

Figure 7. Annual indices (log scale) of population change for the Eastern Wood-pewee in Québec between 1970 and 2009, based on ÉPOQ data (Larivée 2011). Only checklists produced between May 15 and July 15 were used in the analysis.

Ontario Forest Bird Monitoring Program (FBMP)

The long-term FBMP annual trend estimate for the Ontario population of the Eastern Wood-pewee in interior, mature forests shows a near-significant decline of 2.3% per year (n = 201 sites with sufficient sample size; 0.05 < p < 0.10; 95% CI= -4.9, 0.3) between 1987 and 2010 (R. Russell unpubl. data 2011). Regionally, the trend was negative for central Ontario, with a significant decline of -4.7% per year for the same time period (n= 52 sites; p<0.05; CI: -8.1, -1.1). A non-significant decline was estimated for southwestern Ontario (-1.7% per year; n= 149 sites; p>0.05; CI: -4.8, 1.4). A 10-year trend estimate is currently unavailable.

Migration Monitoring

Long-term migration data collected at Long Point, Ontario from 1961-2010 detected a statistically significant increase of 1.8% per year in the fall (p<0.001) and 1.5% per year in spring (p<0.001; T. Crewe unpubl. data; see Figure 8). For the corresponding long-term BBS time period (1970-2010), the LPBO annual average trends were also strongly positive (2.0%; p<0001 for fall; and 1.6%; p<0.01 for spring). The most recent 10-year trend estimates for 2000-2010 show an average non-significant decline of -2.6% (p=0.34) in the fall, but a statistically significant increase of 6.6% per year (p<0.05) in spring. There is large annual variation in population indices at Long Point, especially in spring (Figure 8). Short-term trend estimates based on migration monitoring are heavily influenced by the particular window of years that is selected.

Also available from T. Crewe (unpubl. data) are relatively short-term trend estimates (based on 9-18 years of data) from the following other migration monitoring stations in Canada: Delta Marsh Bird Observatory, MB (1993-2010; fall only; -4.1% per year; p = 0.02); Innis Point Bird Observatory, ON (1997-2010; spring only; -6.0%; p = 0.05); Prince Edward Point Bird Observatory, ON (2001-2010; fall only; -7.0%; p = 0.08); Ruthven Park, ON (1998-2010; spring = -0.5%; p > 0.8; fall = -0.4%; p > 0.8). While all these recent estimates point to recent declines, care again needs to be taken when interpreting population changes based on short-term data sets that have high annual variation.

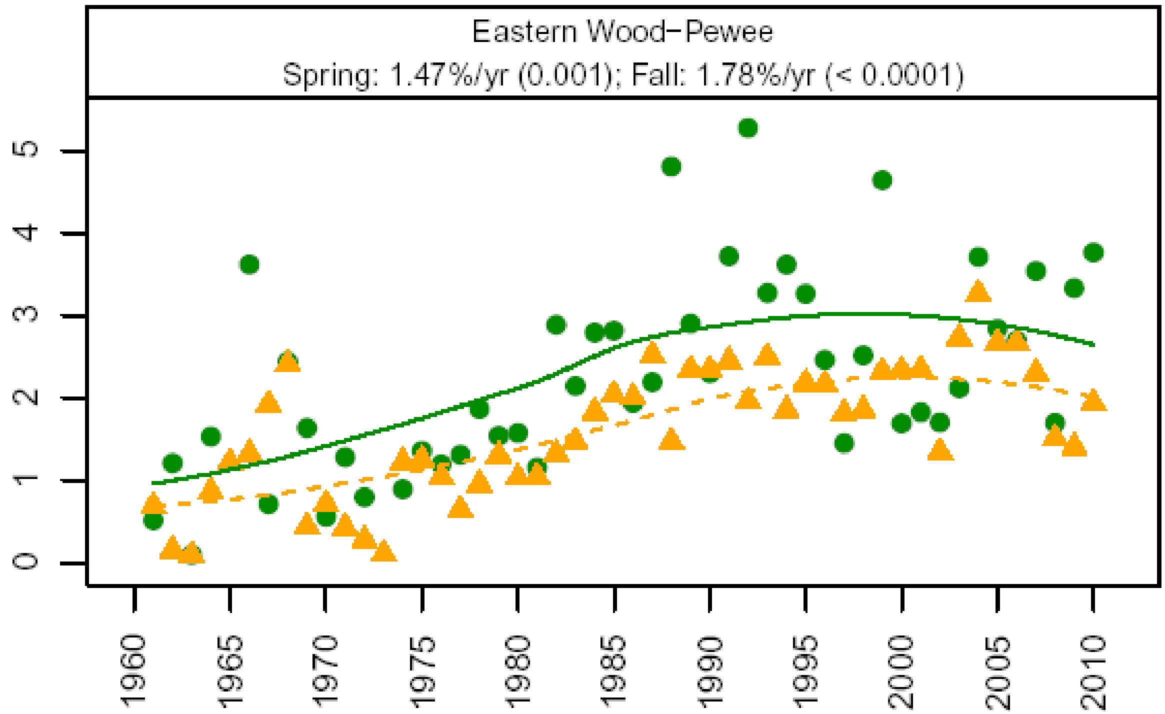

Figure 8. Long-term trends in spring and fall migration indices of Eastern Wood-pewees recorded at Long Point Bird Observatory, Ontario (1961-2010). Spring indices and trend are denoted by green circles and the solid green line. Fall indices and trend are denoted by orange triangles and the orange dashed line (graphic courtesy of T. Crewe unpubl. data 2011).

Population Trend Summary

BBS data for Canada and most provinces indicate a significant decline in the population of Eastern Wood-pewees for the period 1970-2011. For Canada and most eastern provinces, these trends seem to hold also for the more recent period from 2001-2011. The negative trend pattern obtained from the BBS also corresponds somewhat with results from other databases such as ÉPOQ (Québec) and FBMP (Ontario).

While evidence for a province-wide decline in Ontario is not apparent with the breeding bird atlas results, results suggest that declines have occurred in the southern part of the province, whereas increases have occurred at the northern edge of the species' breeding range, where the species is uncommon and BBS coverage is relatively weak. Unlike BBS results, LPBO results from counts of spring and fall migrants suggest an overall increasing population trend since 1961, with relatively more stable levels occurring from 2000-2010.

For the Eastern Wood-pewee, the lack of strong concordance of trend results between the various monitoring programs is difficult to reconcile, and points to the existence of biases among programs. In 2008, the Ontario Ministry of Natural Resources led a scientific review panel that assessed the relative strengths of various kinds of bird monitoring programs for each species in Ontario, based on trend precision, survey coverage, survey design, and overall trend reliability (Francis *et al.* 2009). For the Eastern Wood-pewee, the panel concluded that the BBS was the most reliable monitoring program. BBS is highly standardized, covers the majority of the breeding range of the species, is representative of regional habitat cover, and shows lower annual statistical variance than estimates from other programs.

Rescue Effect

In the event of the extirpation of the Canadian population, immigration of birds from the central and northern United States is likely. However, the potential for continued rescue is decreasing. The population in the United States shows a persistent decline in the core of the species' breeding range between 1966-2010 (1.2%/year, -1.4, -1.1 CI, n= 2099 routes) as well as in most states bordering the eastern Canadian provinces (Sauer *et al.* 2011; Figure 9).

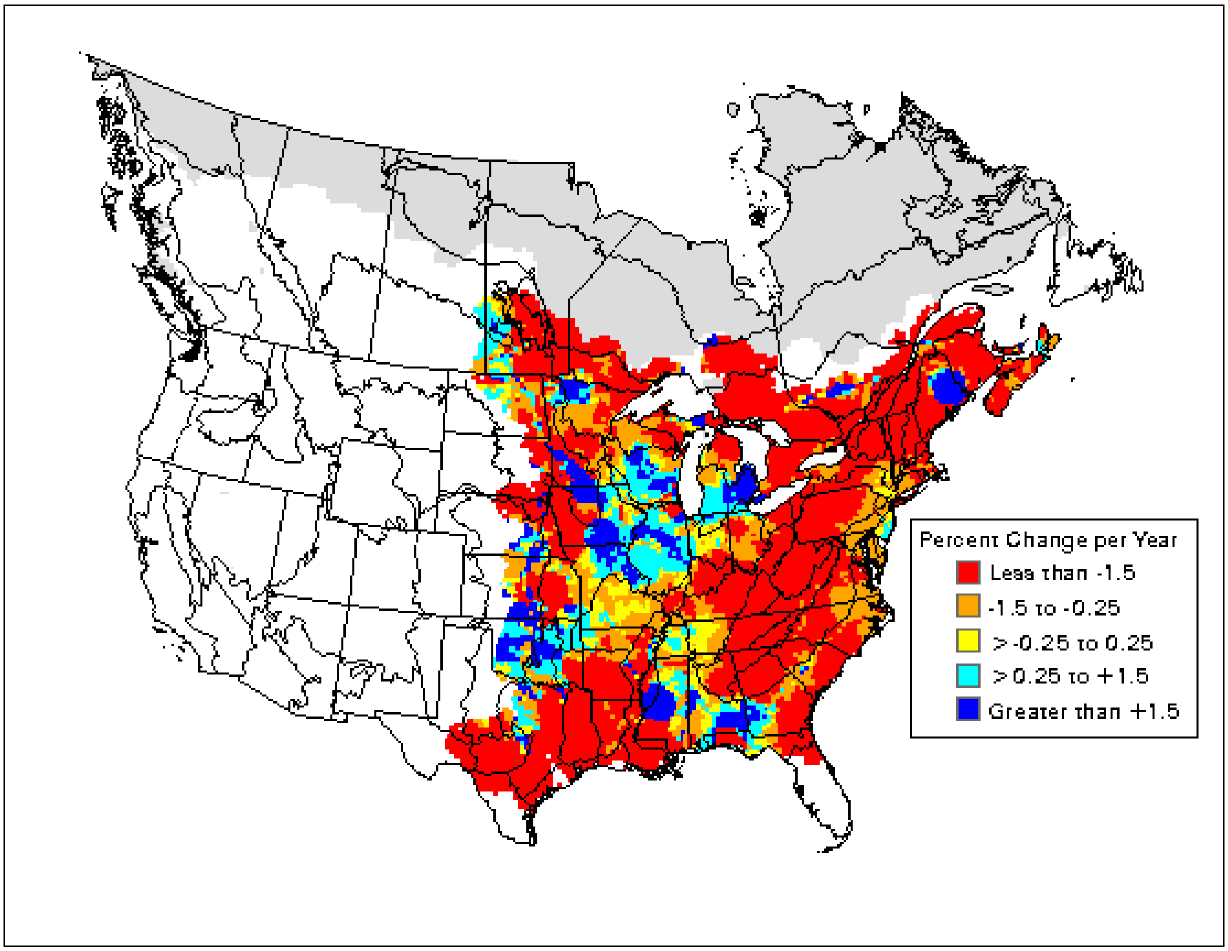

Figure 9. BBS trend map for Eastern Wood-pewee in the United States and Canada for the period from 1966 to 2010 (Sauer *et al.* 2011).

THREATS AND LIMITING FACTORS

Threats and limiting factors for Eastern Wood-pewees on the breeding grounds are poorly known (McCarty 1996). There is also little documented information on threats and limiting factors on the wintering grounds or during migration (McCarty 1996). Because Eastern Wood-pewees spend most of the year in South America and substantial time in migration, some of the key threats are likely operating outside Canada.

Habitat Loss/degradation

Outright loss of suitable forested habitat does not appear to be a significant issue across most of the pewee's Canadian breeding range, though some regions like New Brunswick are seeing losses in mature forest cover owing to forest management (see **Habitat trends** section).

The species does not appear to be very sensitive to forest fragmentation effects (Blake and Karr 1987; Robbins *et al*. 1989; Freemark and Collins 1992; Desrochers *et al*. 2010). Generally, size of forest fragments also does not appear to be an important factor affecting habitat selection by Eastern Wood-pewees (Stauffer and Best 1980; Blake and Karr 1987; Robbins *et al*. 1989; Freemark and Collins 1992). However, in Nebraska, the Eastern Wood-pewee was generally not present in regions with <24% forest cover (Perkins *et al*. 2003).

Development for human habitation can negatively affect the species' abundance in an area. In Ontario and Pennsylvania, pewees occur less frequently in woodlots with surrounding development than in those without houses (Friesen *et al.* 1995; Keller and Yahner 2007). A preliminary analysis of breeding bird atlas data in the Maritimes also indicated negative effects were associated with human-occupied areas and roads (M. Campbell unpubl. data). Likewise, in another study (in Ohio), pewee density in a forested urban environment was found to be lower than in outlying natural forests (Beissinger and Osborne 1982).

Changes in forest habitat supply and/or quality could have profound effects on survivorship of wintering populations of pewees. However, little is known about the pewee's habitat requirements outside the breeding period, particularly on its South American wintering grounds. A recent study that examined change in forest area in Latin America between 2001 and 2010 found that deforestation rates were particularly severe in South America, especially within the moist forest biome (Aide *et al.* 2012).

Large-scale Changes in Availability of Aerial Insects

Since at least the mid-1980s, many North American birds that specialize on a diet of flying insects have been experiencing widespread population declines (Nebel *et al.* 2010). As has been suggested for other aerial insectivores, Eastern Wood-pewee populations could be negatively affected by a possible change in the availability of insect prey (Nebel *et al.* 2010). There are many possible causes of changes in insect food supply, including an increase in decalcification of forest soils and aquatic ecosystems brought about by acid precipitation, and climate-change effects that may be causing asynchrony between the timing of insect emergence and the breeding season of aerial insectivores (Nebel *et al.* 2010). At the more local level, Eastern Wood-pewees can also be adversely impacted by widespread spraying for Gypsy Moths (*Lymantria dispar*), because the spray kills other non-target insects that serve as food (Sample *et al.* 1993; Whitmore *et al.* 1993).

While this threat has the potential to be severe and widespread, little is known about the status or trends of populations of flying insects within the pewee's breeding or wintering ranges.

Mortality During Migration and/or Wintering

Sillett and Holmes (2002) suggested that mortality in long-distance migratory birds, such as the Eastern Wood-pewee, may be occurring mostly via processes acting during the non-breeding season. For example, severe storms can kill migrants over the Gulf of Mexico, including Eastern Wood-pewees (Wiedenfeld and Wiedenfeld 1995). Indeed, long-distance migrants that originate in Canada and winter in South America are generally declining more strongly than shorter-distance migrants (North American Bird Conservation Initiative Canada 2012). While the mechanisms that are driving this pattern are largely unknown, poor annual survivorship stemming from factors on the wintering grounds (or during migration) has the potential to present a high level of threat in terms of scope and severity.

Nest Predation

The only study that assessed reproductive success of the Eastern Wood-pewee in Canada found a high rate of nest predation (Falconer 2010). In this 2-year study in central Ontario, daily survival rate (DSR) and period survival (PS), assuming a 32-day nesting period, were greater in deciduous forests (DSR= 0.997 [0.967-0.985 CI], PS= 47.5%) than in pine plantations (DSR= 0.959 [0.946-0.968 CI], PS= 26.2%; Falconer 2010). High rates of nest predation by Blue Jays and Red Squirrels, the most common predators in the study area, were thought to be at least partly responsible for the low nest survival rate. While Falconer (2010) suggested that the decline of Eastern Wood-pewees in the Lower Great Lakes Region might be linked to increasing populations of Blue Jays, population increases of jays have generally been rather modest. It is also difficult to understand why wood-pewee nests would preferentially be targeted by jays. On balance, it would seem that this is a low threat in terms of scope and severity.

Degradation of Breeding Habitat from Over-browsing by White-tailed Deer

McCarty (1996) suggested that over-browsing by White-tailed Deer (*Odocoileus virginianus*) could be a potential threat to Eastern Wood-pewees. Over-browsing is known to dramatically change the structure of deciduous and mixed forests in eastern North America by decreasing plant and tree diversity and density, and by reducing the shrub/sapling layer (e.g., Collard *et al.* 2011; Tanentzap *et al.* 2011). Although removal of the shrub layer by deer may fulfill the wood-pewee's structural habitat needs in the short term, long-term decreases in understory composition and density could have negative effects (DeGraaf *et al*. 1991; deCalesta 1994), perhaps by reducing the density and diversity of insect prey (e.g., Baines *et al.* 1994; Allombert *et al.* 2005).

In Pennsylvania, Eastern Wood-pewees were reported to be locally absent from sites with deer densities >8 deer/km^2 due to change in habitat structure of the intermediate canopy (deCalesta 1994). However, in another local study in Virginia, there did not appear to be any relationship between deer density and pewee abundance (McShea and Rappole 2000). Although deer densities can be very high in some parts of the species' range in Canada, such as at Rondeau Provincial Park (55 deer km^2 in the 1980s; Tanentzap *et al.* 2011), the pewee still persists as one of the park's most common forest birds (Gartshore 1994). Similar situations occur elsewhere in Ontario, notably at Long Point and Point Pelee (McCracken *et al.* 1981; Lepage *et al.* 2009). Given the weakness of the evidence for an effect, over-abundance of deer should be regarded as posing a low level threat to the Eastern Wood-pewee.

PROTECTION, STATUS, AND RANKS

Legal Protection and Status

In Canada, the Eastern Wood-pewee and its nests and eggs are protected under the *Migratory Birds Convention Act*. It occurs in national parks and historic sites across eastern Canada, where it is protected by the *Canada National Parks Act.* In Québec, it is protected under the *Loi sur la conservation et la mise en valeur de la faune* (L.R.Q., c. C-61.1) (*Act respecting the conservation and development of wildlife*) (R.S.Q., c. C-61.1). By this law, it is illegal to disturb, destroy, or damage the eggs or nest of an animal. It is also prohibited to hunt, capture, or keep in captivity without a specific permit. This species is not listed under the *Loi sur les espèces menacées ou vulnérables* (L.R.Q., chapitre E-12.01) (*Act respecting threatened or vulnerable species*) (R.S.Q., c E-12.01) and it is not on the list of wildlife species which are likely to be designated vulnerable or threatened. In Ontario, the *Fish and Wildlife Conservation Act* (S.O. 1997, c.41, 7. [1]) offers similar protection, as does the New Brunswick *Fish & Wildlife Act* (S.N.B. 1980, c. F-14.1).

Non-Legal Status and Ranks

At the global level, the species is considered secure (G5, last reviewed in 1996; see Table 3) by NatureServe (2012). The species is considered ‘Least concern’ according to the IUCN Red List (NatureServe 2012).

In Canada, the Eastern Wood-pewee is considered ‘secure’ (N5; last reviewed in 2011; NatureServe 2012). It is considered ‘apparently secure’ (S4) in Saskatchewan, Manitoba, Ontario, and Prince Edward Island, ‘vulnerable’ to ‘apparently secure’ (S3/S4) in Québec, and ‘secure’ (S5) in New Brunswick (NatureServe 2012; Table 3). The General Status Ranking for the Eastern Wood-pewee considers the species secure in Canada and most provinces except Nova Scotia and Ontario where it is sensitive (CESCC 2011; Table 3).

In the United States, the species is considered ‘secure’ nationally (N5). At the state level, it is considered ‘secure’ (S5) or ‘apparently secure’ (S4) in most states, except South Dakota, where it is considered ‘vulnerable’ (S3; NatureServe 2012).

Habitat protection and ownership

In Canada, Eastern Wood-pewee habitat occurs on a mix of both public and private lands, but little information is available on their relative proportions. In New Brunswick, there is about 1 million ha of habitat suitable for pewees (much of it Crown land), which accounts for about 14% of the province’s land base (Sabine pers. comm. 2012).

Crown forests in Canada receive various kinds and intensities of active management. For example, on Crown land in Ontario, the supply of all forest habitat types and development stages, including mature deciduous, mixed and coniferous stands, is regulated through the *Crown Forest Sustainability Act* (1994) and the Class Environmental Assessment for Forestry (2003). These Acts require forest management to emulate natural disturbances and natural landscape patterns to conserve biological diversity and likely therefore maintain habitat for the Eastern Wood-pewee in Crown forests (OMNR 2009). Likewise, in New Brunswick, the maintenance of habitat for wildlife species is a requirement of Crown forest management under the *Crown Lands and Forest Act, 2011*. Area targets and stand/landscape descriptions have been developed for six types of old forest habitats, including Old Tolerant Hardwood Habitat, which is favoured by Eastern Wood-pewees. Forest management plans include the spatial identification of area to meet habitat targets in appropriate stand and landscape configurations (New Brunswick Department of Natural Resources 2005).

Relatively small portions (likely less than 10%) of the deciduous and mixed forests in southeastern Canada are protected within national and provincial parks, migratory bird sanctuaries and national wildlife areas. According to Parks Canada’s Biotics database, the Eastern Wood-pewee is present in 21 protected areas managed by Parks Canada (Parks Canada 2011). The species is also reported on 13 Department of

National Defence establishments, where it is believed to be a fairly common breeder (D. Nernberg unpubl. data 2011). It also occurs in a large number of provincially protected natural areas. For example, in New Brunswick, there are about 61 Protected Natural Areas totalling about 158,000 ha (2.1% of the provincial landbase) that are managed under the province's *Protected Natural Areas Act*. Industrial, commercial, agricultural uses and development are prohibited in these areas.

Table 3. Ranks assigned to the Eastern Wood-pewee in North America, based on NatureServe (2012) and General Status Ranks (CESCC 2011).

Region	Rank*	General Status**
Global	G5	---
United States	N5B	---
Canada	N5B	Secure
Saskatchewan	S4B	Secure
Manitoba	S4S5B	Secure
Ontario	S4B	Sensitive
Québec	S3S4B	Secure
New Brunswick	S5B	Secure
Nova Scotia	S4B	Sensitive
Prince Edward Island	S4B	Secure

* The NatureServe global rank was last reviewed in 1996; the Canadian national rank was reviewed in 2011. G = global status rank; N= national status rank; S = rank assigned to a province or state; S1 indicates that a species is critically imperiled because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines, making it especially vulnerable to extirpation; S2 indicates that a species is imperiled because of rarity or other factors making it very vulnerable to extirpation, usually with 6 to 20 occurrences or few individuals remaining (i.e., 1000 to 3000); S3 indicates that a species is vulnerable at the subnational level because it is rare or uncommon, or found only in a restricted range, or because of other factors making it vulnerable to extirpation; S4 indicates a species is apparently secure; S5 indicates that a species is secure because it is common, widespread, and abundant in the state/province.
** Secure: Species that are not believed to belong in the categories *Extirpated*, *Extinct*, *At Risk*, *May Be At Risk*, *Sensitive*, *Accidental* or *Exotic*. This category includes some species that show a trend of decline in numbers in Canada but remain relatively widespread or abundant. Sensitive: Species that are not believed to be at risk of immediate extirpation or extinction but may require special attention or protection to prevent them from becoming at risk.

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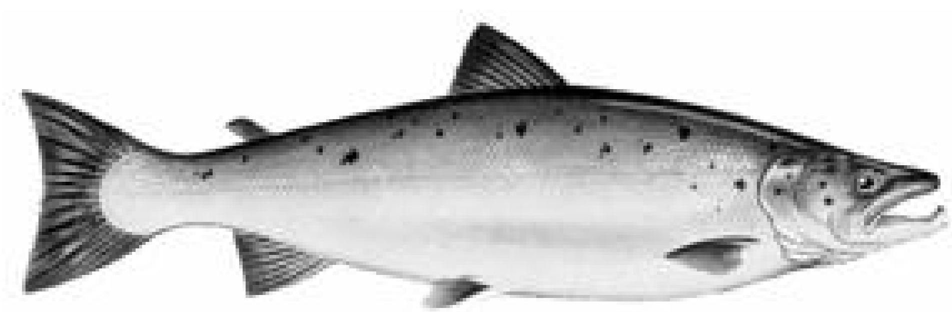
COSEWIC
Assessment and Status Report

on the

Atlantic Salmon
Salmo salar

Nunavik population, Labrador population, Northeast Newfoundland population, South Newfoundland population, Southwest Newfoundland population, Northwest Newfoundland population, Quebec Eastern North Shore population, Quebec Western North Shore population, Anticosti Island population, Inner St. Lawrence population, Lake Ontario population, Gaspé-Southern Gulf of St. Lawrence population, Eastern Cape Breton population, Nova Scotia Southern Upland population, Inner Bay of Fundy population, Outer Bay of Fundy population

in Canada



Nunavik Population – DATA DEFICIENT
Labrador Population – NOT AT RISK
Northeast Newfoundland Population – NOT AT RISK
South Newfoundland Population – THREATENED
Southwest Newfoundland Population – NOT AT RISK
Northwest Newfoundland Population – NOT AT RISK
Quebec Eastern North Shore Population – SPECIAL CONCERN
Quebec Western North Shore Population – SPECIAL CONCERN
Anticosti Island Population – ENDANGERED
Inner St. Lawrence Population – SPECIAL CONCERN
Lake Ontario Population – EXTINCT
Gaspe-Southern Gulf of St. Lawrence Population – SPECIAL CONCERN
Eastern Cape Breton Population – ENDANGERED
Nova Scotia Southern Upland Population– ENDANGERED
Inner Bay of Fundy Population – ENDANGERED
Outer Bay of Fundy Population – ENDANGERED
2010

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

COSEWIC. 2010. COSEWIC assessment and status report on the Atlantic Salmon *Salmo salar* (Nunavik population, Labrador population, Northeast Newfoundland population, South Newfoundland population, Southwest Newfoundland population, Northwest Newfoundland population, Quebec Eastern North Shore population, Quebec Western North Shore population, Anticosti Island population, Inner St. Lawrence population, Lake Ontario population, Gaspé-Southern Gulf of St. Lawrence population, Eastern Cape Breton population, Nova Scotia Southern Upland population, Inner Bay of Fundy population, Outer Bay of Fundy population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xlvii + 136 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Previous report(s):

COSEWIC. 2006. COSEWIC assessment and status report on the Atlantic Salmon *Salmo salar* (Lake Ontario population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 26 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

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COSEWIC
Assessment Summary

Assessment Summary – November 2010

Common name
Atlantic Salmon – Nunavik population

Scientific name
Salmo salar

Status
Data deficient

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and several years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population, which breeds in rivers flowing into Ungava Bay and eastern Hudson Bay, is the northernmost population of the species in North America, and the westernmost population of the entire species. It is separated by approximately 650 km from the nearest population to the south. Little is known about abundance trends in this population, although limited catch per unit effort data suggest increased abundance in recent years.

Occurrence
Quebec, Newfoundland and Labrador, Atlantic Ocean

Status history
Species considered in November 2010 and placed in the Data Deficient category.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Labrador population

Scientific name
Salmo salar

Status
Not at risk

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and several years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers along the Atlantic coast of Labrador and southwest along the Quebec coast to the Napetipi Rivers (inclusive). Freshwater habitats remain largely pristine. Abundance data are not available for most rivers; however, for rivers for which data are available, the number of mature individuals appears to have increased by about 380% over the last 3 generations.

Occurrence
Newfoundland and Labrador, Atlantic Ocean

Status history
Designated Not at Risk in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Northeast Newfoundland population

Scientific name
Salmo salar

Status
Not at risk

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers along the northeast coast of Newfoundland, from the northern tip of the island to the southeastern corner of the Avalon Peninsula. Recent abundance data show no clear trends in the number of mature individuals. Since 1992, the negative effects of poor marine survival have been at least partially offset by a near cessation of fishing mortality in coastal fisheries. Illegal fishing is a threat in some rivers.

Occurrence
Newfoundland and Labrador, Atlantic Ocean

Status history
Designated Not at Risk in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – South Newfoundland population

Scientific name
Salmo salar

Status
Threatened

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers from the southeast tip of the Avalon Peninsula, Mistaken Point, westward along the south coast of Newfoundland to Cape Ray. The numbers of small (one-sea-winter) and large (multi-sea-winter) salmon have both declined over the last 3 generations, about 37% and 26%, respectively, for a net decline of all mature individuals of about 36%. This decline has occurred despite the fact that mortality from commercial fisheries in coastal areas has greatly declined since 1992; this may be due to poor marine survival related to substantial but incompletely understood changes in marine ecosystems. Illegal fishing is a threat in some rivers. The presence of salmon aquaculture in a small section of this area brings some risk of negative effects from interbreeding or adverse ecological interactions with escaped domestic salmon. Genetic heterogeneity among the many small rivers in this area is unusually pronounced, suggesting that rescue among river breeding populations may be somewhat less likely than in other areas.

Occurrence
Newfoundland and Labrador, Atlantic Ocean

Status history
Designated Threatened in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Southwest Newfoundland population

Scientific name
Salmo salar

Status
Not at risk

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers from Cape Ray northwards along the west coast of Newfoundland to approximately 49°24' N, 58°15' W. Both small (one-sea-winter) and large (multi-sea-winter) salmon have increased in number over the last 3 generations, about 132% and 144%, respectively, giving an increase in the total number of mature individuals of about 134%.

Occurrence
Quebec, Newfoundland and Labrador, Atlantic Ocean

Status history
Designated Not at Risk in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Northwest Newfoundland population

Scientific name
Salmo salar

Status
Not at risk

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers along the west coast of Newfoundland from approximately 49°24' N, 58°15' W to the tip of the Great Northern Peninsula. The total number of mature individuals appears to have remained stable over the last 3 generations, and the number of large (multi-sea-winter) salmon appears to have increased by about 42%.

Occurrence
Newfoundland and Labrador, Atlantic Ocean

Status history
Designated Not at Risk in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Quebec Eastern North Shore population

Scientific name
Salmo salar

Status
Special concern

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers along the north shore of the St. Lawrence River estuary from the Napetipi River (not inclusive) westward to the Kegaska River (inclusive). This population shows opposing trends in the abundance of small (1 sea-winter) and large (multi-sea-winter) fish. Small salmon have declined 26% over the last 3 generations, whereas large salmon have increased 51% over the same period; pooling the data for both groups suggests a decline of about 14% for all mature individuals considered together. The small size of the population, about 5000 mature fish in 2008, is cause for concern. As is the case for most populations of the species, poor marine survival related to substantial but incompletely understood changes in marine ecosystems is also a concern.

Occurrence
Quebec, Atlantic Ocean

Status history
Designated Special Concern in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Quebec Western North Shore population

Scientific name
Salmo salar

Status
Special concern

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers along the north shore of the St. Lawrence River from the Natashquan River (inclusive) to the Escoumins River in the west (inclusive). Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over the last 3 generations, approximately 34% and 20%, respectively, for a net decline of all mature individuals of about 24%. As is the case for most populations of the species, poor marine survival related to substantial but incompletely understood changes in marine ecosystems is a concern.

Occurrence
Quebec, Atlantic Ocean

Status history
Designated Special Concern in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Anticosti Island population

Scientific name
Salmo salar

Status
Endangered

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers on Anticosti Island. Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over 3 generations, approximately 32% and 49%, respectively, for a net decline of all mature individuals of about 40%. The population size is small, about 2,400 individuals in 2008. As is the case for most populations of the species, poor marine survival related to substantial but incompletely understood changes in marine ecosystems is a concern.

Occurrence
Quebec, Atlantic Ocean

Status history
Designated Endangered in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Inner St. Lawrence population

Scientific name
Salmo salar

Status
Special concern

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This highly managed population breeds in rivers tributary to the St. Lawrence River upstream from the Escoumins River (not included) on the north shore and the Ouelle River (included) on the south shore. Small (one-sea-winter) and large (multi-sea-winter) fish have both remained approximately stable in abundance over the last 3 generations. The small size of the population, about 5,000 individuals in 2008, is of concern. The rivers in this area are close to the largest urban areas in Quebec and the population has undergone a large historical decline due to loss of habitat. As is the case for most populations of the species, poor marine survival related to substantial but incompletely understood changes in marine ecosystems is a concern.

Occurrence
Quebec, Atlantic Ocean

Status history
Designated Special Concern in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Lake Ontario population

Scientific name
Salmo salar

Status
Extinct

Reason for designation
Once a prolific resident throughout the Lake Ontario watershed, there has been no record of this population since 1898. The Lake Ontario population was extinguished through habitat destruction and through over-exploitation by food and commercial fisheries. As the original strain is gone, re-introduction is not possible. Recent attempts to introduce other strains of the species have resulted in some natural reproduction, but no evidence of self-sustaining populations.

Occurrence
Ontario, Atlantic Ocean

Status history
Last reported in 1898. Designated Extirpated in April 2006. Status re-examined and designated Extinct in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Gaspé-Southern Gulf of St. Lawrence population

Scientific name
Salmo salar

Status
Special concern

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers from the Ouelle River (excluded) in the western Gaspé Peninsula southward and eastward to the northern tip of Cape Breton. Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over the last 3 generations, approximately 34% and 19%, respectively, for a net decline of all mature individuals of about 28%. This recent 3-generation decline represents a continuation of a decline extending back at least to the 1980s. The number of mature individuals remains over 100,000; however, the majority spawn in a single major river system, the Miramichi, in New Brunswick. Freshwater habitat quality is a concern in some areas, particularly in Prince Edward Island where some remaining populations are maintained by hatchery supplementation. Invasive and illegally introduced species, such as smallmouth bass, are a poorly understood threat in some freshwater habitats. Poor marine survival is related to substantial but incompletely understood changes in marine ecosystems.

Occurrence
Quebec, New Brunswick, Nova Scotia, Atlantic Ocean

Status history
Designated Special Concern in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Eastern Cape Breton population

Scientific name
Salmo salar

Status
Endangered

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in Cape Breton Island rivers draining into the Atlantic Ocean and Bras d'Or Lakes. The numbers of adults returning to spawn has declined by about 29% over the last 3 generations; moreover, these declines represent continuations of previous declines. The total number of mature individuals in 5 rivers, thought to harbour the majority of the population, was only about 1150 in 2008. There is no likelihood of rescue, as neighbouring regions harbour genetically dissimilar populations, and the population to the south is severely depleted. A current threat is poor marine survival related to substantial but incompletely understood changes in marine ecosystems.

Occurrence
Nova Scotia, Atlantic Ocean

Status history
Designated Endangered in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Nova Scotia Southern Upland population

Scientific name
Salmo salar

Status
Endangered

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers from northeastern mainland Nova Scotia, along the Atlantic coast and into the Bay of Fundy as far as Cape Split. Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over the last 3 generations by approximately 59% and 74%, respectively, for a net decline of all mature individuals of about 61%. Moreover, these declines represent continuations of greater declines extending far into the past. During the past century, spawning occurred in 63 rivers, but a recent (2008) survey detected juveniles in only 20 of 51 rivers examined. There is no likelihood of rescue, as neighbouring regions harbour severely depleted, genetically dissimilar populations. The population has historically suffered from dams that have impeded spawning migrations and flooded spawning and rearing habitats, and other human influences, such as pollution and logging, that have reduced or degraded freshwater habitats. Acidification of freshwater habitats brought about by acidic precipitation is a major, ongoing threat, as is poor marine survival related to substantial but incompletely understood changes in marine ecosystems. There are a few salmon farms in this area that could lead to negative effects of interbreeding or ecological interactions with escaped domestic salmon.

Occurrence
Nova Scotia, Atlantic Ocean

Status history
Designated Endangered in November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Inner Bay of Fundy population

Scientific name
Salmo salar

Status
Endangered

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population once bred in 32 rivers tributary to the inner Bay of Fundy, from just east of the Saint John River, to the Gaspereau River in Nova Scotia; however, spawning no longer occurs in most rivers. The population, which is thought to have consisted of about 40,000 individuals earlier in the 20th century, is believed to have been fewer than 200 individuals in 2008. Survival through the marine phase of the species' life history is currently extremely poor, and the continued existence of this population depends on a captive rearing program. There is no likelihood of rescue, as neighbouring regions harbour severely depleted, genetically dissimilar populations. The population has historically suffered from dams that have impeded spawning migrations and flooded spawning and rearing habitats, and other human influences, such as pollution and logging, that have reduced or degraded freshwater habitats. Current threats include extremely poor marine survival related to substantial but incompletely understood changes in marine ecosystems, and negative effects of interbreeding or ecological interactions with escaped domestic salmon from fish farms. The rivers used by this population are close to the largest concentration of salmon farms in Atlantic Canada.

Occurrence
New Brunswick, Nova Scotia, Atlantic Ocean

Status history
Designated Endangered in May 2001. Status re-examined and confirmed in April 2006 and November 2010.

Assessment Summary – November 2010

Common name
Atlantic Salmon – Outer Bay of Fundy population

Scientific name
Salmo salar

Status
Endangered

Reason for designation
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers tributary to the New Brunswick side of the Bay of Fundy, from the U.S. border to the Saint John River. Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over the last 3 generations, approximately 57% and 82%, respectively, for a net decline of all mature individuals of about 64%; moreover, these declines represent continuations of greater declines extending far into the past. There is no likelihood of rescue, as neighbouring regions harbour severely depleted, genetically dissimilar populations. The population has historically suffered from dams that have impeded spawning migrations and flooded spawning and rearing habitats, and other human influences, such as pollution and logging, that have reduced or degraded freshwater habitats. Current threats include poor marine survival related to substantial but incompletely understood changes in marine ecosystems, and negative effects of interbreeding or ecological interactions with escaped domestic salmon from fish farms. The rivers used by this population are close to the largest concentration of salmon farms in Atlantic Canada.

Occurrence
New Brunswick, Atlantic Ocean

Status history
Designated Endangered in November 2010.

COSEWIC
Executive Summary

Atlantic Salmon
Salmo salar

Nunavik population, Labrador population, Northeast Newfoundland population, South Newfoundland population, Southwest Newfoundland population, Northwest Newfoundland population, Quebec Eastern North Shore population, Quebec Western North Shore population, Anticosti Island population, Inner St. Lawrence population, Lake Ontario population, Gaspé-Southern Gulf of St. Lawrence population, Eastern Cape Breton population, Nova Scotia Southern Upland population, Inner Bay of Fundy population, Outer Bay of Fundy population

Wildlife species information

The Atlantic Salmon (*Salmo salar*) is a member of the family Salmonidae. This species has a fusiform body shape and matures at sizes ranging from 10 to 100+ cm. Atlantic Salmon exhibit plastic life histories and may have multiple reproductive and migratory phenotypes within a population, including freshwater resident and oceanic migrant forms. All phenotypes reproduce in fresh water. The oceanic migrant (anadromous) form is the best known phenotype, and with the exception of the extinct Lake Ontario population, is the only form considered in this report. Juveniles spend 1-8 years in fresh water, then migrate to the North Atlantic for 1-4 years, and then return to fresh water to reproduce. Demographically functional units tend to be at the watershed scale, but population subdivision may occur within watersheds. The Canadian range of this species was subdivided into 16 designatable units (DUs) based on genetic data and broad patterns in life history variation, environmental variables, and geographic separation.

Distribution

Atlantic Salmon originally occurred in every country whose rivers flow into the North Atlantic Ocean and Baltic Sea. In Europe, the range of the Atlantic Salmon extended southward from northern Norway and Russia along the Atlantic coastal drainage to Northern Portugal, including rivers in both France and Spain. In North America, the range of the anadromous Atlantic Salmon was northward from the Hudson River drainage in New York State, to outer Ungava Bay and eastern Hudson Bay in Quebec. The Canadian range is roughly one-third the area of the total global range, and extends northward from the St. Croix River (at the border with Maine, U.S.A.) to the outer Ungava Bay and eastern Hudson Bay in Quebec. Recent estimates suggest Canada has at least 700 rivers which either currently support Atlantic Salmon populations, or did so in the past.

Habitat

Rivers with Atlantic Salmon are generally clear, cool and well oxygenated, with low to moderate gradient, and possessing bottom substrates of gravel, cobble and boulder. Freshwater habitat is considered a limiting resource to freshwater production and is used to set conservation requirements for Canadian rivers. There have been substantial declines in habitat quantity and quality in the southern portion of the species' Canadian range. This loss of freshwater habitat may be an important risk factor for declining abundance in several southern DUs. Trends in the quality and quantity of marine habitat are not well understood, but large-scale changes in ocean ecosystems may be adversely affecting Atlantic Salmon across their range.

Biology

Atlantic Salmon is an iteroparous species that returns to natal rivers to spawn with a high degree of fidelity, despite completing ocean-scale migrations. Spawners returning to rivers are comprised of varying proportions of 'maiden fish' (those spawning for the first time) and 'repeat spawners'. Maiden salmon consist of smaller fish that return to spawn after one winter at sea (1SW or Grilse) and larger fish that return after two or more winters at sea (MSW). Some river populations include fish that return to spawn after only a few months at sea. During any breeding season, there can be varying proportions of maiden, consecutive and alternate spawners in the spawning runs. Collectively over the entire range in North America, adult Atlantic Salmon return to rivers from feeding and staging areas in the sea mainly between May and November, but some runs can begin as early as March and April. In general, run timing varies by river, sea age, year, and hydrological conditions. Deposition of eggs in gravel nests, by oviparous mothers, usually occurs in October and November in gravel-bottomed riffle areas of streams or groundwater seepage on shoals in lakes. Fertilization of eggs can involve both adult males and sexually mature precocious males. Mating behaviour typically entails multiple males of several life history types competing aggressively for access to multiple females. This frequently leads to multiple paternity for a given female's offspring. Spawned-out or spent adult salmon (kelts) either return to sea immediately after spawning or remain in fresh water until the following spring. Eggs incubate in the spawning nests over the winter months and hatching usually begins in April. The hatchlings (alevins) remain in the gravel for several weeks living off large yolk sacs. Upon emergence from the gravel in late May – early June, the yolk sac is absorbed and the free-swimming young fish (parr) begin active feeding. Parr rear in fluvial and lacustrine habitats for one to eight years following which they undergo behavioural and physiological transformations and migrate to sea as smolt.

Population sizes and trends

Abundances and trends were highly variable across the 16 DUs, with estimated abundances ranging from estimates of <1000 to 235,874. Although the total Canadian population appears to be relatively stable over the last three generations, this apparent recent stability masks a significant historical decline, regional variability, and a general, although often statistically non-significant decline in abundance for 14 of 16 DUs during the last three generations. The stability of the total Canadian population is driven primarily by estimated increases in abundance in Labrador, although data from this region are relatively limited and there is considerable uncertainty in the resulting abundance estimates and trends. Several of the southern DUs (e.g. DU 16: Outer Bay of Fundy; DU 15: Inner Bay of Fundy; and DU 14: Southern Upland) are at or near their lowest abundance on record. It is also important to point out that several historical analyses in the literature that go back more than four generations show a substantial decline in Canadian abundance. The three-generation analysis completed herein should be considered within this longer-term context.

Threats and limiting factors

Threats to Atlantic Salmon include, but are not limited to, climate change, changes to ocean ecosystems, fishing (commercial, subsistence, recreational, and illegal), dams and obstructions in freshwater, agriculture, urbanization, acidification, aquaculture, and invasive species. The relative contributions of these factors to declines remain unclear and vary among populations. Generally, freshwater threats are less significant in the northern portions of the range. Recent broad-scale declines in marine survival suggest that the most substantial threat(s) to the species are in the marine environment, although in some southern areas, freshwater habitat degradation and fish passage issues are expected to limit population growth if marine survival improves.

Special significance

Atlantic Salmon are contributors to both freshwater and marine ecology, moving nutrients between ecosystems as migrants, and linking energy flow as prey and as predators within ecosystems. They are traditionally used by (i) over 49 First Nations and Aboriginal organizations, (ii) commercial fisheries and (iii) recreational fisheries. They are also the subjects of local art, science and education, and symbols of heritage and health to peoples of Canada.

Existing protection, status, and ranks

The Atlantic Salmon is currently designated or ranked with several international and national bodies. In the United States of America, populations in Maine have *Endangered* status under the *U.S. Endangered Species Act*. In April 2006, the Committee on the Status of Endangered Wildlife in Canada (COSEWIC) assessed the Inner Bay of Fundy population as *Endangered* and the Lake Ontario population as *Extirpated*. The Atlantic Salmon, Inner Bay of Fundy population is currently listed as *Endangered* under Canada's *Species at Risk Act* (SARA).

Aboriginal traditional knowledge

Aboriginal traditional knowledge (ATK) is considered a critical component for status assessments for endangered wildlife (COSEWIC). Atlantic Salmon, in particular, is a species for which considerable ATK exists. COSEWIC's ATK Subcommittee initiated work with Aboriginal communities in eastern Canada to gather ATK for the COSEWIC Status Report on Atlantic Salmon in 2008. The Aboriginal communities indicated, through the ATK Subcommittee members, that ATK was available and expressed a willingness to share the information. However, challenges arose in developing a satisfactory approach for the collection of this ATK. As such, ATK is not available at this time for use in the COSEWIC Status Report for this species. The ATK Subcommittee and COSEWIC will continue to work on gathering ATK on Atlantic Salmon for inclusion in a future report.

TECHNICAL SUMMARY - Nunavik population (DU1)

Salmo salar
Atlantic Salmon — Saumon atlantique
Nunavik population — Population du Nunavik
Range of Occurrence in Canada: Northern Quebec and Labrador / Atlantic Ocean and Hudson Bay

Demographic Information

Generation time (average age of parents in the population)	6.1 yrs
Estimated percent decrease in total number of mature individuals in 2007 versus 1993 (3 generations)	Data deficient, increasing trend in CPUE data
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	N/A
Are the causes of the decline understood?	N/A
Have the causes of the decline ceased?	N/A
Suspected trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	Data deficient
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Suspected trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	≥5216 km^2
Suspected trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	5 known populations
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in area of habitat	Stable

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
	-
Total	-

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Possible threats include recreational and aboriginal fisheries.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Labrador populations are increasing.	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown

Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Data Deficient (Nov 2010)

Status and Reasons for Designation

Status: Data Deficient	**Alpha-numeric code:** Not applicable
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and several years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population, which breeds in rivers flowing into Ungava Bay and eastern Hudson Bay, is the northernmost population of the species in North America, and the westernmost population of the entire species. It is separated by approximately 650 km from the nearest population to the south. Little is known about abundance trends in this population, although limited catch per unit effort data suggest increased abundance in recent 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 Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Labrador population (DU2)

Salmo salar
Atlantic Salmon — Saumon atlantique
Labrador population — Population du Labrador
Range of Occurrence in Canada: Labrador, Quebec / Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	6.3 yrs
Estimated percent increase in total number of mature individuals in 2008 versus 1993 (3 generations)	380
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	N/A
Are the causes of the decline understood?	N/A
Have the causes of the decline ceased?	N/A
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	>2,000 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	91 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
	235,874 (151,049 – 307,731)
Total	235,874 (151,049 – 307,731)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Potential threats include recreational and Aboriginal fisheries, mining and hydroelectric development.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Newfoundland populations are stable or increasing.	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Not at Risk (Nov 2010)

Status and Reasons for Designation

Status: Not at Risk	**Alpha-numeric code:** Not applicable
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and several years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers along the Atlantic coast of Labrador and southwest along the Quebec coast to the Napetipi River (inclusive). Freshwater habitats remain largely pristine. Abundance data are not available for most rivers; however, for rivers for which data are available, the number of mature individuals appears to have increased by about 380% over the last 3 generations.	

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 Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Northeast Newfoundland population (DU3)

Salmo salar
Atlantic Salmon — Saumon atlantique
Northeast Newfoundland population — Population du nord-est de Terre-Neuve
Range of Occurrence in Canada: Newfoundland/Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	4.2 yrs
Estimated percent decline in total number of mature individuals in 2007 versus 1993 (3 generations)	10
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	N/A
Are the causes of the decline understood?	N/A
Have the causes of the decline ceased?	N/A
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	>2,000 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	127 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
	80,505 (63,689 – 129,967 (2007)
Total	80,505 (63,689 – 129,967 (2007)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Recreational and illegal fisheries, poorly understood changes in marine ecosystems resulting in reduced survival during the marine phase of the life history.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Labrador and Newfoundland populations are stable or increasing, excepting DU 4 (south coast of Newfoundland)	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Not at Risk (Nov 2010)

Status and Reasons for Designation

Status: Not at Risk	**Alpha-numeric code:** Not applicable
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers along the northeast coast of Newfoundland, from the northern tip of the island to the southeastern corner of the Avalon Peninsula. Recent abundance data show no clear trends in the number of mature individuals. Since 1992, the negative effects of poor marine survival have been at least partially offset by a near cessation of fishing mortality in coastal fisheries. Illegal fishing is a threat in some rivers.	

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 Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - South Newfoundland population (DU4)

Salmo salar
Atlantic Salmon — Saumon atlantique
South Newfoundland population — Population du sud de Terre-Neuve
Range of Occurrence in Canada: Newfoundland/Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	4.1 yrs
Estimated percent decline in total number of mature individuals in 2007 versus 1993 (3 generations)	36
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	No
Are the causes of the decline understood?	No
Have the causes of the decline ceased?	No
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	>2,000 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	104 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	N Mature Individuals
	21,866 (14,021 – 29,711) (2007)
Total	21,866 (14,021 – 29,711) (2007)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Recreational and illegal fisheries, commercial fishery in St. Pierre and Miquelon, ecological and genetic interactions with escaped domestic Atlantic Salmon, poorly understood changes in marine ecosystems resulting in reduced survival during the marine phase of the life history.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Labrador and Newfoundland populations are stable or increasing.	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Threatened (Nov 2010)

Status and Reasons for Designation

Status: Threatened	**Alpha-numeric code:** A2b
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers from the southeast tip of the Avalon Peninsula, Mistaken Point, westward along the south coast of Newfoundland to Cape Ray. The numbers of small (one-sea-winter) and large (multi-sea-winter) salmon have both declined over the last 3 generations, about 37% and 26%, respectively, for a net decline of all mature individuals of about 36%. This decline has occurred despite the fact that mortality from commercial fisheries in coastal areas has greatly declined since 1992; this may be due to poor marine survival related to substantial but incompletely understood changes in marine ecosystems. Illegal fishing is a threat in some rivers. The presence of salmon aquaculture in a small section of this area brings some risk of negative effects from interbreeding or adverse ecological interactions with escaped domestic salmon. Genetic heterogeneity among the many small rivers in this area is unusually pronounced, suggesting that rescue among river breeding populations may be somewhat less likely than in other areas.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Threatened, A2b. The decline over the last 3 generations has been 36%.
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 Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Southwest Newfoundland population (DU5)

Salmo salar
Atlantic Salmon — Saumon atlantique
Southwest Newfoundland population — Population du sud-ouest de Terre-Neuve
Range of Occurrence in Canada: Newfoundland, Quebec/Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	5.3 yrs
Estimated percent increase in total number of mature individuals in 2007 versus 1993 (3 generations)	134
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	NA
Are the causes of the decline understood?	NA
Have the causes of the decline ceased?	NA
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	>2,000 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	40 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
	44,566 (2007)
Total	44,566 (2007)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Recreational and illegal fisheries, clear cut logging near freshwater habitat.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Labrador and Newfoundland populations are stable or increasing, except DU 4 on the south coast of Newfoundland.	
Is immigration known?	No

Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Not at Risk (Nov 2010)

Status and Reasons for Designation

<table>
<tr><td>Status:
Not at Risk</td><td>Alpha-numeric code:
Not applicable</td></tr>
<tr><td colspan="2">Reasons for designation:
This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers from Cape Ray northwards along the west coast of Newfoundland to approximately 49 24’ N, 58 15’ W. Both small (one-sea-winter) and large (multi-sea-winter) salmon have increased in number over the last 3 generations, about 132% and 144%, respectively, giving an increase in the total number of mature individuals of about 134%.</td></tr>
</table>

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 Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Northwest Newfoundland population (DU6)

Salmo salar
Atlantic Salmon — Saumon atlantique
Northwest Newfoundland population — Population du nord-ouest de Terre-Neuve
Range of Occurrence in Canada: Newfoundland/Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	4.5 yrs
Estimated percent decline in total number of mature individuals in 2007 versus 1993 (3 generations)	0
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	NA
Are the causes of the decline understood?	NA
Have the causes of the decline ceased?	NA
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	>2,000 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	34 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
	31,179 (20,061 – 42,296)(2007)
Total	31,179 (20,061 – 42,296)(2007)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Recreational and illegal fisheries.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Labrador and Newfoundland populations are stable or increasing, except DU 4 on the south coast of Newfoundland.	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Not at Risk (Nov 2010)

Status and Reasons for Designation

Status: Not at Risk	**Alpha-numeric code:** Not applicable
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers along the west coast of Newfoundland from approximately 49 24’ N, 58 15’ W to the tip of the Great Northern Peninsula. The total number of mature individuals appears to have remained stable over the last 3 generations, and the number of large (multi-sea-winter) salmon appears to have increased by about 42%.	

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 Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Quebec Eastern North Shore population (DU7)

Salmo salar
Atlantic Salmon — Saumon atlantique
Quebec Eastern North Shore population — Population de l'est de la Côte-Nord du Québec
Range of Occurrence in Canada: Quebec/Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	4.7 yrs
Estimated percent decline in total number of mature individuals in 2007 versus 1993 (3 generations)	14
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	N/A
Are the causes of the decline understood?	N/A
Have the causes of the decline ceased?	N/A
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	≥4428 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	20 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
	4,949
Total	4,949

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Recreational, Aboriginal and illegal fisheries, hydroelectric development, poorly understood changes in marine ecosystems resulting in reduced survival during the marine phase of the life history.

Rescue Effect (immigration from an outside source)

Status of outside population(s)?
Nearby Labrador and Newfoundland populations are stable or increasing, except DU 4 on the south coast of Newfoundland. DUs to the south and west appear to be stable or decreasing (Nova Scotia, and southern New Brunswick DUs)

Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Special Concern (Nov, 2010)

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code:** Met criterion for Threatened, C1, but designated Special Concern because of the increase in the number of large fish that have greater reproductive potential.
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers along the north shore of the St. Lawrence River estuary from the Napetipi River (not inclusive) westward to the Kegaska River (inclusive). This population shows opposing trends in the abundance of small (one-sea-winter) and large (multi-sea-winter) fish. Small salmon have declined 26% over the last 3 generations, whereas large salmon have increased 51% over the same period; pooling the data for both groups suggests a decline of about 14% for all mature individuals considered together. The small size of the population, about 5000 mature fish in 2008, is cause for concern. As is the case for most populations of the species, poor marine survival related to substantial but incompletely understood changes in marine ecosystems is also a concern.	

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): May meet Threatened C1; population is approximately 5,000 individuals and a combined analysis of small and large salmon suggests a 14% decline over the last 3 generations; however, small and large salmon show opposing trends, and large salmon have increased 51%.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Quebec Western North Shore population (DU8)

Salmo salar
Atlantic Salmon — Saumon atlantique
Quebec Western North Shore population — Population de l'ouest de la Côte-Nord du Québec
Range of Occurrence in Canada: Quebec/Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	4.7 yrs
Estimated percent decline in total number of mature individuals in 2007 versus 1993 (3 generations)	24
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	NA
Are the causes of the decline understood?	NA
Have the causes of the decline ceased?	NA
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	≥6980 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	25 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
	14,821
Total	14,821

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Recreational, Aboriginal and illegal fisheries, hydroelectric development, poorly understood changes in marine ecosystems resulting in reduced survival during the marine phase of the life history.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Labrador and Newfoundland populations are stable or increasing, except DU 4 on the south coast of Newfoundland. DUs to the south and west appear to be stable or decreasing (Nova Scotia, and southern New Brunswick DUs)	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Special Concern (Nov 2010)

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code:** Not applicable
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers along the north shore of the St. Lawrence River from the Natashquan River (inclusive) to the Escoumins River in the west (inclusive). Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over the last 3 generations, approximately 34% and 20%, respectively, for a net decline of all mature individuals of about 24%. As is the case for most populations of the species, poor marine survival related to substantial but incompletely understood changes in marine ecosystems is a concern.	

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 Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Anticosti Island population (DU9)

Salmo salar
Atlantic Salmon — Saumon atlantique
Anticosti Island population — Population de l'île d'Anticosti
Range of Occurrence in Canada: Quebec/Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	5 yrs
Estimated percent decline in total number of mature individuals in 2007 versus 1993 (3 generations)	40
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	No
Are the causes of the decline understood?	No
Have the causes of the decline ceased?	Unknown
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	Unlikely

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	Unlikely
Index of area of occupancy (IAO)	2584 km^2
Observed trend in area of occupancy	Unknown
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	25 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	N Mature Individuals
	2,414 (2008)
Total	2,414 (2008)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Poorly understood changes in marine ecosystems resulting in reduced survival during the marine phase of the life history .

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Quebec and New Brunswick populations appear to be declining or marginally stable.	
Is immigration known?	No

Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Endangered (Nov 2010)

Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code:** C1
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers on Anticosti Island. Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over 3 generations, approximately 32% and 49%, respectively, for a net decline of all mature individuals of about 40%. The population size is small, about 2,400 individuals in 2008. As is the case for most populations of the species, poor marine survival related to substantial but incompletely understood changes in marine ecosystems is a concern.	

Applicability of criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable but the decline in large salmon (49%) almost meets Endangered A2b, and the overall decline (40%) meets Threatened A2b.
Criterion B (Small Distribution Range and Decline or Fluctuation):Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered, C1; the total number of mature individuals was approximately 2,400 in 2008, and the population has declined about 27% over the last 2 generations.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Inner St. Lawrence population (DU10)

Salmo salar
Atlantic Salmon — Saumon atlantique
Inner St. Lawrence population — Population de l'intérieur du Saint-Laurent
Range of Occurrence in Canada: Quebec/Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	3.5 yrs
Estimated percent increase in total number of mature individuals in 2007 versus 1993 (3 generations)	5
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	NA
Are the causes of the decline understood?	NA
Have the causes of the decline ceased?	NA
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	1552 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	9 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
	5,020 (2008)
Total	5,020 (2008)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Poorly understood changes in marine ecosystems resulting in reduced survival during the marine phase of the life history.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Quebec and New Brunswick populations appear to be declining or marginally stable.	
Is immigration known?	No

Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Special Concern (Nov 2010)

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Special Concern	Not applicable

Reasons for designation:
This species requires rivers or streams that are clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This highly managed population breeds in rivers tributary to the St. Lawrence River upstream from the Escoumins River (not included) on the north shore and the Ouelle River (included) on the south shore. Small (one-sea-winter) and large (multi-sea-winter) fish have both remained approximately stable in abundance over the last 3 generations. The small size of the population, about 5,000 individuals in 2008, is of concern. The rivers in this area are close to the largest urban areas in Quebec and the population has undergone a large historical decline due to loss of habitat. As is the case for most populations of the species, poor marine survival related to substantial but incompletely understood changes in marine ecosystems is a concern.

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 Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Lake Ontario population (DU11)

Salmo salar
Atlantic Salmon — Saumon atlantique
Lake Ontario population — Population du lac Ontario
Range of Occurrence in Canada: Ontario/Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	4 yrs
Estimated percent decline in total number of mature individuals in 2007 versus 1993 (3 generations)	N/A
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	N/A
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	No
Are the causes of the decline understood?	Yes
Have the causes of the decline ceased?	Unknown
Observed trend in number of populations	N/A
Are there extreme fluctuations in number of mature individuals?	N/A
Are there extreme fluctuations in number of populations?	N/A

Extent and Area Information

Estimated extent of occurrence	N/A
Observed trend in extent of occurrence	Unknown
Are there extreme fluctuations in extent of occurrence?	Unknown
Index of area of occupancy (IAO)	N/A
Observed trend in area of occupancy	Unknown
Are there extreme fluctuations in area of occupancy?	N/A
Is the total population severely fragmented?	N/A
Number of current locations	0
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	Unknown
Trend in [area and/or quality] of habitat	Unknown

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
	0
Total	0

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Causes of extinction include deterioration in spawning habitat due to timbering, agriculture, and mills and dams across rivers that prevented access to spawning grounds, in addition to extensive commercial and food fisheries. Thiamine deficiency, associated with preying on alewife, has also been implicated as a barrier to restoration of salmon in this area. Invasive species.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Quebec, and New Brunswick populations are either declining, or small and marginally stable.	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	No
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Extinct (Nov 2010)
Ontario's *Endangered Species Act:* Extirpated

Status and Reasons for Designation

Status: Extinct	**Alpha-numeric code:** Not applicable
Reasons for designation: Once a prolific resident throughout the Lake Ontario watershed, there has been no record of this population since 1898. The Lake Ontario population was extinguished through habitat destruction and through over-exploitation by food and commercial fisheries. As the original strain is gone, re-introduction is not possible. Recent attempts to introduce other strains of the species have resulted in some natural reproduction, but no evidence of self-sustaining populations.	

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 Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Gaspé-Southern Gulf of St. Lawrence population (DU12)

Salmo salar
Atlantic Salmon — Saumon atlantique
Gaspé-Southern Gulf of St. Lawrence population — Population de la Gaspésie-sud du golfe Saint-Laurent

Range of Occurrence in Canada :Quebec, New Brunswick, Prince-Edward Island, Nova Scotia / Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	4.6 yrs
Estimated percent decline in total number of mature individuals in 2007 versus 1993 (3 generations)	28
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	N/A
Are the causes of the decline understood?	N/A
Have the causes of the decline ceased?	N/A
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	>2,000 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	78 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	N Mature Individuals
	102,263 (2007)
Total	102,263 (2007)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Recreational and Aboriginal fishing, agriculture, land development, pollution, poorly understood changes in marine ecosystems resulting in reduced survival during the marine phase of the life history, invasive species in freshwater habitats.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Quebec and New Brunswick populations appear to be declining or marginally stable.	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Special Concern (Nov 2010)

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code:** Not applicable
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers from the Ouelle River (excluded) in the western Gaspé Peninsula southward and eastward to the northern tip of Cape Breton. Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over the last 3 generations, approximately 34% and 19%, respectively, for a net decline of all mature individuals of about 28%. This recent 3 generation decline represents a continuation of a decline extending back at least to the 1980s. The number of mature individuals remains over 100,000; however, the majority spawn in a single major river system, the Miramichi, in New Brunswick. Freshwater habitat quality is a concern in some areas, particularly in Prince Edward Island where some remaining populations are maintained by hatchery supplementation. Invasive and illegally introduced species, such as smallmouth bass, are a poorly understood threat in some freshwater habitats. Poor marine survival is related to substantial but incompletely understood changes in marine ecosystems.	

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 Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Eastern Cape Breton population (DU13)

Salmo salar
Atlantic Salmon — Saumon atlantique
Eastern Cape Breton population — Population de l'est du Cap-Breton
Range of Occurrence in Canada: Nova Scotia / Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	5 yrs
Estimated percent decline in total number of mature individuals in 2007 versus 1993 (3 generations)	29 (based on 5 rivers with majority of fish)
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	No
Are the causes of the decline understood?	No
Have the causes of the decline ceased?	No
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	1684 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	30 known rivers
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Stable

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
Only 5 rivers of 30 included in estimate.	1,150 (2008)
Total	1,150 (2008)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Recreational fishing, habitat loss, poorly understood changes in marine ecosystems resulting in reduced survival during the marine phase of the life history

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Quebec and New Brunswick populations appear to be declining or marginally stable. Newfoundland DU 5 is increasing, while DU 4 is declining.	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Endangered (Nov 2010)

Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code:** C1
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in Cape Breton Island rivers draining into the Atlantic Ocean and Bras d'Or Lakes. The numbers of adults returning to spawn has declined by about 29% over the last 3 generations; moreover, these declines represent continuations of previous declines. The total number of mature individuals in 5 rivers, thought to harbour the majority of the population, was only about 1150 in 2008. There is no likelihood of rescue, as neighbouring regions harbour genetically dissimilar populations, and the population to the south is severely depleted. A current threat is poor marine survival related to substantial but incompletely understood changes in marine ecosystems.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Estimated decline is just below the threshold for Threatened A2b, with a decline of ~29% over the last 3 generations.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered C1. The estimated number of mature individuals in 2008, 1150, is based on only 5 of 30 rivers, but these are thought to account for the majority of the population and therefore the total is thought to be well below 2500. The estimated decline of ~29% over 3 generations corresponds to ~20% over 2 generations.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Nova Scotia Southern Upland population (DU14)

Salmo salar

Atlantic Salmon — Saumon atlantique

Nova Scotia Southern Upland population — Population des hautes terres du sud de la Nouvelle-Écosse

Range of Occurrence in Canada: Nova Scotia / Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	4 yrs
Estimated percent decline in total number of mature individuals from 1993 to 2007 (3 generations)	61
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	No
Are the causes of the decline understood?	No
Have the causes of the decline ceased?	No
Observed trend in number of populations	Declining
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Declining
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	4280 km^2
Observed trend in area of occupancy	Declining
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	31 known rivers
Trend in number of locations	Declining
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Declining

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
Only 4 of the 31 rivers included in estimate.	1,427(2008)
Total	1,427(2008)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Acidification, habitat loss, recreational fishing, poorly understood changes in marine ecosystems resulting in reduced survival during the marine phase of the life history, ecological and genetic interactions with escaped domestic Atlantic Salmon.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Nova Scotia and New Brunswick populations appear to be declining.	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	No
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Endangered (Nov 2010)

Status and Reasons for Designation

Status: Endangered	Alpha-numeric code: A2bce; C1
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers from northeastern mainland Nova Scotia, along the Atlantic coast and into the Bay of Fundy as far as Cape Split. Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over the last 3 generations by approximately 59% and 74%, respectively, for a net decline of all mature individuals of about 61%. Moreover, these declines represent continuations of greater declines extending far into the past. During the past century, spawning occurred in 63 rivers, but a recent (2008) survey detected juveniles in only 20 of 51 rivers examined. There is no likelihood of rescue, as neighbouring regions harbour severely depleted, genetically dissimilar populations. The population has historically suffered from dams that have impeded spawning migrations and flooded spawning and rearing habitats, and other human influences, such as pollution and logging, that have reduced or degraded freshwater habitats. Acidification of freshwater habitats brought about by acidic precipitation is a major, ongoing threat, as is poor marine survival related to substantial but incompletely understood changes in marine ecosystems. There are a few salmon farms in this area that could lead to negative effects of interbreeding or ecological interactions with escaped domestic salmon.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2b,c,e with a decline of 61% in the number of mature individuals over the last 3 generations (12 years), in part due to a decline in the quality of the habitat due to acid precipitation. Breeding has ceased in half of the rivers since the 1980s.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered C1. The number of mature individuals in 2008 was 1427 in 4 rivers thought to include the majority of the population, and therefore is thought to be well below 2500. The population is declining, with a 2-generation decline of ~40%.
Criterion D (Very Small Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Inner Bay of Fundy population (DU15)

Salmo salar
Atlantic Salmon — Saumon atlantique
Inner Bay of Fundy population — Population de l’intérieur de la baie de Fundy
Range of Occurrence in Canada: New Brunswick and Nova Scotia / Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	4 yrs
Estimated percent decline in total number of mature individuals over the last 3 generations (11 years; to 2002) NOTE: This value was extracted from the 2006 COSEWIC Status Report on the Atlantic Salmon - Inner Bay of Fundy populations. The declining trend did not change in 2003 (Gibson et al. 2004)	> 94% (this is the lowest 90% confidence limit for the healthiest index river)
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	No
Are the causes of the decline understood?	No
Have the causes of the decline ceased?	No
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	Unknown; actual area of occupancy estimated to be no more than 9 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	19 known rivers, less populations
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Declining

Number of Mature Individuals (in each population)

Population	N Mature Individuals
	<100 (2006)
Total	<100 (2006)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Leading marine considerations: interactions with farmed and hatchery salmon (competition with escapees; parasite and disease epidemics), ecological community shifts (increased predation by native species; lack of forage species), depressed population phenomena (lack of recruits to form effective shoals), environmental shifts (regime shift depressing ocean productivity; altered migration routes leading to depressed survival), fisheries (excessive illegal and/or incidental catch), and the possibility of cumulative interactions among these or more factors. Leading freshwater considerations: interbreeding and competition with escaped farm fish, depressed population phenomena (abnormal behaviour due to low abundance; inbreeding depression), changes in environmental conditions (climate changes leading to premature smolt emigration and decreased freshwater productivity; atmospheric changes increasing ultraviolet radiation; increased contaminant concentrations), historical reduction in habitat quality.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Nova Scotia and New Brunswick populations appear to declining.	
Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Unknown
Is there sufficient habitat for immigrants in Canada?	No
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Endangered (Nov 2010)

Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code:** C2a(i,ii); D1
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population once bred in 32 rivers tributary to the inner Bay of Fundy, from just east of the Saint John River, to the Gaspereau River in Nova Scotia; however, spawning no longer occurs in most rivers. The population, which is thought to have consisted of about 40,000 individuals earlier in the 20th century, is believed to have been fewer than 200 individuals in 2008. Survival through the marine phase of the species' life history is currently extremely poor, and the continued existence of this population depends on a captive rearing program. There is no likelihood of rescue, as neighbouring regions harbour severely depleted, genetically dissimilar populations. The population has historically suffered from dams that have impeded spawning migrations and flooded spawning and rearing habitats, and other human influences, such as pollution and logging, that have reduced or degraded freshwater habitats. Current threats include extremely poor marine survival related to substantial but incompletely understood changes in marine ecosystems, and negative effects of interbreeding or ecological interactions with escaped domestic salmon from fish farms. The rivers used by this population are close to the largest concentration of salmon farms in Atlantic Canada.	

Applicability of Criteria

Criterion A Not applicable, the population declined from about 40,000 earlier in the 20th century to about 250 individuals in 1999.
Criterion B: Not applicable.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered, C2a(i,ii), based on an inferred continuing decline in numbers of mature individuals, and population fragmentation that has resulted in no population estimated to contain more than 250 individuals and for which at least 95% of mature individuals are contained within a single population (Big Salmon River).
Criterion D (Very Small Population or Restricted Distribution): Meets Endangered, D1 (less than 250 mature individuals). The 2003 fall spawning estimate was less than 100 adults, and the most likely estimate was 50-75.
Criterion E (Quantitative Analysis): Not applicable.

TECHNICAL SUMMARY - Outer Bay of Fundy population (DU16)

Salmo salar
Atlantic Salmon — Saumon atlantique
Outer Bay of Fundy population — Population de l'extérieur de la baie de Fundy
Range of Occurrence in Canada: New Brunswick / Atlantic Ocean

Demographic Information

Generation time (average age of parents in the population)	4 yrs
Estimated percent decline in total number of mature individuals in 2007 versus 1993 (3 generations)	64
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	N/A
Are the causes of the decline clearly reversible?	No
Are the causes of the decline understood?	No
Have the causes of the decline ceased?	No
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	No

Extent and Area Information

Estimated extent of occurrence	>20,000 km^2
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IAO)	6928 km^2
Observed trend in area of occupancy	Stable
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	17 known rivers
Trend in number of locations	Declining
Are there extreme fluctuations in number of locations?	No
Trend in [area and/or quality] of habitat	Declining

Number of Mature Individuals (in each population)

Population	**N Mature Individuals**
Only 4 rivers included in estimate.	7,584 (2008)
Total	7,584 (2008)

Quantitative Analysis

Threats (actual or imminent, to populations or habitats)

Recreational fishing, habitat loss, genetic and ecological interactions with escaped domestic Atlantic Salmon, poorly understood changes in marine ecosystems resulting in reduced survival during the marine phase of the life history.

Rescue Effect (immigration from an outside source)

Status of outside population(s)? Nearby Nova Scotia and New Brunswick populations appear to declining.	

Is immigration known?	No
Would immigrants be adapted to survive in Canada?	Likely
Is there sufficient habitat for immigrants in Canada?	No
Is rescue from outside populations likely?	No

Current Status

COSEWIC: Endangered (Nov 2010)

Status and Reasons for Designation

Status:	**Alpha-numeric code:**
Endangered	A2b
Reasons for designation: This species requires rivers or streams that are generally clear, cool and well-oxygenated for reproduction and the first few years of rearing, but undertakes lengthy feeding migrations in the North Atlantic Ocean as older juveniles and adults. This population breeds in rivers tributary to the New Brunswick side of the Bay of Fundy, from the U.S. border to the Saint John River. Small (one-sea-winter) and large (multi-sea-winter) fish have both declined over the last 3 generations, approximately 57% and 82%, respectively, for a net decline of all mature individuals of about 64%; moreover, these declines represent continuations of greater declines extending far into the past. There is no likelihood of rescue, as neighbouring regions harbour severely depleted, genetically dissimilar populations. The population has historically suffered from dams that have impeded spawning migrations and flooded spawning and rearing habitats, and other human influences, such as pollution and logging, that have reduced or degraded freshwater habitats. Current threats include poor marine survival related to substantial but incompletely understood changes in marine ecosystems, and negative effects of interbreeding or ecological interactions with escaped domestic salmon from fish farms. The rivers used by this population are close to the largest concentration of salmon farms in Atlantic Canada.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2b. The 3-generation decline in overall numbers of mature salmon is 64% and the decline in large (multi-seawinter) salmon is 82%
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 Population or Restricted Distribution): Not applicable.
Criterion E (Quantitative Analysis): Not applicable.

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
(2010)

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

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

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

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

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

Canada

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

COSEWIC Status Report

on the

Atlantic Salmon
Salmo salar

Nunavik population, Labrador population, Northeast Newfoundland population, South Newfoundland population, Southwest Newfoundland population, Northwest Newfoundland population, Quebec Eastern North Shore population, Quebec Western North Shore population, Anticosti Island population, Inner St. Lawrence population, Lake Ontario population, Gaspé-Southern Gulf of St. Lawrence population, Eastern Cape Breton population, Nova Scotia Southern Upland population, Inner Bay of Fundy population, Outer Bay of Fundy population

in Canada

2010

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WILDLIFE SPECIES INFORMATION

Name and classification

Class: Osteichthyes / Actinopterygii
Order: Salmoniformes
Family: Salmonidae
Latin binomial: *Salmo salar* L.
Designatable Unit: See DU Section
Common species names:
English – Salmon, ouananiche (non-anadromous life history form)
French – Saumon atlantique
Other common names exist for various forms and life history stages of the species (e.g., see Froese and Pauly 2004).

Morphological description[i]

The most complete morphological description of Atlantic Salmon can be found in Scott and Crossman (1973) where it is described as having a 'trout-like' body with an average length of about 18 inches (457 mm), somewhat compressed laterally, with the greatest body depth usually at the dorsal fin origin or slightly posterior to it. The anadromous salmon has a blue-green back, silvery sides and a white belly (Carcao 1986). There are several X-shaped and round spots mostly above the lateral line (Carcao 1986). When a marine salmon re-enters freshwater it loses the silvery guanine coat replacing it with hues of greenish or reddish brown and large spots that are edged with white (Scott and Crossman 1973, Carcao 1986). Juvenile salmon, or parr, display 'parr marks' (pigmented vertical bands), with a single red spot between each parr mark along the lateral line (Scott and Crossman 1973). When parr are ready to migrate to sea, they are known as smolts. At this stage the parr marks are lost and the fish become silvery (Scott and Crossman 1973).

Spatial population structure[ii]

A well-known characteristic of Atlantic Salmon is that mature adults generally return to their natal streams to spawn (recently reviewed in Hendry *et al.* 2004). However, some salmon do stray, spawn successfully, and produce offspring that are capable of surviving to spawn in later years. Analyses of molecular genetic variation can help determine the extent of reproductive isolation among salmon from different locations and hence the potential for adaptive differences to accrue (Waples 1991). Analyses of molecular genetic variation can also help identify highly divergent lineages that may have accumulated substantial genetic differences over long periods of reproductive isolation (Utter *et al.*1993).

A variety of studies of genetic variation within and among Atlantic Salmon populations have been carried out. Most have involved sample collections from several rivers from one or two regions, and a few have included collections from one or two rivers from several or all regions. These studies have all shown some degree of population structuring and genetic differentiation. They also suggest that individual rivers and in some cases even tributaries represent relatively independent demographic units.

The most informative genetic analysis of Atlantic Salmon populations in Quebec, New Brunswick and Labrador is that carried out by Dionne *et al.* (2008). Using a combination of landscape genetics and hierarchical analysis of genetic variance they identified seven regional groups (1: Ungava; 2: Labrador; 3: Lower North Shore; 4: Higher North Shore; 5: Quebec City; 6: Southern Quebec; 7: Anticosti; Figure 1) and showed that genetic variance among rivers within regions (2.02%) was less than variance among regions (2.54%). The extent of genetic differentiation among rivers from different regions was on average double that observed among rivers within any given region, although genetic differences between most pairs of rivers within regions were still statistically significant. Genetic divergence among populations and regions was correlated with coastal distance among rivers and degree of difference in temperature regime. In another study, Dionne *et al*. (2007) found that salmon appear to show some local adaptation in the form of genetic variation in MHC genes that is correlated with latitudinal changes in temperature regimes, which in turn are thought to drive clines in pathogen diversity.

Recent work in insular Newfoundland revealed genetic differentiation within rivers, primarily between anadromous and non-anadromous life history forms, but also among anadromous forms within relatively small watersheds (<1000 km^2) (mean F_{ST} = 0.015-0.019, $P < 0.05$) for all pair-wise comparisons) (Adams 2007) (Figure 2). Adams (2007) did pair-wise comparisons of eight rivers in southern Labrador (Eagle River and south) and found a mean F_{ST} of 0.017 ($P < 0.001$). The divergence among rivers seemed to be influenced by river size. Divergence among several subsets of rivers (e.g., Alexis River and proximate rivers) was lower than expected, with no significant differences in multiple pair-wise comparisons. An examination of within-river structure by Dionne *et al.* (2009a) suggested significant within-river population structure. However, the degree was highly variable among rivers.

The influences of temporal variation, effective population size, life history variation, and local adaptation on gene flow among rivers and regions of Newfoundland and Labrador have also been examined (Palstra *et al.* 2007) (Figure 3). These authors demonstrated temporal stability across multiple generations and also suggested that metapopulation dynamics might be important in maintaining stability in smaller populations. Palstra *et al.* (2007) also suggested that the magnitude and directionality of gene flow among populations is variable and may even reverse direction when moving from contemporary to evolutionary time scales. Their work also suggested some level of correlation in life history and demographic attributes, and genetic population structure.

Verspoor (2005) reported that “variation among loci was highly heterogeneous at all polymorphic loci” for samples taken across Atlantic Canada, but did not provide information on specific pair-wise comparisons. King *et al.* (2001), in a hierarchical gene diversity analysis, partitioned variance among provinces or states, among rivers within provinces or states, and within rivers. The proportion of variance associated with among-river comparisons was 2.99% (within province or state), as opposed to 5.28% among countries in Europe. Pair-wise tests for significant differences among populations (rivers) were not provided. Bootstrap analyses were used by McConnell *et al.* (1997) to test for pair-wise differences among sample collections from different rivers for three different genetic distance measures, Roger's modified genetic distance, allele sharing genetic distance, and Goldstein's (δμ)2 distance. All pair-wise estimates of Roger's distance and nearly all estimates of allele sharing genetic distance were significant, but very few estimates of Goldstein's $(\delta\mu)^2$ distance were significant; most of these involved the Gander River, Newfoundland. Again, only a few rivers in each region were surveyed in this study.

Verspoor (2005) presented the most geographically comprehensive study published to date, and included multiple river populations from multiple regions (Newfoundland and Labrador, Quebec, Gulf, and Maritimes). In this study, variation was surveyed at 23 allozyme loci, of which 15 were informative (genetically variable). Multi-Dimensional Scaling analyses (Figure 4), and neighbour joining trees (Figure 5), both based on Nei's DA distance, suggested the presence of six large-scale groupings of Atlantic Salmon in Eastern Canada: Labrador and Ungava, Gulf of Saint Lawrence, Newfoundland (excluding Gulf rivers), Atlantic Shore/Southern Upland of Nova Scotia, inner Bay of Fundy (iBoF), and outer Bay of Fundy (oBoF). Labrador and Ungava rivers grouped together, as did salmon from Newfoundland, excluding those from rivers that drain into the Gulf of Saint Lawrence. Generally speaking, salmon from the Atlantic coast of Nova Scotia (Southern Upland) clustered together and were distinct from all other samples analyzed, as were salmon from the inner Bay of Fundy. Many of the regional groupings identified above have also been reported in other studies, involving different molecular markers. Verspoor *et al.* (2002) identified an mtDNA haplotype in multiple inner Bay of Fundy rivers, at moderate to high frequency, that was completely absent in outer Bay of Fundy samples. In a recently expanded, though not yet published analysis of mtDNA in Atlantic salmon from Eastern Canada, Verspoor also noted the complete absence of the inner Bay mtDNA haplotype in 16 rivers of the Southern Upland. Verspoor *et al.* (2002) also identified an mtDNA haplotype in nearly all surveyed Southern Upland rivers that was absent in samples from all other surveyed salmon populations in Eastern Canada.

Spidle *et al.* (2003) and King *et al.* (2001), in surveys of variation in largely overlapping suites of microsatellites, found the inner Bay and Southern Upland populations included in the analysis to be highly distinct from all other populations analyzed (Figure 6). In a UPGMA tree of microsatellite-based pair-wise estimates of Roger's genetic distance (McConnell *et al.* 1997), the 10 Southern Upland populations all clustered together, as did Stewiacke and St. Croix, NS populations (two inner Bay populations). The Gaspereau River again grouped separately from all other rivers, a likely result of a population bottleneck and rapid recent genetic drift.

Substantial evidence also exists for the distinctiveness of Newfoundland populations relative to other North American salmon populations in microsatellite allele (Spidle *et al.* 2003, King *et al.* 2001) and mtDNA haplotype (King *et al.* 2000) frequencies. Particularly notable are the presence of ‘European’ haplotypes in northeast coast Newfoundland populations, suggesting some post-glacial colonization of this area from European refugial populations.

Few surveys included samples from Labrador, and even fewer considered samples from Ungava (but see Fontaine *et al.* 1997 and Dionne *et al.* 2008). King *et al.* (2001) and Spidle *et al.* (2003) identified the Labrador populations as highly distinct from other populations. Adams (2007) compared samples from eight rivers in southern Labrador to four rivers from northeastern Newfoundland and found evidence of divergence at 10 microsatellite loci (F_{ST} = 0.021). The divergence, however, was similar to comparisons between insular Newfoundland rivers.

Non-genetic data support much of the broad-scale population structure inferred from the genetic data. For example, Chaput *et al.* (2006a) examined variation in life histories across the Canadian range of the species, including smolt age, small and large salmon proportions in returns, sea-age at maturity, proportion of small and large females, and fork length of small and large fish. This study was able to demonstrate clusters of populations with similar life history variation. For example, one clear differentiation was the dominance of grilse (one-sea-winter age at maturity) spawners in insular Newfoundland versus MSW-dominated populations in other areas. Populations also clustered based on smolt age and at-sea growth. Schaffer and Elson (1975) and Hutchings and Jones (1998) also demonstrated clear divergence in sea-age at maturity and size across regions.

Morphology and meristics have also been used to define salmon stocks in the North Atlantic. Claytor and MacCrimmon (1988) and Claytor *et al.* (1991) were able to show regional differentiation based on morphology, but meristic metrics were less successful. They concluded that insular Newfoundland, Labrador/Quebec, and the Maritime populations represented three very distinct regions. They also suggested, but with less certainty, that sub-structuring was likely in the Maritime regions.

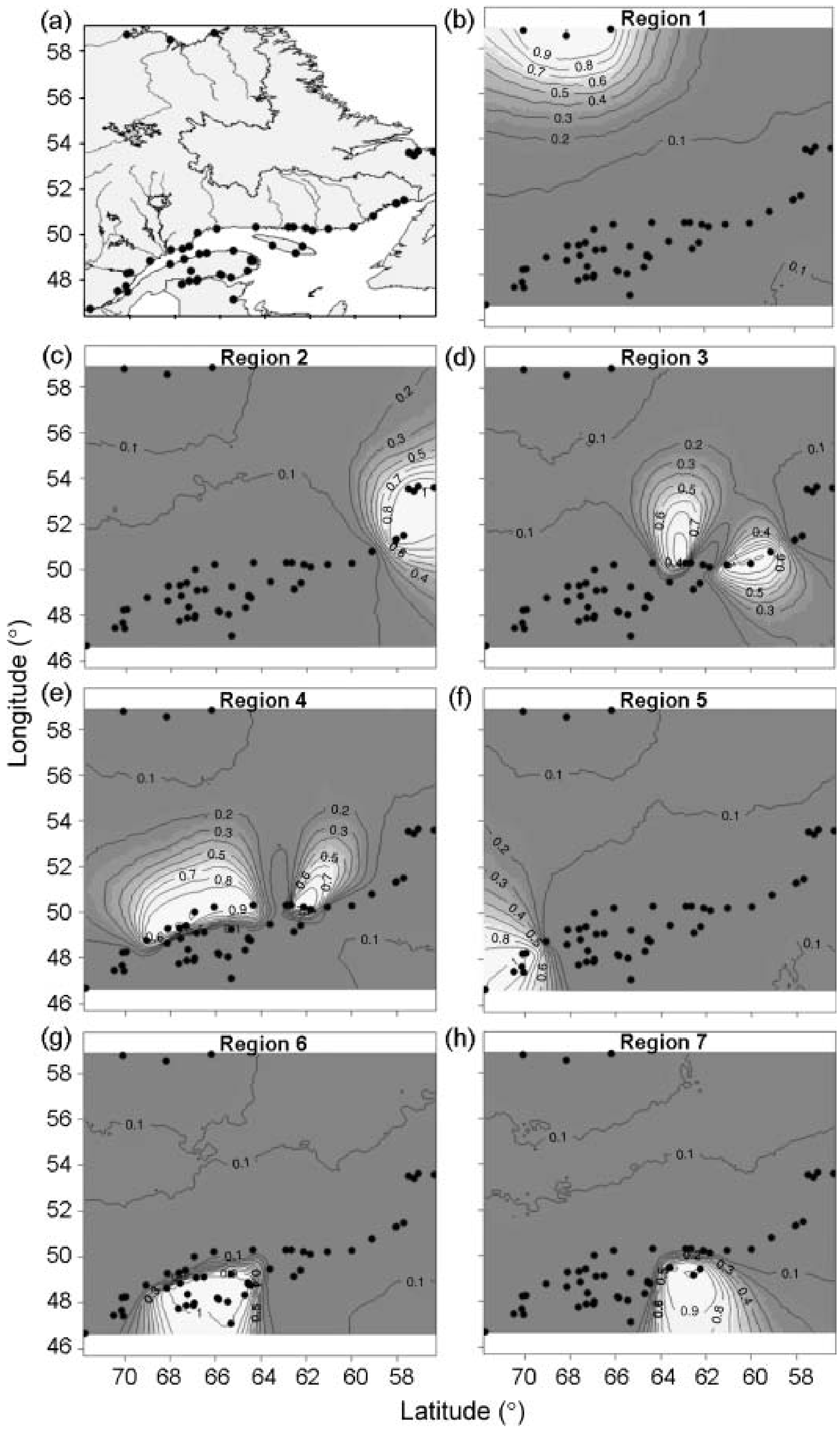


Figure 1. Posterior probabilities for each Atlantic Salmon river-specific population belonging to each of the seven regional groups in Quebec and Labrador identified by landscape genetics analysis. The white area denotes a 90-100% probability that populations belong to their respective regional group. (a) Map of the river-specific populations included in the analysis. (b) Regional group 1: 'Ungava' (3 Rivers); (c) Regional group 2: 'Labrador' (7 rivers); (d) Regional group 3: 'Lower North Shore' 4 rivers); (e) Regional group 4: 'Higher North Shore' (10 rivers); (f) Regional group 5: 'Quebec City' (6 rivers); (g) Regional group 6: 'Southern Quebec' (18 rivers); (h) Regional group 7: 'Anticosti' (3 rivers) (Dionne *et al.* 2008).

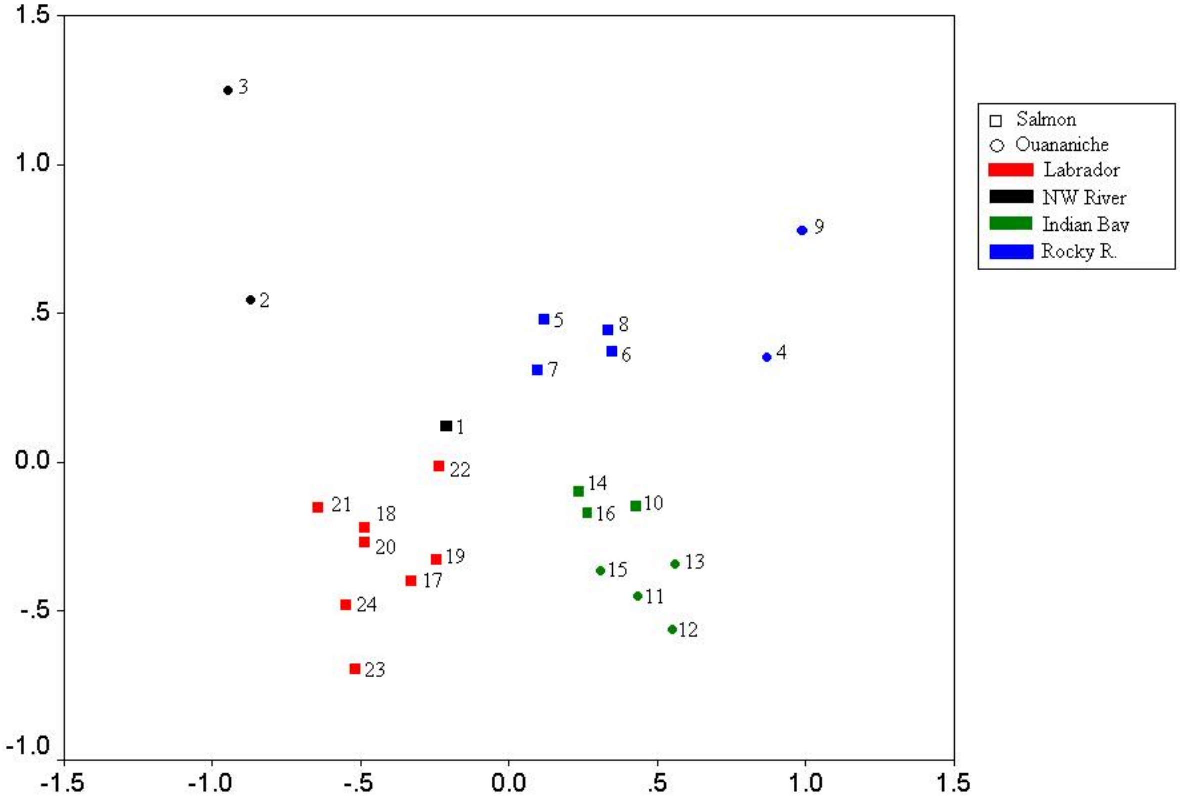


Figure 2. Multidimensional scaling plot based in Nei's unbiased distance for multiple samples taken from 4 Newfoundland Rivers and 8 Labrador rivers. (1) Northwest River Salmon, (2) Northwest Pond ouananiche (non-anadromous form), (3) Endless Lake ouananiche, (4) Rocky River ouananiche Sample 1, (5) Rocky River salmon, (6) Rocky River smolt, (7) Little Salmonier River salmon, (8) Little Salmonier River juveniles, (9) Rocky River ouananiche sample 2, (10) Indian Bay Big Pond salmon, (11) Moccasin Pond ouananiche, (12) Wings Pond ouananiche, (13) Third Pond ouananiche, (14) Indian Bay Big Pond smolt, (15) Indian Bay Big Pond ouananiche, (16) Hungry Brook juveniles, (17) Eagle River, (18) Sandhill River, (19) St. Lewis River, (20) Alexis River, (21) Shinney's Brook, (22) Black Bear River, (23) Paradise River, (24) Reed Brook (Adams 2007).

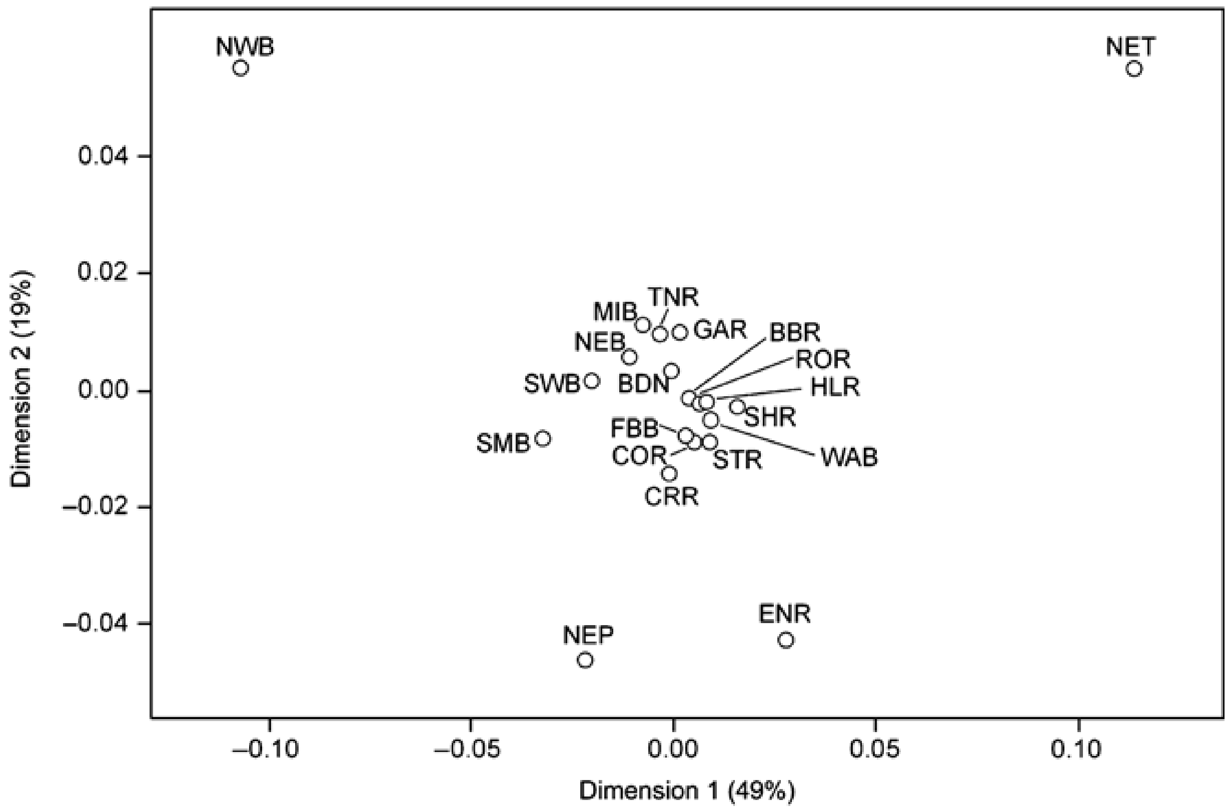
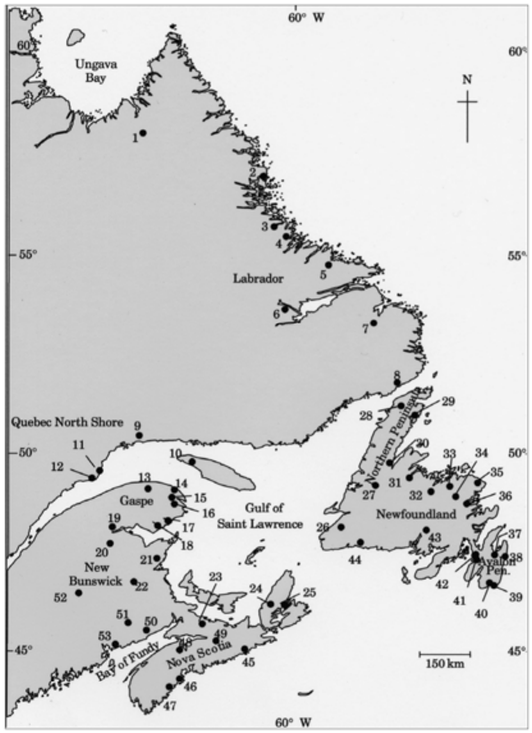


Figure 3. Multidimensional scaling plot for 20 rivers in Newfoundland and Labrador, using the first two dimensions that capture 68% of the genetic variation. ENR English River, WAB Western Arm Brook, TNR Terra Nova River, MIB Middle Brook, GAR Gander River, FBB Flat Bay Brook, ROR Robinsons River, HLR Highland River, CRR Crabbes River, COR Conne River, SWB Southwest Brook, SMB Simmins Brook, BDN Baye Du Nord River, NWB Northwest Brook, NEB Northeast Brook, BBR Biscay Bay River, NEP Northeast River Placentia, NET Northeast Brook Trepassey, STR Stoney River (Palstra *et al.* 2007).

A



B

Region	River	No.
Ungava	George	1
Labrador	Webb	2
	Flowers	3
	Hunt	4
	Big	5
	Cape Caribou	6
	Eagle	7
	Pinware	8
	Moisie	9
Gulf of Saint Lawrence	Bec Scie	10
	Petite, de La	11a
	Trinite	11b
	Godbout	12
	Ste Anne	13
	Dartmouth	14
	St. Jean	15
	York	16
	Port Daniel	17a
		17b
	Bonaventure	18
	Matapedia	19
	Restigouche	20
	Nepisiquit	21
	Bartholemew	22
	Philip	23
	Margaree	24
	North	25
	Crabbes	26a
		26b
	Humber	27
NE coast of Newfoundland	Western Arm	28
	NE Roddickton	29
	Main	30
	Indian	31a
		31b
		31c
	Exploits	32a
		32b
		32c
	Campbellton	33
	Gander	34
	Ragged Hbr	35
	Middle	36
	North Arm	37
Avalon	Mobile	38
	Biscay Bay	39a
		39a
		39b
	NE Trepassey	40
	SE Placentia	41
	NE Placentia	42a
South Coast of Newfoundland	Conne	43
	Cinq Cerf	44
Southern Uplands NS	Liscombe	45
	Medway	46
	LaHave	47
Inner Bay of Fundy	Gaspereau	48
	Stewiake	49
Outer Bay of Fundy	Hammond	50
	Saint John	51
	Tobique	52
	Maguagadavic	53

C

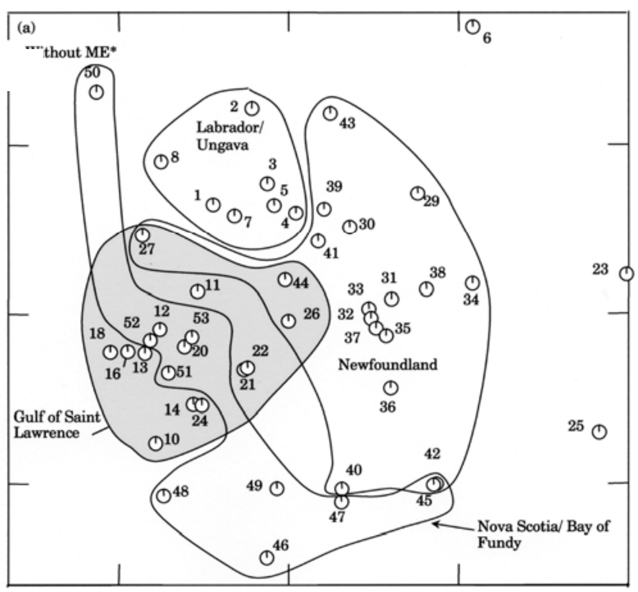


Figure 4. Allozyme variation in Canadian Atlantic Salmon populations. A, map showing locations of 53 rivers that were included in a multilocus allozyme study (Verspoor 2005). B, list of rivers. C, multidimensional scaling plot for 48 rivers based on Nei's DA genetic distance. Large-scale groupings of Atlantic Salmon populations proposed by Verspoor (2005) are indicated. Modified from Verspoor (2005).

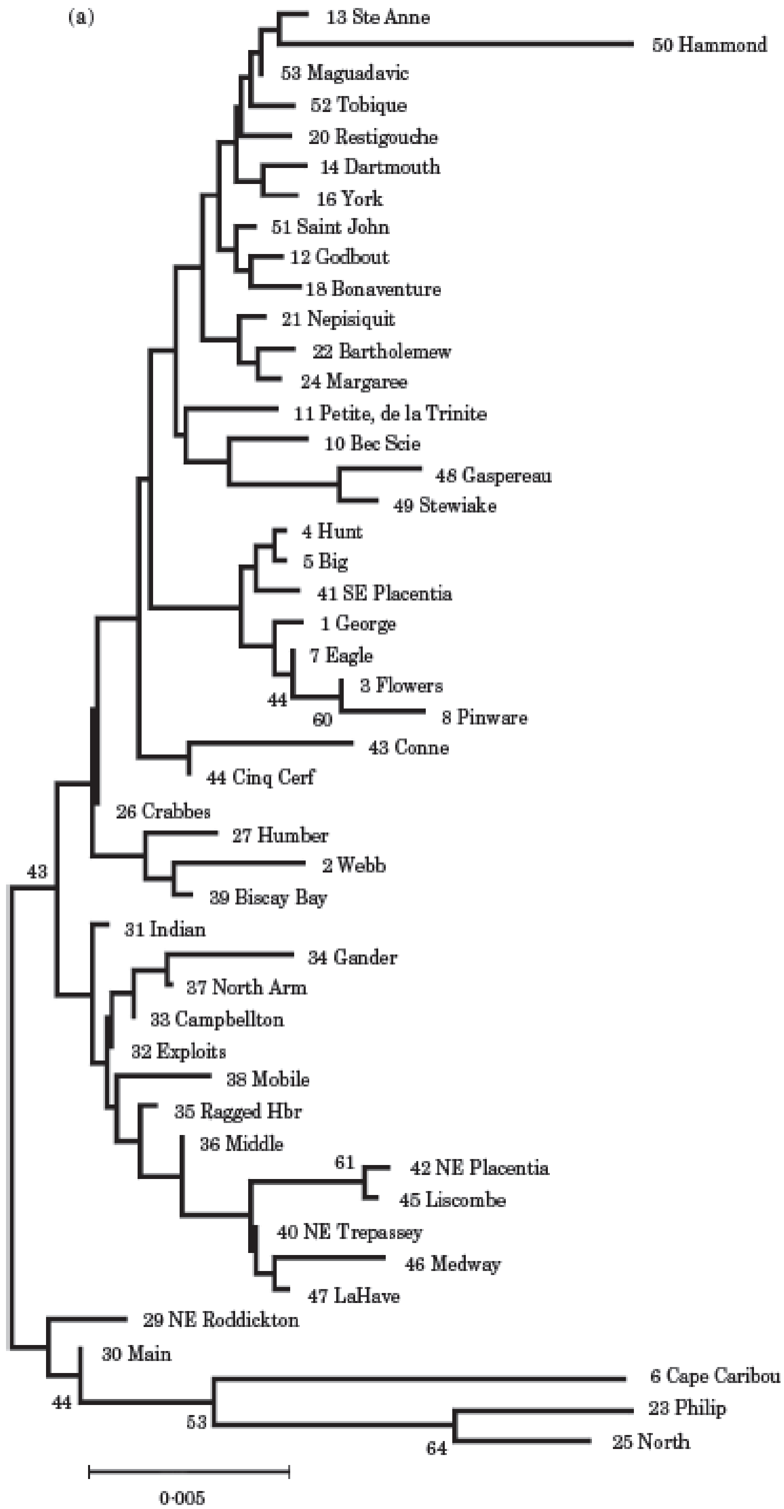


Figure 5. Neighbour-joining dendrogram based on allozyme data using Nei's genetic distance, for 48 Canadian rivers (Verspoor 2005). See Figure 4 for regional groupings, river numbers are congruent.

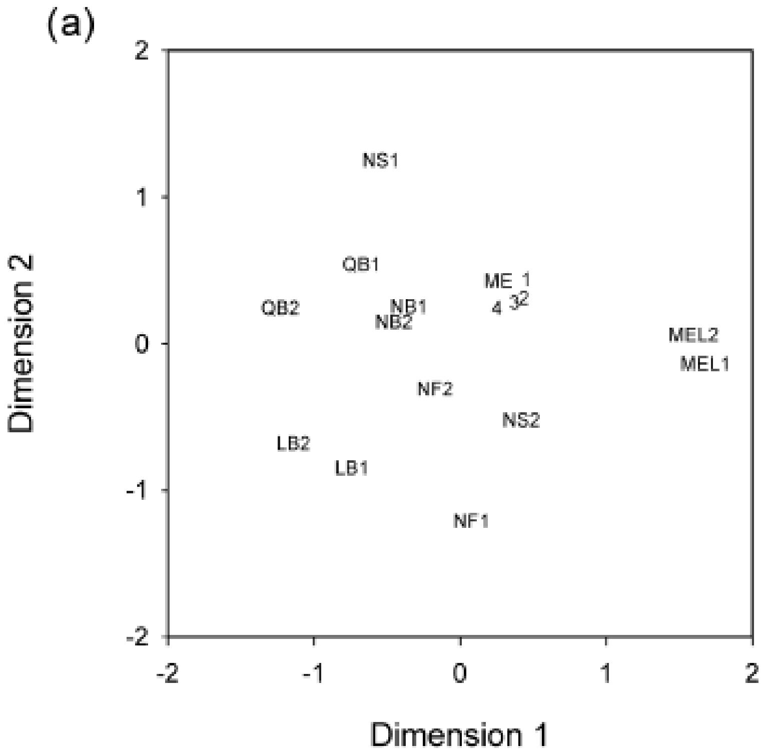


Figure 6. Multidimensional scaling plot based on microsatellite data for 16 rivers in Canada (Newfoundland (NF), Quebec (QB), Nova Scotia (NS), New Brunswick (NB) and Maine (ME, MEL)). NF1 Conne, NF2 Gander, ME1,2,3,4 (Maine), NS1 Stewiacke, NS2 Gold, QB1 St. Jean, QB2 Saguenay, NB1 Naswaak, NB2 Miramichi, MEL1,2 (Maine Landlocked), LB1 Sandhill, LB2 Michaels (King *et al.* 2001).

DESIGNATABLE UNITS

COSEWIC guidelines state that “a population or group of populations may be recognized as a DU if it has attributes that make it “discrete” and evolutionarily “significant” relative to other populations”. Evidence of discreteness can include “inherited traits (e.g. morphology, life history, behaviour) and/or neutral genetic markers (e.g. allozymes, DNA microsatellites…” as well as large disjunctions between populations, and occupation of different eco-geographic regions.

The well-known homing behaviour of Atlantic Salmon, as well as the morphological, life history, behavioural and molecular genetic data cited above, all indicate that the criterion of ‘discreteness’ is routinely satisfied at the level of rivers (as representative of discrete breeding populations), and indeed in some cases may be met at the level of tributaries within river drainages. Since Atlantic Salmon are believed to have spawned in ~700 rivers in Canada, this could suggest the possibility of a huge number of DUs; however, the second criterion of ‘evolutionary significance’ needs to be considered as well. The COSEWIC guidelines suggest four criteria for ‘significance’, three of which may be applicable to Atlantic Salmon.

The first ‘significance’ criterion is “evidence that the discrete population or group of populations differs markedly from others in genetic characteristics thought to reflect relatively deep intraspecific phylogenetic divergence”. This criterion is met for Atlantic Salmon at the ocean basin scale: a variety of molecular genetic data indicate that North American populations of Atlantic Salmon are divergent from European populations (*e.g.,* King *et al.* 2000, 2001, Verspoor 2005). This deep split between eastern and western Atlantic Salmon populations is, however, of little relevance for assigning DUs of Canadian populations, except perhaps in one case. Atlantic Salmon populations in northeastern Newfoundland (DU 3, below) show the presence of ‘European’ mtDNA genotypes that do not naturally occur in any salmon populations to the south, suggesting that post-glacial colonization of this part of Newfoundland was in part from Europe (King *et al.* 2000). Apart from the mtDNA data for DU 3, there is little evidence of deep genetic distinctions (in neutral markers) among groups of Atlantic Salmon populations in Canada. The lack of evidence may in part be due to the relative lack of geographically comprehensive studies of genetic variation among Atlantic Salmon populations in Canada. Most studies have only sampled a portion of the Canadian range. The most geographically extensive genetic study to date is that of Verspoor (2005), which examined allozyme variation in 53 populations spanning most of the Canadian range. Verspoor (2005) suggested that the allozyme data supported the presence of six major population groups of salmon; however, the distinctions between groups were not large, and were not supported by statistical criteria (Figures 4 and 5).

The second ‘significance’ criterion of relevance is “persistence of the discrete population or group of populations in an ecological setting unusual or unique to the wildlife species, such that it is likely or known to have given rise to local adaptations”. As for discreteness, there is abundant evidence of varying local adaptations in Atlantic Salmon. Since Atlantic Salmon spend the first one to several years of their life in fresh water, many adaptations reflect local or regional variation in freshwater habitat attributes including, but not limited to, temperature, length of growing season, and pH. Other potentially adaptive variation includes variation among populations in the proportions of populations maturing as precocious male parr, or as one-sea-winter (1SW) or multi-sea-winter (MSW) salmon. Additional adaptive variation may include varying migration routes to distant ocean feeding grounds. At the molecular level, Dionne *et al.* (2007) found evidence of latitudinal clines in genetic variation at MHC loci, which they interpreted as evidence of adaptation to latitudinally varying assemblages of parasites.

Past attempts to artificially enhance local salmon populations by stocking them with hatchery-bred salmon derived from other populations have provided indirect evidence of local adaptation. For example, Ritter (1975) showed that the performance of hatchery-bred Atlantic Salmon stocked as smolts in rivers varied dramatically depending on the geographic distance between the ‘source’ populations (which were in the Gulf of St. Lawrence) and the ‘destination’ rivers in which they were stocked. Catches of salmon, both in distant marine fisheries and in local fisheries in or around the stocked river itself, were much lower when the salmon were stocked in rivers distant from the source rivers than when they were stocked in nearby rivers (Figure 7). Ritter (1975) concluded that the salmon did poorly when stocked outside their home region because of a mismatch between their adaptations and the locations in which they were stocked. Similarly, two reports on the status of Atlantic Salmon populations in Maine concluded that years of stocking of Maine rivers from several Canadian populations had not significantly eroded the genetic distinctiveness of a number of Atlantic Salmon populations in Maine, presumably because the stocked salmon were maladapted to local conditions (National Research Council 2002, 2004).

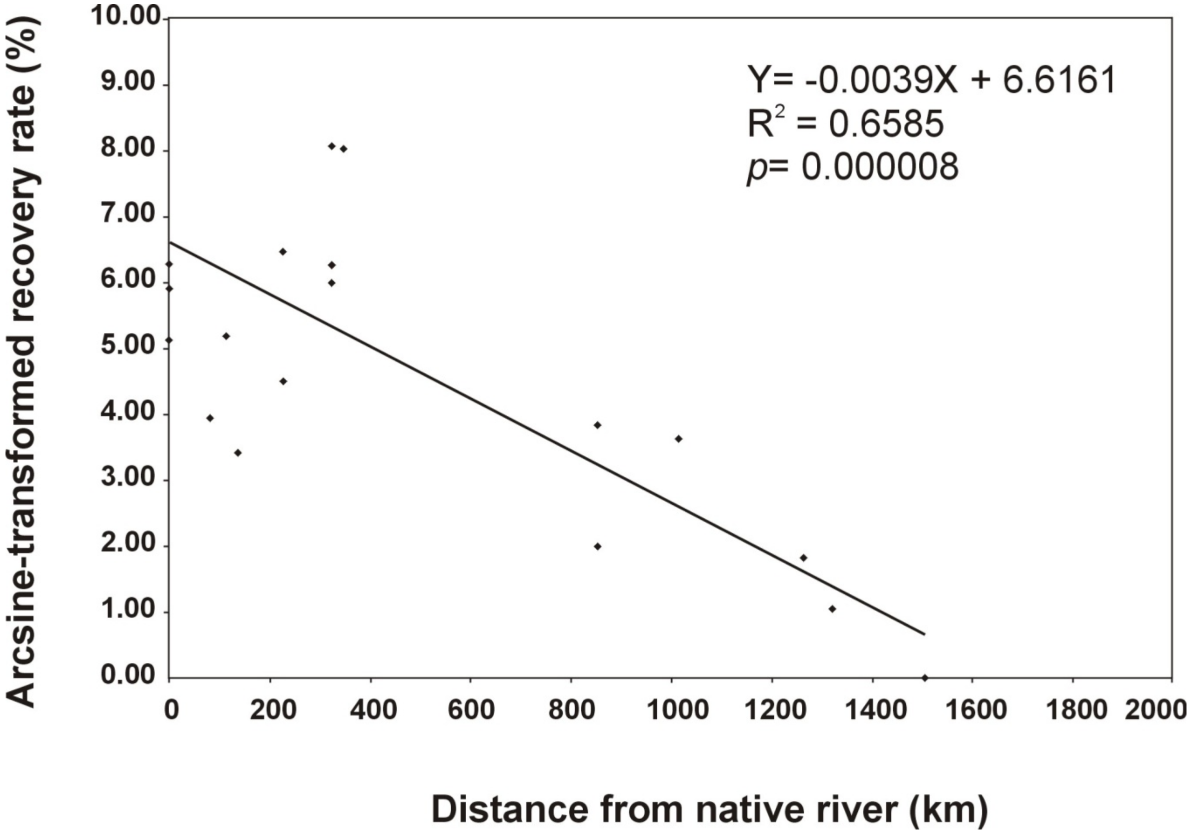


Figure 7. Recovery rates for stocked Atlantic Salmon versus distance from the native river. Shown are total recovery rates (both distant water ocean fisheries and in- or near-river terminal fisheries) for Atlantic Salmon stocked as smolts in rivers at varying distances from their native river. The results for distant water ocean fisheries and in- or near-river terminal fisheries are similar when analyzed separately (results not shown). Analysis of data from Ritter (1975) courtesy of C. Havie and P. O'Reilly.

The various lines of evidence cited above all indicate that Atlantic Salmon populations are locally adapted, and that they are therefore not ecologically exchangeable at some spatial scales. The difficulty lies in determining what those spatial scales are, or where differences among populations become great enough to merit status as DUs. Although it does not directly address this issue, the third COSEWIC 'significance criterion of relevance to Atlantic Salmon may be of some help. It refers to "evidence that the loss of the discrete population or group of populations would result in an extensive gap in the range of the wildlife species in Canada". Many of the DUs proposed below represent a sizable fraction of the species' range in Canada, as well as showing some attributes of distinctiveness, and those DUs that are relatively small in area tend to have particularly strong evidence of genetic or ecological distinctiveness. It can be argued that the loss of any one of these units would represent a substantial loss of diversity within Atlantic Salmon in Canada.

Among the factors considered were genetic divergence, life history and morphometric variation, and geographic separation. As noted above, neutral genetic markers alone are not sufficient to define DUs, but they can, however, provide information on relative levels of gene flow among populations. Life history variation that was considered included data such as smolt age, sea age at maturity, run timing, migratory route, proportion female, and mean length at various life stages. Geographic separation was generally considered significant for major divisions such as insular Newfoundland versus mainland Canada, or north and south of the Gulf of St. Lawrence.

DU boundaries in Quebec and Labrador were guided in large part by the results of the extensive study conducted by Dionne *et al*. (2008). Using data from 13 microsatellite loci on salmon from 51 rivers, they used a combination of hierarchical and landscape genetic analyses in an effort to disentangle the relative influences of a range of factors (temperature, latitude, 'coastal distance' [from the southernmost population, the Miramichi], 'migration tactic' [shorter migrating 1SW vs. longer migrating MSW salmon], an index of the 'difficulty of upstream migration', and stocking history) on genetic structure of Atlantic Salmon populations in the Quebec-Labrador region. They identified seven regional groupings of Atlantic Salmon, which have been adopted as DUs. Temperature and distance, both between rivers and from the southern boundary of the study area, emerged as key determinants of the genetic structure of Atlantic Salmon populations. The influence of distance from the south was suggested to be the "historical footprint of the North American colonization process" from a glacial refugium southward of the contemporary range. In other words, historical effects dating from early post-glacial colonization remain evident in contemporary population structure. Importantly, evidence of dispersal was detected, both within and among population groupings, but genetic differentiation between rivers was lower for dispersal within population groups than it was for similar levels of dispersal between population groups. This observation led the authors to hypothesize that gene flow (as opposed to dispersal) between population groups is constrained by differing thermal regimes which promote local adaptation within groups.

The Department of Fisheries and Oceans (DFO) has previously defined 28 Conservation Units (CUs) for Atlantic Salmon (DFO and MRNF 2008; Figure 8); whereas, 16 DUs are recognized (Figure 9). Despite the difference in the numbers of DUs and CUs, and the fact that the DUs were developed independently, the 16 DUs share many features with the 28 CUs. The majority of boundaries between DUs coincide with CU boundaries. Nine DUs (1, 3, 5, 6, 9, 11, 14, 15, 16) correspond to (differently numbered) CUs. Two DUs (4, 13) each comprise two CUs. One DU (2) combines two very large and one very small CU in Labrador, and unlike the CUs, extends into Quebec. Three DUs within Quebec have different boundaries than the CUs in the same area and together include five CUs and parts of two others. DU 12 (Gaspé-

Southern Gulf of St. Lawrence) comprises all of six CUs, and part of another. The similarities between DUs and CUs reflects the similarity of the definition used for CUs ("groups of individuals likely exhibiting unique adaptations that are largely reproductively isolated from other groups, and that may represent an important component of a species' biodiversity"; DFO and MRNF 2008) to the criteria used by COSEWIC to recognize DUs. The differences largely reflect two factors: the availability of newer data, particularly those in Dionne *et al.* (2008), which formed the basis for decisions about DU structure in the Quebec-Labrador region, and an operational strategy of lumping CUs within DUs when evidence supporting splitting was judged to be weak. The relatively large DU 2 (Labrador) and DU 12 (Gaspé – Southern Gulf of St. Lawrence) reflect this strategy of lumping CUs in the absence of strong data for splitting. The structure for these large DUs may require refinement in the future as more data become available. In the following descriptions, DUs are cross-referenced with DFO CUs and Salmon Fishing Areas, and Quebec Fishing Zones. A tabular comparison of DU characteristics is presented in Table 1.

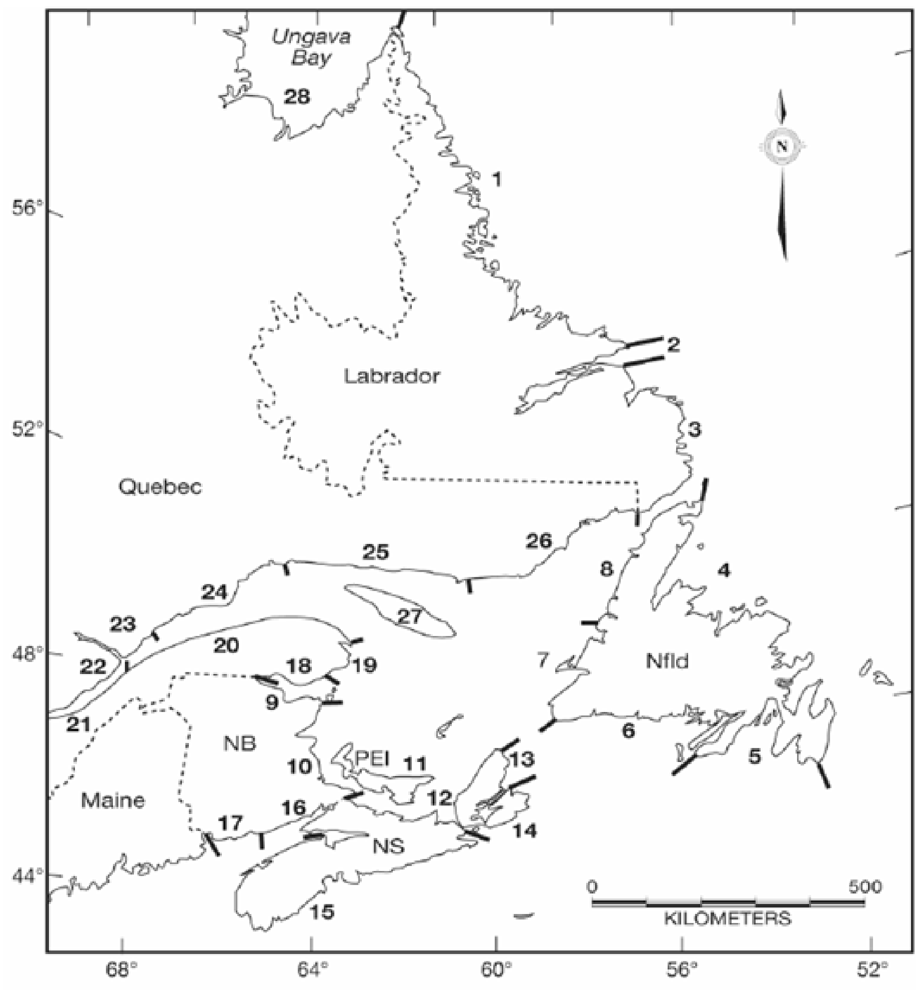


Figure 8. Conservation Units (CUs) proposed by the Department of Fisheries and Oceans for Atlantic Salmon (DFO and MRNF 2008).

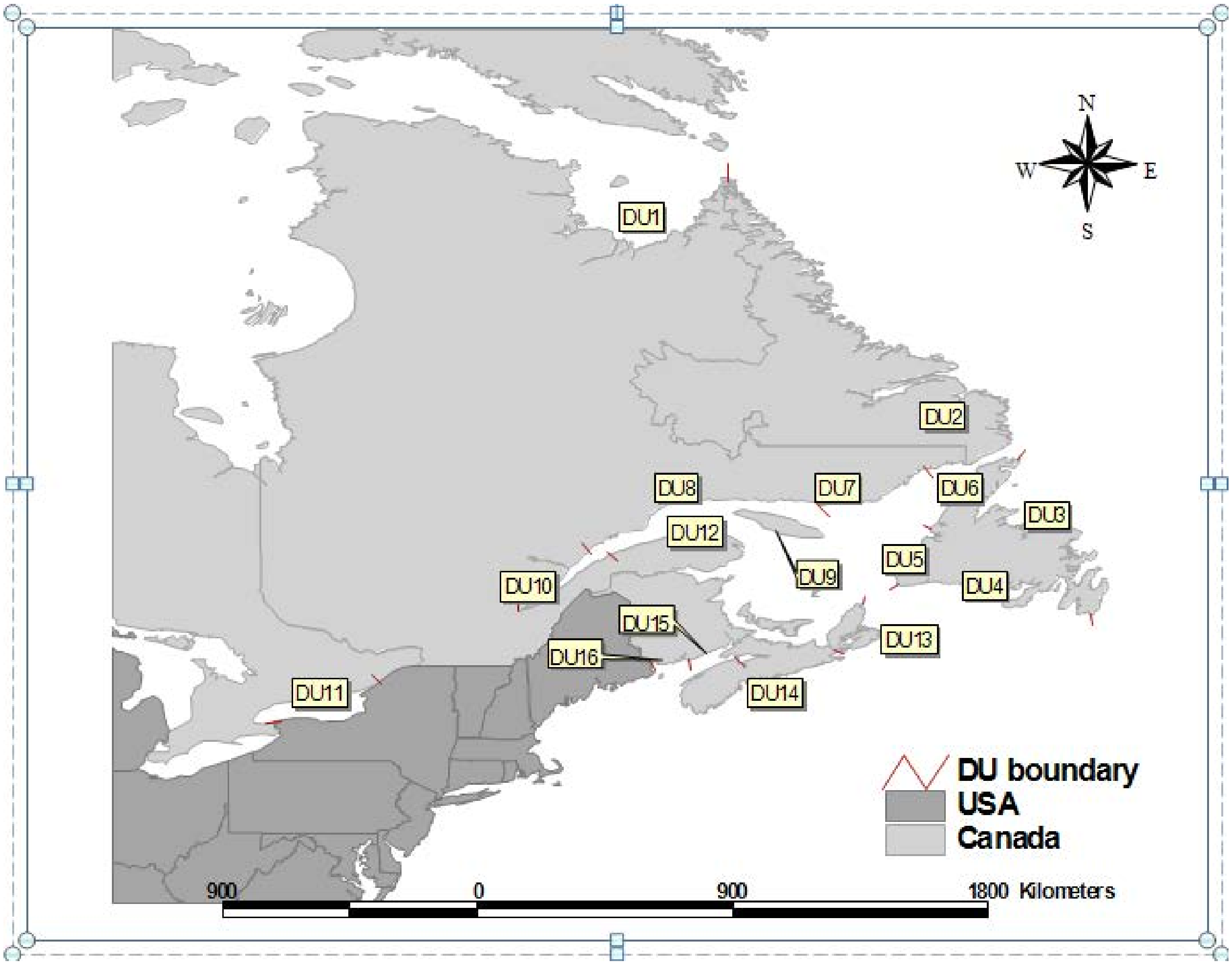


Figure 9. Proposed designatable units (DU) for Atlantic Salmon in eastern Canada.

Designatable Unit 1 – Nunavik (Quebec fishing area designation - Q11; CU 1)

This DU extends from the tip of Labrador (approximately 60°29' N, 64°40' W) west along Ungava Bay to the western extent of the species' range, and represents the most northerly known populations of Atlantic Salmon in North America. Atlantic Salmon in this unit are geographically disjunct from southern populations with a substantial distance between these populations and those along the Labrador coast (~650 km; limited survey work and Aboriginal traditional knowledge suggest there are no self-sustaining populations between DU 1 and DU 2). Some portions of the Ungava populations also appear to have local migratory patterns (Power 1969, Robitaille *et al.* 1986), while others range broadly (Power *et al.* 1987). Genetic data suggest that these populations are distinct from their nearest neighbours and there is little genetic evidence of straying between Ungava and other regions (Fontaine *et al.* 1997, Dionne *et al.* 2008). There have been no known stocking events in this DU.

Designatable Unit 2 – Labrador (Salmon Fishing Areas – 1, 2, 14a, and 5 rivers of Quebec fishing area – Q9; CUs 2, 3 and part of 26)

This DU extends from the northern tip of Labrador (approximately 60°29' N, 64°40' W) south along the coast of Labrador to the Napitipi River in Quebec. Given the large size of this geographic region there is substantial potential for smaller regional groupings within the DU, particularly in the Lake Melville area. However, the available information only supports a clear separation from other regions at the southern portion of the DU. Within DU 2, genetic data suggest reasonable potential for gene flow and hence re-colonization throughout much of the southern portion of the unit (King *et al.* 2001, Verspoor 2005, Adams 2007 (F_{ST} = 0.017), Dionne *et al.* 2008). There is evidence from tagging studies, however, that salmon from the southern portion of this unit do not migrate north of Lake Melville (Anderson 1985, Reddin and Lear 1990). Within-unit comparisons showed weak differentiation between northern and southern rivers where pair-wise heterogeneity was calculated (King *et al.* 2001). Verspoor (2005) did not detect a pattern of differentiation between northern and southern Labrador samples. However, the only sample from Lake Melville (Cape Caribou) was significantly different from the other Labrador samples and suggests the potential for a separate DU at Lake Melville. Unfortunately the Cape Caribou sample was comprised only of a small sample of parr and thus other supporting information is required to justify the creation of a separate DU for Lake Melville. The DU 2 populations did show significant divergence from other nearby DUs including DU 7 (Eastern North Shore) (Dionne *et al.* 2008) and the insular Newfoundland DUs (F_{ST} = 0.021; Adams 2007).

The salmon in DU 2 also appear to have variable life histories with no clear pattern across the DU (Chaput *et al.* 2006a). They show significant life history divergence from the nearby DUs of insular Newfoundland and the eastern North Shore of Quebec (Chaput *et al.* 2006a) (MSW versus grilse populations). There have been no known stocking events in this DU.

Designatable Unit 3 – Northeast Newfoundland (Salmon Fishing Areas 3-8; CU 4)

This DU extends from the northern tip of Newfoundland (approximately 51°37' N, 55°25' W) south and east along the northeast coast of the Island to the southeast tip of the Avalon Peninsula (approximately 46°38' N, 53°10' W). The salmon of the northeast coast of Newfoundland are unique in North America, in that they appear to have genetic profiles intermediate to European and North American salmon (King *et al.* 2000). Genetic data also suggest that there are distinct differences between salmon populations in DU 3 and salmon populations in both Labrador, and southern and western Newfoundland (Verspoor 2005, Adams 2007, Palstra *et al.* 2007). The salmon in DU 3 also exhibit life history variation distinct from other nearby DUs (Chaput *et al.* 2006). Mean age of smoltification was intermediate between Labrador and the rest of insular Newfoundland (3-5 years versus 5-7 in Labrador and 2-4 in southern Newfoundland DUs), and a high proportion of grilse were relatively small 1SW females. This portion of the Canadian range also has the highest incidence of repeat spawners. Juveniles in this DU make heavy use of lacustrine habitat for rearing (e.g., Hutchings 1986). The Exploits and Terra Nova Rivers were stocked extensively in the 1980s and 90s after new habitat was made accessible with fishways (Mullins *et al.* 2003).

Designatable Unit 4 – South Newfoundland (Salmon Fishing Areas 9-12; CUs 5, 6)

This DU extends from the southeast tip of the Avalon Peninsula, Mistaken Point (approximately 46°38' N, 53°10' W) westward along the south coast of Newfoundland to Cape Ray (approximately 47°37' N, 59°19' W). Unlike DU 3, freshwater habitat in DU 4 tends to have relatively low pH values (5.0-6.0). Genetic data suggest that populations along this coast have reduced gene flow among local rivers and between DU 4 and other regions of the Island (Palstra *et al.* 2007). Adams (2007) also demonstrated significant genetic differences between two rivers from DU 3 and two rivers found on the southern Avalon (southeastern DU 4) using a suite of 10 microsatellite markers. Like Palstra *et al.* (2007), Verspoor (2005) found significant genetic differentiation among south coast rivers, but there did not appear to be a geographic pattern to the divergence. The relatively high levels of population structure in DU 4, as evidenced by the substantially higher interregional F_{ST} values on the south coast of the Island reported by Palstra *et al.* (2007), suggest potential subdivision of this DU in the future.

Salmon in DU 4 also experience substantially different ocean conditions than fish in DUs 2-3, entering an area influenced by the Gulf Stream versus the Labrador Current. Population trends for south coast rivers also appear to be distinct from the other DUs in Newfoundland. Much like the genetic data, the life history data for the south coast are variable and show no clear geographic pattern (Chaput *et al.* 2006a). There is a mix of early and late runs, smolt age is variable and both the proportion of female grilse and migratory routes appear to vary along the coast. Rocky River was stocked after the construction of a fishway at the river mouth. Anadromous salmon were absent prior to the fishway construction.

Designatable Unit 5 – Southwest Newfoundland (Bay St. George region) (Salmon Fishing Area 13; CU 7)

This DU extends from Cape Ray (approximately 47°37’ N, 59°19’ W) northwards along the west coast of Newfoundland to approximately 49 24’ N, 58 15’ W. This particular DU is the only region of insular Newfoundland with significant numbers of MSW salmon (Dempson and Clarke 2001) and minimal lacustrine habitat. Genetic comparisons of populations in this region with those in the rest of the Island suggest the populations here represent a distinct group, but that within the region gene flow appears to be higher than in DUs 3 and 4 (lowest F_{ST} values reported by Palstra *et al.* (2007) and Verspoor (2005)). DU 5 also has the youngest mean smolt ages (3 years) on insular Newfoundland and the lowest proportion of female grilse. DU 5 is separated from mainland DUs by the Gulf of St. Lawrence, and genetic data suggest low levels of gene flow between insular populations and the mainland (Verspoor 2005). Hughes Brook and Corner Brook stream have both been stocked in this DU.

Designatable Unit 6 – Northwest Newfoundland (Salmon Fishing Area 14a; CU 8)

This DU extends northward along the west coast of Newfoundland, from approximately 49 24’ N, 58 15’ W to the tip of the Great Northern Peninsula (approximately 51°37’ N, 55°25’ W). Smolts from populations of DU 6 most likely migrate northward through the Strait of Belle Isle (B. Dempson, Dept. of Fisheries and Oceans, Pers. Comm.) and they have life histories that are mixed and intermediate between DU 2 and DU 5 (Chaput *et al.* 2006a). Freshwater habitat in DU 6 is significantly more alkaline than the rest of insular Newfoundland, due to a large amount of limestone in the region’s geology. Unfortunately, genetic data for this DU are sparse. Several rivers in this DU such as the Big East, St. Genevieve and River of Ponds have a MSW component. From 1972-1976, DFO annually transferred 50-300 adult salmon from Western Arm Brook into a good spawning habitat upstream from the fishway in the Torrent River.

Designatable Unit 7 – Quebec Eastern North Shore, (Quebec Fishing Area – 9, western portion; most of CU 26)

This DU extends from the Napitipi River (not inclusive) westward along the north shore of the St. Lawrence to the Kegaska River (inclusive) in the west. Dionne *et al.* (2008) used microsatellite markers, temperature, difficulty of river ascension, and 1SW percentage to differentiate among regions of the North Shore. DU 7 is characterized by populations with high proportions of 1SW salmon and rivers with lower temperature regimes than DU 8. The genetic data also suggest these populations have lower levels of gene flow within the DU than within other areas of the North Shore (Dionne *et al.* 2008) (mean F_{ST} = 0.037 versus 0.027 in DU 8). There are no known stocking events in this DU.

Designatable Unit 8 – Quebec Western North Shore (Quebec Fishing Areas – 7 and 8; CUs 24, 25)

This DU extends eastward from the Natashquan River (inclusive) along the Quebec North Shore to the Escoumins River in the west (inclusive). Dionne *et al.* (2008) provided microsatellite, habitat and life history data that segregate this region of the North Shore from DUs 7 and 10. The eastern edge of the DU appears to be a transitional area to DU 7 (Dionne *et al.* 2008) and does not have a clear geographic feature as a boundary. The western edge of the DU transitions into DU 10 in a similar fashion. The salmon of DU 8 have the highest proportion of MSW salmon by a significant margin relative to the other populations in the North Shore DUs. Stocking in this DU was substantial and has occurred in multiple rivers (Fontaine *et al.* 1997; Dionne *et al.* 2008).

Designatable Unit 9 – Anticosti Island (Quebec Fishing Area 10; CU 27)

This DU encompasses Anticosti Island. DU 9's freshwater habitat is lower gradient than DU 7's. However, in terms of temperature, DU 9's freshwater habitat is similar to DU 7's (based on degree days: 945 versus 938) but is cooler than DU 8, 10, 11 or 12. Genetic data from Dionne *et al.* (2008) show divergence of DU 9 with neighbouring DUs. These data also suggest that gene flow within DU 9 is high with no significant differences among several rivers (F_{ST} = 0.002). Some stocking has occurred in this DU in the past, mainly in the Jupiter River. For example, one-year and two-year-old smolts, as well as fall fingerlings, were stocked in this river during 1993 to 1995 (Caron *et al*. 1996).

Designatable Unit 10 – Inner St. Lawrence (Quebec Fishing Area 4, 5 and 6; CUs 21, 22, 23, part of 20)

This DU extends west along the northern shore of the St. Lawrence from the Escoumins River (not included) into the lower St. Lawrence River and returns eastward along the southern shore of the St. Lawrence to the Ouelle River (included). DU 10 is characterized by a higher proportion of 1SW salmon than DU 8 and a lower mean age at smoltification. Freshwater habitat is also the warmest along the Quebec North Shore. The genetic data from Dionne *et al.* (2008) suggests limited gene flow between this DU and DUs 8 and 12. Stocking in this DU was substantial and has occurred in multiple rivers (Fontaine *et al.* 1997, Dionne *et al.* 2008).

Designatable Unit 11 – Lake Ontario[iii]

Approximately 67 tributaries of Lake Ontario were known to support runs of Atlantic Salmon. Scales obtained from two adult museum specimens indicate an exclusively freshwater growth history, suggesting that at least some salmon populations that originally inhabited Lake Ontario were potamodromous (freshwater resident) (Blair 1938).

Some authors have suggested that prior to the construction of the R.H. Saunders Dam in 1958 in the St. Lawrence River, some Atlantic Salmon would have migrated a distance of 2,400 km to the Atlantic Ocean (summarized in Parsons 1973). However, since potamodromous individuals in Lake Ontario experienced improved growth in Lake Ontario, similar to that acquired in the marine environment for anadromous populations, it seems there would have been few ecological benefits for Lake Ontario salmon to undertake an extensive marine migration. Unfortunately, there are few data to support or oppose the existence of anadromy in at least some Lake Ontario populations. Nonetheless, Lake Ontario Atlantic Salmon differed notably from other DUs in Canada in that age of smoltification was the lowest in the Canadian range, there were spring and fall spawning runs, and if anadromy did occur, it would likely have required prolonged staging in freshwater. These facts, along with the general concurrence of biologists that at least many populations were potamodromous, suggest that Lake Ontario Atlantic Salmon population were likely reproductively isolated from other Atlantic Salmon populations in North America.

Designatable Unit 12 – Gaspé-Southern Gulf of St. Lawrence (Quebec Fishing Area 1, 2 and 3; Salmon Fishing Areas 15, 16, 17 and 18; CUs 9, 10, 11, 12, 18, 19, part of 20)

This DU extends from the Ouelle River (excluded) in the western Gaspé to the northern tip of Cape Breton (approximately 47°02’ N, 60°35’ W). Data from Dionne *et al.* (2008) suggest that the Gaspé and northeastern New Brunswick represent a regional grouping. The mean F_{ST} (0.011) between rivers was the second lowest among the seven regions identified, after DU 9. Dionne *et al.* (2008) did not include the southeastern Gulf of St. Lawrence in their analysis, but the authors of this report could find no evidence that the southeastern Gulf exhibited genetic or life history divergence from the western Gulf of St. Lawrence. There is some evidence from neutral genetic markers that rivers of western Cape Breton may be divergent from the western Gulf (P. O’Reilly, Dept. of Fisheries and Oceans, Pers. Comm.), but more data are needed. Verspoor (2005) also found relatively little evidence of divergence within this region. Thus, the southeastern Gulf rivers were included in the unit. Genetic data are not available for Atlantic salmon on Prince Edward Island. While salmon populations in small streams probably reflect the province’s original populations, those in larger PEI streams are heavily influenced by stocking from eastern New Brunswick. Size distributions and run-timing of adults returning to these streams are also broadly similar to those found elsewhere in the southeastern Gulf (Cairns *et al*. 2009). For these reasons, PEI salmon populations are placed within DU 12. As stated above, this region has an extensive history of stocking (Fontaine *et al.* 1997 Breau *et al*. 2009, Cairns *et al*. 2009, Cameron *et al*. 2009, Chaput *et al*. 2010). PEI both provided salmon eggs for other rivers in the Maritimes and received substantial numbers of eggs and juveniles from mainland rivers. For most of this DU, stocking events have been common for at least the past 100 years.

Designatable Unit 13 – Eastern Cape Breton (Salmon Fishing Area 19; CUs 13, 14)

This DU extends from the northern tip of Cape Breton Island (approximately 47°02’ N, 60°35’ W) to northeastern Nova Scotia (approximately 45°39’N, 61°25’ W). The populations in this DU appear to be genetically distinct from its southern neighbour, DU 14 (Nova Scotia Southern Upland) (Verspoor 2005). Within this DU there is substantial life history variation between Atlantic coast rivers and the Bras d’Or Lakes rivers. The Atlantic rivers, for example have higher proportions of 1SW fish. Substantial differences in freshwater habitat (e.g., stream gradient) and divergent demographic trends suggest that there is some structuring within the DU. However, sparse genetic data do not appear to support any clear geographic pattern (P. O’Reilly, Dept. of Fisheries and Oceans, Pers. Comm.). Stocking in this DU has occurred in some rivers since at least 1902 when the federal government opened the Margaree hatchery (DFO 1997), but for the most part has been discontinued for over a decade.

Designatable Unit 14 – Nova Scotia Southern Upland (Salmon Fishing Area 20-21; CU 15)

This DU extends from northeastern mainland Nova Scotia (approximately 45°39’N, 61°25’ W) southward and into the Bay of Fundy to Cape Split (approximately 45°20’ N, 64°30’ W). Both mtDNA and microsatellite data suggest that gene flow between DU 14 and the neighbouring DUs (13 and 15) is minimal (DFO and MRNF 2008). Many rivers in DU 14 have freshwater habitat with relatively low pH. They also have lower proportions of MSW fish than their northern neighbours. Southerly populations in DU 14 also have some of the youngest smolt ages reported in Canada (Chaput *et al.* 2006a). This DU also has an extensive history of stocking, including recent efforts to slow the decline of a few of the severely depressed populations in the DU (J. Gibson Pers. Comm.).

Designatable Unit 15 – Inner Bay of Fundy (portions of Salmon Fishing Areas 22 and 23; CU 16)

This DU extends from Cape Split (approximately 45°20’ N, 64°30’ W) around the Inner Bay of Fundy to a point just east of the Saint John River estuary (approximately 45°12’ N, 65°57’). This DU has strong genetic differentiation from nearby DUs and appears to exhibit unique migratory behaviour (within the Bay of Fundy/Gulf of Maine) (COSEWIC 2006b). Over 40 million salmon of differing ages have been stocked into rivers of this region since the turn of the 20^{th} century. Early sources are unclear, but recent stocking has been done with inner Bay of Fundy progeny (Gibson *et al.* 2003). These recent stocking events, intended to maximize exposure of salmon to wild environments, are a part of a captive-rearing program thought to have prevented, at least temporarily, the extinction of salmon in this DU (Gibson *et al*. 2008).

Designatable Unit 16 – Outer Bay of Fundy (Portion of Salmon Fishing Area 23; CU 17)

This DU extends westwards from just east of the Saint John River estuary (approximately 45°12' N, 65°57') to the border with the United States of America. Genetic data suggest minimal gene flow between this DU and nearby DUs 14 and 15 (King *et al.* 2000, Verspoor *et al.* 2002 and Verspoor 2005). Within this DU the Serpentine River has a unique run of salmon that return late in the fall and spawn the following year (Saunders 1981). DU 16 also has a higher proportion of MSW salmon migrating to the North Atlantic than DU 15 (Amiro 2003). Termination of this DU at the border with the United States reflects the scope of this report. From a biological perspective, the U.S. populations may be included in the DU (relationship not examined in this case).

Table 1. Summary of DU characteristics.

DU	Adjacent DUs	Salmon/Quebec Fishing Areas	Genetic Variation	Phenotypic Variation	Geographic	Ecological/Habitat
1 - Nunavik	2	Q11	Limited gene flow with other DUs based on neutral markers Verspoor (2005), Dionne *et al.* (2008), Fontaine *et al.* (1997).	Evidence of local migratory routes.	Disjunct from the rest of the species distribution (~650 km of coastline).	At the northern extreme of the species' range in Canada, Arctic-like conditions.
2 - Labrador	1,3,6,7	SFA 1,2, 14b and 6 rivers from Q9	Minimal evidence of sub-structuring in southern portion of DU, data deficient in northern portion. Some evidence Lake Melville may be distinct King *et al.* (2001), Adams (2007), Dionne *et al.* (2008).	Higher incidence of MSW fish. Smolt primarily age 4+ (Chaput *et al.* 2006a).	Separated from insular Newfoundland by the Strait of Belle Isle.	Arctic and subarctic conditions in much of the DU. Anadromous Arctic char and brook trout abundant in many watersheds.
3 - Northeast Newfoundland	2,4,6	SFA 3-8	'European-type' mtDNA genotypes present in this area, Low levels of gene flow with other DUs based on neutral genetic markers. Some evidence of within-DU sub-structure King *et al.* 2000, Verspoor (2005), Adams (2007), Palstra *et al.* (2007).	Primarily grilse populations. Smolt predominantly age 4 (Chaput *et al.* 2006a). Highest incidence of repeat spawners in Canadian range. Substantial non-anadromous population components.	All rivers flow directly into open Northeast Atlantic and the Grand Banks.	Relatively low natural pH 6.1-6.5. Low gradient rivers.
4 - South Newfoundland	3,5	SFA 9-12	Evidence of within-DU sub-structuring, but no geographic pattern. Low levels of gene flow with other DUs based on neutral markers Verspoor (2005), Adams (2007), Palstra *et al.* (2007).	Some rivers have early run timing, and median smolt age of 3 years (Chaput *et al.* 2006a). Substantial non-anadromous population components.	Rivers empty into a region influenced by the Gulf Stream versus the Labrador Current.	Relatively low pH water usually < 5.5. Some areas are high gradient systems. Milder climate relative to northern portions of insular Newfoundland.

DU	Adjacent DUs	Salmon/Quebec Fishing Areas	Genetic Variation	Phenotypic Variation	Geographic	Ecological/Habitat
5 - Southwest Newfoundland	4,6	SFA 13	Evidence of higher rates of gene flow within this DU than among adjacent DUs and within other DUs Verspoor (2005), Palstra *et al.* (2007).	Earliest ages of smoltification on the Island. Only DU on insular Newfoundland with a substantial MSW component (Chaput *et al.* 2006a).	Rivers empty in the Cabot Strait and Gulf of St. Lawrence. Close proximity to southern DUs (e.g., DU 13).	Many low gradient streams, limited lacustrine habitat.
6 - Northwest Newfoundland	2,5,7	SFA 14a	Data deficient.	Small MSW component (Chaput *et al.* 2006a).	Rivers flow into the Strait of Belle Isle.	Lacustrine habitat abundant.
7 - Quebec Eastern North Shore	2,6,8,9	Part of Q8 and Q9	Neutral markers suggest higher gene flow within this region than among adjacent DUs. Data suggest western border with DU 8 may be ambiguous. Dionne *et al.* (2008).	Characterized by populations with high proportions of 1SW salmon (Chaput *et al.* 2006a).	No clear geographic boundary with DU 8 or DU 2, but separated from other DUs by Gulf of St. Lawrence	Rivers with lower temperature regimes than DU 8
8 - Quebec Western North Shore	7,9,10	Part of Q7 and Q8	Neutral markers suggest within DU gene flow is higher than among adjacent DUs. Some evidence of transitional areas on borders. Dionne *et al.* (2008)	Highest proportion of MSW salmon by a significant margin relative to the other DUs of the North Shore (Chaput *et al.* 2006a).	No clear geographic boundary with DU 7 or DU 10, but separated from other DUs by Gulf of St. Lawrence.	Higher gradient rivers than nearby DUs (Dionne *et al.* 2008).
9 - Anticosti Island	7,8,10,12, 13	Q10	Neutral markers suggest gene flow within this DU may be variable. Low levels of distinction among some rivers, but clearly divergent from mainland Dionne *et al.* (2008).	Higher proportion of 1SW salmon than many nearby DUs (Chaput *et al.* 2006a).	Distinct island system in the Gulf of St. Lawrence.	Lower gradient rivers (Dionne *et al.* 2008).
10 - Inner St. Lawrence	8,11,12	Q4,5,6	Neutral markers suggest divergence from adjacent DUs Dionne *et al.* (2008).	Lower mean age at smoltification than nearby DUs (Chaput *et al.* 2006a).	NA	Freshwater habitat is also the warmest along the Quebec North Shore.
11- Lake Ontario	10	FMZ 20	Data deficient	Likely potamodromous with the possibility of some anadromous populations. Had the youngest smolt ages in Canadian range.	Inland lake system	Unknown
12 - Gaspé-Southern Gulf of St. Lawrence	9,10,13	Q1,2,3 and SFA 15,16,17,18	Data deficient, but some evidence of divergence at eastern (Dionne *et al.* 2008) and western edges (P. O'Reilly pers. comm.)	Variable life histories across the DU, but no clear geographic pattern (Chaput *et al.* 2006a).	Encompasses entire southern Gulf of St. Lawrence and PEI.	Variable across the DU. PEI is a distinct island system. Miramichi River is the dominant system.

DU	Adjacent DUs	Salmon/Quebec Fishing Areas	Genetic Variation	Phenotypic Variation	Geographic	Ecological/Habitat
13 - Eastern Cape Breton	12,14	SFA 19	Absence of mitochondrial haplotype observed in DU 14 Verspoor *et al.* (2005).	Variable life histories across the DU. Some evidence of western and eastern geographic pattern (Chaput *et al.* 2006a).	Island system. Many of the DU rivers flow into the open Atlantic Ocean. Large inland lake system.	Higher gradient rivers than nearby DUs.
14 - Nova Scotia Southern Upland	13,15	SFA 20, 21	Allozyme, mitochondrial, and microsatellite data suggest divergence among DUs 14,15,16. Verspoor (2005), Verspoor *et al.* (2005). O'Reilly, pers. com.	Lower proportions of MSW fish than their northern neighbours. Southerly populations in DU 14 also have some of the youngest smolt ages reported in Canada (Chaput *et al.* 2006a).	Rivers flow into Western North Atlantic Ocean	Many rivers in DU 14 have freshwater habitat with relatively low pH.
15 - Inner Bay of Fundy	14,16	Portions of SFA 22 and 23	Allozyme, mitochondrial, and microsatellite data suggest divergence among DUs 14,15,16. Verspoor (2005), Verspoor *et al.* (2005). O'Reilly, pers. com.	Unique migratory behaviour.	Confined to the inner Bay of Fundy.	Unique Bay of Fundy tidal system.
16 - Outer Bay of Fundy	15	Portion of SFA 23	Allozyme, mitochondrial, and microsatellite data suggest divergence among DUs 14,15,16 Verspoor (2005), Verspoor *et al.* (2005). O'Reilly, pers. com.	DU 16 has a higher proportion of MSW salmon migrating to the North Atlantic than DU 15 (Chaput *et al.* 2006a). Several systems with unusual run timing.		

DISTRIBUTION

Global range[iv]

Atlantic Salmon originally occurred in every country whose rivers flow into the North Atlantic Ocean and Baltic Sea (Mills 1989) (Figure 10). The range of Atlantic Salmon extended southward from northern Norway and Russia along the Atlantic coastal drainage to Northern Portugal including rivers in both France and Spain (MacCrimmon and Gots 1979). In North America, the range of the anadromous Atlantic Salmon was northward from the Hudson River drainage in New York State, to outer Ungava Bay in Quebec (MacCrimmon and Gots 1979). Non-migratory or non-anadromous forms of Atlantic Salmon occur in areas of Europe, and North America.

The current distribution is reduced compared to the historical range and the number of rivers supporting spawning runs in each country, as well as the estimated population sizes, are much lower than those recorded historically.

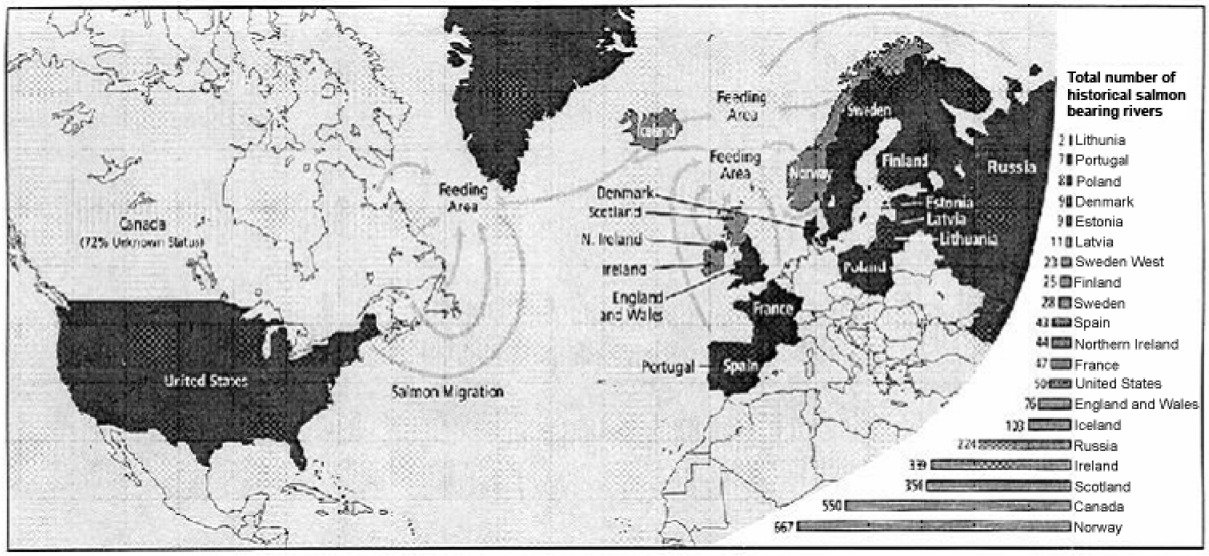


Figure 10. Current global distribution of Atlantic Salmon (*Salmo salar*), excluding Canada. Arrows indicate migration patterns of wild salmon. The total number of historical salmon-bearing rivers worldwide is indicated at the right of map. COSEWIC (2006).

Canadian range[v]

The Canadian range is roughly one-third the area of the total global range, and extends northward from the St. Croix River (at the border with Maine, U.S.A.) to outer Ungava Bay of Quebec, plus one population in Eastern Hudson Bay (MacCrimmon and Gots 1979, Scott and Crossman 1973). Salmon occupy or have occupied at least 700 rivers in the Canadian range[vi], not including many smaller rivers that have been occupied intermittently.

Extent of occurrence and area of occupancy

With the exception of the extinct Lake Ontario population (DU 11) the extent of occurrence of each of the Atlantic Salmon DUs includes a large portion of the North Atlantic Ocean, substantially greater than 20,000 km^2. Accurate estimates of area of occupancy during the most spatially confined life history stages, spawning and early rearing of juveniles, are not possible for the great majority of rivers occupied by salmon, based on current knowledge. To determine whether index of area of occupancy (IAO) might fall below important thresholds (2,000 km^2 or 500 km^2) for status assessments of individual DUs, estimates of IAO were made for eight DUs with small numbers of rivers. DU 15 (Inner Bay of Fundy), for which area of occupancy was previously estimated to be 9 km^2 (COSEWIC 2006b) was not included in this analysis. IAO was estimated using

2 x 2 km grids overlaying potential river habitat, beginning with main stems of known spawning rivers. If these summed to less than 2,000 km^2 for any DU, tributaries were also included in the analysis. Where available, information about barriers limiting access of migratory salmon was taken into account.

Using this approach, estimated IAO exceeded the 2,000 km^2 threshold for each of the following six DUs (see Technical Summaries for exact values of estimates): DU 1, 7, 8, 9, 14, 16. Two DUs 10 (Inner St. Lawrence) and13 (Eastern Cape Breton), had estimated IAOs below 2,000 km^2, 1552 and 1684 km^2, respectively.

HABITAT

Atlantic Salmon have complex and plastic life histories that begin in freshwater and may involve extensive migrations through freshwater and marine environments before returning to fresh water to spawn**.**

Freshwater habitat requirements[vii]

Atlantic Salmon rivers are generally clear, cool and well oxygenated, with low to moderate gradient, and possessing bottom substrates of gravel, cobble and boulder (COSEWIC 2006b).

Habitat is considered a limiting resource to freshwater production and is used to set conservation requirements for Canadian rivers (O'Connell *et al.* 1997a). Loss of freshwater habitat since European colonization has resulted in dramatic declines in the range and abundance of Atlantic Salmon (Leggett 1975). A relatively small but locally significant amount of habitat has been created by enhancing passage through the removal of natural barriers. This has increased salmon population size in several rivers (e.g. Mullins *et al.* 2003).

Freshwater habitat use by Atlantic Salmon is diverse, widely documented and the subject of substantial reviews (Bjornn and Reiser 1991, Gibson 1993, Bardonnet and Bagliniere 2000, Armstrong *et al.* 2003a, Rosenfeld 2003, Amiro 2006). Spawning beds are often gravel areas with moderate current and depth (Fleming 1996), but habitats used by juvenile and adult salmon range across freshwater fluvial, lacustrine and estuarine environments. Individual fish may often use several habitat types during their freshwater residency (Erkinaro and Gibson 1997, Bremset 2000) for demographic (Saunders and Gee 1964), and ecological reasons (Morantz *et al.* 1987, Bult *et al.* 1999).

Juvenile salmon typically maintain relatively small feeding territories in streams, which can be relocated when individuals undergo larger-scale movements to seek improved foraging conditions, refuge (thermal or seasonal) and/or precocious spawning (McCormick *et al.* 1998). In some areas (e.g. Newfoundland), juveniles also occupy lacustrine habitats where growth benefits are accrued (Hutchings 1986). In winter, parr may occupy interstitial spaces in the substrate (Cunjak 1988) and/or move to lacustrine habitats (Robertson *et al.* 2003). Ultimately, home ranges in freshwater are abandoned when smolt begin to migrate to the marine environment (the Lake Ontario populations, which likely migrated to lake environments, were an exception to this generalization). The propensity for migration underscores the importance of habitat connectivity, not only to allow adults to reach spawning grounds, but also for seasonal movements of juveniles and ontogenetic shifts in habitat.

In Lake Ontario, adult 'Lake' salmon typically remained in the lake until immediately prior to spawning, at which time they ascended their natal streams and established spawning sites. The small size of most tributaries of Lake Ontario and their low flow and volume were, in most cases, unfavourable for the extended residency of large salmon (Parsons 1973). Adults rarely remained in the streams longer than one week after spawning (Parsons 1973). Little is known about the preferred lacustrine habitat of Atlantic Salmon except that lakes with deep, cool, oligotrophic conditions, a forage base that includes rainbow smelt (*Osmerus mordax*), and the presence of feeder streams providing suitable spawning and nursery habitat, appear to be the most ecologically suitable (MacCrimmon *and* Gots 1979, Cuerrier 1983). Historically, Lake Ontario salmon may have depended on cisco and later alewife before smelt entered the lake in the 1930s. Lake Ontario most likely served the same function for adult and juvenile lake salmon as the ocean did for anadromous populations.

Chemical conditions also play a role in defining salmon habitat. Atlantic Salmon populations can experience reduced production or even extirpation in conditions of low pH (DFO 2000). Tolerance is life-stage dependent with fry and smolt being the most sensitive. Generally rivers that have pH's between 4.7 and 5.0 are considered moderately impacted and those below 4.7 are considered acidified (DFO 2000), and are unlikey to be able to support salmon populations.

Temperature has been described as the most pervasive abiotic attribute controlling the production of teleost fishes in streams (Heggenes *et al.* 1993). Relative to other salmonids, Atlantic Salmon parr are relatively tolerant of high water temperatures (Elliot 1991). Temperatures above 22°C are unsuitable for feeding (Elliot 1991) and the maximum incipient lethal temperature (the temperature at which all salmon would exit a habitat if the opportunity were available) was estimated to be 27.8°C (Garside 1973). There is a gradual increase in smolt age associated with increasing latitude which is considered to depend upon growth opportunities in spring and summer (Metcalfe and Thorpe 1990). Therefore, it is entirely possible that an optimum temperature regime exists, affecting Atlantic Salmon abundance via smolt productivity.

Available habitat is a direct function of discharge (Bovee 1978) and exposure of juvenile populations to extended low flow periods may limit production in streams. Low flows have also been widely observed to delay entry of returning spawners to freshwater environments (Stasko 1975, Brawn 1982). Variation in flow, however, is normal in the temperate streams that salmonids occupy. Atlantic Salmon have been noted for their capacity to cope with this variation in flow and associated physical constraints relative to other sympatric salmonids. Juvenile salmon were noted to move from pool to riffle habitats at higher discharges (Bult *et al.* 1999), which is complementary to the noted preference of pools at low discharge (Morantz *et al.* 1987). This adaptability enables juvenile salmon to occupy extensive sections of streams that experience flow and temperature variation.

The migratory behaviour exhibited by Atlantic Salmon makes them particularly vulnerable to the negative effects of obstructions. Both natural and man-made barriers to fish passage severely reduce the production of salmon by restricting mature salmon from reaching spawning habitat and preventing juveniles from reaching feeding and refuge habitats. In general, most obstructions in excess of 3.4 m in height will block the upstream passage of adult salmon (Powers and Orsborn 1985). Ideally, a passable falls will have a vertical drop into a plunge pool with a depth 1.25 times the height. Depending on the shape of the falls and plunge pool, the maximum height can be considerably less. Furthermore, since jumping and swimming capacity is a function of body length (Reiser and Peacock 1985), the ability of juveniles to surmount barriers is greatly reduced relative to adults.

Marine habitat requirements[viii]

Salmon move, as juvenile smolts or post-spawning ‘kelts’, from fresh water to brackish estuaries and then to the open ocean (Figure 11). O’Connell *et al.* (2006) report that it is in the ocean where “growth… is rapid relative to that in fresh water… mass increases about 75-fold between the smolt stage and 1SW salmon stage, and over 200-fold from smolts to 2SW salmon”. Overall natural mortality in the sea is high and variable and there are many factors that can affect the survival of Atlantic Salmon, some habitat-related (Reddin 2006). However, Reddin (2006) also reports “population-specific information is lacking concerning the cause of these mortalities and this is partly because detailed information on migration routes and distribution is generally unavailable for specific populations, although it is thought that their distributions generally overlap in the North Atlantic.”

Survival rates associated with the transition from fresh water to ocean life for Atlantic Salmon, whether for smolts or kelts, have an important influence on year-class strength (Reddin 2006). It is generally thought that water temperature is the main controlling environmental variable for smoltification (although photoperiod is also important). The smolt transformation process is accompanied by changes in metabolic rate, with increases in energy demands underpinning the need for the fish to immediately begin feeding. Of all the variables influencing survival of 'postsmolt' (individuals experiencing their first several months at sea) salmon, temperature is particularly important because temperature regulates metabolic rate. If postsmolts are to survive, individuals must quickly adapt to their new physical environment and be able to escape predators and capture prey. Temperatures occupied by salmon range from below 0 to nearly 20°C, although most were 8-15°C (Reddin 2006). The length of time spent in or near the home estuary is thought to be as brief as 1-2 tidal cycles and may limit opportunities for predation. In general, postsmolt movement to oceanic areas is rapid. Tracking studies confirmed this rapid movement away from estuaries towards the open sea and showed that migration was influenced by tidal currents and wind (Hedger *et al.* 2008; Martin *et al.* 2009). One exception was in the Gulf of St. Lawrence where salmon postsmolts were caught in a nearshore zone late in the summer; presumably long after they had left their home river and estuary (Dutil and Coutu 1988). In North America, movement of postsmolts, once in the open sea, is generally northwards.

Research surveys for postsmolts in the Northwest Atlantic have yielded highest catches and catch rates between 56° and 58° N in the Labrador Sea; capture dates and behaviour suggest that some postsmolts probably overwinter there as well (Reddin 2006). Postsmolts in the Labrador Sea originate from rivers over much of the geographical range of salmon in North America, but the degree of their migration to the Labrador Sea varies by population. Postsmolts have also been caught as bycatch in herring gear in the northern Gulf of St. Lawrence in late summer. The winter destination of these salmon remains unknown. Postsmolts from rivers in the inner Bay of Fundy have been observed to remain in the Bay of Fundy until late summer. Although the overwinter location of iBoF salmon is unknown, the lack of tag recoveries from distant intercept fisheries indicates that iBoF salmon do not go as far north as other salmon stocks.

In spring, adult salmon are generally concentrated in abundance off the eastern slope of the Grand Bank and less abundantly in the southern Labrador Sea and over the Grand Bank. During summer to early fall, adult, non-maturing salmon are concentrated in the West Greenland area and less abundantly in the northern Labrador Sea and Irminger Sea. There are notable exceptions to these tendencies. As for postsmolts from the same area, few adult salmon from the iBoF are caught outside the Bay itself. Another exception is Ungava Bay, where salmon from local rivers are known to overwinter. In some cases adults from 'spring run' populations may be migrating up-river while other conspecifics from nearby populations are well out to sea.

Sea surface temperature (SST) and ice distribution control run timing and distribution in the Northwest Atlantic (Reddin 2006). Salmon are found at sea in water with SSTs of 1-12.5°C, with peak abundance at SSTs of 6-8°C. In the Labrador Sea, 80% of the salmon were found in SSTs between 4-10°C (Reddin 2006). Similarly, tagged Atlantic Salmon kelts were found in temperatures ranging from a low near 0°C to over 25°C, although most of the time kelts stayed in seawater of 5-15°C (Reddin *et al.* 2004). Lethal temperatures for adult salmon occur below 0°C (Fletcher *et al.* 1988). This may explain the tendency of salmon to avoid ice-covered water as reported by May (1973). The significant relationship for SSTs and salmon catch rates suggests that salmon may modify their movements at sea depending on SST.

Lethal seawater temperatures for both wild and farmed salmon smolts adapting to seawater occurred at both low and high temperatures (Sigholt and Finstad 1990, Handeland *et al.* 2003). At the lower end of the temperature range, mortalities of postsmolts occurred at sea temperatures of 6-7°C while at the higher end, mortalities occurred at temperatures over 14°C. This suggests that there may also be environmental windows for successful smolt transition into the sea.

Friedland (1998) reviewed ocean climate influences on salmon life history events including those related to age at maturity, survival, growth and production of salmon at sea. He concluded that ocean climate and ocean-linked terrestrial climate events affect nearly all aspects of salmon life history. For example, higher sea surface temperature has been implicated in increasing the ratio of grilse to MSW salmon (Saunders *et al.* 1983, Jonsson and Jonsson 2004), perhaps through growth rates (Scarnecchia 1983). Also, Scarnecchia (1984), Reddin (1987), Ritter (1989), Reddin and Friedland (1993), Friedland *et al.* (1993), Friedland *et al.* (1998, 2003a, 2003b), and Beaugrand and Reid (2003) showed significant correlations between salmon catches/production and environmental cues, including those related to plankton productivity.

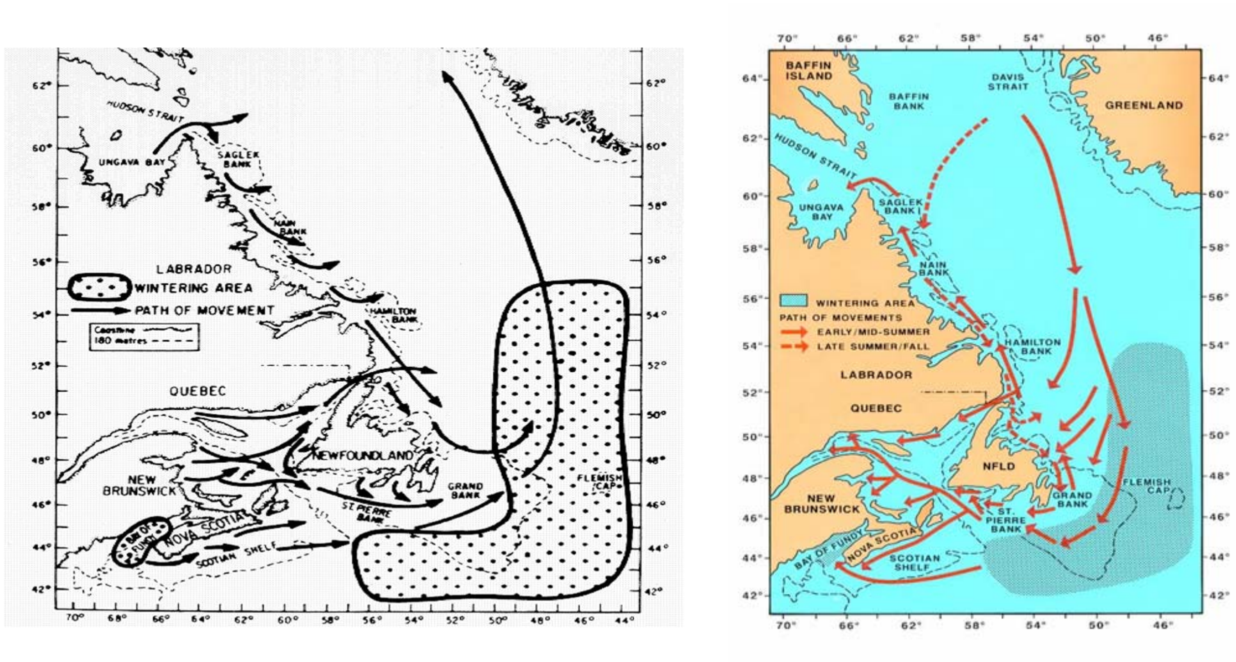


Figure 11. Routes of marine migration of postsmolt (left panel) and returning adults (right panel). Figure modified from Reddin (2006).

Freshwater habitat trends[ix]

Dams, with and without fish passages, probably account for the majority of salmon habitat lost in North America. Prior to the development of hydroelectric power there were extensive small mill dams. From 1815 to 1855 more than 30 mills a year were being built in the Atlantic provinces (Dunfield 1985). In Nova Scotia alone, there were a total of 1,798 dams in 1851. In both Nova Scotia and New Brunswick, surveys documented severe habitat loss and destruction caused by dams and mill waste. Estimates made at the time indicated that 70-80% of the habitat for salmon was affected. A similar situation was occurring in ‘Upper Canada’ at this time and by 1866, salmon in many tributaries of Lake Ontario were severely depleted or extirpated (Dunfield 1985).

With the development of the *Fisheries Act,* shortly after confederation in Canada, some habitat conditions improved. However, a new trend of development began for hydroelectricity in the late 1920s. This technology required the construction of high-head concrete dams that flooded vast areas of rivers. Fish passage structures, when installed, proved to be difficult to operate effectively and in many cases were eventually abandoned due to the lack of fish. Many of the major rivers were developed for hydroelectric power over the next 40 years and more salmon populations were lost. Because hydro developments were often associated with existing falls, not all hydroelectric power developments directly caused the loss of salmon populations. No complete inventory of dams and habitat loss is found in the literature. However, it is notable that five of the largest rivers in Nova Scotia, all of which had salmon prior to European colonization, were subsequently developed for hydropower and no longer have indigenous salmon populations (DFO and MRNF 2008). This observation is clearly not unique to Nova Scotia. Gains in habitat, though modest compared to losses, were achieved by providing passage around natural barriers. For example in Newfoundland, enhancements from the 1940s to the 1990s opened up over 21,600 ha of fluvial habitat to salmon (Mullins *et al.* 2003).

Overall, prior to 1870 as much as 50% of the habitat, or the populations that used those areas, were lost. The majority of these populations and areas were in the Upper St. Lawrence and Lake Ontario (Leggett 1975). The net loss of productive capacity by 1989 was estimated at 16% since 1870, 8% due to loss in productive capacity, 7% due to impoundment, and 3% due to acidification (Watt 1989). During the same period, there was a 2% increase from fish passage development (Watt 1989).

In addition to reductions in habitat availability, freshwater habitat quality has suffered in some areas due to acidification. North American emissions of SO_2 increased during the industrial revolution and peaked in the early 1970s. Approximately 60% of wet sulfate deposition is from human activities in North America. Reductions in emissions have since been achieved and are reflected in both wet sulfate depositions and hydrogen ion concentrations at monitored sites. Anthropogenic sulfate deposition has decreased about one-third since the mid-1980s (DFO 2000). This has caused a large decrease in the deposition of acidifying substances. Unfortunately, the reduction in atmospheric hydrogen (H^+) deposition has not resulted in a substantial decrease in lake acidity at negatively affected sites in Nova Scotia. Furthermore, reduction in acid deposition has not been reflected in the acid neutralization capacity (ANC). As a result, 22% of the 65 salmon rivers on the Southern Upland are ‘acidified’ and are known to have lost their salmon populations (DFO 2000).

There have been recent efforts to restore habitat in and around traditional salmon spawning streams, particularly in riparian areas, in the Lake Ontario drainage. It is important to note that continued increase in urbanization (and associated increase in impervious cover) of the Greater Toronto Area is likely to have direct and indirect impacts on the chemical and biological characteristics of streams in the region (Stanfield and Kilgour 2006, Stanfield *et al.* 2006). Within the lake itself, there have also been many changes that may negatively affect Atlantic Salmon survival including the introduction of Pacific salmon and other non-native salmonid species (Christie 1973, Scott *et al.* 2003), and the invasion of Lake Ontario by species such as Sea Lamprey (*Petromyzon marinus*) (Christie 1972) and dreissenid mussels.

Quebec and Atlantic populations are also facing varying degrees of changing land-use patterns (e.g. urbanization, forestry, agriculture) and threats from invasive species. These are qualitatively outlined in the Threats and Limiting Factors section.

Marine habitat trends[x]

Climate change is a critical issue for Atlantic Salmon, as it can alter productivity and cause ecological regime shifts (Hare and Francis 1995, Steele 2004, Beamish *et al.* 1997). In the northwest Atlantic, there is evidence that a basin-scale shift (as a consequence of changes in the North Atlantic Oscillation Index) has negatively affected the productivity of Atlantic Salmon (Reddin *et al.* 2000, Chaput *et al.* 2005), and may be linked to downturns in salmon abundance (Dickson and Turrell 2000) and recruitment (Beaugrand and Reid 2003, Jonsson and Jonsson 2004, Chaput *et al.* 2005) in the North Atlantic. Recent research has also suggested that there may be substantial impacts on early growth in the marine environment as a consequence of climate change (Friedland *et al.* 2005, 2006, 2009).

Recent downturns in Atlantic Salmon abundance in the late 1980s and 1990s are unprecedented in magnitude and have drawn attention to the lack of knowledge of salmon ecology during the marine phase (Reddin 2006). Because declines in salmon abundance have been widespread, and because apart from DUs 14-16, there have been few indications of reduced smolt production in fresh water, it has been concluded that the main cause lies within the ocean phase (Reddin and Friedland 1993, Friedland *et al.* 1993). For many rivers where marine survival has been measured, the lowest recorded values have occurred in recent years. These low survivals have coincided with greatly reduced marine exploitation (fishing) achieved through massive reductions in effort or in some cases complete bans (ICES 2005), leaving the conclusion that something other than fishing is the main cause. Beaugrand and Reid (2003) have detected large-scale changes in the biogeography of calanoid copepod crustaceans in the northeast Atlantic in relation to sea surface temperature. It seems that copepod assemblages associated with warm water have shifted about 10° latitude northwards. Declines in a number of biological variables, including salmon abundance, have shown to be correlated with these changes (DFO and MRNF 2008). This regional temperature increase therefore appears to be an important factor driving changes in the dynamics of northeast Atlantic pelagic ecosystems with possible consequences for biogeochemical processes, all fish stocks, and fisheries. Regime shifts associated with climate change are predicted to continue, particularly in the Labrador Sea; now considered to be the "centre of action of climate change in the North Atlantic for the 21st century" (Dickson *et al.* 2007 in Green *et al.* 2008).

Unlike other populations in Canada, inner Bay of Fundy (iBoF) salmon are thought to overwinter in the Bay of Fundy / Gulf of Maine. Nonetheless, poor marine survival remains the primary driver of the collapse of iBoF stocks. Significant declines in marine habitat quality and abundance in this region may be occurring due to at least three mechanisms. First, over 400 tidal barriers have been constructed in the Bay of Fundy, and while their placement predates 1970 (Wells 1999), it is possible that cumulative effects through time have negatively altered the iBoF ecosystem for salmon. Second, a large aquaculture industry has grown in the western Bay of Fundy, northern Gulf of Maine, and southwest region of the Scotian Coast in the past 30 years. Third, primary production is apparently declining in parts of the western North Atlantic (Gregg *et al.*

2003). This decline might cause dramatic changes in energy flow, fish physiological condition and fish community structure, as recently indicated for the eastern Scotian Shelf (Choi *et al.* 2004). Potential causes of the decline in primary production include climate change (Drinkwater *et al.* 2003) and enormous removals of fish biomass by marine fisheries that cannot be matched by net primary production (Choi *et al.* 2004).

Habitat protection/ownership

All or part of 36 salmon rivers occur within the federally protected lands of National Parks (Terra Nova National Park DU 3: 9 rivers; Gros Morne National Park DU 6: 10 rivers; Kouchibouguac National Park DU 12: 4 rivers; Cape Breton National Park DU 13: 11 rivers; Fundy National Park DU 15: 2 rivers; Kejimkujik National Park and Historic Site DU 14: 1 river). Each national park contains only a small proportion of individuals within the corresponding DU and in some cases local populations are extirpated (e.g., Mersey River of Kejimkujik National Park and Historic Site). All remaining rivers flow through lands that are privately or provincially owned.

The federal government's constitutional responsibilities for sea coast and inland fisheries are administered via the *Fisheries Act*. The Act provides Fisheries and Oceans Canada (DFO) with powers, authorities, duties and functions for the conservation and protection of fish and fish habitat (as defined in the *Fisheries Act*) essential to sustaining commercial, recreational and Aboriginal fisheries. The *Fisheries Act* contains provisions that can be applied to regulate flow needs for fish, fish passage, killing of fish by means other than fishing, the pollution of fish-bearing waters, and harm to fish habitat. Environment Canada has been delegated administrative responsibilities for the provisions dealing with regulating the pollution of fish-bearing waters while the other provisions are administered by DFO.

BIOLOGY

The Atlantic Salmon is a member of the family Salmonidae. The fish of this family are fusiform in body shape with a distinguishing characteristic being the presence of an adipose fin between the dorsal and caudal fins that lacks rays. Fish of this family include the salmon, trout, and whitefishes and are commonly sought after by sport fishers in temperate zones. Species of this family generally prefer cool oligotrophic water and frequently exhibit migratory behaviour. Salmonids typically reproduce by digging nests or 'redds' in gravel substrates and depositing fertilized eggs. Atlantic Salmon carry out some of the most extensive migrations in the family, and have one of the widest distributions. It is the adaptation to this ocean-scale migratory behaviour that defines the life history and biology of the species.

Life cycle and reproduction[xi]

Atlantic Salmon display considerable phenotypic plasticity and variability in life history characters (Figure 12). They possess an innate ability to return to their natal rivers to spawn with a high degree of fidelity, despite completing ocean-scale migrations. Spawners returning to rivers are comprised of varying proportions of ‘maiden fish’ (those spawning for the first time) and ‘repeat spawners’ (those that have spawned at least once previously). Most maiden salmon consist of smaller fish that return to spawn after one winter at sea and larger fish that return after two or more winters at sea (‘2, 3, or 4-sea-winter’, also designated as ‘multi-sea-winter’ [MSW]). There can be significant numbers of consecutive and alternate spawners present in any breeding season. Some rivers also possess a component that returns to spawn after only a few months at sea (0-sea-winter [0SW]). This life history strategy likely does not represent more than a minor component of most populations, with the exception of an unusual population in DU 3 that is entirely 0SW.

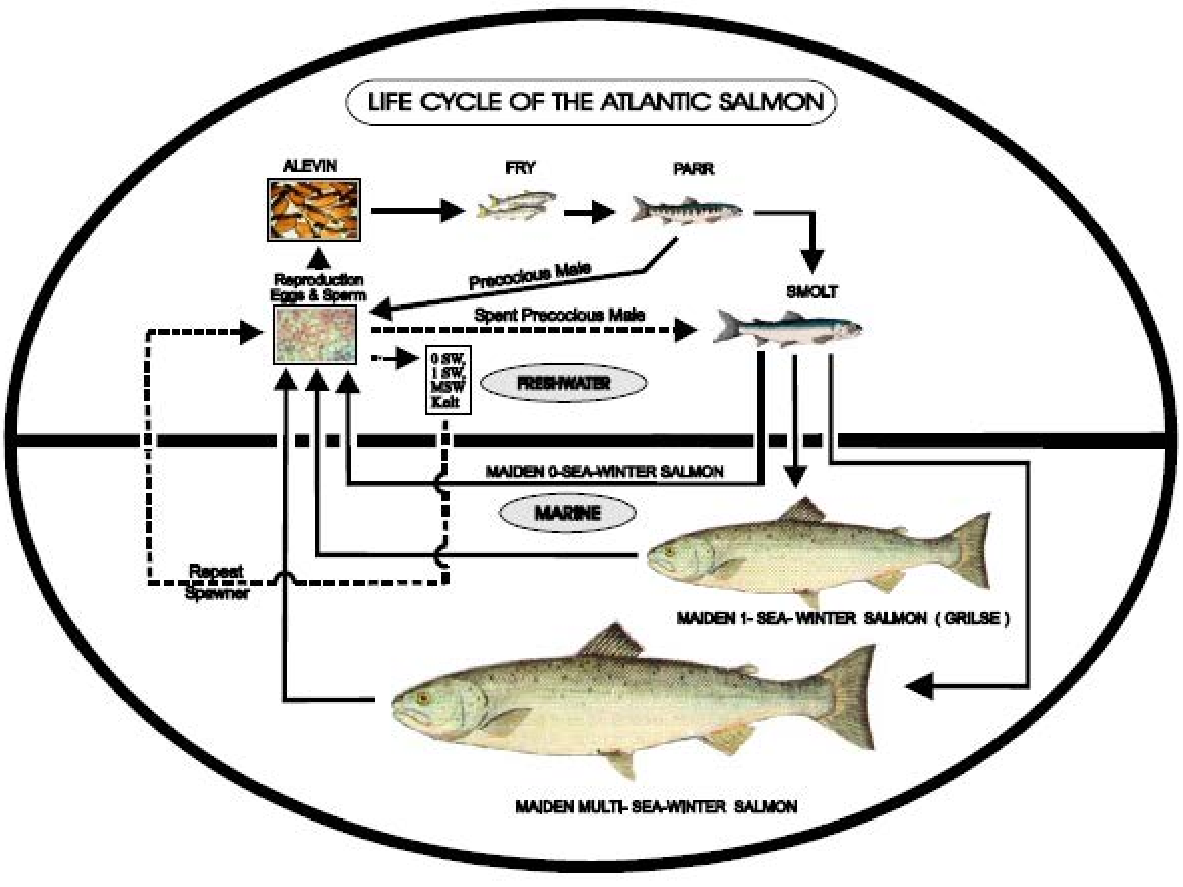


Figure 12. Generalized life cycle of the Atlantic Salmon (from O’Connell *et al*. 2006).

Collectively over its entire range in North America, adult Atlantic Salmon return to rivers from feeding and staging areas in the sea mainly between May and November, but some runs can begin as early as March and April. In general, run timing varies by river, sea age, year, and hydrological conditions. Deposition of eggs in redds (gravel nests), by oviparous mothers, usually occurs in October and November in gravel-bottomed riffle areas of streams or groundwater gravel shoals in lakes. Fertilization of eggs can involve both adult males and sexually mature precocious males (as young as age 1). Mating behaviour typically entails multiple males of several life history types competing aggressively for access to multiple females. This frequently leads to multiple paternity for a given female’s offspring (Jones and Hutchings 2002). Spawned-out or spent adult salmon (kelts) either return to sea immediately after spawning or remain in fresh water until the following spring. Eggs incubate in the spawning nests or redds over the winter months and hatching usually begins in April. The hatchlings or alevins remain in the gravel for several weeks living off large yolk sacs. Upon emergence from the gravel in late May – early June, the yolk sac is absorbed and the free-swimming young fish, now referred to as ‘fry’ begin active feeding. Parr rear in fluvial and lacustrine habitats for 2-8 years after which time they undergo behavioural and physiological transformations and migrate to sea as smolt.

The substantial variation in freshwater smolt age and sea age at maturity creates substantial variation in age at spawning, ranging from 2-14 years. Typically, salmon smoltify between the ages of 2 to 5 years and return after 1-2 years at sea. A generation time of approximately 5 years is thought an appropriate estimate for much of the species’ range in Canada (O’Connell *et al.* 2006). Atlantic Salmon are a relatively short-lived fish species with a maximum age in the 12-14 year range with life spans typically falling in the 4-8 year range (Gibson 1993).

The phenotypic plasticity in life histories found within salmon populations tends to create relatively complex demographic population structures. Not only can the breeding individuals of a population consist of 7-8 cohorts, but sex ratios tend to be highly skewed across the range of age classes. For example, early maturing juveniles are almost exclusively male, while MSW fish are predominantly female in many populations. The exact proportions of mature male parr, grilse, 1, 2, and 3SW fish in a given population is highly variable and the mechanisms driving this differentiation remain unclear.

Fecundity varies considerably both within and among salmon stocks. Egg number and size increase with body size (Thorpe *et al.* 1984, Jonsson *et al.* 1996, O’Connell *et al.* 2008). In a dwarf or stunted freshwater resident population from Newfoundland, mean fecundity was 33.0 eggs (Gibson *et al.* 1996). In contrast, Randall (1989) reported mean fecundities of 12,606 and 16,585 eggs for 3SW and previous spawning salmon in the Restigouche River. Although absolute fecundity varies greatly among individuals, owing to high variability in adult body size, relative fecundity (eggs per kilogram) as a measure of reproductive effort varies much less and is inversely related to fish size. In the Miramichi River, New Brunswick, relative fecundity ranged from 1,331 eggs/kg in previous spawning salmon (mean length 82.1cm) to 2,035 eggs/kg in 1SW fish (Randall

1989). Rouleau and Tremblay (1990) reported values of 1,628 eggs/kg for 2SW salmon; 1,256 eggs/ kg for 3SW salmon; and 1,244 eggs/kg for repeat spawners. In a survey of 10 Newfoundland rivers, mean relative fecundity varied from 1,278 to 2,500 eggs/kg (O'Connell *et al.* 1997).

Natural mortality is highly variable both across and within life-stages of the Atlantic Salmon. Early survival from egg to smolt appears to be in the range of 0.03-3.0% (Chaput *et al.* 1998, Adams 2007, Fournier and Cauchon 2009, Gibson *et al.* 2009). Anadromous adult survival has been estimated in the range of 0.3-10% in recent generations (Reddin 2006, Fournier and Cauchon 2009), but reconstructions of historical runs suggest that marine survival may have been substantially higher in the past. For example, smolt-to-adult survival may have been about 15% in some Newfoundland populations when excluding marine fishery-related mortality (Dempson *et al.* 1998). This decline in marine survival has been implicated as a potentially important factor in the declines of salmon abundance.

Predation[xii]

Chaput and Cairns (2001) suggest that predation by birds and fish on drifting Atlantic Salmon eggs is a common phenomenon. The presence of salmon eggs has been reported in the stomachs of Atlantic Salmon and several other fish species (e.g., Brook Trout (*Salvelinus fontinalis*) and American Eel (*Anguilla rostrata*); Gibson 1973, Hilton *et al.* 2009).

A wide variety of predators feed on juvenile Atlantic Salmon, but predation by birds, particularly the Common Merganser (*Mergus merganser*), the Belted Kingfisher (*Megaceryle alcyon*), and the Double-crested Cormorant (*Phalacrocorax auritus*), is most widely documented (Cairns 1998, Dionne and Dodson 2002, Cairns 2006, DFO *and* MRNF 2008). Bioenergetic models estimate that Common Mergansers and Belted Kingfishers harvest 21-45% of juvenile salmon in Maritime rivers in each juvenile year (age 0+ to 2+) (Cairns 2001). In the northern portions of the species' range, the Common Loon (*Gavia immer*) may also be a significant predator of juvenile salmon, consuming substantial amounts of biomass in lacustrine systems (Kerekes *et al.* 1994). Mammals such as Mink (*Neovison vison*) and Otter (*Lutra canadensis*) prey on juvenile salmon (DFO *and* MRNF 2008), as do adult salmon (mainly non-anadromous individuals) and other fish species.

Outgoing smolts may be eaten by returning adult salmon (in marine habitat), other fish species (e.g. Striped Bass *Morone saxatilis*), mergansers, loons, gulls (*Larus* spp.), and seals (*Phoca* spp.) (DFO *and* MRNF 2008). Feltham (1995) estimated that Common Merganser predation removed 3-16% of smolt production in a Scottish river. Dieperink *et al.* (2002) tracked downstream movement of smolts in a Danish river with radio tags and determined that predation was light in the river, but was intense in the first few hours after sea entry, with major losses to gulls and cormorants. Larsson (1985) estimated that predation removed at least 50% of smolts from Swedish study sites before they reached the Baltic Sea. Higher survival (71-88%) was reported in smolts leaving Passamaquoddy Bay to the open Bay of Fundy (Lacroix *et al.* 2005). Fish known to feed heavily on salmon in estuaries, such as gadoids (Hansen *et al.* 2003), presumably also eat salmon in the open sea. Atlantic Salmon have been found in stomachs of Skate (Rajidae), Halibut (*Hippoglossus hippoglossus*), Porbeagle Shark (*Lamna nasus*), Greenland Shark (*Somniosus microcephalus*), and Pollock (*Pollachius pollachius*) (Wheeler and Gardner 1974, Mills 1989, Hislop and Shelton 1993, Hansen *et al.* 2003).

Salmon at sea may be preyed upon by Bottlenose Dolphins (*Tursiops* spp.), Belugas (*Delphinapterus leucas*) and Harbour Porpoises (*Phocoena phocoena*) (Middlemas *et al.* 2003). Seals and otters may prey on salmon in both freshwater and marine environments. In Europe, Thompson and MacKay (1999) found that 19.5% of returning salmon in northeast Scotland were scarred, but they felt, on the basis of scar patterns, that most of the damage had been inflicted by toothed whales and/or dolphins rather than by seals. Baum (1997) reported that 2% of adults returning to the Penobscot River in Maine had seal bites, and that the percent of scarred animals had risen in recent years. Avian predators, e.g. raptor species such as osprey (*Pandion haliaetus*) and bald eagle (*Haliaeetus leucocephalus*), also prey on adult salmon during migrations through estuaries and rivers (White 1939).

The Harp Seal (*Pagophilus groenlandicus*) population has increased concurrent with the salmon decline (Cairns 2001). Northern Gannets (*Morus bassanus*) from one colony (Funk Island) during one month (August) were estimated to consume 2.7% of post-smolt biomass in the NW Atlantic between 1990 and 2000 (Montevecchi and Myers 1997, Montevecchi *et al.* 2002). Gannet populations in the NW Atlantic approximately doubled between 1984 and 1999.

Physiology[xiii]

Atlantic Salmon, are ectothermic and so are dependent upon the surrounding water temperature to cue migratory patterns, to drive metabolic processes, and to determine the rate of progression from one life stage to the next (Dymond 1963, Elson 1975, Wilzbach *et al.* 1998). Water temperature (along with river discharge) is an important factor affecting returning adults during river ascent (Banks 1969). Dependent upon the location of the population, adult salmon ascend spawning streams following afternoon temperature maxima between 16°C and 26°C (Elson 1975). Optimum temperature for egg fertilization and incubation is approximately 6°C (MacCrimmon *and* Gots 1979). Most juvenile growth occurs at temperatures above 7°C (Elson 1975). The preferred or optimal summer stream temperature for the growth and survivorship of Atlantic Salmon is 17°C (Javoid and Anderson 1967), while the upper incipient lethal temperature for Atlantic Salmon is 27.8°C (Garside 1973); however, adult and juvenile salmon may live for short periods above the incipient lethal temperature (Fry 1947). A sudden increase in incipient temperature in excess of 10°C may bring about the death of resident salmon at temperatures considerably below the upper lethal temperature (MacCrimmon *and* Gots 1979).

Atlantic Salmon juveniles undergo a series of changes at approximately 2-7 years of age (generally older in the northern part of the range) and at a critical body length (varies according to location and population), which lead to outmigration (McCormick *et al.* 1998). Behavioural changes include loss of positive rheotactic behaviour and territoriality, adoption of downstream orientation and schooling tendencies (McCormick *et al.* 1998). The out-migrating period is a critical stage for imprinting to chemical signals used for homing (McCormick *et al.* 1998). The transition is cued by photoperiod and temperature, while temperature and water flow appear to be key factors regulating the timing of downstream movements (McCormick *et al.* 1998). In the ocean, salmon are found at sea in water with SSTs between 1 and 12.5°C, with peak abundance at SSTs of 6-8°C (see Marine Habitat Requirements).

Acidification is an important freshwater stressor for Atlantic Salmon in some regions (summarized in DFO 2000). Increased H^+ ion concentrations coupled with the low concentrations of Ca^{++} are responsible for increased mortality of salmon in acidified rivers of Nova Scotia. In fresh water, the osmotic gradient results in the passive diffusion of water into the blood and of ions out of the blood. Passive losses of ions are countered by active uptake of Na^+ and Cl^- from the water to maintain a balanced state. When pH is ≤ 5.0, active uptake of Na^+ and Cl^- is reduced and passive efflux is increased resulting in a net loss of both ions. The loss of ions results in a shift of water from the extracellular fluids (e.g., plasma) to the intracellular fluids, causing a reduction in blood volume. In addition, red blood cells swell and additional cells are released from the spleen. The reduced blood volume and increased number and size of the red blood cells may cause a doubling of blood viscosity and arterial pressure. Death is a result of failure of the circulatory system. Mortality due to exposure to low pH in fresh water varies with the life stage of salmon.

All freshwater stages are unaffected when pH is above 5.4 but mortality of fry (19-71%) and smolts (1-5%) occurs when pH is below about 5.0. Mortality of parr and smolts is relatively high (72-100%) when pH declines to the 4.6-4.7 range. Eggs and alevins begin to experience lethal effects at pH's below 4.8. Levels of pH ≤5.0 also interfere with the smoltification process and seawater adaptation. Due to the natural buffering capacity of the ocean, acidification issues for Atlantic Salmon are restricted to freshwater environments.

Dispersal and migration

Given that salmon have re-colonized glaciated portions of North America since glacial retreat, it is clear that this species has some ability to disperse to new habitat. Ocean-scale migrations also suggest the potential for extremely long-range dispersal (Reddin 2006). The natal fidelity that salmon exhibit has a limiting effect on the proportion of migrants among populations. Most data suggest immigration rates for Atlantic salmon are on average 10% per river or less (e.g. Dionne *et al*. 2008, Jonsson *et al*. 2003) and below the threshold required for demographic coupling. Most straying also appears to happen relatively close to the natal rivers (Jonsson *et al.* 2003), but recent evidence suggest mixing between rivers of different regions (Dionne *et al.* 2008).

The presence of conspecifics in the destination river and the level of local adaptation may influence the success of strays. For example, return rates of stocked salmon decline as the distance between the stocked river and the source river increases (Ritter 1975). Furthermore, both natural immigrants and stocked salmon appear to have higher reproductive success when locally adapted populations are absent or suppressed (Mullins *et al.* 2003). In such cases, dispersal to new habitat and expansion of populations within freshwater systems can occur relatively rapidly (Mullins *et al.* 2003), particularly with human intervention (Bourgeois *et al.* 2000).

The migratory behaviour of both anadromous and potamodromous salmon is diverse. Some individuals move less than a few hundred metres their entire lives (Gibson 1993), some populations complete short migrations to estuaries or along the nearby coast, and many populations complete ocean-scale migrations (Reddin 2006). The migratory routes taken by individual populations may have some genetic basis (Reddin 2006), but even within populations there may be variability in migratory timing and route (Klemetson *et al.* 2003). This heritable migratory behaviour is likely due, at least in part, to local adaptation, meaning immigrants may be at a disadvantage compared to locally adapted residents, as suggested by Dionne *et al.* (2008) for Atlantic Salmon and Tallman and Healey (1994) and Hendry *et al.* (2000) for other salmonids.

Interspecific interactions[xiv]

Atlantic Salmon juveniles are territorial and year-class abundance declines over time as a result of competition for resources (Chaput 2001). Atlantic Salmon in fresh water compete for resources with conspecifics and potentially with other species, particularly other salmonids. Juvenile Atlantic Salmon are opportunistic predators of aquatic invertebrates (Gibson 1993), especially those drifting at the surface. Body size is the prime determinant of Atlantic Salmon territory size and, though environmental factors such as food availability may influence territory size, the degree of influence is first ‘filtered’ through an individual’s requirement for space (Grant *et al.* 1998). As such, competitors that exclude Atlantic Salmon from rearing habitat or use other resources of their freshwater environment will negatively affect Atlantic Salmon.

In some parts of the Atlantic Salmon’s range (particularly Newfoundland, Labrador and Quebec; Scott and Crossman 1973), non-anadromous forms of Atlantic Salmon occur in sympatry with anadromous runs. In some cases these life history variants are genetically distinct from anadromous individuals while in others there is no genetic divergence (Adams 2007). Non-anadromous juveniles are phenotypically indistinguishable from their anadromous counterparts and likely occupy similar niches at the expense of anadromous conspecifics.

Where Atlantic Salmon are sympatric with native Brook Trout, salmon displace trout from riffle habitat but may be at a competitive disadvantage in pools (Gibson 1993). Gibson and Dickson (1984) found that Atlantic Salmon juveniles showed enhanced growth in an otherwise fishless area of boreal Quebec, and also in a stream from which Brook Trout had been removed. However, density and biomass relationships between Brook Trout and Atlantic Salmon were not detected across several watersheds in another area of Newfoundland (Cote 2007). Similarly, no significant relationships between survivorship of Atlantic Salmon fry and abundance of Brook and Rainbow Trout were detected in streams of Vermont. Instead, fry survival was, in part, positively related to abundance of Brook Trout parr (Raffenberg *and* Parrish 2003).

Interactions between Atlantic Salmon and salmonids not native to eastern North America have also been studied. Rainbow Trout (*Oncorhynchus mykiss*), native to the Pacific coast, now occur in many Atlantic Salmon rivers and are expanding their range in some areas (e.g. Newfoundland; Porter 2000). While the two species demonstrate some degree of habitat overlap, and engage in some interspecific competition (Fausch 1998), juvenile Atlantic Salmon are more closely associated with positions near the substrate (riffle areas) and Rainbow Trout with the water column (or pool habitats) (Hearn and Kynard 1986, Volpe *et al.* 2001). Recent research conducted in Lake Ontario streams also suggests that Atlantic Salmon and Rainbow Trout juveniles can coexist successfully in streams where the habitat is suitable for both species (Stanfield and Jones 2003). Outcomes for salmon resulting from these interactions are often situation-specific, as habitat conditions (Jones and Stanfield 1993), dominance behaviour (Blanchet *et al.* 2007) and prior residence come into play (Volpe *et al.* 2001). Blanchet *et al.* (2008) suggested that increased daytime activity in the presence of juvenile Rainbow Trout might increase predation risk for juvenile Atlantic Salmon.

Two other Pacific-origin salmonids, Chinook Salmon (*Oncorhynchus tshawytscha*) and Coho Salmon (*Oncorhynchus kisutch*), occur in the Great Lakes. High densities of stocked Chinook Salmon have potential to negatively affect Atlantic Salmon behaviour and survival (Scott *et al.* 2003) and interfere with spawning behavior (Scott *et al.* 2005). Similarly, Coho Salmon can affect growth and survival (Jones and Stanfield 1993); however, they are much less likely to have significant impacts due to relatively low abundance and different habitat requirements (Stanfield and Jones 2003).

Atlantic Salmon and Brown Trout (*Salmo trutta*) interactions are relatively well studied. The Brown Trout, a native of Europe, has been introduced to numerous North American systems used by Atlantic Salmon and appears to be expanding its range in Newfoundland (Westley *et al.* submitted). Brown Trout tend to use the margins of runs and pools where water velocity is lower, in contrast to riffle specialization by Atlantic Salmon (Fausch 1998, Bremset and Heggenes 2001, Heggenes *et al.* 2002). Gibson and Cunjak (1986) reported that introduced Brown Trout in the Avalon Peninsula, Newfoundland, were largely segregated from Atlantic Salmon by habitat choice and to some degree, by food habits. Nevertheless there is overlap in types of habitat used by the two species (Heggenes and Dokk 2001). The occurrence of competition between

Brown Trout and Atlantic Salmon is not universal (e.g. Gibson and Cunjak 1986) and appears to be scale-dependent (sample resolution of studies reporting competition are generally <100 m^2; Westley *et al.* submitted). Negative impacts include competition for females, winter shelter (Harwood *et al.* 2002a,b) and spawning habitat, and genetic and survival repercussions associated with hybridization between Brown Trout and Atlantic Salmon (Gephard *et al.* 2000). Competition between these species is most intense at spawning and early juvenile stages (Westley *et al.* submitted). In general, seemingly contradictory results suggest that the view that competition forces an inverse relation between other salmonids and Atlantic Salmon populations may not be tenable at all geographic scales (Cairns 2006).

There are several other non-indigenous species of freshwater fish that have become established in many watersheds containing wild Atlantic Salmon. The species of most concern include Smallmouth Bass (*Micropterus dolomieu*), and species in the pike family: Chain Pickerel (*Esox niger*) and Muskellunge (*Esox masquinongy*). These species are potentially both competitors and predators of juvenile Atlantic Salmon. Introductions are generally the result of directed and illegal transfers of live fish between watersheds. The introduction of non-native species into existing salmon habitat represents a real and expanding threat to the persistence of salmon in the affected and adjacent drainages (DFO and MRNF 2009).

Correlations between survival and growth during first summer/winter at sea suggest food resources may be a limiting factor during some marine phases (Peyronnet *et al.* 2007). However, variable environmental conditions in the ocean, rather than competition-induced shortages, are provided as explanations driving marine growth (Peyronnet *et al.* 2007). Examinations of smolt output and sea survival suggest these two parameters are not linked (Gibson 2006, Reddin 2006) and provide indirect evidence that competition in marine waters is relatively unimportant for Atlantic Salmon. Unfortunately, the vast scale of the Atlantic Salmon's ocean habitat precludes field experiments to directly measure competitive interactions of Atlantic Salmon with other species (Cairns 2006).

Interactions with prey species in the marine environment may also play an important role in marine survival. Studies from the eastern Atlantic show Atlantic Salmon prey on a variety of taxa including, but not limited to: Atlantic Herring (*Clupea harengus*), Capelin (*Mallotus villosus*), Sandeels (Ammodytidae), Gadids, Lantern Fishes (Myctophidae), Barracudinas (paralepidids), various invertebrates (amphipods, copepods, euphausids and crustaceans (shrimps)) (Haugland *et al.* 2006). Atlantic Salmon appear to focus on invertebrates early in their marine phase, but fishes appear to become a more important diet item as salmon grow older and larger (Reddin 1988, Hislop and Shelton 1993, Hansen and Quinn 1998). The diet of Atlantic Salmon in the marine environment is variable both temporally and spatially, suggesting they feed opportunistically as they migrate. This variability in diet makes it difficult to link marine growth and survival to the abundance of specific prey species.

Numerous disease-causing agents have been identified in wild Atlantic Salmon (Bakke *and* Harris 1998). These include *Renibacterium salmoninarium* (bacterial kidney disease (BKD) causing agent), *Aeromonas salmonicida* (furunculosis), infectious pancreatic necrosis virus, *Vibrio anguillarum* and *Edwardsiella tarda* (DFO 1999). There is documented history of some of these diseases in Maritime rivers including furunculosis and BKD (Cairns 2001). Furunculosis can become an important factor in adult in-river survival especially during periods of low flow and warm water. A new disease agent, infectious salmon anemia virus (ISA), was discovered in aquaculture-reared fish in 1997 (DFO 1999). Myxozoa species (likely introduced) have also been reported in juvenile Atlantic Salmon from several Canadian rivers (Dionne *et al.* 2009b).

Within Lake Ontario, recent emergence of viruses new to the Lake Ontario basin have the potential to cause disease and mortality in wild Atlantic salmon (e.g. Viral Haemorrhagic Septicaemia (VHS) detected in 2005). Additionally, salmonid species in Lake Ontario are carriers of the bacteria known to cause bacterial kidney disease (BKD). Atlantic Salmon strains currently being reared to support Lake Ontario restoration efforts are susceptible to disease outbreaks and seasonal mortality when infected with these bacteria.

Adaptability

Atlantic Salmon exhibit a wide range of variation in both phenotypic plasticity and adaptive genetic variation across its range (Taylor 1991, Gibson 1993, de Leaniz *et al*. 2007). From individuals that spend their entire life cycle within a few metres of the natal stream and attain a size of < 10 cm, to 100+ cm individuals that undertake ocean-scale migrations, it is clear that this species has the capacity to adapt to a wide variety of conditions on relatively short demographic and evolutionary scales (Gibson 1993). However, while Atlantic Salmon appear to be flexible within the natural range of variation for freshwater habitat in eastern Canada, the species does not appear to adapt well to major anthropogenic disturbances. In particular human activities that interrupt migratory behaviour (e.g., dams), or drastically impact water quality (e.g., acidification) have led to extirpations in the past (Amiro 2003).

This species adapts well to domestication as is evident in the global aquaculture industry. Recent studies suggest that salmon show a selection response to domestic conditions within a single generation. Unfortunately, rapid selection under domestic conditions can create challenges when attempting to supplement natural populations with hatchery-raised fish. Genetic data suggest that stocked fish have often had limited reproductive success (e.g., Fontaine *et al.* 1997, Saltveit 2006). Transplants of wild stock have been relatively rare. However, there have been documented successes (e.g., Rocky River in DU 4) (Bourgeois *et al.* 2000), usually within a short geographic distance between source and destination sites and into habitats devoid of naturally occurring anadromous populations. Transplanting salmon among DUs may be more difficult due to a higher probability of maladaption. For example, Ritter (1975) showed declining return rates of stocked salmon as the distance to the source population increased. de Leaniz *et al.* (2007) recently reviewed much of the evidence for local adaptation and the role it plays in Atlantic Salmon fitness and ultimately population dynamics. The authors concluded that while local adaptation is likely important, quantitative evidence of its role in processes such as migratory timing, disease resistance or growth rate are scarce.

POPULATION SIZES AND TRENDS

The data compiled for the analysis of all Canadian DUs were provided by the Canadian Department of Fisheries and Oceans and the Quebec Ministère des Resources naturelles et de la Faune. Spawning escapement estimates (the number of fish available to spawn each year after all fisheries have taken place) were used throughout the trend analysis. Escapement was chosen over pre-fishery abundance based on COSEWIC criteria to use “mature individuals who are capable of reproducing”. Within COSEWIC, definitions of mature individuals are further defined as follows: “Mature individuals that will never produce new recruits should not be counted”. Assuming a significant proportion of the salmon captured historically in commercial and recreational fisheries would have reproduced, the use of spawning escapement data in trend analysis would, relative to the abundance of fish before the fisheries occur, will underestimate the extent of decline in several DUs (compare the trends shown in Figures 13 and 14). However, when spawning escapement is used for the trends analysis, the effectiveness of management actions such as fishery closures (described in the next section) is taken into account in the analysis. Canadian abundance reconstruction suggests significant declines in pre-fishery abundance across all DUs and the North American population as a whole (Chaput 2009; Figure 14). This decline appears to have stabilized in most northern regions during the last 3 generations (DUs 1-3, 5-7), but not in the south.

The analysis of population trends was standardized to provide consistent assessments across DUs. Catch data were used primarily in the analysis despite the potential error associated with these types of data (O’Connell 2003) as it was widespread and common to most areas. These data do, however, carry significant risk and uncertainty. O’Connell (2003) demonstrated that major differences can occur when using recreational catch data to infer total returns. He showed that in one case returns were overestimated by approximately 60% in four of seven years. A review of the status of salmon (Dempson *et al.* 2006) stated that stocks for which only angling data were available are not routinely evaluated, in the Newfoundland-Labrador region. Reasons for this included changes in daily and season bag limits, the introduction of split seasons and quotas in some areas in some years, the switch from DFO Guardian-provided recreational catch data to that obtained from a licence stub return system, the complexities and confusion of interpreting catch-and-release statistics over the years, and the fact that in some areas and years 35-65% of all potential fishing days may be unavailable owing to environmental closures. O’Connell *et al.* (1998) also showed there could be substantial differences between angling data derived from the licence stub system versus that provided by DFO Guardians for years when the two methods overlapped. This depended on the year and area in question, and was much more pronounced for released fish rather than retained salmon. Despite these well-documented potential problems these were the only data available for all DUs that would allow nation-wide comparison. In some areas, data were limited (e.g. DUs 1 and 2) and/or better info was available (DUs 13, 14). Details on sampling effort and data quality issues are provided for each DU. River-specific trend data from other sampling methods are presented graphically where available. Where the catch data trends diverge from river-specific data, the differences are noted in the DU text.

COSEWIC specifies time frames of 10 years or three generations (whichever is longer) in the examination of population trends. The complex and variable life history of Atlantic Salmon results in different generation times within and among rivers. A DU-specific generation time was determined by averaging the modal smolt age for the rivers presented in Chaput *et al.* (2006a)[xv] and adding 1 or 2 years for the marine phase of life, depending on whether MSW fish were common in the specific DU. This approach would slightly underestimate generation time in populations where repeat spawning frequency is high. Smolt ages were typically consistent or within one year of other rivers within a DU. Abundance trends were analyzed using a time series for which the length was determined by multiplying the generation time by three and roughing up to the whole number. For example, if the generation time was 4.1 years, the trend was analyzed over 13 years.

Abundance trends were assessed with a general linear model using a negative binomial error distribution (all statistics computed using R; R Development Core Team (2007)). Values for the calculation of percent change in abundance were taken from the predicted values of the general linear model (latest year and that from 3 generations previous). These estimates of change isolate temporally driven change and are more robust to spurious results. The statistical significance of the estimates trends was assessed at the 95% confidence level. Forward projections have not been provided due to the known dangers of predicting outcomes beyond the range of the data collected. They would also require unrealistic assumptions of static conditions and the absence of abundance-dependent phenomena such as depensation (which would hasten the decline) or compensation (which would slow or halt the decline). Because significant declines have occurred during the last four decades (Reddin 2010; Figure 14), and because for some DUs, the inclusion of just one extra generation resulted in significant trends that were not detected in analyses using three generations, where available longer time series are presented graphically for each DU.

The estimate of abundance for Canada is based on the sum of all DU-specific data and should be considered a minimum value as full abundance estimates were not available for DUs 1, 13 and 14. The ‘complete’ data set spans 1993-2007. The Canadian estimate of abundance of spawning, wild adult Atlantic Salmon was 524,288, in 2007. Of these 414,163 were small salmon and 110,154 were large salmon. Where data were available, 2008 appeared to have improved returns versus 2007. The lowest estimate over the data set was 364,373 in 1994 while the highest was 611,405 (1996). Overall, the model-based estimate of total abundance appears to have increased slightly since 1993 (by 11%), but the trend in the data was non-significant (P = 0.41; Figure 15). Small salmon abundance has increased by 19% from 1993 levels, while large salmon abundance has decreased by 14% of 1993 levels. Neither trend was significant over three generations (P = 0.246 and 0.136 respectively). However, within this broad assessment there are population components and regions that are experiencing significant declines (i.e., MSW salmon and DUs 4, 8, 9, 14, 15, 16; Table 2) or are extinct (DU 11[xvi]). Regions at the southern extent of the Canadian range (Nova Scotia Southern Upland, DU 14; inner and outer Bay of Fundy, DUs 15 and 16) have undergone marked declines. Trends from individual DUs suggest that small and large salmon may be on differing trajectories of abundance, although neither trend is significant at the Canadian scale in the last three generations. Reddin and Veinott (2010) also suggest that small salmon are increasing in abundance while large salmon are declining. The analysis used in this report was applied to the data for Newfoundland and Labrador, presented by Reddin and Veinott (2010) and Reddin (2010), and it was determined that the increasing trend in small salmon abundance was marginally significant (P = 0.061) and the declining trend in large salmon abundance was highly significant (P < 0.001). The overall trend for total salmon was not significant (P = 0.302). Large salmon have declined to 59% of 1993 levels. The divergent trends for MSW and 1SW salmon abundance are difficult to explain, but the data suggest that the risk of extended periods at sea may be relatively higher than it was historically. Repeat spawners (with the exception of DUs 14-16) have experienced improved survival in recent years (e.g. Cameron *et al.* 2009).

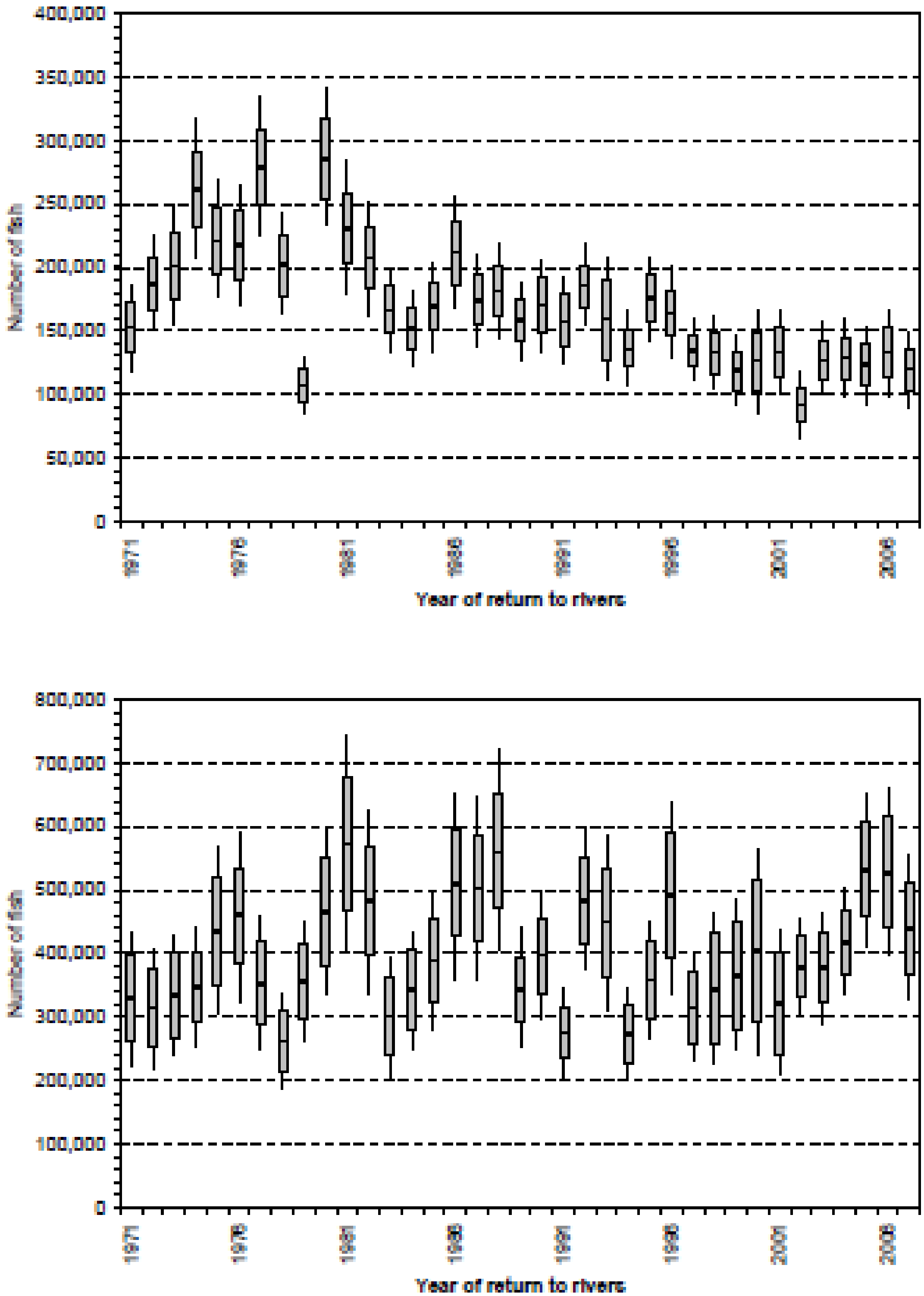
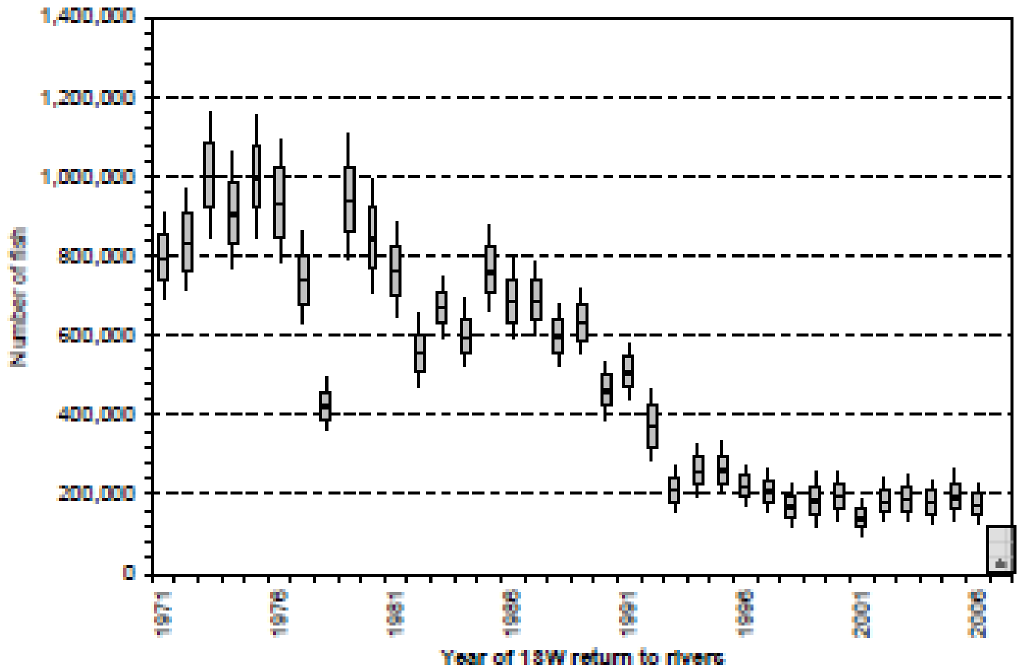


Figure 13. Posterior distributions from Monte Carlo simulation of estimated returns to the rivers/coast (after sea fisheries of Newfoundland and Labrador and St. Pierre and Miquelon) of large salmon (upper) and small salmon (lower) for eastern North America, 1971 to 2007. Box plots are interpreted as follows: dash is the median, rectangle defines the 5th to 95th percentile range, vertical line indicates minimum and maximum values from 10,000 simulations (taken from Chaput 2009).



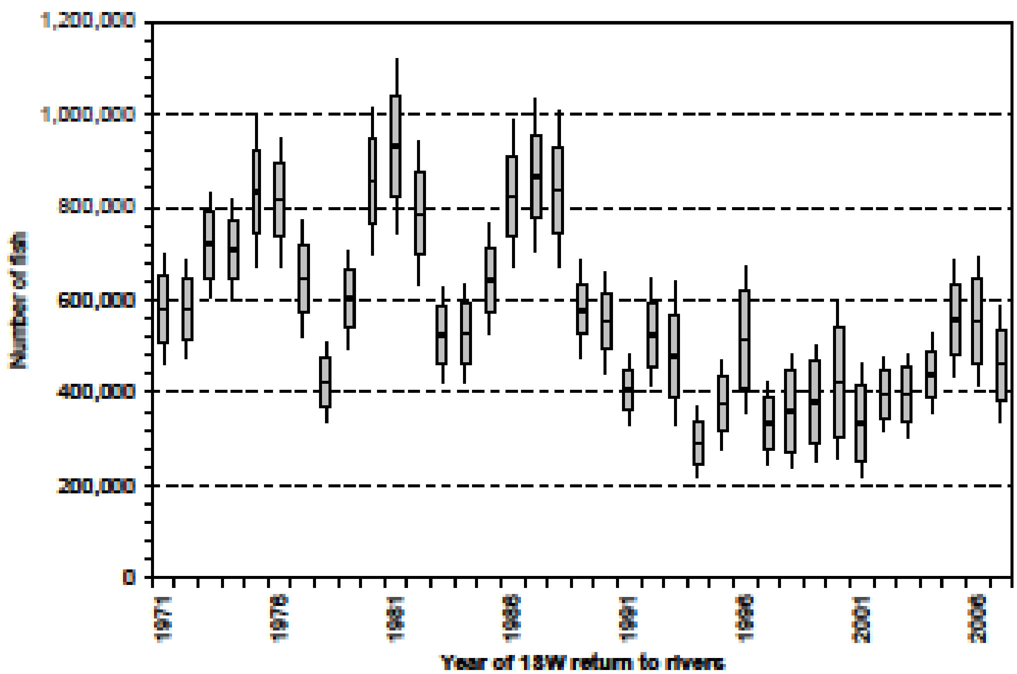


Figure 14. Posterior distributions from Monte Carlo simulation of estimated pre-fishery abundance of large salmon (upper) and small salmon (lower) from eastern North America, 1971 to 2007. Pre-fishery abundance for large salmon is only available to the 1SW year of 2006. Box plots are interpreted as follows: dash is the median, rectangle defines the 5th to 95th percentile range, vertical line indicates minimum and maximum values from 10,000 simulations (taken from Chaput 2009).

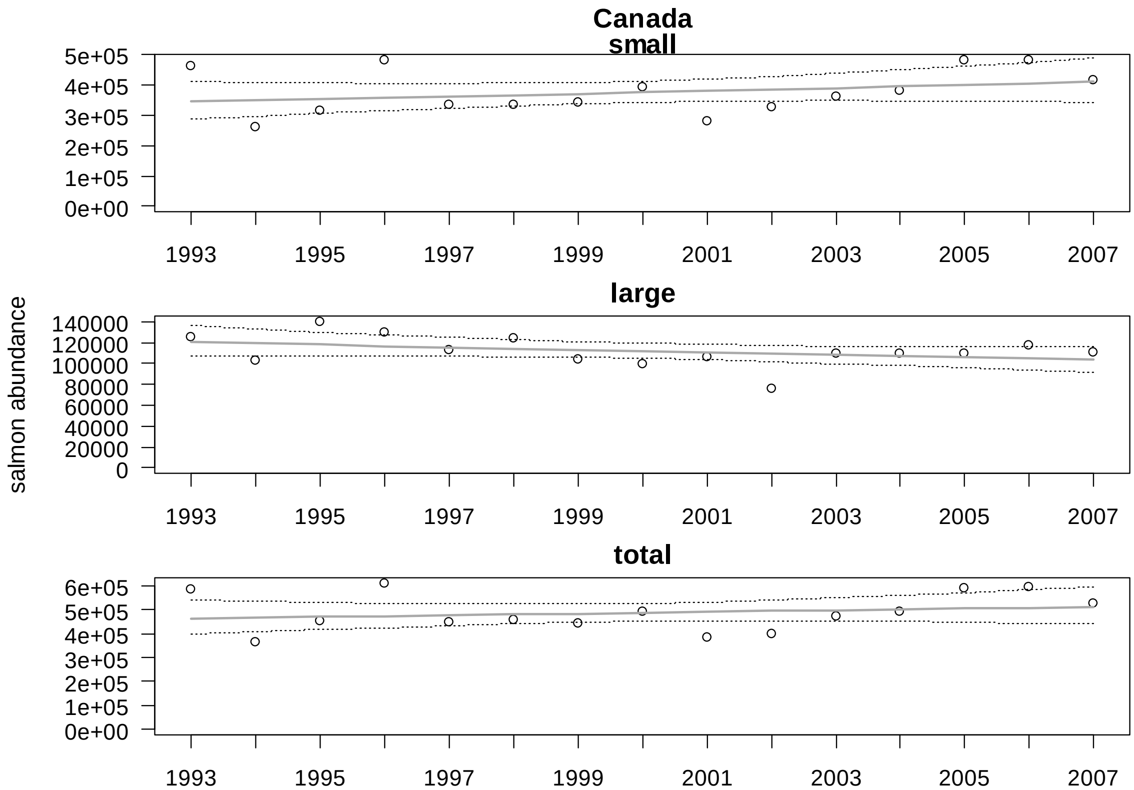


Figure 15. Small, large and total Atlantic Salmon escapement for Canada (small: top panel; large: middle panel; total: bottom panel) over the past 3 generations (15 years). Superimposed is the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance.

Fisheries management[xvii]

The abundance of Atlantic salmon in Canada has been significantly influenced by fisheries management policy. To provide further context, a brief overview of fisheries management is presented.

As early as the 1970s, fisheries managers began placing restrictions on commercial Atlantic salmon harvests to replenish depleted stocks (May 1993). When pronounced declines in abundance were observed in the 1980s, a wide range of additional management measures were introduced for conservation purposes. The closures of commercial fisheries were expanded in 1984 to include all the commercial fisheries of the Maritime Provinces and portions of Quebec. Further reductions were introduced through the late 1980s and early 1990s, leading to a moratorium on commercial Atlantic Salmon fishing for insular Newfoundland in 1992, followed by a moratorium in 1998 for Labrador, and culminating with the closure of all commercial fisheries for Atlantic Salmon in eastern Canada in 2000.

In 1984, mandatory catch and release in recreational fisheries of all large Atlantic Salmon was introduced in the Maritime Provinces and insular Newfoundland. Since then, more restrictive angling management measures have been introduced in an attempt to compensate for declining survival and Atlantic Salmon abundance, including reduced daily and season bag limits, mandatory catch and release of large and in some cases all sizes of Atlantic Salmon, and in large portions of the Maritimes, the total closure of all directed fisheries.

The need for increasingly severe restrictions on harvests over the past decades reflects the chronically unrealized expectations of Atlantic salmon stock recovery. Though population increases did occur, they were often short-lived (e.g. Dempson *et al.* 2004). Over longer terms, harvest restrictions in most DUs have generally contributed to the stabilization of declining populations or slowed declines (the exceptions being DUs 2 and 5). As stated previously, the positive contributions of these management restrictions may have had the effect of lessening the degree of reduction in the productive capacity of Atlantic salmon populations, as indicated by spawning escapement indices, but could mask the actual decline in overall abundance of salmon based on the indicators of total returns or pre-fishery abundance.

Table 2. Trends in Atlantic Salmon spawner abundance for designatable units of eastern Canada. Probability values associated with inferred trends are given in parentheses. Note that DUs annotated with asterisks reflect abundance estimates for a subset of rivers. DD - Data Deficient.

Designatable Unit	Recent Abundance (Year)	Small Salmon % change over 3 generations (p-value)	Large Salmon % change over 3 generations (p-value)	Total Salmon % change over 3 generations (p-value)
1 - Nunavik	DD	DD	DD	DD
2 - Labrador	235,064 (2008)	+443.9 (<0.001)	+127.9 (0.016)	+380 (<0.001)
3 - NE Newfoundland	80,505 (2007)	-11.0 (0.569)	+1.7 (0.946)	-9.6 (0.619)
4 - S Newfoundland	21,866 (2007)	-37.3 (0.063)	-26.2 (0.293)	-36.1 (0.071)
5 - SW Newfoundland	44,566 (2007)	+132.1 (<0.001)	+143.7 (<0.001)	+133.6 (<0.001)
6 - NW Newfoundland	31,179 (2007)	-4.2 (0.838)	+41.7 (0.126)	0.0 (0.999)
7 - Qc E North Shore	5,901 (2008)	-26.3 (0.0.085)	50.8 (0.115)	-13.79 (0.287)
8 - Qc W North Shore	15,135 (2008)	-34.0 (0.031)	-20.1 (0.143)	-24.4 (0.013)
9 - Anticosti Island	2,414 (2008)	-31.7 (0.076)	-48.7 (0.017)	-40.2 (0.007)
10 - St. Lawrence	4,169 (2008)	-1.8 (0.951)	+11.5 (0.429)	+5.27 (0.772)
11 - Lake Ontario	Extinct[1]	-	-	-
12 - Gaspé-Gulf	103,149 (2007)	-34.0 (0.119)	-18.5 (0.217)	-27.8 (0.100)
13 - E Cape Breton*	1,150 (2008)	-7.9 (0.789)	-14.5 (0.542)	-28.9 (0.202)
14 - NS Southern Upland*	1427 (2008)	-58.6 (0.002)	-74.0 (0.001)	-61.3 (<0.001)
15 - I Bay of Fundy	<200	-	-	-
16 - O Bay of Fundy	7584 (2008)	-56.6 (0.024)	-81.6 (<0.001)	-64.3 (0.001)

[1] Currently assessed as Extirpated (COSEWIC 2006a); however, this report proposes that it be revised to Extinct, in keeping with the implication of the current COSEWIC guidelines for recognizing DUs, that loss of an entire DU represents an extinction event, not an extirpation.

Designatable Unit 1 – Nunavik

Data were limited to the sporadic angling effort and catch statistics for Ungava Bay (MRNF 2009, MRNF unpublished data). The limitations of these data restricted the analysis to assessment of catch per unit effort (CPUE). As with all fishery-dependent data, the assumptions of constant catchability of the salmon and the equivalence of effort over the data set are likely to be violated. However, given that the fishery is limited to angling, changes in fishing gear and techniques are less of a factor than in commercial fisheries. Unfortunately, catchability of Atlantic Salmon is heavily influenced by water conditions. Angler data are the only type consistently available for almost all salmon populations, thus a broad assessment requires its utilization.

The data for Ungava Bay was from four of the five known salmon rivers during the time period 1984 – 2008. Mean rod-days per year was 1,014 with a range of 415-1,615. Effort has generally been declining over the time series. No estimate of abundance could be calculated. There also was a significant increasing trend in CPUE over the time series (GLM on catch with effort offset: P=0.007). While the data only include four rivers with commercial angling activities, salmon have been reported from other rivers in this DU. The George River and the Koksoak River had substantially higher CPUE estimates than the Feuilles and Baleine rivers, suggesting higher abundances over the time series. There have been no known extirpations in this area.

Designatable Unit 2 – Labrador

Data for the Labrador DU were diverse. There were commercial catch data (1969-2001) (Reddin 2010) and count data from four counting fences (2002-2008). These data were used in conjunction with habitat data to estimate abundance per habitat unit over time, which was then scaled up for the whole region, which includes 85 Labrador salmon rivers (Reddin 2010). The five rivers from Quebec that are part of DU 2 have spawner abundance time series, based on catch data, that were added to the Labrador data to derive an abundance time series for the entire DU.

There is considerable uncertainty associated with these data since it assumes the four index rivers in southern Labrador are representative of a huge geographical region (scaling from ~1,700 to 65,500 km^2), which includes varying intensities of Aboriginal fishing and habitat quality. Furthermore, information from Quebec rivers is based on angler data (MRNF 2009, MRNF unpublished data) and habitat scaling (Caron and Fontaine 1999) that are also characterized by considerable uncertainty.

The most recent estimate of adult abundance for DU 2 is 235,064 with 206,093 being small salmon (<63 cm) and 28,970 being large salmon (>63 cm). The lowest abundance during the last three generations was 30,555 in 1991. The highest abundance over the same time frame was 242,758 in 2005. During the last three generations there have been significant increases in abundance of small (P<0.001), large (P=0.016) and total salmon (P<0.001) (Figure 16). The abundance of small salmon (based on the curve fit in Figure 16) is 443.9% greater than the 1990 abundance while large salmon abundance is up by 127.9% over the same period. Total salmon are at levels 380.0% of those in 1990 (Figure 16). Data for counting fence facilities in DU 2 (English River, Muddy Bay Brook, Sandhill River and Southwest Brook) are provided in Figure 17. Additional river-specific abundance data are provided in Appendix 1 (see Big Brook, Pinware, Forteau and du Vieux Fort rivers).

As with all following DUs (except DU 11), it should be noted that using statistics of adult salmon spawners as a measure of population health has the disadvantage of potentially masking the severe declines observed in pre-fishery abundance. In this case, when commercial fishery-related mortality is accounted for, current levels of salmon abundance in DU 2 are much lower than expected (Reddin 2010).

The only known population to be lost from this DU was Bobby's Brook, located near the Alexis River. There has been no evidence of re-colonization of this tributary to date (D. Reddin, Dept. of Fisheries and Oceans, pers. comm.).

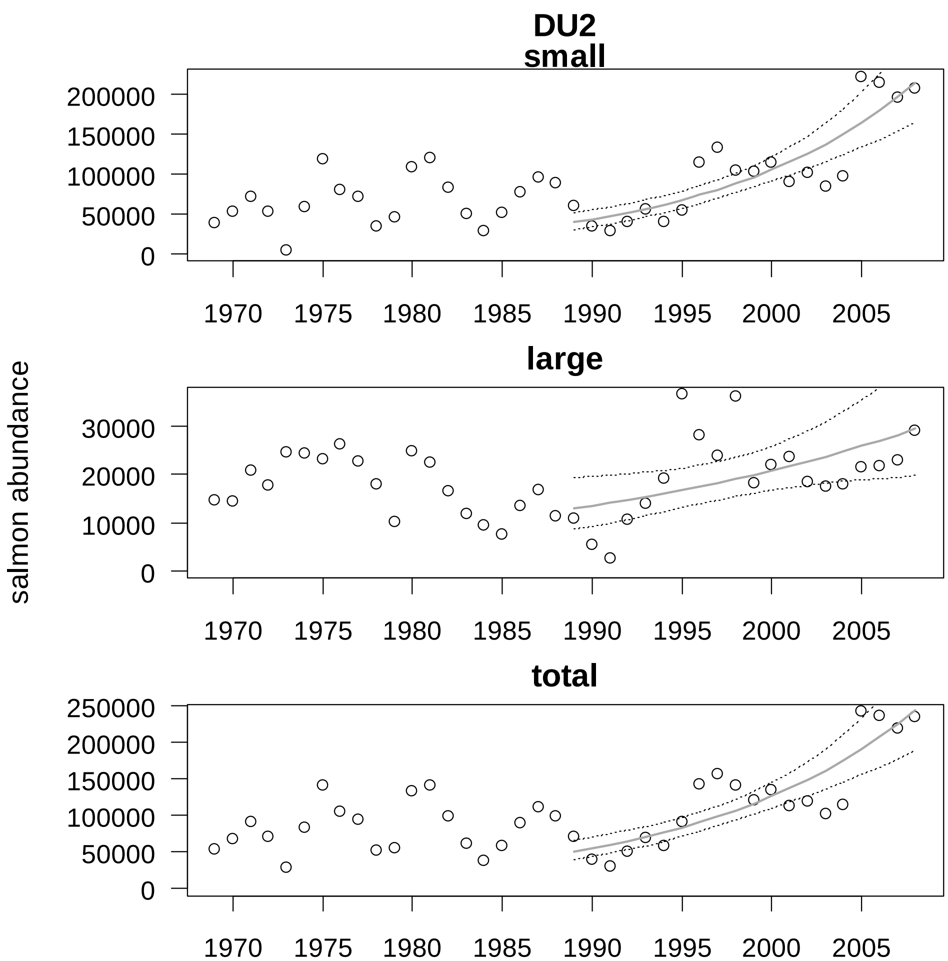


Figure 16. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 2 (1969-2007). Superimposed is the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance over the past 3 generations. Note that pre-1984 data for Quebec components of DU 2 were unavailable and are not included in this plot. Since 1984, the Quebec component only contributed an average of 4% of the run (range: 1-12%).

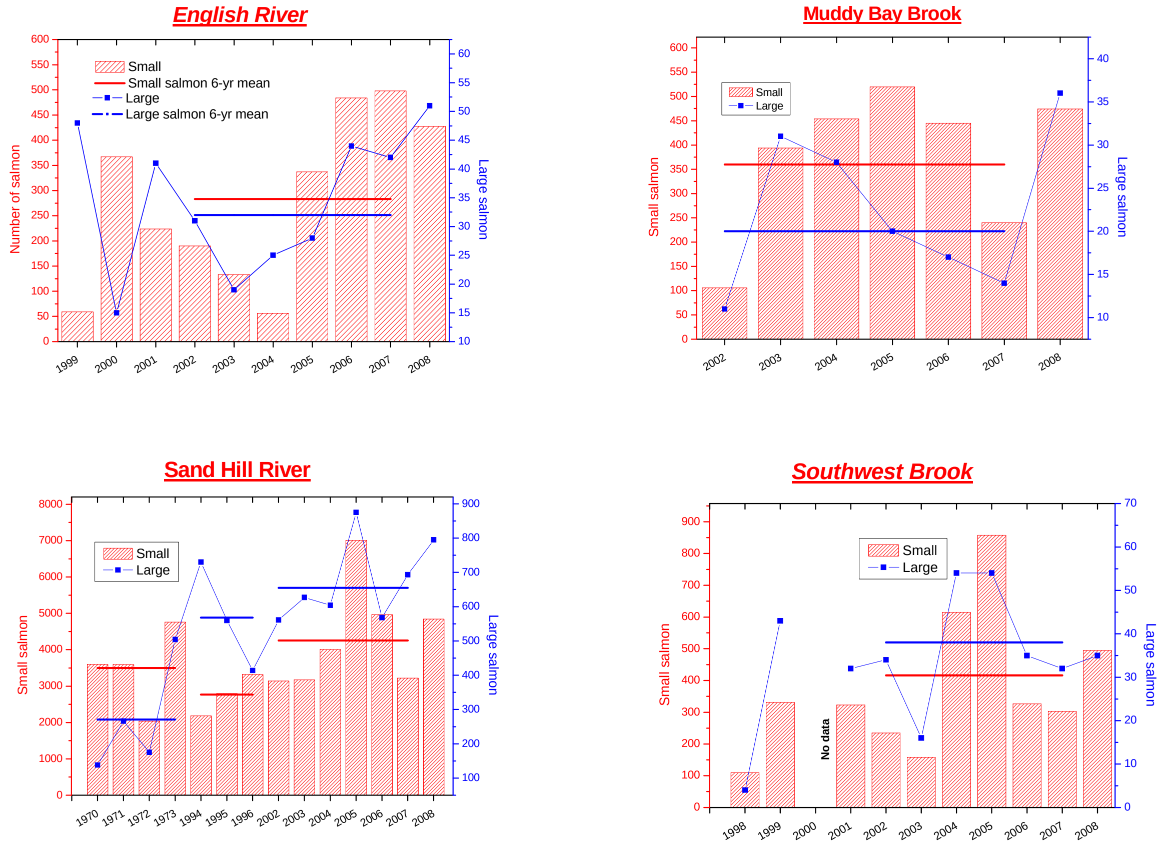


Figure 17. Salmon abundance in four index rivers in Southern Labrador (taken from Reddin 2010). Note that the time periods are not identical among the panels and that the Sand Hill data include breaks in the time periods.

Designatable Unit 3 – Northeastern Newfoundland

The data available for DU 3 consists of angler (1969-2007) and commercial (1969 – 1992) catch data, and counts from 6-8 counting fences (mean of 7 per year). Estimates of abundance for the entire DU were calculated based on angler catch and effort data, adjusted for catch rates based on data from rivers with counting fences (Reddin and Veinott 2010, but see O'Connell 2003). Rivers with no angling catch were not included in the abundance estimates provided. Another challenge with these data is the large increase in abundance of salmon in the enhanced Exploits River, where extensive unused habitats were made available (Mullins *et al.* 2003). In some years, the Exploits and Gander rivers can account for nearly half the population of this DU and this swamping effect should be considered when examining trends for DU 3.

DU 3 has 127 documented salmon populations, with a substantial number of small streams that appear to have transient populations (juveniles are always present but adults return sporadically; C. Bourgeois, Dept. of Fisheries and Oceans, pers. comm.). The most recent estimate of adult abundance for DU 3 is 80,505 (51,883-109,267) from 2007, with 68,654 being small salmon, and 11,851 being large salmon[xviii]. The lowest abundance during the last three generations was in 2002 with 58,584 (Figure 18). The highest abundance during the last three generations was 141,968 in 1996. There were no significant trends in abundance for small, large or total salmon for this DU over the last three generations (P = 0.569, 0.947, and 0.618 respectively). The abundance of total salmon has declined by 9.5% over this time period (based on the curve fit in Figure 18), while small are 9.6% less abundant than three generations ago in 1994 (Figure 18). Large salmon abundance is estimated to have increase by 1.7% during this time period. As in Labrador, the non-significant trends in abundance, presented here for the past three generations, seem incomplete without considering the effects of commercial fishery closures that occurred in 1992 and remain in effect now. The returns data presented here do not include the commercial removals that were very high in the years up to 1991 (Reddin and Veinott 2010). Inclusion of these data is problematic because the landings include some salmon not originating from rivers within the DU. Reconstruction of pre-fishery abundance paints a picture of a substantial decline that has stabilized during the past 3 generations (DFO 2008). Additionally, more recent runs have not met increased expectations associated with improving escapement levels post-moratorium. Freshwater productivity has remained stable (DFO 2008) and there have been no reported extirpations of salmon in DU 3. Data from individual rivers monitored with counting fences (Exploits River, Gander River, Middle Brook, Terra Nova River and Campbellton River) are provided in Figure 19. Supplementary abundance data (for Indian Bay Brook, Northwest River and Indian River) are provided in Appendix 1.

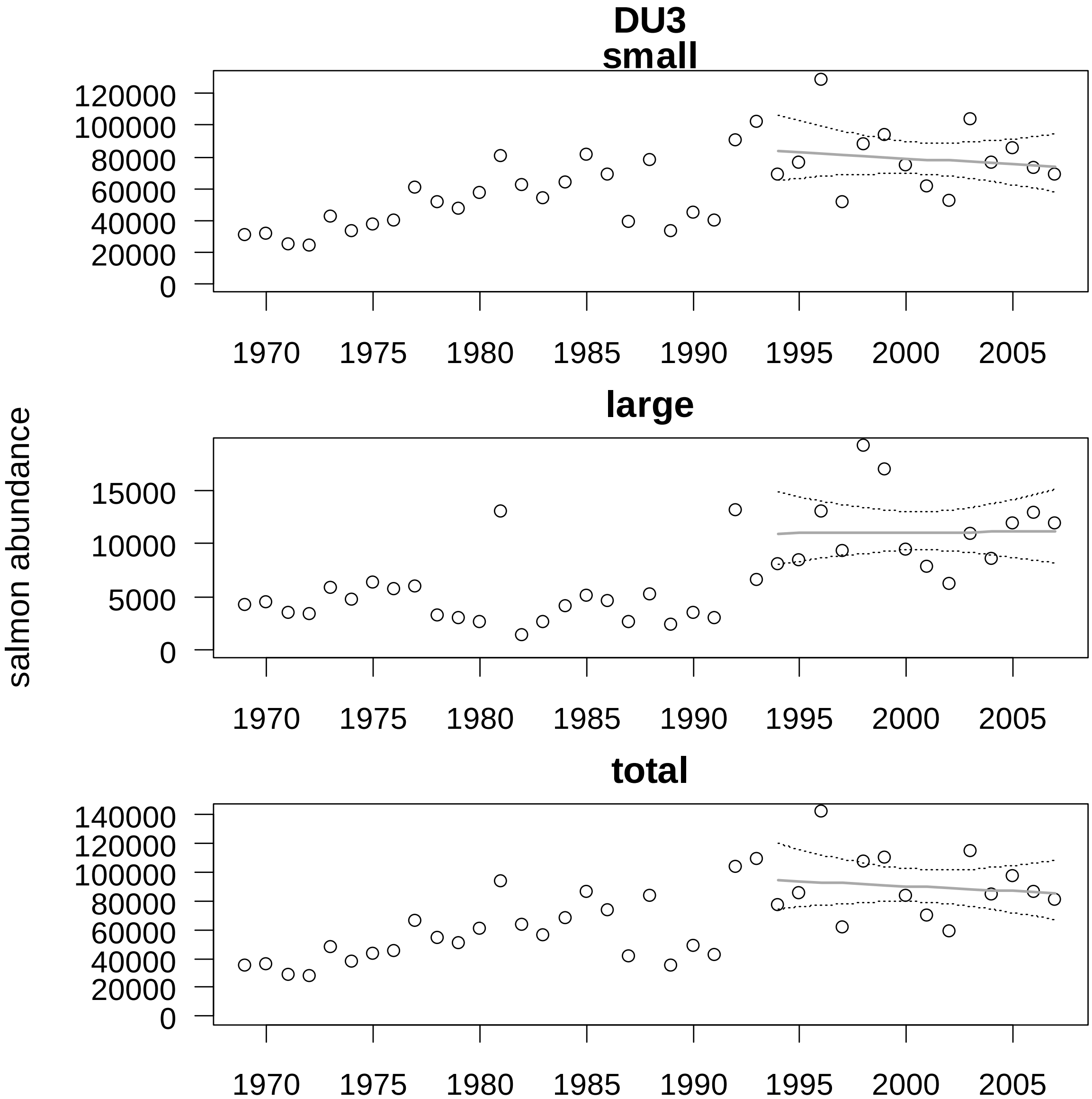


Figure 18. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 3 (1969-2007). Superimposed is the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance over the past 3 generations.

Figure 19. Small (left panels) and large (right panels) salmon abundance from counting fence facilities (Exploits, Gander, Middle, Terra Nova and Campbellton) of DU 3 (taken from Reddin and Veinott 2010).

Designatable Unit 4 – South Newfoundland

The data available for DU 4 consisted of angler (1969-2007) and commercial (1969 – 1992) catch data, and counts from 5 counting fences (mean of 4 per year) (Reddin and Veinott 2010). Angler catch data was based on a mean estimate of 20,527 rod days per year with a range of 12,208 – 32,642. There are 104 known rivers in this DU, with no known extirpations and one introduced population (Rocky River). Conne River had the highest estimated abundance over the time series, peaking at just over 10,000 returning adults. Most rivers in this DU appear to have mean abundances of less than 500 spawning adults (Dempson *et al.* 2006). Angling effort has declined by nearly 50% over the last 15 years. Estimates of abundance for the DU were calculated based on angler catch and effort data, adjusted using the catchability data from the rivers with counting fences (Reddin and Veinott 2010). The fishery-independent data from this DU are heavily biased to the eastern side of the DU and may not be representative of the entire DU. Furthermore, rivers with no angling catch were not included in the abundance estimates provided.

The most recent estimate of adult abundance for DU 4 is 21,866 (14,021-29,711) from 2007, with 18,633 (12,411-24,854) being small salmon, and 3,233 (1,610-4,857) large (Figure 20). The lowest abundance during the last three generations was in 2001 with 18,409. The highest abundance during the last three generations was 60,008 in 1996. The abundance of small salmon (based on the curve fit in Figure 20) declined by 37.3% since 1994. The abundance of large salmon has declined by 26.2% since 1994, and total salmon abundance has declined by 36.0% (Figure 20). Estimated declines in the abundance of small and total salmon are marginally insignificant ($P = 0.063$ and 0.071 respectively), but the estimated decline in large salmon abundance is not significantly different from zero ($P = 0.293$). It is worth noting that while trends in abundance were similar between catch data and counting facility data for this DU, the counting facility data and total catch information suggest that 2007 was the lowest year on record not 2001. Additionally, these decline rates are sensitive to the length of the time series used. Extending the time series back one additional year yields decline rates of 52.5% and 50.1% for small and total salmon respectively, both of which are statistically significant ($P < 0.01$).

Previously published trends for individual populations, where counting fences exist, can be found in Figure 21. Supplementary abundance data (for Biscay Bay River) are provided in Appendix 1.

The Conne River has exhibited the most substantial decline, strongly influencing the total abundance for DU 4.

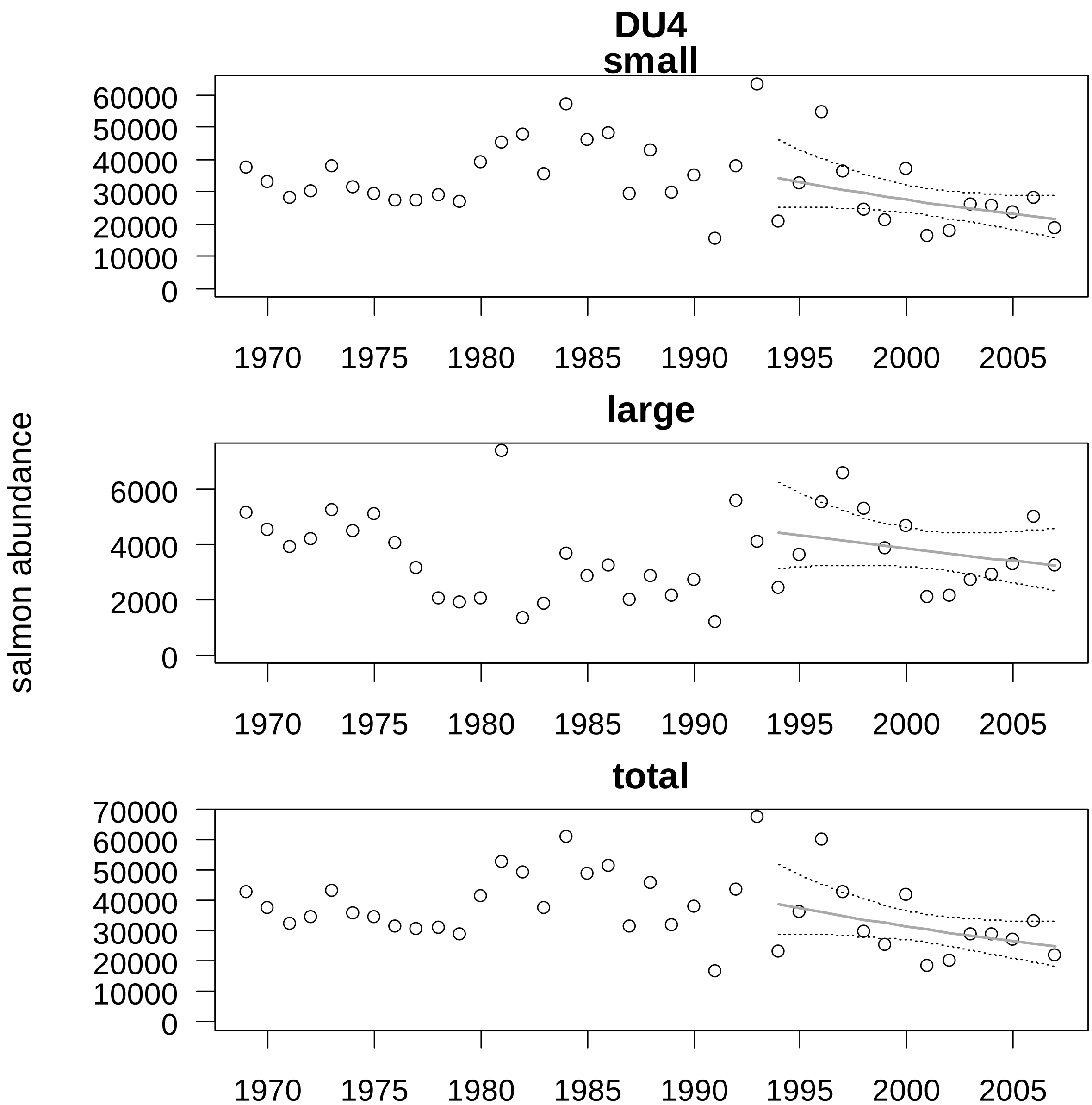


Figure 20. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 4 (1969-2007). Superimposed is the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance over the past 3 generations.

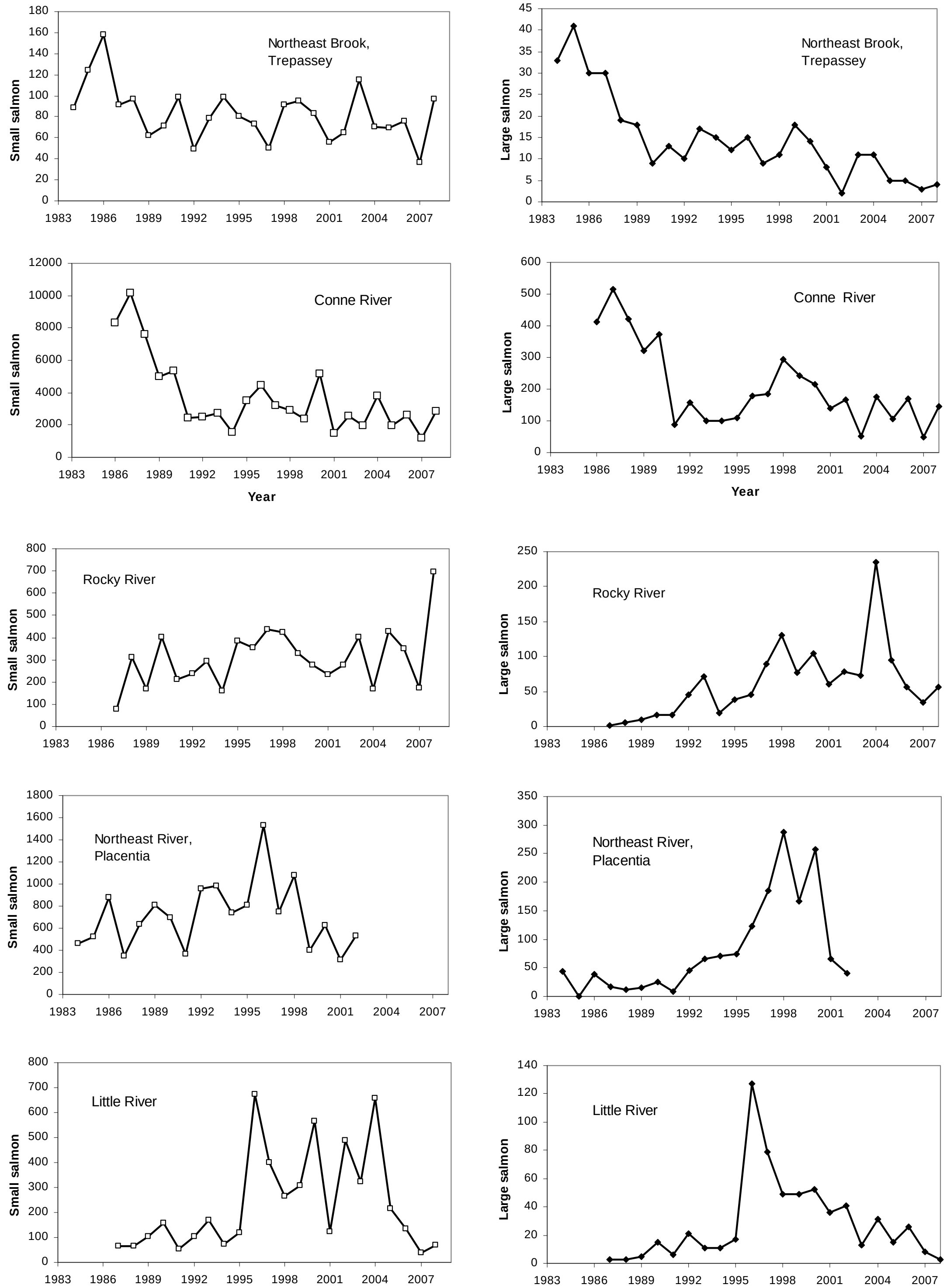


Figure 21. River-specific trend data from the five active counting facilities (Northeast Trepassey, Conne, Rocky, Northeast Placentia, and Little Rivers) in DU 4. Data for small (left panels) and large salmon (right panels) are presented separately for each river (taken from Reddin and Veinott 2010).

Designatable Unit 5 – Southwest Newfoundland

The data available for DU 5 consisted of angler (1969 – 2007) and commercial (1969 – 1992) catch data, and counts from two counting fences. Five of the DU 5 rivers are also assessed with annual swim-through surveys. Angler catch data was based on a mean estimate of 25,899 rod days per year with a range of 18,544-38,487. Angling effort has increased significantly (P= 0.004); by nearly 240% over the data set. Estimates of abundance for the entire DU were calculated based on angler catch and effort data, adjusted using catch rate data from rivers with counting fences (Reddin and Veinott 2010). Furthermore, where angling data were unavailable, abundance was scaled according to available habitat. While these fishery-dependent data are corrected with fishery-independent data, estimates should be considered with the same caveats described above.

DU 5 has an estimated 40 rivers with salmon populations. There have been no known extirpations in this DU. The most recent estimate of adult abundance for DU 5 is 44,566 (32,143-56,988) from 2007, with 37,679 (27,828-47,531) being small salmon, and 6,886 (4,315-9,457) being large salmon. The lowest abundance during the last three generations was in 1991 with 15,488 salmon while the highest abundance was 68,441 in 2006. There was a significant increase in the abundance of small, large and total salmon (all P values < 0.001). The abundance of small salmon (based on the curve fit in Figure 22) is 132.1% greater than three generations previous. Over the same time period, the abundance of large salmon increased by 143.7, while total salmon abundance is 133.6% greater (Figure 22). Despite increasing trends and four of five monitored rivers meeting conservation requirements, population abundance in these rivers is considered low (DFO 2008). Trends for individual populations where counting fences exist can be found in Reddin and Veinott (2010). The Humber River is the largest population in this DU with abundance estimates ranging from 6,125 to 32,118 salmon. Abundance in populations south of the Humber, in the Bay St. George region, ranged from 235 to 3,684 salmon, with Harry’s River having the highest abundance estimates. Data for snorkel-surveyed rivers (Harry’s, Robinsons, Crabbes, Fischells and M. Barachois) are provided in Figure 23. Supplementary abundance data (for Highlands, Flat Bay, Humber and Grand Bank rivers) are provided in Appendix 1.

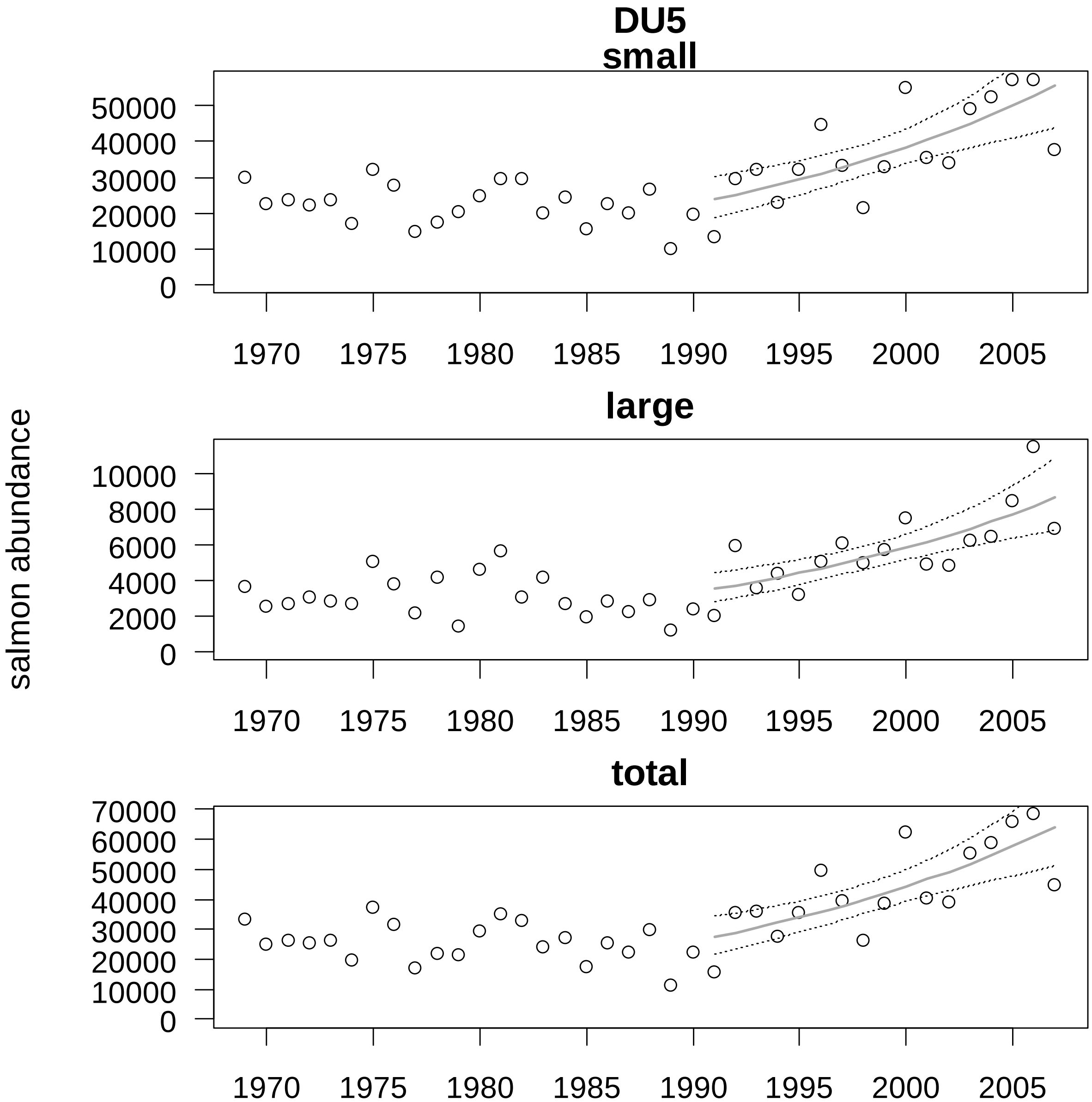


Figure 22. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 5 (1969-2007). Superimposed is the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance over the past 3 generations.

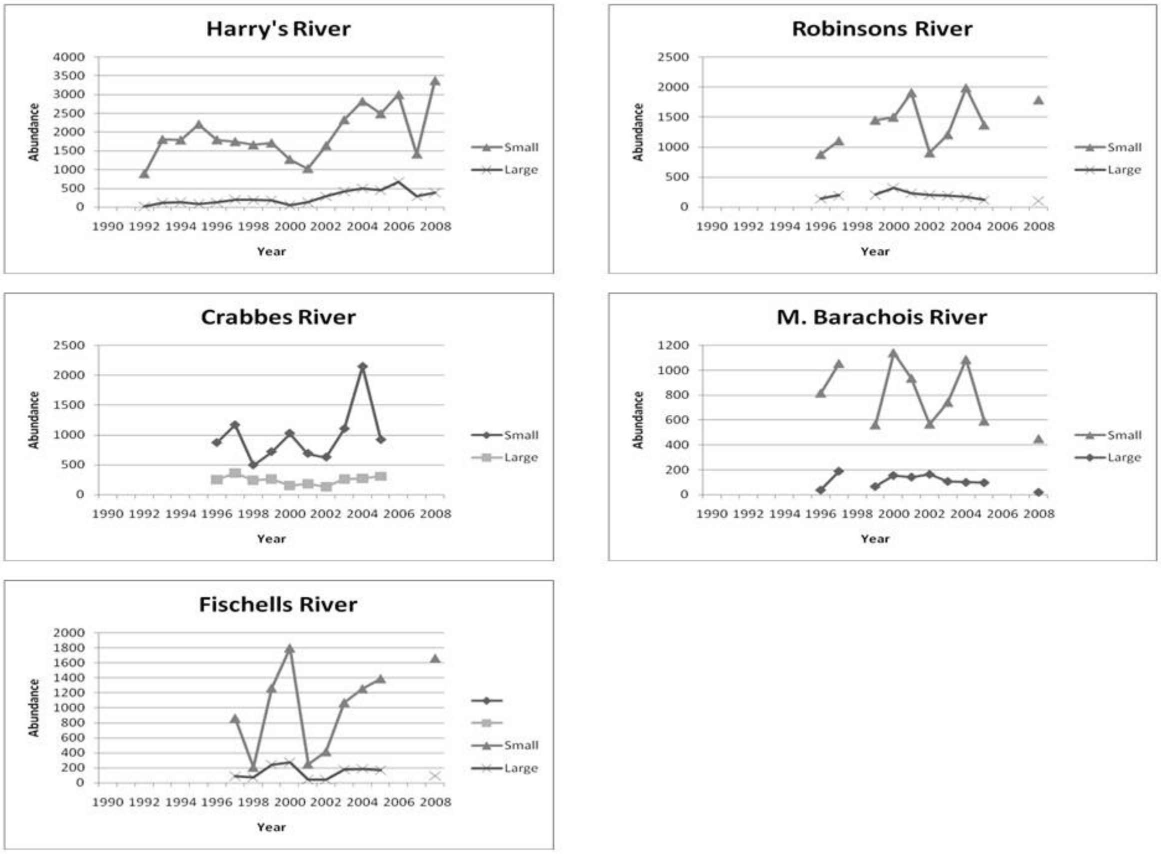


Figure 23. Abundance estimates for Atlantic Salmon in snorkel-surveyed rivers of DU 5 (taken from Reddin and Veinott 2010).

Designatable Unit 6 – Northwest Newfoundland

The data available for DU 6 consisted of angler (1969 – 2007) and commercial (1969 – 1992) catch data, and counts from three counting fences; although data are not available from the three fences in all years (Reddin and Veinott 2010). Angler catch data was based on a mean estimate of 15,517 rod days per year with a range of 10,386-19,695. Angling effort has decreased significantly (P= 0.004) to 82% of mid-90s values. The Torrent River has had a substantial amount of habitat made available as part of an enhancement project. Significant increases in abundance of this population may influence overall trends in the DU. Estimates of abundance for the entire DU were calculated based on angler catch and effort data, adjusted using catch rate data from rivers with counting fences (Reddin and Veinott 2010). Estimates should be considered with the same caveats described above.

There are 34 salmon rivers in DU 6, of which none have been extirpated. The most recent estimates of adult abundance for DU 6 is 31,179 (20,061-42,296) from 2007, with 26,603 (17,786-35,420-9,457) being small salmon, and 4,576 (2,275-6,876) being large salmon (Figure 24). Abundance estimates during the last three generations range from 19,369 salmon in 1994 to 51,570 salmon in 1996. There were no significant trends in the abundance of small, large or total salmon (P = 0.838, 0.125, and 0.999 respectively). The abundance of small salmon (based on the curve fit in Figure 24) has decreased by 4.2% over the last three generations. The abundance of large salmon is 41.7% greater over the same time period, and the trend line for the abundance of total salmon has a slope of zero over this time period (Figure 24). Abundance estimates were available from two monitored rivers in this DU in 2008 (Torrent River and Western Arm Brook) and both were above the conservation requirement (DFO 2008). Supplementary abundance data (for Lomond, Torrent rivers and Western Arm Brook) are provided in Appendix 1.

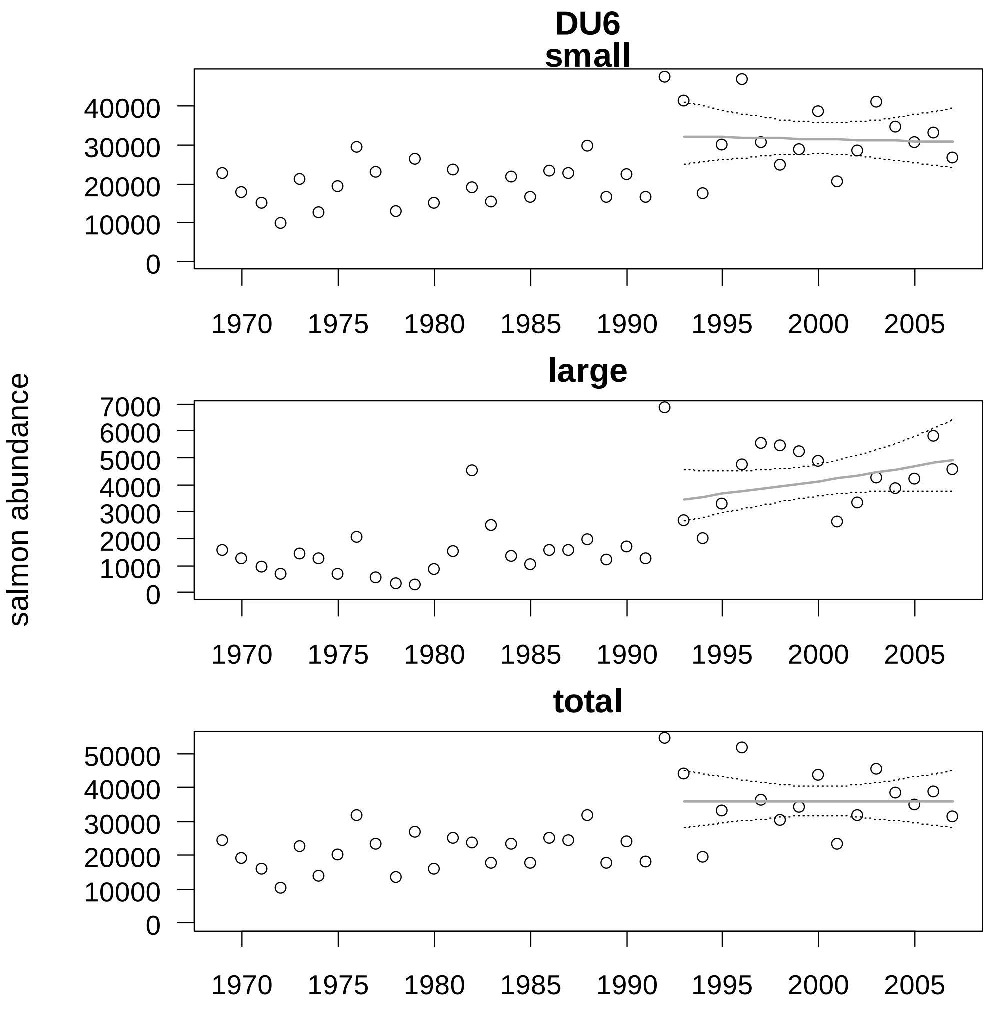


Figure 24. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 6 from 1969 to 2007. Superimposed is the fit from the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance over the past 3 generations.

Designatable Unit 7 – Quebec Eastern North Shore

Data from Quebec are derived from various methods, including direct counts (fence and snorkel surveys), extrapolations from index rivers (based on available habitat) and angler data (MRNF 2009, MRNF unpublished data). The Ministère des Ressources naturelles et de la Faune in Quebec assigns a classification to the data for each river C1-C6 (C1 being the highest quality data) that rates the quality of the abundance data. Many of these classifications can include multiple data types (e.g., counting fences and snorkel swim-throughs). The general data classifications for the rivers in each DU are presented for DUs 7-10. DU 7 had four C3 rivers, three C5 rivers and eight C6 rivers.

All 15 salmon rivers of DU 7 were represented in the data set over the time period 1984 – 2008. Mean rod-days per year was 2,402 with a range of 1,892-3,230. Effort has been declining over the time series ($P<0.001$). The most recent estimate of adult abundance for DU 7 is 5,901 salmon in 2008, of which 69% were small salmon (Figure 25). Abundance estimates during the last three generations range from 4,026 salmon in 1997 to 7,785 salmon in 1993. There were no significant trends in small, large and total salmon abundance ($P=0.085$, $P=0.115$; $P=0.297$ respectively). The abundance of small salmon (based on the curve fit in Figure 25) declined by -26.3% during the last three generations; however, this decline was partially offset by a 50.8% increase in the abundance of (more fecund) large salmon, with the total number of salmon down by 13.8% (Figure 25). Supplementary abundance data (for the Musquanousse and Vieux Fort) are provided in Appendix 1.

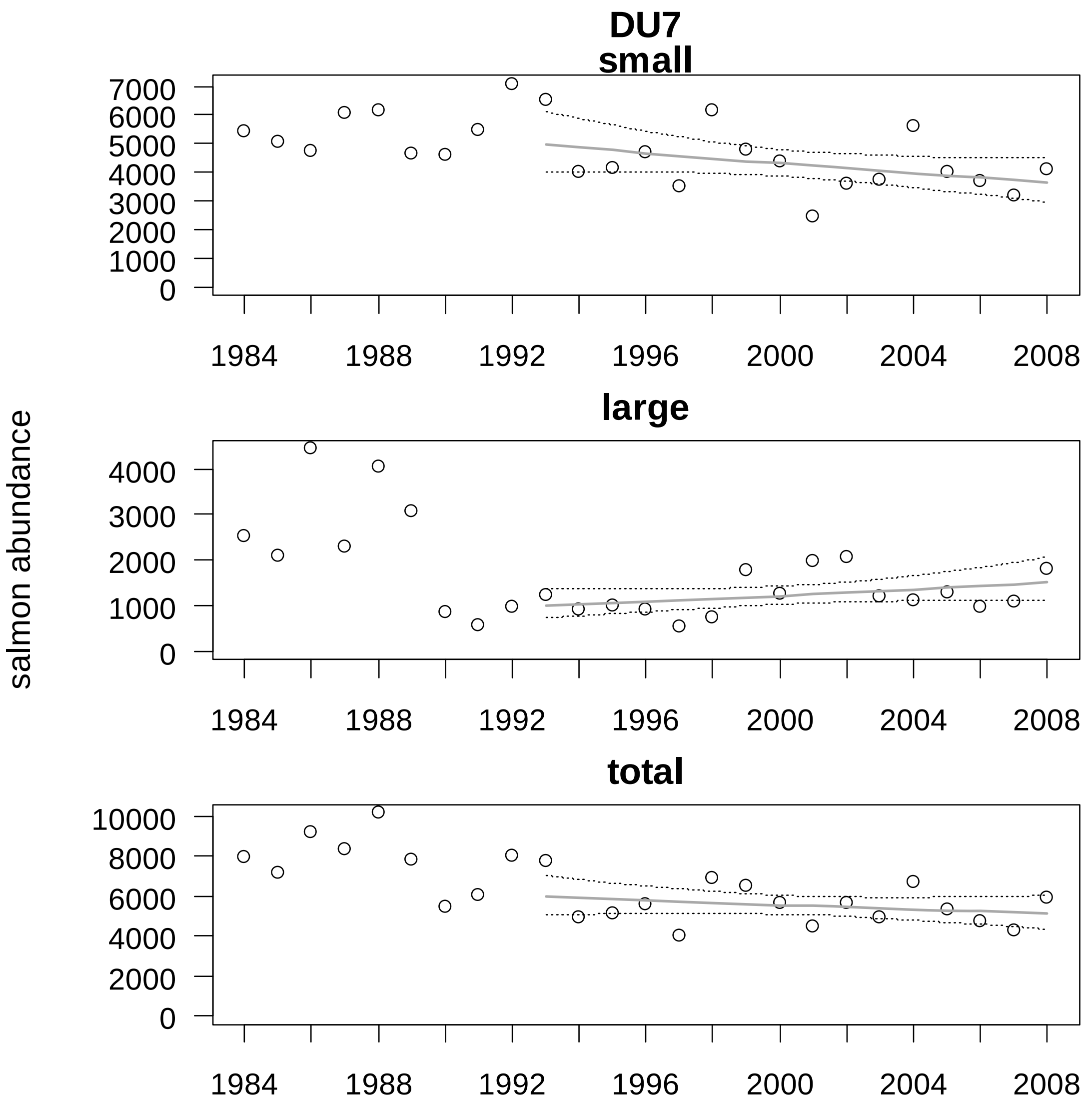


Figure 25. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 7 from 1984-2008. Superimposed is the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance over the past 3 generations.

Designatable Unit 8 – Quebec Western North Shore population

Data from Quebec are derived from various methods, including direct counts (fence and snorkel surveys), extrapolations from index rivers (based on available habitat) and angler data (MRNF 2009, MRNF unpublished data). DU 8 has three C1 rivers, nine C3 rivers, three C4 rivers, seven C5 rivers, and seven C6 rivers (See DU 7 for description of river data classification).

The 29 salmon rivers of DU 8 are represented over the time period 1984 – 2008. The most recent estimate (2008) of adult abundance for DU 8 is 15,135, of which 73% are large salmon. Abundance estimates during the last three generations range from 9,865 salmon in 2002 to 17,341 salmon in 1995. There were significant declines in small and total salmon abundance (P=0.031, P=0.013 respectively). A significant trend was not associated with large salmon abundance (P=0.143). Over the last three generations, the abundance of small salmon (based on the curve fit in Figure 26) declined by 33.9%, while large salmon declined by 20.1% and total salmon by 24.4% (Figure 26).

Data for de la Trinité river, an index river monitored with a fish ladder, is provided in Figure 27. Supplementary abundance data (Laval, Mistassini, Godbout, de la Trinité, aux Rochers, Jupitagon, Mingan, de la Corneille, Piashti, Watshishou, Petite Rivière de la Watshishou, des Escoumins) are provided in Appendix 1. There have been no populations lost from DU 8.

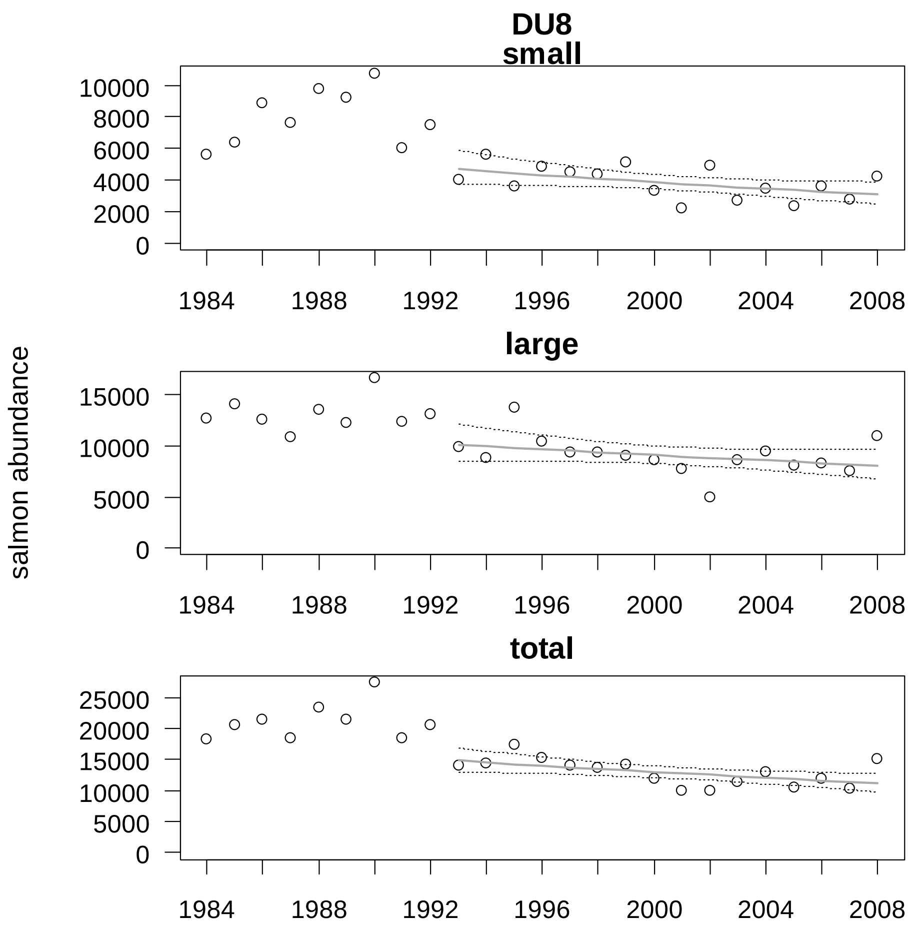


Figure 26. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 8 from 1984-2008. Superimposed is the fit from the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance over the past 3 generations.

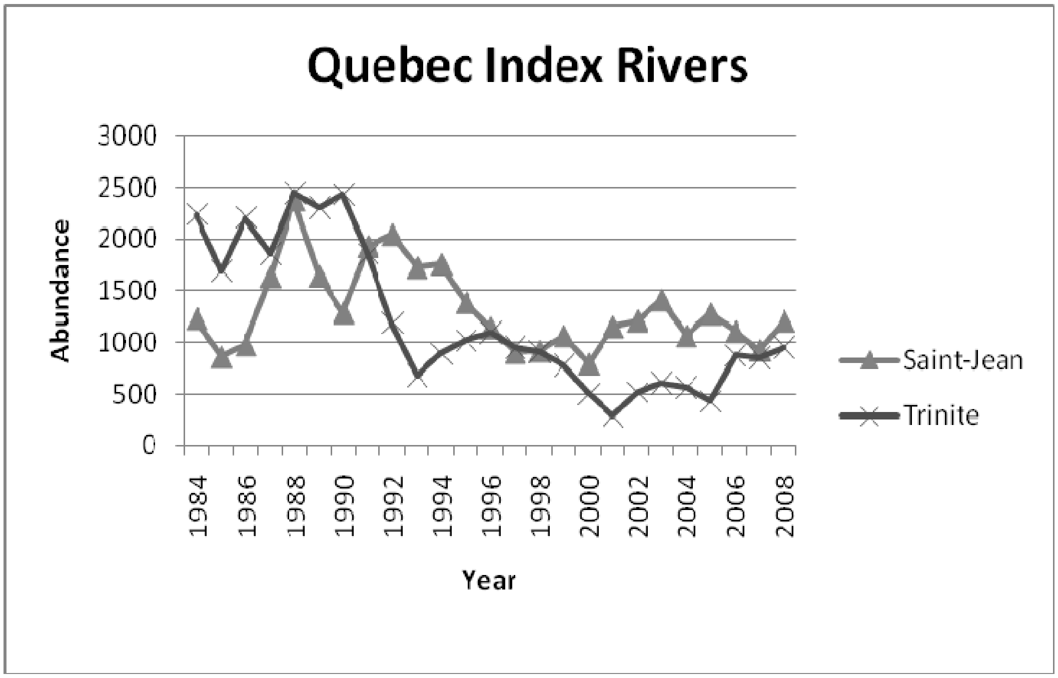


Figure 27. Quebec Index Rivers (Saint-Jean and Trinité). Counting fence data from 1984-2008. Note the Saint-Jean lies within DU 12 while the Trinité is within DU 8.

Designatable Unit 9 – Anticosti Island

Data from Quebec are derived from various methods, including direct counts (fence and snorkel surveys), extrapolations from index rivers (based on available habitat) and angler data (MRNF 2009, MRNF unpublished data). Salmon abundance data is available from 25 rivers on Anticosti Island and 24 of them were classified according to the type of data available. DU 9 has one C1 river, one C3 river, 19 C4 rivers, and three C6 rivers (See DU 7 for description of river data classification).

The most recent estimate (2008) of adult abundance for DU 9 is 2,414 salmon, comprised of 1,362 small and 1,052 large salmon. Abundance estimates during the last three generations range from 1,390 salmon in 2005 to 4,855 salmon in 1996. The declining trend in abundance detected for small salmon (Figure 28) was marginally insignificant (P = 0.077), and statistically significant declines in large and total salmon were observed (respective P-values: 0.017 and 0.007). The abundance of total salmon (based on the curve fit in Figure 28) has declined by 31.7% over the last 3 generations. The abundance of both large (48.7%) and small (40.2%) salmon has declined during this period. Supplementary abundance data (á l'Huile, MacDonald, á la Patate, Vaureal, aux Saumons, du Renard, Petite rivière de la Loutre, Bell, Box, Dauphine, Petite rivière de la Chaloupe, Maccan, de la Chaloupe, Ferree, Martin, du Pavillon, aux Plats, Chicotte, Galiote, du Brick, Jupiter, à la Loutre, Bec-scie) are provided in Appendix 1. There have been no populations lost in DU 9.

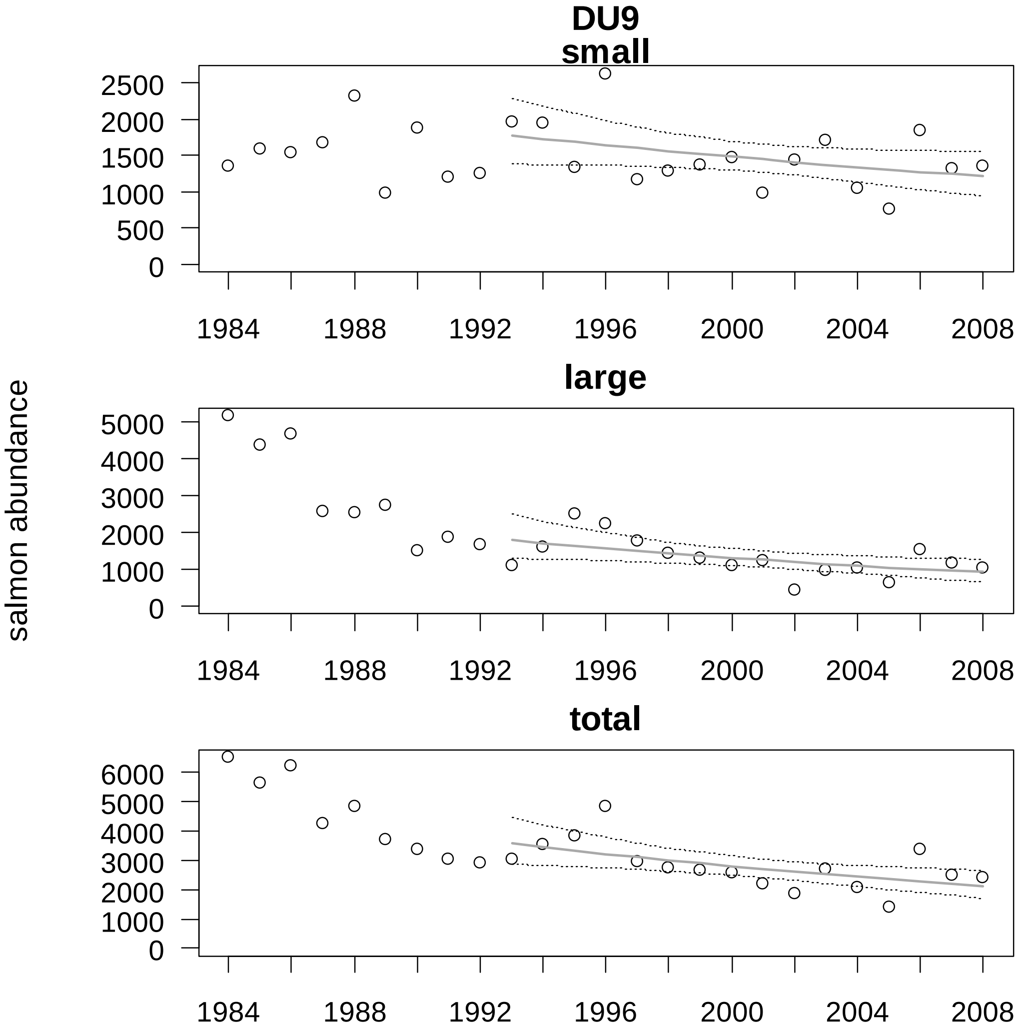


Figure 28. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 9 from 1984-2008. Superimposed is the fit from the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance over the past 3 generations.

Designatable Unit 10 - Inner St. Lawrence

Data from Quebec are derived from various methods, including direct counts (fence and snorkel surveys), extrapolations from index rivers (based on available habitat) and angler data (MRNF 2009, MRNF unpublished data). The nine known salmon rivers of DU 10 are represented in the dataset. DU 10 has six C1 rivers, and three C4 rivers (See DU 7 for description of river data classification).

The most recent estimate (2008) of adult spawner abundance for DU 10 is 4,169 salmon, the highest over the last three generations, consisting of 2,230 small salmon and 1,939 large salmon.The lowest spawner abundance during the last three generations was in 2007 (2,208 salmon). There were no significant trends in abundance for small, large or total salmon (small: P=0.951; large: P=0.429; total: P=0.772; Table 2).

The abundance of large and total salmon (based on the curve fit in Figure 29) has increased by 11.5% and 5.3% respectively since 1997, while small salmon abundance has declined by 1.8% during this time period. Supplementary abundance data (Ouelle, Malbaie, St.-Jean, à Mars, Ste.-Marguerite principale, Ste.-Marguerite NE) are provided in Appendix 1.

Despite relatively stable trends, effective population sizes for salmon in the rivers of DU 10 are relatively low (Dionne *et al.* 2007). Furthermore, many populations in this area have been supplemented by stocking (M. Dionne, Quebec Ministère des Ressources naturelles et de la Faune, pers. comm.). To date, all known salmon rivers contain populations.

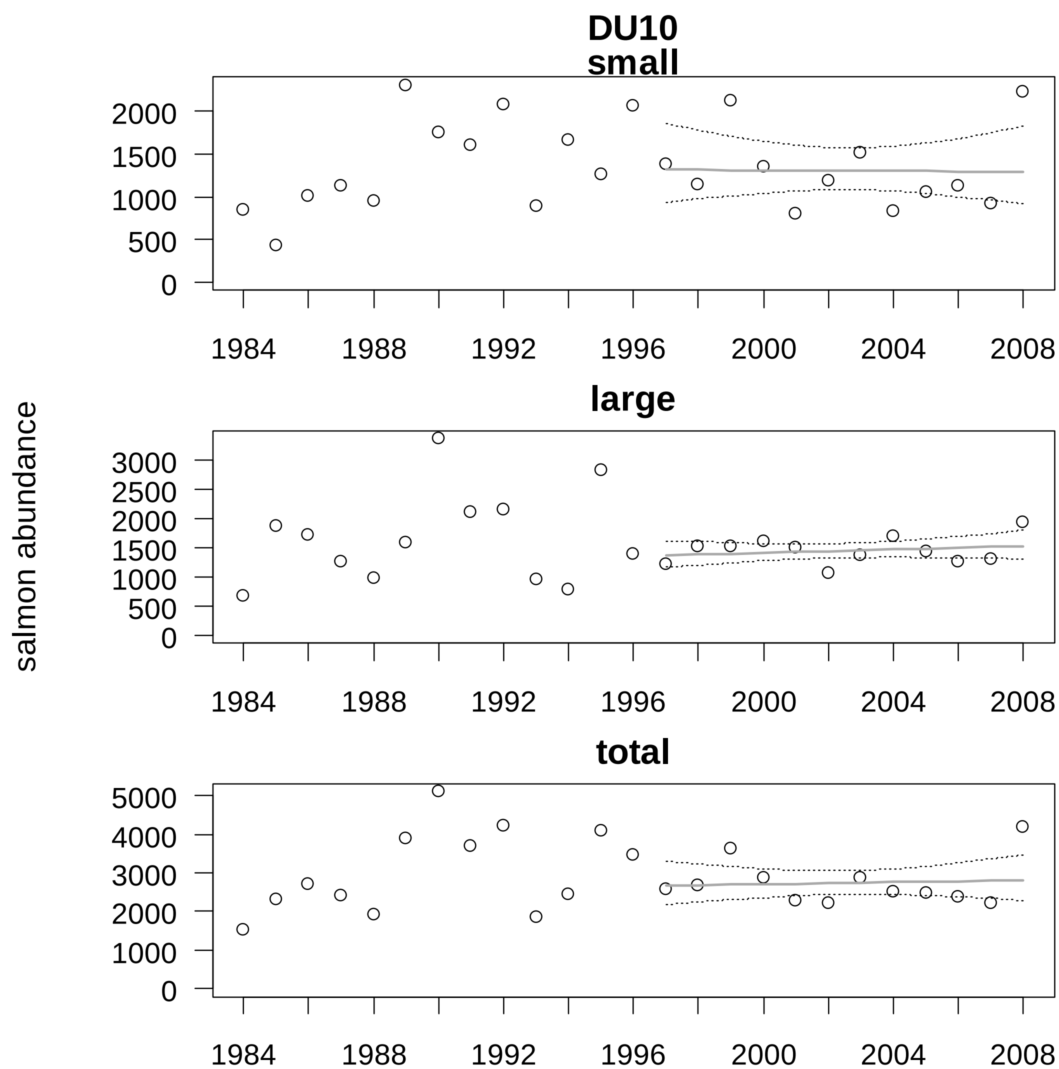


Figure 29. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 10 from 1984-2008. Superimposed is the fit from the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance over the past 3 generations.

Designatable Unit 11 - Lake Ontario

The Lake Ontario DU has been assessed as extirpated[xix] (COSEWIC 2006a). Attempts are ongoing to re-establish populations through stocking. Since no known genetic material remains from the original populations, different strains are being used for restoration efforts. These efforts have not yet succeeded in producing self-sustaining, naturally reproducing populations.

Designatable Unit 12 – Gaspé–Southern Gulf of St. Lawrence

DU 12 has 78 rivers that contain salmon populations distributed across four provincial jurisdictions (Quebec, PEI, Nova Scotia, and New Brunswick). The data available for DU 12 came from a variety of sources as the DU is comprised of several Quebec and Gulf Salmon Fishing Areas. The specific data sources and collection details can be found in (Breau *et al.* 2009, Cairns *et al.* 2009, MRNF 2009, MRNF unpublished data, Cameron *et al.* 2009, Chaput *et al.* 2010, Fournier *and* Cauchon 2009, Secteur Faune Québec 2009, Dionne *et al*. 2010). Broadly, the data consist of angler catch statistics (1970-2008), counts from up to nine counting fences (range 6 - 9), snorkel surveys, and mark-recapture estimates. The primary estimate of abundance for the whole DU is based on the angler-catch data. While these fishery-dependent data are corrected with fishery-independent data, estimates should be considered with the same caveats described above.

The latest estimate (2007) of adult spawner abundance for DU 12 is 103,149 salmon. The lowest abundance during the last three generations was in 1999 with 77,323 salmon, while the highest abundance was 213,329 salmon in 1993. There were no statistically significant trends in the abundance of small, large or total salmon in this DU (P values: 0.119, 0.217 and 0.100 respectively). The abundance of small, large and total salmon (based on the curve fit in Figure 30) has decreased by 34.0%, 18.5% and 27.8% respectively over the last three generations. These values are sensitive to the length of the time series. For example, increasing or decreasing the length of the time series for total salmon changes the decline rate estimates to 46% or 1.5% respectively. The Miramichi River accounts for the majority of salmon in this DU (>50% of the total DU population in the majority of years). The swamping effect of this single large river should be considered when examining these data. In general, juvenile distribution and densities are good and most rivers are known or are suspected of meeting conservation requirements (Breau *et al.* 2009, Cameron *et al.* 2009, Chaput *et al.* 2010). Southern areas of SFA 16 and PEI are exceptions, as distribution of juveniles is sparse and densities are low (Cairns *et al.* 2009, Chaput *et al.* 2010). Adult salmon abundance in the latter areas is also considered to be below conservation levels (Cairns *et al.* 2009, Chaput *et al.* 2010). Furthermore some small rivers of the Northumberland Strait also appear to be in decline (Gibson *et al.* 2006). PEI in particular is experiencing significant habitat degradation, related to land-use issues and its indigenous stocks have likely been largely replaced by stocked fish in at least some rivers (D. Cairns, Dept. of Fisheries and Oceans, pers. comm.). Abundance data from counting fence facilities and/or dominant rivers of DU 12 are provided (Figures 31-35). Supplementary abundance data (Matapedia, Cascapedia, Petite rivière Cascapedia, Bonaventure, Petite rivière Port Daniel, Port Daniel du Milieu, Port Daniel Nord, du Grand Pabo Ouest, du Grand Pabo, du Petit Pabo, Grande Rivière, St.-Jean, York, Dartmouth, Madeleine, Ste.-Anne, Cap Chat, Matane, Mitis, Restigouche, Nepisiguit, Tabusintac, Bouctouche, Morell, Philip, East Pictou, Sutherlands, West Antigonish) are provided in Appendix 1.

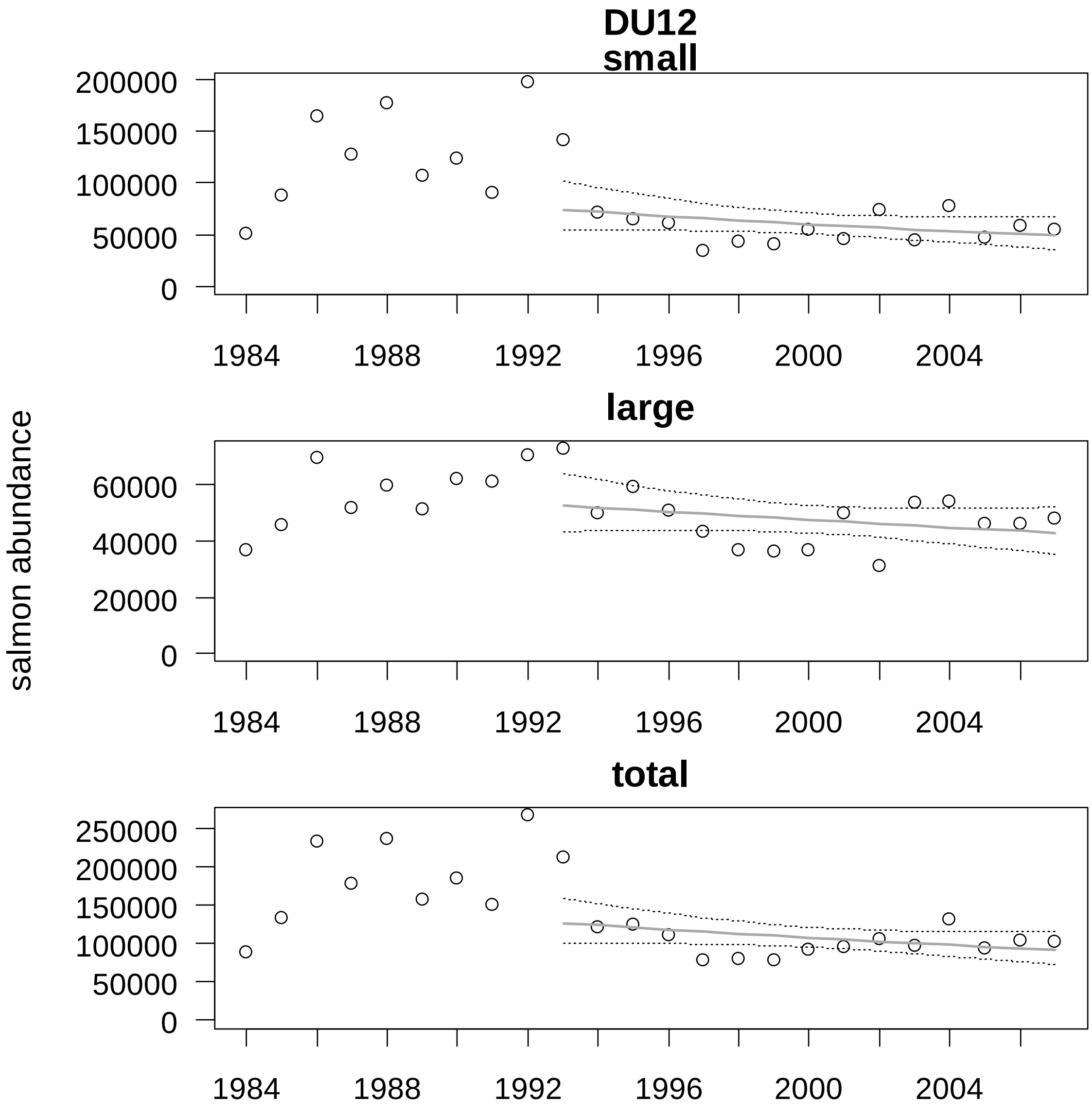


Figure 30. Atlantic Salmon returns (small: top panel; large: middle panel; total: bottom panel) for DU 12 over the past 3 generations. Superimposed is the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance.

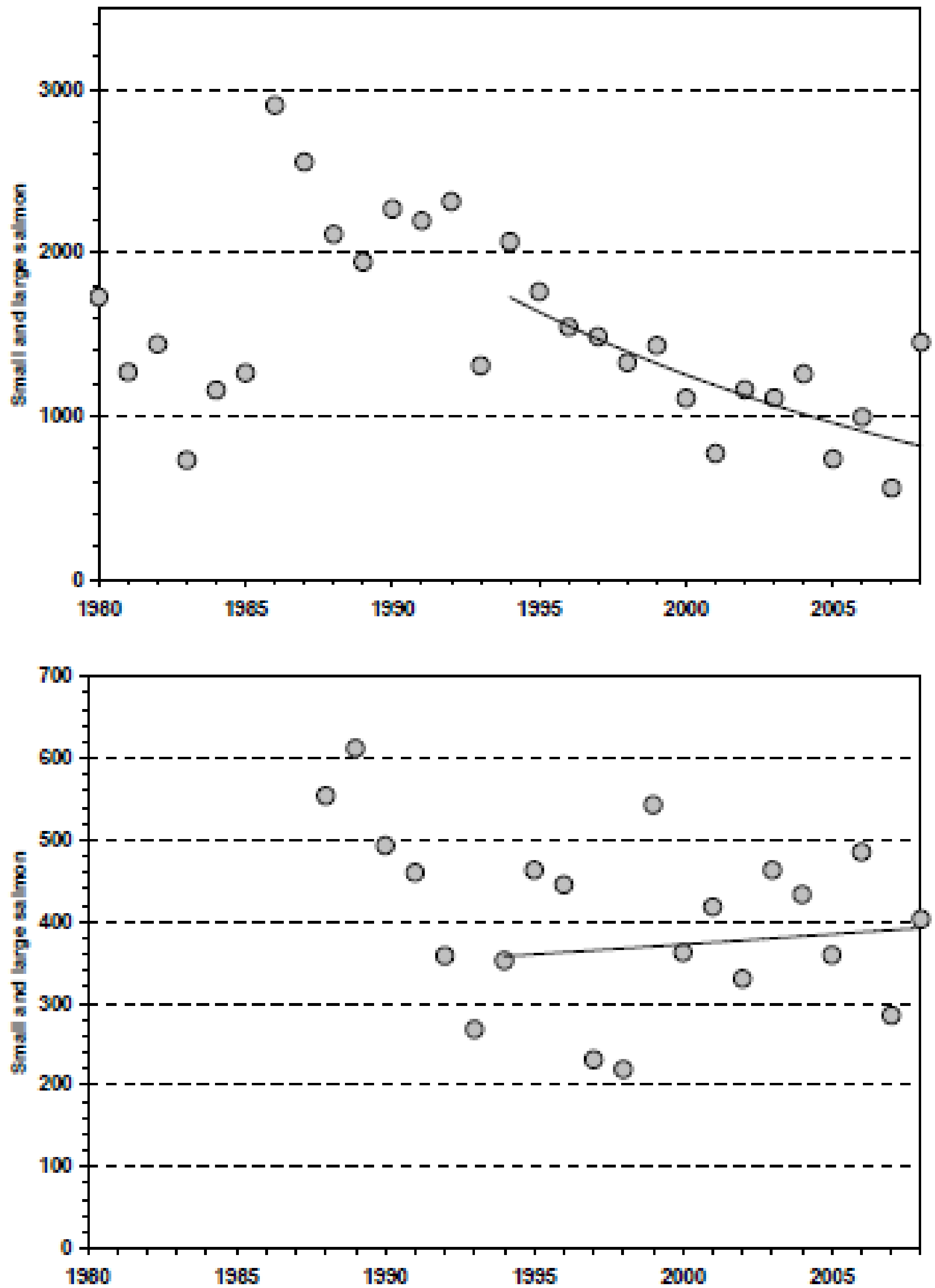


Figure 31. Counts of all adult salmon at the Northwest Upsalquitch Barrier (upper) and Causapscal Barrier (bottom), Restigouche River (taken from Cameron *et al.* 2009).

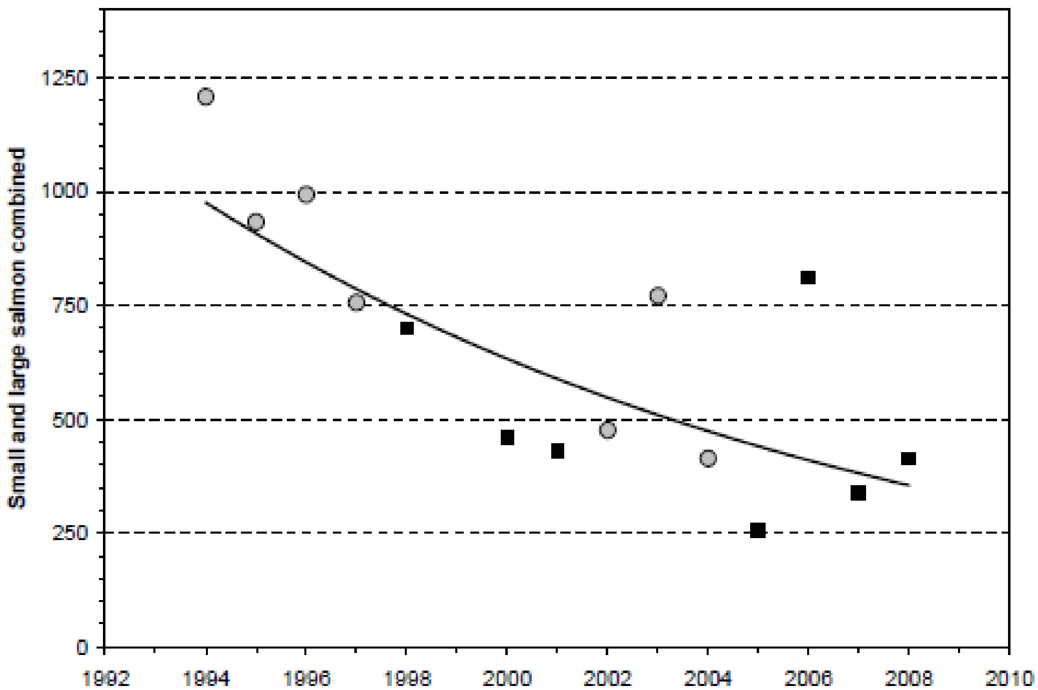


Figure 32. Counts of salmon at the Jacquet River barrier. Square black symbols show years with incomplete counts due to fence washouts or early removal due to inclement weather (taken from Cameron *et al.* 2009).

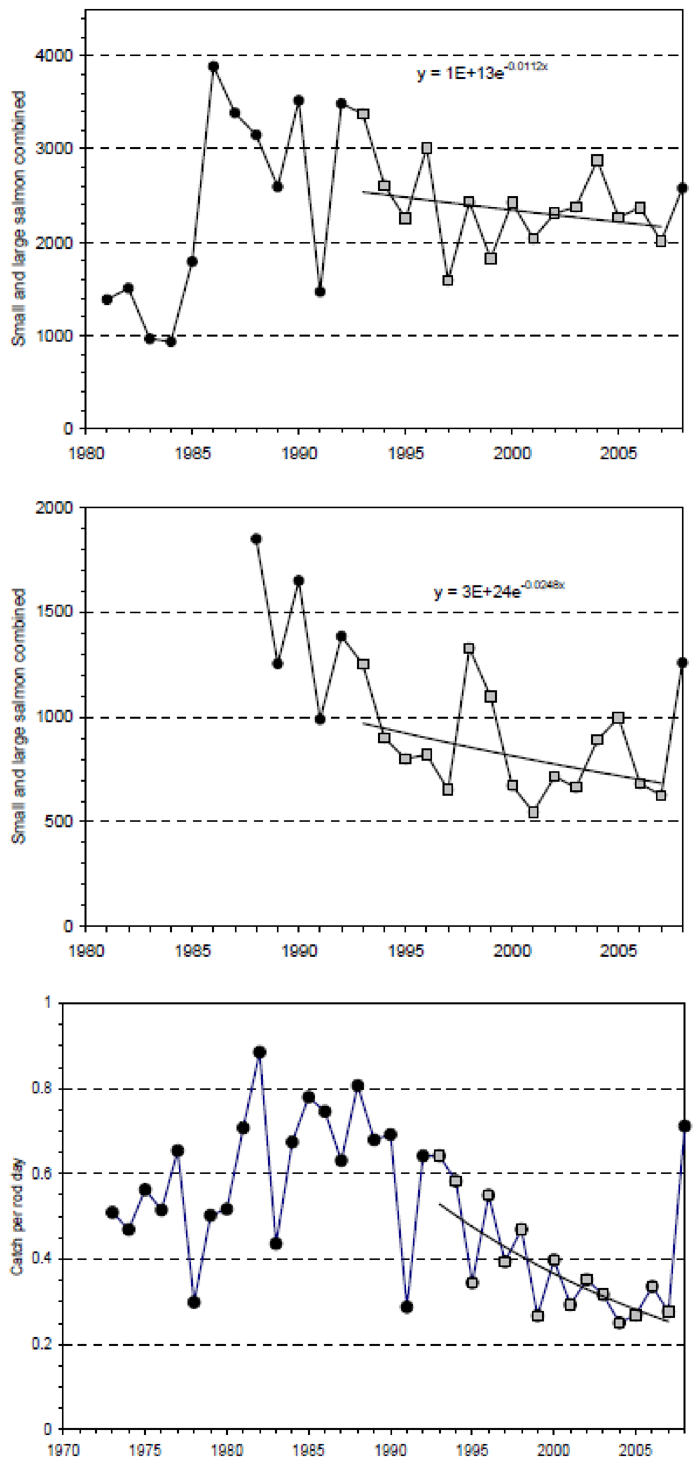


Figure 33. Counts of salmon (size groups combined) at the two headwater barriers in the Southwest Miramichi (upper panel), at the single headwater barrier in the Northwest Miramichi (middle panel) and catch per rod day from the crown reserve angling waters of the Northwest Miramichi (lower panel) (taken from Chaput *et al.* 2010).

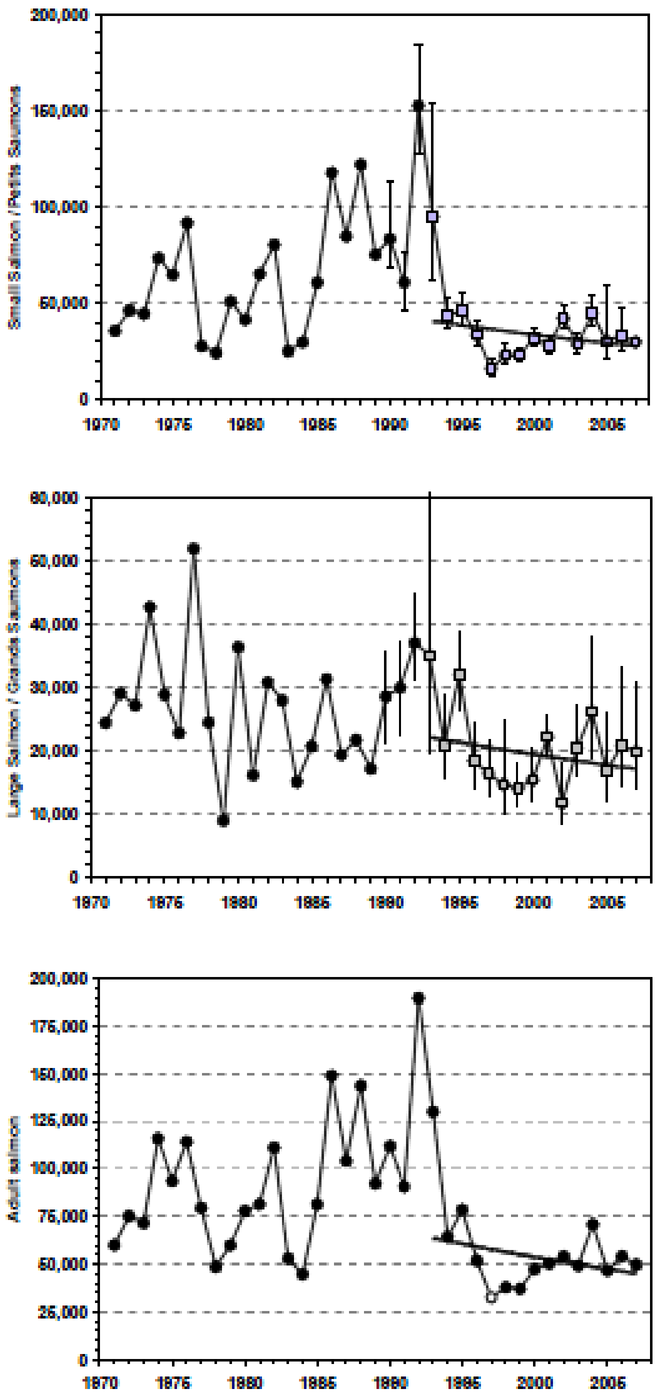


Figure 34. Estimates of returns of small salmon (upper), large salmon (middle) and size groups combined (lower) to the Miramichi River, 1971 to 2007. Trend line is an exponential function for the most recent 15 years (1993 to 2007) (taken from Chaput *et al.* 2010).

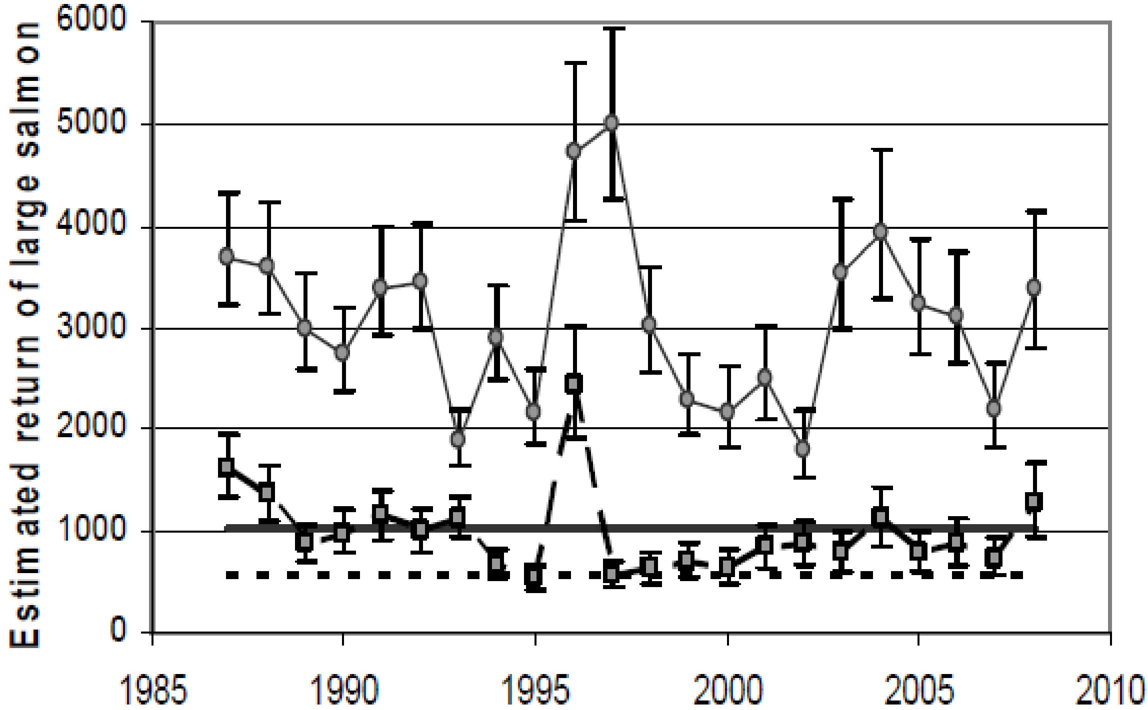


Figure 35. Estimated returns of large (upper series with error bars) and small salmon (lower series with error bars) to the Margaree River, 1987 to 2008. The conservation requirement for large salmon is depicted with a solid line and for small salmon with a dashed line (taken from Breau *et al.* 2009).

Designatable Unit 13 – Eastern Cape Breton

The data available for DU 13 came from a variety of sources including angler catch statistics (1970-2008), fishway counts (1 river), snorkel surveys on four rivers 1994-2008 (except Clyburn 1987-2008) and mark-recapture estimates. Where angler data has been used, its utility as an index has been validated using fishery-independent methods. Data reflect both returns and escapement – depending on the data source. There was no total estimate of abundance available for this DU, but low angler effort on other rivers suggests much of the salmon abundance in this DU is within assessed rivers (Gibson and Bowlby 2009). The spawner abundance data presented here are a sum for rivers with estimates (based on the data provided in Gibson and Bowlby 2009). Since Grand River data was not provided in terms of small and large salmon, data from this river are included only for total salmon. As such the results provided for total salmon do not equal the sum of small and large individuals.

There are 30 rivers in DU 13 with reported recreational catch. The most recent (2008) estimate of adult abundance for DU 13 is 1,150 salmon, of which 407 were small, and 743 were large. During the last three generations, total abundance in the five assessed rivers has ranged from 513 salmon in 2002, to 1,825 salmon in 1996. There were no significant trends in the abundance of small, large or total salmon ($P = 0.789$, 0.542, and 0.202 respectively) when the abundance time series for this DU are analyzed in aggregate. The abundance of small salmon (based on the curve fit in Figure 36) has declined by 7.9% since 1993, whereas the abundance of large salmon is 14.5% below 1993 levels. The abundance of salmon for both size categories combined has decreased by 28.9% during this time period (Figure 36). Despite the lack of a statistically significant declining trend over three generations, four of five DU 13 rivers were below conservation requirements in 2008 and two had “marked” declines (Gibson and Bowlby 2009). Furthermore, a declining trend can be detected for small (39.6% over four generations; $P = 0.058$), large (67.2%; $P < 0.001$) and total (69.1%; $P < 0.001$) salmon when the data series is extended by five years (four generations). The difference in the trends in total abundance from the large and small abundance series reflects the large decline in abundance in the Grand River (Figure 37), which was not included in the small and large abundance series. Data for individual river systems are plotted in Figure 37. Juvenile abundance levels in the region are not high in comparison to DU 12 rivers, although juveniles remain widespread (Gibson and Bowlby 2009). To date, there have been no known extirpations in this DU.

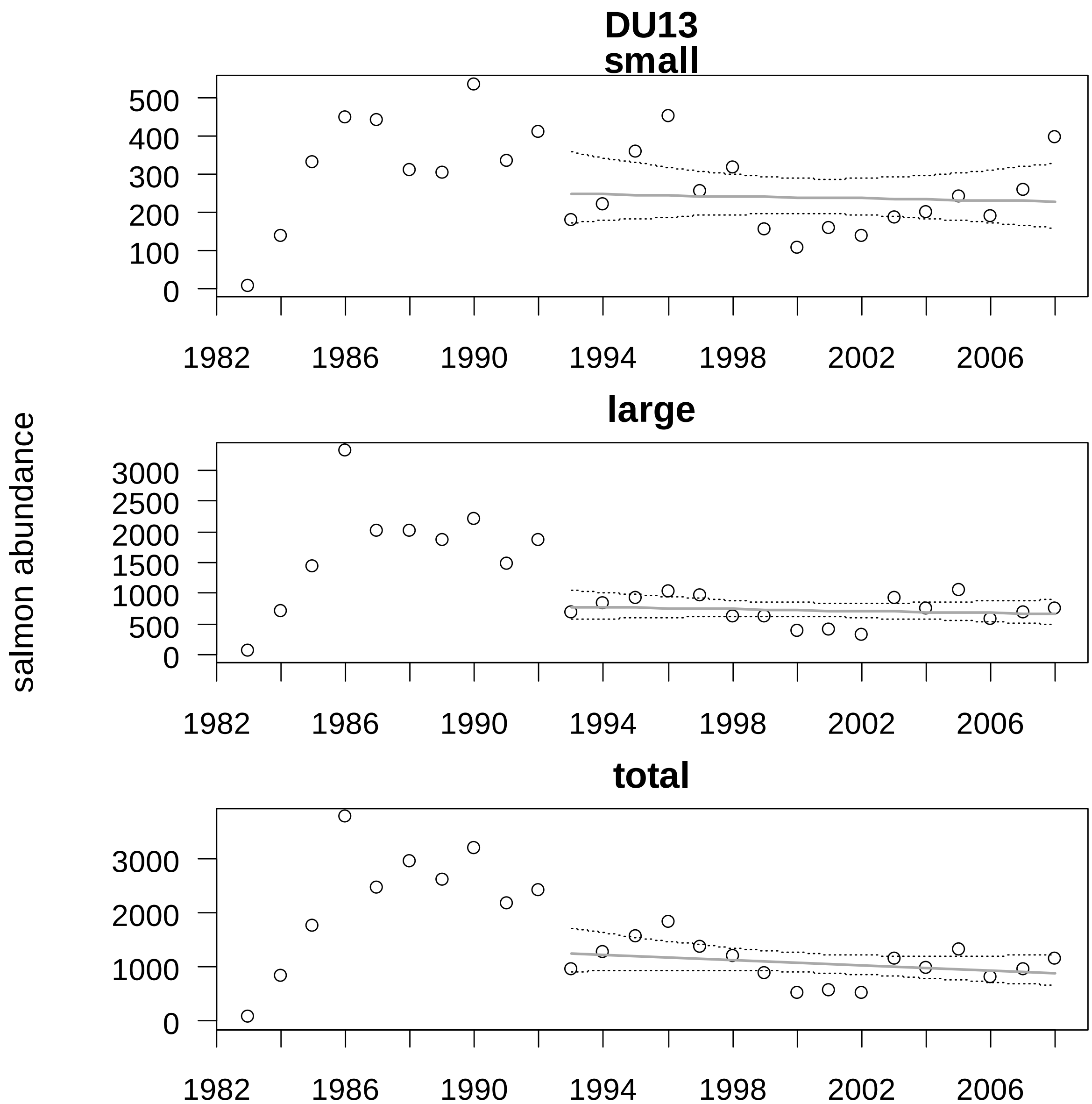


Figure 36. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 13 over the past 3 generations. Superimposed is the fit from a general linear model (+/- 2SE prediction intervals) used to determine trends in abundance. Note contributions from the Grand River are not included in small and large salmon plots due to data limitations.

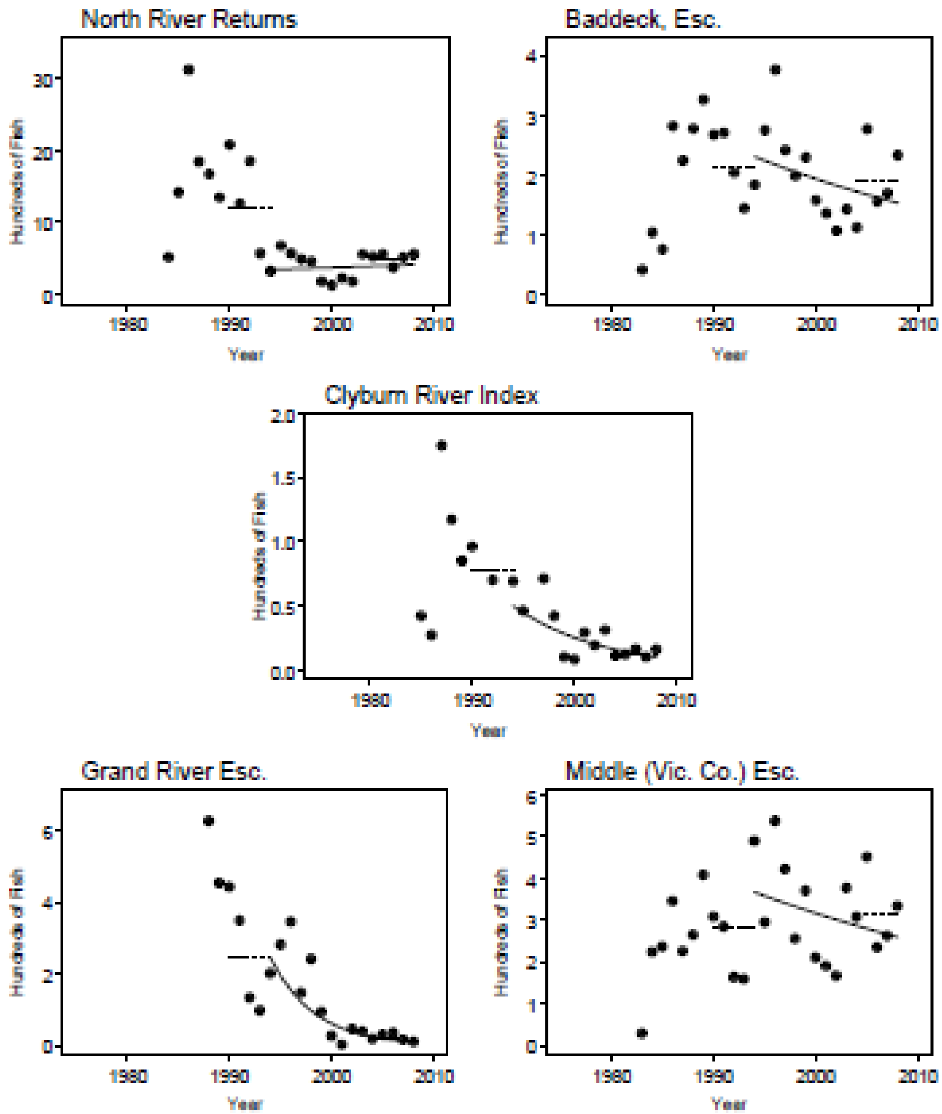


Figure 37. Adult Atlantic Salmon abundance time series (size categories combined) for five eastern Cape Breton rivers. The solid line is the estimated abundance from a log-linear model fit to data for the last three generations. The dashed line shows the 5-year mean abundance for 2 time periods separated by 15 years. The points are the observed data (taken from Gibson and Bowlby 2009).

Designatable Unit 14 – Nova Scotia Southern Upland

The data available for DU 14 come from a variety of sources including angler catch statistics (1970-2008), fishway counts (3 rivers), and mark-recapture estimates (1 river). The trend data used for this section rely entirely on fishery-independent data: the sum of the spawner escapement counts on the two main index rivers was used to assess trends. Abundance estimates from the assessed rivers are not extrapolated to the entire DU using the recreational catch because most rivers are closed to fishing. As such there is no total estimate of abundance available for this DU. The abundance data presented here are a sum for rivers with estimates (based on data in Gibson *et al.* 2009). In recent years, the monitored rivers are biased towards systems with lower acidification impacts. Such rivers, however, are thought to currently contain the majority of salmon in this DU.

Within the previous century, 63 rivers with this DU are known to have contained salmon, although presently, salmon are extirpated from many. The most recent estimate (2008) of adult abundance for the two index rivers is 1,427 salmon, consisting of 1,264 small and 164 large salmon. The lowest abundance during the last 3 generations was 755 salmon in 2007, while the highest abundance was 3,557 salmon in 1996. Abundance of salmon in this DU during the 1980s at times exceeded 10,000. There has been a significant decline in the abundance of small ($P = 0.003$), large ($P = 0.002$) and total salmon ($P < 0.001$) in this DU based on the curve fit in Figure 38. Small salmon abundance declined by 58.6% since 1996 (Figure 38). The abundance of large salmon was down by 74.0%, and total salmon declined by 61.3% during that period. Since recent counts represent systems with relatively low levels of acidification, declines in acidified rivers of DU 14 are expected to be greater (Gibson *et al.* 2009). DU 14 has experienced a substantial decline in the number of individual populations. DFO (2000) predicted that 55% of rivers in this DU are extirpated with an additional 36% at risk of extirpation.

A comparison of juvenile abundance estimated from electrofishing surveys between 2000 and 2008 (Gibson *et al.* 2009) are indicative of ongoing declines and low juvenile abundance (Figure 39). These surveys were similar in terms of total effort and coverage, although marginally more sites were completed in 2008 (143 vs. 128), but one less river was visited (51 rather than 52). Total shocking time was slightly greater in 2008 (143,385 seconds vs. 104,331 seconds), but the total area surveyed was lower (98,019 m^2 vs. 128,841 m^2). Approximately one-quarter as many juvenile salmon were captured in 2008 (977 salmon) than in 2000 (3,733 salmon). In 2000, juvenile Atlantic Salmon were found in 54% of the rivers (28 of 52), but were only found in 39% (20 of 51) of the rivers in 2008.

Under current conditions, maximum lifetime reproductive rates (indicative of the compensatory reserve) of salmon in this DU are very low and abundance will likely continue to decline because the populations have little intrinsic capacity to rebound following events that further lower abundance (Gibson *et al.* 2009). Only a few populations (e.g. the LaHave and St. Mary’s rivers) may be viable under current conditions and then only at low population size (Gibson *et al.* 2009). Because of their low reproductive rates, these populations may also be at risk as a result of stochastic processes. Annual salmon counts at the Morgan Falls fishway on the LaHave River, the primary index of abundance in this DU, are provided in Figure 40. Supplementary abundance data (Liscomb, St. Marys, and East River (Sheet Hbr.)) are provided in Appendix 1.

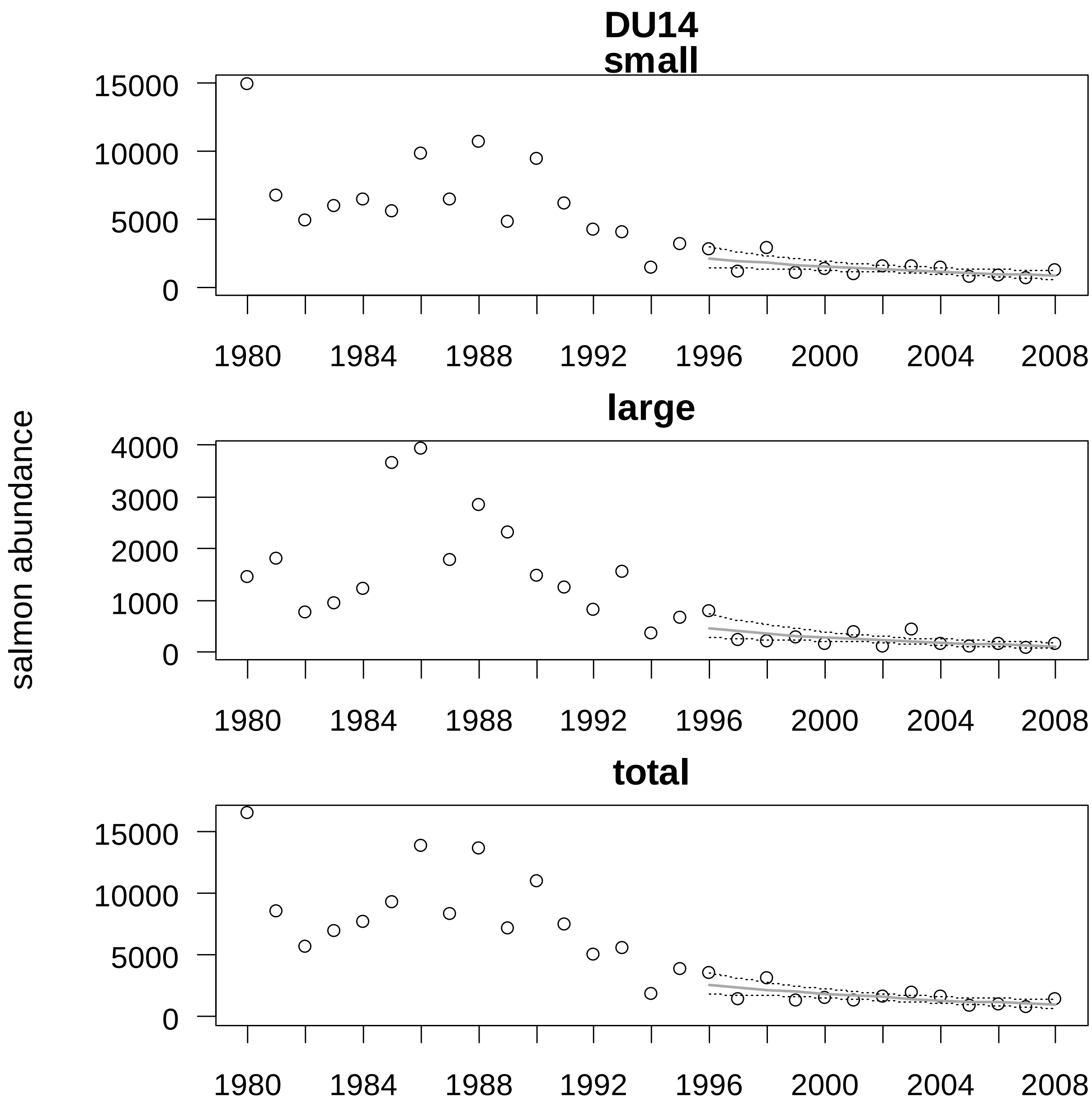


Figure 38. Atlantic Salmon escapement from 1980 to 2008 (small: top panel; large: middle panel; total: bottom panel) for DU 14. Superimposed is the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance over the past 3 generations.

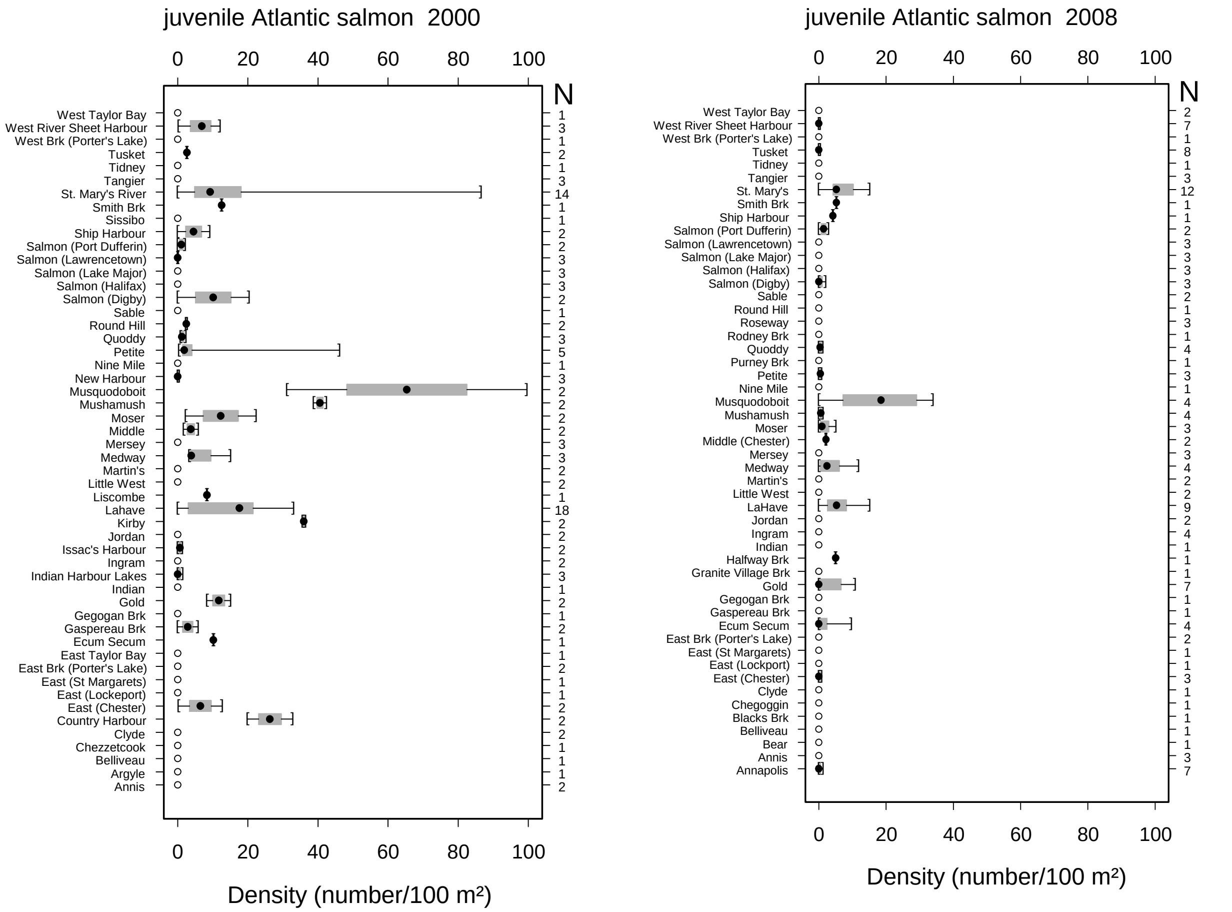


Figure 39. Box plots showing the density of Atlantic Salmon in Southern Upland rivers based on electrofishing during 2000 and 2008. The dot shows the median density and the box shows the inter-quartile spread. Open dots indicate that no salmon were captured in the river. The whiskers are drawn to the minimum and maximum. “N” is the number of sites that were electrofished in each river (adapted from Gibson *et al.* 2009).

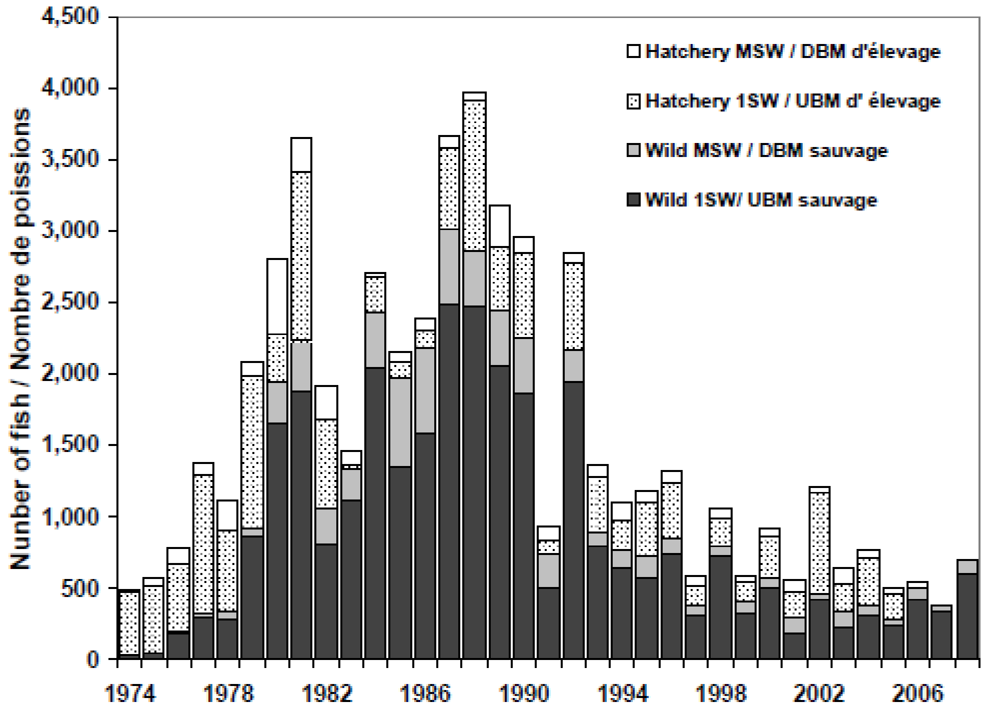


Figure 40. Counts of Atlantic Salmon at Morgans Falls fishway on the LaHave River, NS, from 1974 to 2008, divided into the proportions of wild-origin and hatchery-origin 1SW and MSW adults (taken from Gibson *et al.* 2009).

<u>Designatable Unit 15 – Inner Bay of Fundy</u>

This DU has been designated as Endangered under the SARA. A full status report was prepared in 2006 (COSEWIC 2006b). Current estimates for this DU (2008) suggest the total number of wild fish is likely to be less than 200 individuals.

<u>Designatable Unit 16 – Outer Bay of Fundy</u>

Small and large returns to the Saint John River from 1993 to 2008 were calculated by using the estimated returns to the Nashwaak River (upriver of the counting fence), raised by the amount of habitat available in the Saint John River downstream of Mactaquac Dam plus the total returns destined for above Mactaquac Dam. The returns to the other outer Bay of Fundy rivers were determined by using the total returns to both the Magaguadavic and St. Croix rivers raised by the amount of habitat available to salmon between the Saint John River and the Maine border. Added to the estimated Saint John River returns, these estimates provided the total estimated 1SW and MSW returns to DU 16 (Jones *et al.* 2009).

There are 17 salmon rivers in DU 16. The most recent estimate of adult abundance for DU 16 is 7,584 from 2008. Of these 6,629 were small and 955 were large. The lowest abundance during the last three generations was in 2007 (3,486 salmon). The highest abundance during the last three generations was 20,010 salmon in 1996. There have been significant declines in the abundance of large ($P < 0.001$), small ($P = 0.024$) and total salmon ($P = 0.001$). The abundance of small salmon (based on the curve fit in Figure 41) has declined by 56.5% since 1996 (Figure 41). The abundance of large salmon has declined by 81.6% of 1996 abundance and total salmon are down by 64.3%. Adult escapement is well below conservation requirements for the entire area and juveniles, though well distributed, are also at low densities (Jones *et al.* 2009). While all monitoring facilities show strong declining trends, the St. Croix and the Magaguadavic rivers have been effectively extirpated of wild fish. Data from the Saint John River (Mactaquac), Magaguadavic River and St. Croix River are provided in Figures 42-44.

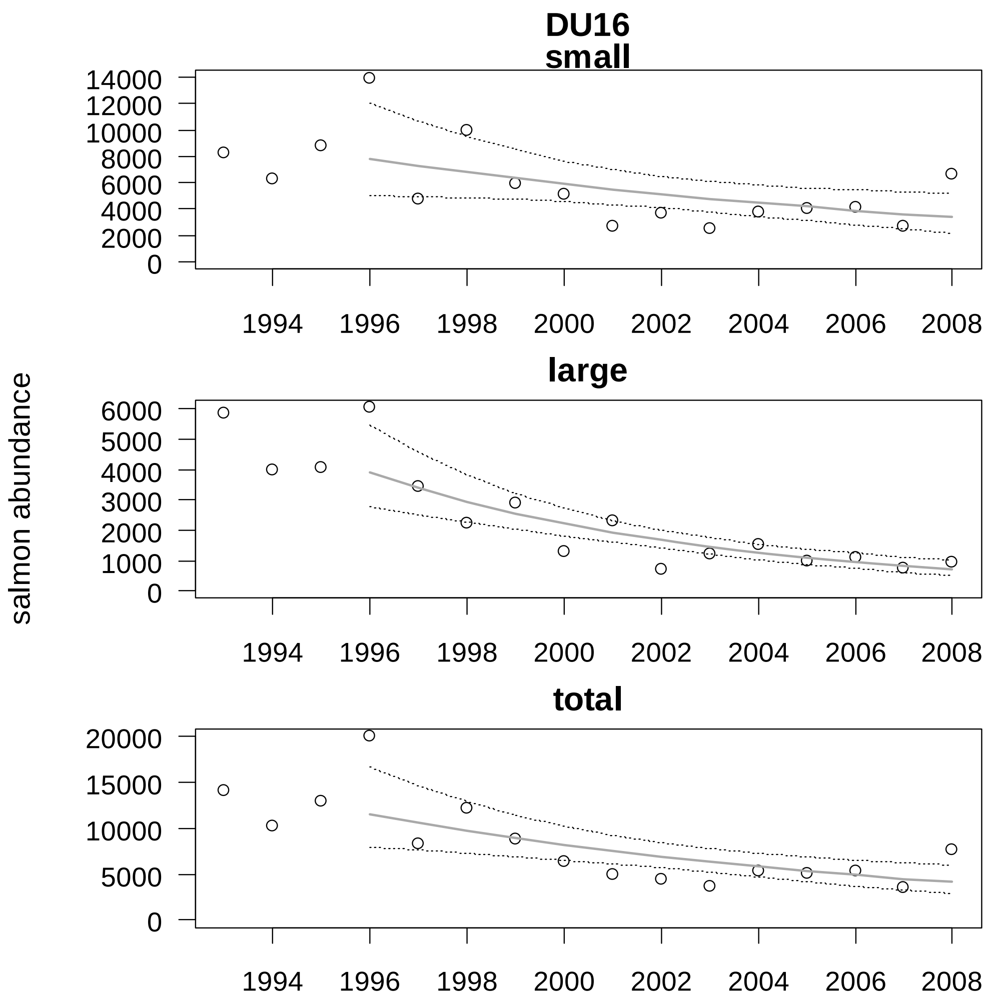


Figure 41. Atlantic Salmon escapement (small: top panel; large: middle panel; total: bottom panel) for DU 16 over the past 3 generations. Superimposed is the general linear model (+/- 2SE prediction intervals) used to determine trends in abundance.

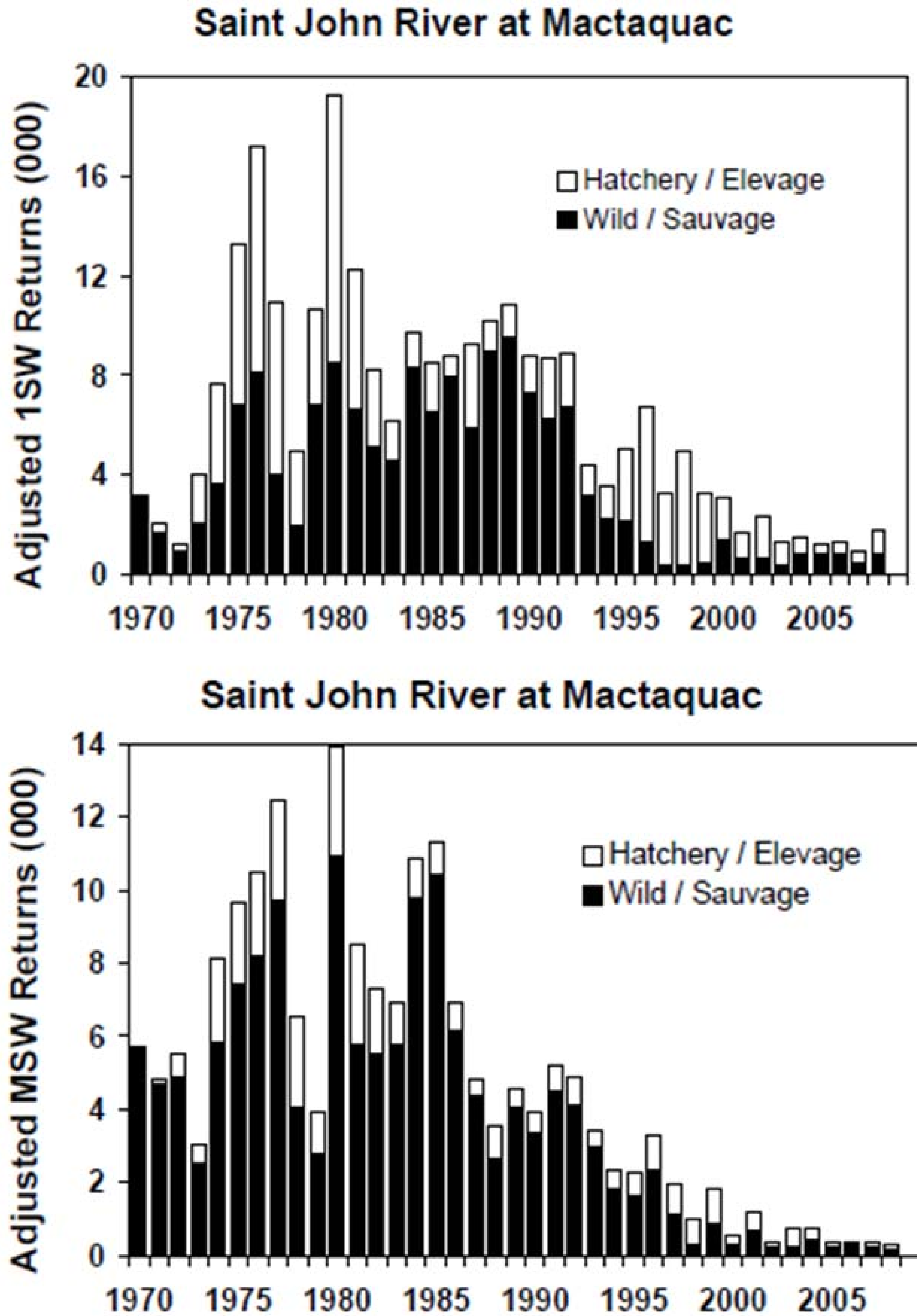


Figure 42. Estimated total adjusted returns of wild and hatchery 1SW and MSW salmon destined for Mactaquac Dam, Saint John River, 1970–2008 (taken from Jones *et al.* 2009).

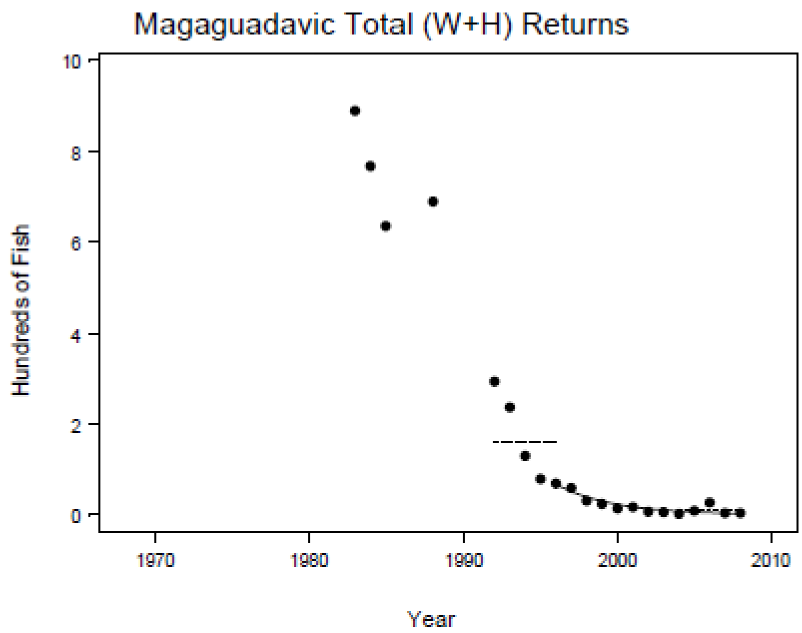


Figure 43. Trends in abundance of adult Atlantic Salmon in the Magaguadavic River during the last 15 years. The solid line is the predicted abundance from a log-linear model fit by least squares. The dashed lines show the 5-year mean abundance for 2 time periods separated by 15 years. The points are the observed data (taken from Jones *et al.* 2009).

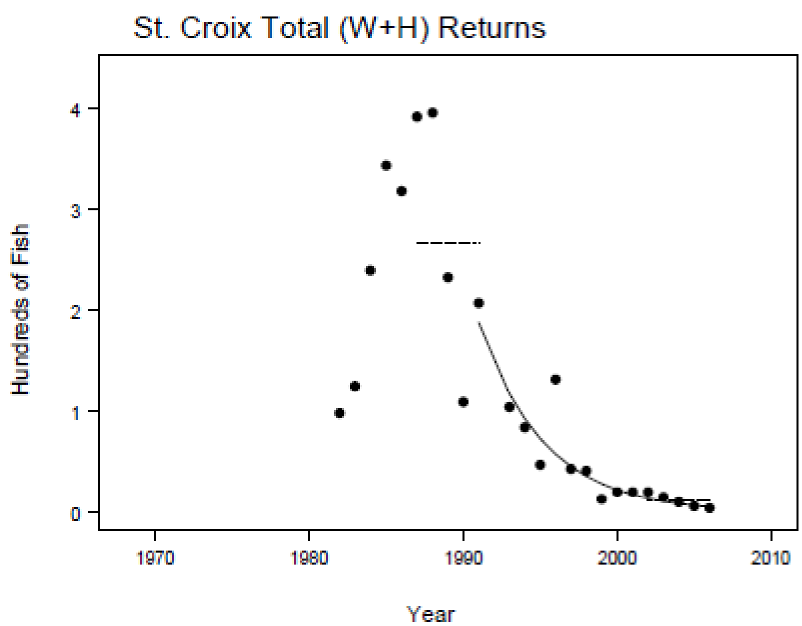


Figure 44. Trends in abundance of adult Atlantic Salmon in the St. Croix River during the last 15 years assessed (1992-2006). The solid line is the predicted abundance from a log-linear model fit by least squares. The dashed lines show the 5-year mean abundance for 2 time periods separated by 15 years. The points are the observed data (taken from Jones *et al.* 2009).

THREATS AND LIMITING FACTORS[xx]

The causes of the widespread decline of Atlantic Salmon (WWF 2001) are not well understood. Several major reviews have attempted to identify and prioritize causes but there is currently no consensus. For example, a group of experts discussed 62 factors potentially threatening the survival of Atlantic Salmon in eastern North America (Cairns 2001). Of the 12 leading factors, five were related to predation, five to life history, one to fisheries, and one to physical/biological environment. Furthermore, two were related to freshwater life stages, nine were related to marine life stages, and one was related to a freshwater cause that manifested itself in the marine stage.

Throughout the range of Atlantic Salmon, poor marine survival has been cited as the primary cause for observed declines (Potter and Crozier 2000, Reddin *et al.* 2000, Amiro 2003, Gibson *et al.* 2004, 2009). Poor marine survival continues to threaten many populations of Atlantic Salmon despite a massive reduction in fishing mortality (COSEWIC 2006b) and adequate freshwater conditions in most, but not all (see DU 14) areas (DFO 2008, Breau *et al.* 2009, Cameron *et al.* 2009, Chaput *et al.* 2010). While the mechanism(s) of marine mortality is uncertain, what is clear is that the recent period of poor sea survival is occurring in parallel with many widespread changes in the North Atlantic ecosystem.

Changes in climate in the early 1990s have resulted in significant physical and biological changes in the North Atlantic including: an enhanced outflow of low-salinity waters from the Arctic through the Labrador Sea, enhancement of stratification on the northwest Atlantic shelf, changes to the seasonality of phytoplankton production, greater abundance of small copepods and a decrease in abundance of older life stages (Greene *et al.* 2008). The relationship between salmon abundance and temperature is reasonably well established (Friedland *et al.* 1993) and therefore changes related to sea surface temperature may be some of the key factors affecting natural mortality (Cairns 2001).

The impacts of climate will not be limited to marine environments. From 1990–2100, mean surface air temperature is projected to increase by 1.4-5.8ºC, with more rapid warming in the Northern regions of North America (IPCC 2001). In Atlantic Canada, a 2-6°C increase is expected in the next century with increases in air temperature expected to be greatest in western New Brunswick and Quebec, and lowest in Labrador. The responses of Atlantic Salmon populations across its range in eastern Canada are uncertain, but they are expected to differ across the latitudinal range.

Directed fishing has had catastrophic effects on many fish species (e.g. Pauly *et al.* 2002) including Atlantic Salmon. In Lake Ontario, directed fishing acted in concert with habitat loss to collapse the Atlantic Salmon fishery within 26 years of beginning commercial-scale harvesting (Dunfield 1985). This population was subsequently extirpated by the turn of the 20th century (COSEWIC 2006a).

In eastern Canada, the final closure of major intercept fisheries in 1992 shifted the emphasis of commercial mixed stock salmon fisheries towards Aboriginal and recreational salmon fisheries on river-specific stocks. Fisheries are principally managed on a river-by-river basis and, in the few areas where retention of the dominant egg-bearing size group is allowed, harvests are closely controlled to achieve conservation goals (based on egg-deposition rates). Harvests by all users in Canada in 2008 totalled 132t, the lowest of 47 years of record and only about 5% of peak landings reported 1960 – 1980 (DFO and MRNF 2009). These landings constituted approximately 9.5% of returns to Canadian rivers in 2008.

In 2006, 64% of the reported harvest of Atlantic Salmon occurred in the recreational fisheries. In this fishery, 100% of the effort occurs in fresh water and is therefore river-specific. Impacts of recreational fishing are managed with retention quotas, restrictions on retaining large salmon, gear types, exclusive catch and release fisheries and complete closures. Harvest in the total Canadian recreational fisheries in 2006 was 35,171 small and large salmon (7% of total returns), of which slightly less than 10% were large (MSW) salmon; this was the lowest total harvest reported in 33 years of record (ICES 2007).

The practice of catch and release has increased in recreational fisheries. In 2006, about 58% of the total number of salmon caught were released (ICES 2007). Under the right conditions, catch and release angling is considered to be a useful management tool (Dempson *et al.* 2002) but still results in some mortality. Water temperature and handling duration are among factors that affect the survival rate of released fish. The incidence of short-term mortalities in Newfoundland were observed to be ~10% (Dempson *et al.* 2002). Values of 3-10% are used when accounting for catch and release-related mortality in stock assessments in Atlantic Canada.

Limited Aboriginal food fisheries take place in eastern Canada, subject to agreements or through licences issued to Aboriginal groups. Most of these fisheries occur in fresh water or in estuaries close to river mouths. Although the reports of harvests are incomplete, the fisheries often affect river-specific stocks. In large areas of eastern Canada, Aboriginal harvests of Atlantic Salmon have been curtailed due to concern about stock status, at times on a voluntary basis. Some of the Aboriginal food fisheries of Labrador take place in what are considered to be coastal waters. These fisheries have moved closer to river mouths and likely harvest few salmon from other than local rivers. The estimated harvest in all Aboriginal peoples' fisheries in 2006 was 59t, the second highest of 17 years of record (ICES 2007).

Commercial fisheries for Atlantic Salmon in Canadian waters, which as recently as 1980 yielded a harvest of 2,412t (ICES 2007), have been closed since 2000. Salmon of Canadian origin are still captured in the marine fisheries of St. Pierre and Miquelon and at West Greenland. Reported harvests of the St. Pierre and Miquelon marine gill net fishery have ranged between 1.5 and 3.6t per year over the past 10 years (ICES 2007). In the context of total harvests, the fishery is small but it is a mixed stock and interception fishery. A recent genetic analysis of a sample of the catches from 2004 indicated that 98% of the fish were of Canadian origin (ICES 2006). As this fishery occurs in a marine area adjacent to the south coast of Newfoundland, it likely has an impact on stocks of the immediate area and the Maritime Provinces.

The fishery of West Greenland is a mixed stock interception fishery and harvests fish of North American and European origin. The salmon caught in that fishery are mostly (>90%) non-maturing 1SW salmon, most of which are destined to return to home waters as multi-sea-winter (2SW primarily) fish. Fish from all multi-sea-winter producing areas of eastern Canada are intercepted in this fishery. In the past ten years, the harvested fish have been predominantly North American in origin. The fishery, which is conducted for local consumption, had a reported harvest of between 2,300 and 4,000 fish of North American origin from 2002 to 2006 (ICES 2007).

Illegal harvests of Atlantic Salmon occur in both marine and fresh waters to varying degrees throughout Atlantic Canada. Poaching in marine waters is more frequent in waters around Newfoundland and Labrador and the Quebec Lower North Shore than elsewhere (DFO and MRNF 2009). In Newfoundland, net-scarred salmon (those that had survived entanglement within nets) approached 10% in some rivers of Newfoundland (Dempson *et al.* 1998). Illegal harvesting is most frequently carried out using gillnets or bait nets, the latter illegally set so as to increase the bycatch of salmon (DFO 2007). Poaching in inland waters is carried out by a variety of means, including jigging and sweeping of pools by nets (DFO 2007). Some management measures deter illegal fishing through fostering community stewardship, targeted enforcement and protecting salmon in vulnerable freshwater habitats. While quantification of the magnitude of mortality associated with illegal fishing is difficult, circumstantial evidence suggests mortality related to illegal fishing can imperil localized stocks (e.g. Cote 2005).

Bycatch associated with monitored commercial fisheries is not considered significant. Bycatch through commercial fisheries is thought to have significantly declined due to the moratorium on some groundfish species since 1992. Dempson *et al.* (1998) indicate very few salmon are caught in both inshore and offshore fisheries. Bait-fishing is also thought to cause minimal bycatch given current bait-fishery restrictions (Reddin *et al.* 2002). Bycatch from Aboriginal fisheries off Labrador do result in salmon mortality. However, these catches count against established quotas, which when reached, trigger additional measures to limit mortality of salmon (ICES 2007). The bycatch of the Ungava Aboriginal fishery is, however, considered “significant” (DFO and MRNF 2009). There are no reported bycatches of salmon from any other Aboriginal fisheries in eastern Canada.

Obstructions can severely reduce the productive habitat and production of salmon (DFO and MRNF 2008). Low head and surmountable dams delay, at the very least, upstream migration until such time as water discharges are adequate for salmon to leap the obstruction. Higher dams equipped with fish passages have varying passage efficiencies, 100% being very uncommon (Fay *et al.* 2006). Even when upstream passage is available, the impoundments behind these dams can delay and/or prevent smolt emigration, increase the energetic costs of smolt movements and, dependent on discharge conditions, can result in increased predation (NRC 2004).

In addition to direct loss of productive habitat from flooding, dams also alter natural river hydrology and geomorphology, interrupt natural sediment and debris transport processes, and alter natural temperature regimes (Ruggles and Watt 1975, Wheaton *et al.* 2004). These impacts can adversely change aquatic community composition and affect the entire aquatic ecosystem structure and function.

Ruggles (1980) identified the following unnatural conditions created by dams that can threaten anadromous salmonid populations: passage over spillways, passage through turbines, passage through impoundments, exposure to atmospheric gas saturation, pollutants, predators, unnatural temperatures, disease organisms and increased vulnerability to exploitation from angling. Smolts are vulnerable to the impacts of dams and may become impinged on screens, entrained in forebays, accrue lethal abrasions or be killed in turbines during downstream migration. Dams can also alter flow patterns of rivers, increase water temperature, and concentrate pollutants, all of which are factors that can adversely affect resident parr and migrating smolts (Foerster 1934, Saunders 1960). Entrainment mortality for salmonids can range between 10-30% at hydroelectric dams (Fay *et al.* 2006). Passage through turbines can also lead to indirect mortality from increased predation and disease (Odea 1999). Where multiple dams exist, the losses of downstream migrating smolts from turbine entrainment are often cumulative and biologically significant (Gibson *et al.* 2009). Because of their larger size, turbine mortality of kelts is expected to be significantly greater than 10 to 30% (FERC 1997). Mortality of salmon in hydropower generation plants, although potentially mitigated with fish passage facilities and water management, can pose a significant threat to the persistence of Atlantic Salmon.

Juvenile Atlantic Salmon can use extensive areas of freshwater habitat (e.g. Robertson *et al.* 2003) and must be able to access feeding and refuge habitat. Lack of habitat connectivity affects the abundance and distribution of Atlantic Salmon populations but may also reduce access to habitats, which improve growth (e.g. Hutchings 1986) and survival (Breau *et al.* 2007).

Improperly designed culverts create barriers to fish passage through hanging outfalls, increased water velocities, or insufficient water velocity and depths within. After a study of culvert installation on the newly constructed Trans-Labrador Highway, Gibson *et al.* (2005) concluded that culverts create more passage barriers to fish passage than other structures. Culverts can also degrade habitat quality through direct loss of habitat through scour, deposition of sediment and loss of food production within the vicinity of the crossing (Bates 2003).

Water withdrawals for agricultural, mining, or other industries can directly impact Atlantic Salmon spawning and rearing habitat (Maine Atlantic Salmon Task Force 1997). They have the potential to expose and reduce salmon habitat and contribute to more variation and higher water temperatures. Adequate water quantity and quality are especially critical to adult migration and spawning, fry emergence and smolt emigration (DFO and MRNF 2008). During summer and winter low flows, juvenile salmon survival is directly related to discharge (Gibson 1993, Cunjak 1988, Cunjak 1996), with better survival in years with higher flows (Ghent and Hanna 1999). As a result, water withdrawals have the potential to limit carrying capacity and reduce parr survival.

Land management activities, particularly land clearing for development, has the potential to negatively affect freshwater habitat of salmon and food sources. Habitat alteration resulting from sedimentation, run-off pollution, channelization and changes to hydrological regimes are all associated with development (Trombulak and Frissell 2000, Wheeler *et al.* 2005, Fay *et al.* 2006).

Juvenile salmon can be adversely affected by contaminants in fresh water. Pesticide effects on salmonids may range from acute (e.g. fish kills in PEI; Cairns *et al.* 2009) to chronic (leading to increased cumulative mortality; DFO and MRNF 2009). Sub-lethal concentrations of contaminants, such as endocrine-disrupting chemicals, may compromise survival of salmon at sea (Fairchild *et al.* 2002, Moore *et al.* 2003, Waring *and* Moore 2004). Sources of these compounds may include agriculture, sewage, pesticide spraying (e.g. forest spraying; Fairchild *et al.* 1999) and industrial effluents (e.g. pulp and paper mills; McMaster 2001). A caging study in the Miramichi River showed a general trend of better feeding and growth in Atlantic Salmon smolts caged at sites with fewer known anthropogenic inputs, of which pulp and paper mill effluent was a major contributor (Jardine *et al.* 2005). In addition, chemical pollution from chlorinated organic compounds, which are widely distributed in the North Atlantic Ocean, has been proposed as a complementary factor affecting the sea survival of Atlantic Salmon (Scott 2001). The limited studies to date have only examined a minute number of the vast variety of chemicals currently being used and introduced.

Acidification of fresh water in eastern Canada is primarily a result of depositions of airborne pollutants originating in the central U.S. and Canada, though inputs are augmented by local sources as well (DFO 2000). Currently, acid impacts on Atlantic Salmon are most pronounced in the Southern Upland region of Nova Scotia (DU 14) where 22% of rivers are acidified and have lost populations and a further 31% are moderately impacted by acidification and maintain remnant populations (DFO 2000). Assuming a smolt-to-adult return rate of 5%, a value higher than is presently being observed, acidification impacts will likely result in the extirpation of 85% of the Southern Upland populations. The underlying geology of the Southern Upland is the principle reason for the vulnerability to acidification.

Other areas in Atlantic Canada that are somewhat vulnerable to the effects of acid depositions are southwestern and northeastern Newfoundland (Environment Canada 2004). Although there has been a reduction in sulphate emissions and depositions, there has not been a corresponding increase in pH or acid neutralizing capacity in these areas. Furthermore, at the projected sulphate deposition rates, the time for recovery of base cations in these catchments is 60-80 years (Clair *et al.* 2004). Based on the cumulative effects and extirpations, the estimated time to recovery for affected drainages, and the large area affected, acidification remains a significant threat to one DU (14, Nova Scotia Southern Upland) and is a burden if not a threat to perhaps one other (DU 4) in Newfoundland.

Infiltration of sediment into stream bottoms has been suggested as a cause for significant decrease in the survival, emergence and over-wintering success of Atlantic Salmon juveniles (Chapman 1988). Sediment size and movement in a stream (bedload) is a natural process; however, a multitude of impacts can greatly increase the input and accumulation of sediments to streams (Meehan 1991, Wheeler *et al.* 2005). The result is the loss of habitat as interstitial spaces become filled with sediment. All but the oldest of juvenile salmon occupy interstitial spaces at some stage and therefore exceeding the equilibrium input of sediments into streams can have devastating effects. As little as 0.02% silt has been shown to decrease the survival of eggs to the pre-eyed stage by 10% (Julien and Bergeron 2006). As stated above, sedimentation is often a by-product of road construction, urban development, agriculture and some industries.

Aquaculture is an industry associated with much controversy as inferences have been made that associate the decline in European wild salmon stocks with the rise in farmed salmon production (e.g. Gausen *and* Moen 1991, Heggberget *et al.* 1993, Hansen *et al.* 1997). Similar concerns have been voiced in eastern Canada, as growth of the Canadian industry has coincided with severe declines in wild populations in nearby rivers in the Bay of Fundy (DU 15, 16) and the Bay D'Espoir region (DU4) of the south coast of Newfoundland (Carr *et al.* 1997, Amiro 1998, Chang 1998, Dempson *et al.* 1999).

The concern for wild stocks is based on the potential for interactions that result in inter-breeding and subsequent loss of fitness, competition for food and space, disruption of breeding behaviour, and transmission of disease (Cairns 2001). In North America, farm-origin salmon, have been reported in 87% of the rivers investigated within 300 km of aquaculture sites (Morris *et al.* 2008). Though the abundance of farmed salmon in rivers is highly variable, it can exceed those of wild fish (Jones *et al.* 2006, Morris *et al.* 2008). There is strong evidence for the introgression of genetic material from European-origin aquaculture salmon into some wild Atlantic Salmon populations within the inner Bay of Fundy (Patrick O'Reilly, pers. comm.).

Even small percentages of escaped farmed salmon have the potential to negatively affect resident populations, either through demographic or genetic changes in stock characteristics (Hutchings 1991). There have been many reviews and studies showing that the presence of farmed salmon results in reduced survival and fitness of wild Atlantic Salmon, through competition, interbreeding and disease (e.g., Gross 1998, Fleming *et al.* 2000, NRC 2002, 2004, McGinnity *et al.* 2003). For example, an experimental cross between 4th-generation farmed Atlantic Salmon of the Saint John River and wild individuals from the Stewiacke River, showed a significant decrease in F1 survival to the pre-eyed embryonic stage relative to pure crosses (Lawlor 2003). The use of more exotic species (e.g. rainbow trout) in and around salmon rivers could also pose a problem with escapes into the wild (see interspecific interactions).

Another concern related to aquaculture is the possibility of disease/parasite transmission from artificially propagated fish to wild stocks. In Norway many salmon populations have been destroyed by the parasite *Gyrodactylus salaris* (Heggberget *et al.* 1993, McVicar 1997) and over 70 rivers affected with furunculosis (Johnsen *and* Jensen 1994; in both cases the outbreaks originated with hatchery-propagated salmonids. However, in North America there is no evidence to indicate that farmed salmon have transferred these diseases to wild fish (DFO 1999).

It has been suggested that intensive aquaculture may cause salmon to alter migratory behaviour (Amiro 2001), and that attraction of predators such as seals to aquaculture facilities might result in an increased rate of predation of wild fish in the area (Cairns and Meerburg 2001), but both of these suggestions remain unverified.

As outlined in Interspecific Interactions, invasive and/or introduced species have potential to negatively interact with Atlantic Salmon, particularly in freshwater. Potential interactions include predation, competition for habitat, food and mates as well as hybridization. In the Great Lakes, Zebra Mussels (*Dreissena polymorpha*) and Alewife (*Alosa pseudoharengus*) may have created conditions that are less conducive to restoration efforts. The latter has also been implicated in the collapse of Lake Ontario Atlantic Salmon. Endemic salmon may have suffered the effects of thiamine deficiency (including mortality and impaired ability to reach spawning grounds) as alewife became a prominent food source (Ketola *et al.* 2000). In general, negative interactions between salmon and non-native species are often context-specific or not well understood.

In areas where populations have collapsed, further declines caused through inbreeding depression and abnormal behaviour associated with low population size are a concern (e.g. iBoF; COSEWIC 2006b).

Cairns (2001) noted that it is very improbable that the decline in Atlantic Salmon is due to any single cause, and factors contributing to a decline are likely to have acted in a cumulative manner (see projections of Gibson *et al*. 2009 for an example of cumulative interactions of stressors). Directed fishing and habitat alterations are considered in many DUs to have a medium effect on populations (DFO and MRNF 2009). A semi-quantitative assessment, by regional fisheries scientists and managers, of the impact of habitat-related threats to salmon is summarized by DU in Table 3 (taken from DFO and MNFR 2009). Potential sources of mortality were assessed with respect to the proportion of salmon that would be affected, and the time frame in which salmon had been vulnerable to the threat. The most wide-ranging habitat threats to Atlantic Salmon originate from transportation infrastructure, agriculture, forestry and mining operations, and municipal waste-water discharge. The least severely threat-impacted areas are in Quebec, Newfoundland and Labrador (DUs1-9). Conversely, the Maritime Provinces (DUs 14-16) are the most severely threat-impacted with several threats affecting > 30% of salmon or a loss of > 30% of spawners (Table 3). Salmon of DU 14 (Nova Scotia Southern Upland) are severely impacted by acid rain, which has caused the loss of populations in several of the 63 rivers within the DU. In combination with the persisting low marine survival (ecosystem change) listed for DUs 12-16, acid rain is threatening the loss of the majority of the remaining salmon populations within that area (Amiro 2000, DFO 2000). Based on the ubiquitous effects poor marine survival is having on Atlantic Salmon populations, ecosystem effects (e.g. Friedland 1998) should be considered a threat for all DUs.

Table 3. Summary assessment of threats to Atlantic Salmon (in terms of salmon affected and lost to habitat alterations) for proposed designatable units (DU) as reported by fisheries managers (modified from DFO and MRNF 2009). Dark shading highlights '>30% of salmon affected'; light shading is '5-30% affected' and no shading is <5% affected-often not applicable unassessed, uncertain.

			Salmon Affected : Spawners Lost												
			Regulated Habitat Alterations										Other		
Proposed DU	**Atlantic Salmon Conservation Unit**	No. salmon rivers	Municipal waste water	Industrial effluents (pulp *and* paper, etc.)	Hydroelectric *and* water storage dams	Water extraction	Urbanization (hydrology)	Transportation Infrastructure (roads culverts *and* fish passage)	Aquaculture siting	Agriculture, forestry, mining	Dredging	**Cumulative**	Shipping transport	Air pollutants / acid rain	Ecosystem change
DU2	1. North Labrador	28	L:L	L:L	L:L	L:L	L:L	L:L	L:L	L:L	L:L	**L:L**	L:L	L:L	LU:LU
DU2	2. Lake. Melville Labrador	20	L:L	L:L	L:M	L:L	L:L	M:M	L:L	L:L	L:L	**U:U**	L:L	L:L	LU:LU
DU2	3. South Labrador	41	L:L	L:L	L:L	L:L	L:L	M:M	L:L	L:L	L:L	**U:U**	L:L	- : -	LU:LU
DU3	4. NE Coast NF	127	M:M	L:L	M:M	L:L	L:L	M:M	L:L	M:M	L:L	**U:U**	L: -	- : -	LU:LU
DU4	5. SE Coast NF	49	L:L	L:L	L:L	L:L	L:L	M:M	L:L	M:M	L:L	**U:U**	U:U	MU:MU	LU:LU
DU4	6. South Coast NF	55	L:L	- :L	M:M	L:L	L:L	L:L	M:M	L:L	L:L	**U:U**	- : -	MU:MU	LU:LU
DU5	7. SW Coast NF	40	L:L	L:L	L:L	L:L	L:L	U:U	L:L	M:M	L:L	**U:U**	- : -	- : -	LU:LU
DU6	8. NW Coast NF	34	L:L	L:L	L:L	L:L	L:L	L:L	L:L	L:L	L:L	**L:L**	L:L	- : -	LU:LU
DU12	9. Northern NB	15	L:L	L:L	LM:LM	L:L	L:L	M:M	N/A	M:M	L:L	**M:M**	U:U	L:U	LU:LU
DU12	10. Central NB	25	LM:L	L:L	L:L	L:L	L:L	M:M	N/A	LM:L	L:L	**M:M**	U:U	L:U	LU:LU
DU12	11. PEI	5*	L:L	N/A	MH:MH	L:L	L:L	MH:MH	L:L	MH:MH	L:L	**MH:MH**	U:U	U:U	LU:LU
DU12	12. NE NS	33	LM:LM	L:L	L:L	L:L	L:L	M:M	N/A	L:L	L:L	**M:M**	U:U	U:U	LU:LU
DU13	13. CB East Highlands	8	M:L	U:U	L:L	L:L	H:U	H:U	H:U	H:U	L:L	**U:U**	H:U	L:L	H:U
DU13	14. CB East Lowlands	21	H:U	U:U	L:L	L:L	H:U	H:U	H:U	H:U	L:L	**MH:U**	H:U	L:L	H:U
DU14	15. NS Southern Upland	63	H:U	L:L	H:M	U:U	H:U	H:U	U:U	H:U	L:L	**H:U**	L:L	H:H	H:U
DU15	16. IBoF NS/NB	37	H:U	L:L	M:L	U:U	H:U	H:U	H:U	H:U	L:L	**H:M**	L:U	L:L	H:H
DU16	17. OBoF NB	17	H:U	H:U	H:M	MH:U	H:U	H:U	M:U	H:U	L:L	**H:M**	H:U	U:U	H:H
DU12	18. Chaleur Bay PQ	5	L:L	L:L	N/A	L:L	L:L	L:L	N/A	L:L	- : -	**L:L**	- : -	L:L	L:L
DU12	19. Gaspé Peninsula PQ	10	U:U	U:U	N/A	N/A	L:L	L:L	U:U	U:U	- : -	**L:L**	U:U	U:U	U:U
DU12	20. Lower St. Lawrence N. Shore Gaspé PQ	9	L:L	N/A	L:L	L:L	L:L	L:L	N/A	L:L	- : -	**L:L**	- : -	L:L	L:L
DU10	21. Appalachian Region PQ	0													
DU10	22. Quebec City Region PQ	3	L:L	U:U	U:U	U:U	U:U	L:L	U:U	U:U	U:U	**U:U**	U:U	U:U	M:M
DU10	23. Saguenay-Lac Saint-Jean PQ	4	L:L	U:U	U:U	U:U	U:U	M:U	U:U	-: -	U:U	**U:U**	U:U	U:U	H:L
DU8	24. Upper North Shore PQ	12	N/A	N/A	L:L	L:L	N/A	N/A	N/A	UL:UL	N/A	**- : -**	N/A	N/A	U:U
DUs7,8	25. Middle North Shore PQ	17	N/A	N/A	L:L	N/A	N/A	N/A	N/A	UL:UL	N/A	**- : -**	N/A	N/A	U:U
DUs2,7	26. Lower North Shore PQ	21	N/A	N/A	L:L	N/A	N/A	N/A	N/A	N/A	N/A	**- : -**	N/A	N/A	U:U
DU9	27. Anticosti PQ	25	N/A	N/A	N/A	N/A	N/A	N/A	N/A	U:U	N/A	**- : -**	N/A	N/A	U:U
DU1	28. Ungava PQ	4	L:L	N/A	N/A	L:L	L:L	L:L	L:L	L:L	L:L	**L:L**	U:U	U:U	U:U

a- Where 'salmon affected' symbol 'L' is < 5% of salmon in DU are affected; 'M' is 5-30% are affected, 'H' is >30% are affected and 'U' is uncertain; 'salmon lost' symbol 'L' is < 5% of salmon spawners in DU are lost; 'M' is 5-30% are lost, 'H' is >30% are lost and 'U' is uncertain; N/A = Not Applicable and '-' = Not Assessed.

*Cairns *et al.* 2009 state there were at least 22 salmon rivers in PEI.

SPECIAL SIGNIFICANCE[xxi]

Atlantic Salmon are contributors to both freshwater and marine ecology, moving nutrients between ecosystems as migrants and linking energy flow as prey and as predators within ecosystems. They are the principle host species for the Eastern Pearl Mussel (*Margaritifera margaritifera*) and possibly the Dwarf Wedgemussel (*Alasmidonta heterodon*) (Hanson *and* Locke 2001, National Recovery Team 2002). They are traditionally used by (i) over 49 First Nations and Aboriginal organizations, (ii) commercial fisheries, and (iii) recreational fisheries (DFO and MRNF 2009). They are also the subjects of local art, science and education and symbols of heritage and health to peoples of Canada.

EXISTING PROTECTION, STATUS, AND RANKS

The Atlantic Salmon is currently listed or ranked with several international and national bodies. In the United States of America, endemic populations in Maine have Endangered status under the *U.S. Endangered Species Act*. In April 2006, COSEWIC assessed the Atlantic Salmon Inner Bay of Fundy population as Endangered and the Lake Ontario population as Extirpated. The Atlantic Salmon Inner Bay of Fundy population is currently listed as Endangered under Canada's *Species at Risk Act,* and the Lake Ontario population is currently listed as Extirpated under Ontario's *Endangered Species Act,* 2007. Fisheries management actions also provide significant protection for Atlantic salmon. These measures are complex and vary across jurisdictions but generally include: fishery closures, limitations on gear types (both Aboriginal and recreational), seasonal restrictions, retention and release policies (e.g. quotas, catch and release, no retention of MSW fish). Salmon habitat is also protected and managed under the *Fisheries Act* by the Department of Fisheries and Oceans. Under provincial legislation the Atlantic Salmon is listed as Extirpated in Ontario, Sensitive in New Brunswick, Secure in Nova Scotia, Quebec, and Newfoundland and Labrador, and not assessed in Prince Edward island.

NON-LEGAL STATUS AND RANKS[xxii]

Internationally, Atlantic Salmon are listed as Least Concern on the IUCN Red List of Threatened Species (last assessed 1996). They are also ranked by the WWF on a per river basis throughout its global range, as 15% Extinct, 12% Critical, 20% Endangered, 10% Vulnerable, and 43% healthy (N = 2,005 rivers in 19 countries).

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Dr. Adams completed his B.Sc. at St. Mary's University and his M.Sc. and Ph.D at Dalhousie University, both located in Halifax, Nova Scotia, Canada. Dr. Adams completed a post-doc at Memorial University of Newfoundland and now works with the Department of Natural Resources, Goverment of Newfoundland and Labrador. Dr. Adams has over 15 years experience studying salmonid fish, primarily Atlantic salmon.

Dr. Cote received a B.Sc in Biology from Wilfrid Laurier University (1996) and a Ph.D. in Biology from the University of Waterloo (2000). He has been an aquatic ecologist with Parks Canada (Terra Nova National Park) since 2000 and has 17 years experience studying emperilled marine and anadromous fish populations. He holds an adjunct faculty position at Memorial University of Newfoundland and has authored 18 primary and 8 secondary publications.

Appendix 1: River-specific salmon abundance trend information, presented by region (taken from Gibson *et al.* 2006).

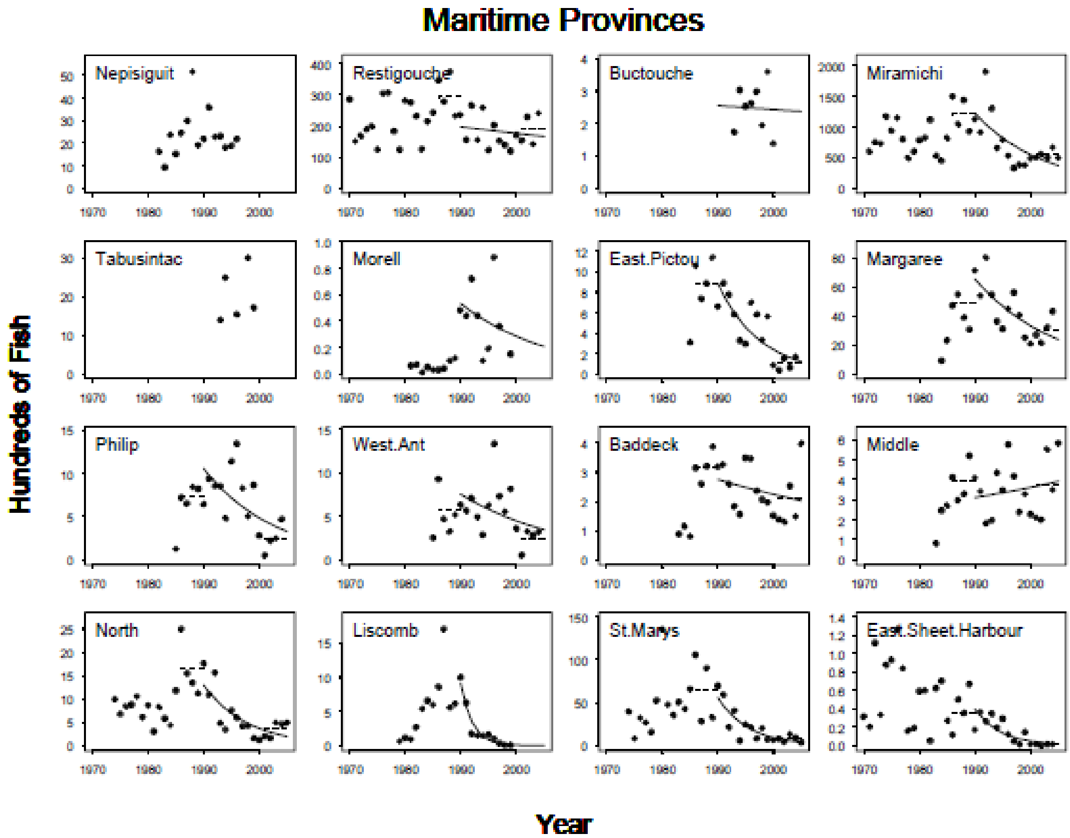
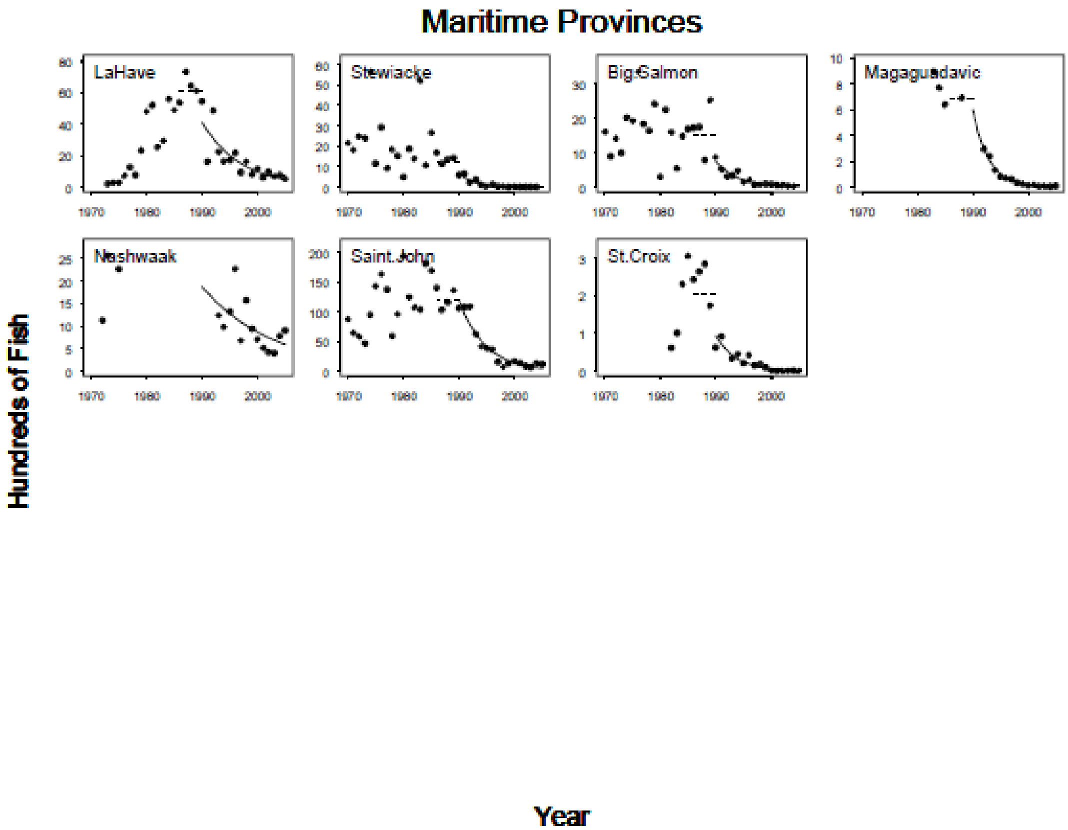


Figure A1. Trends in abundance of salmon populations in the Maritime Provinces from 1970 to 1990. The curved solid line shows the trend from 1990 to 2005 obtained from a log-linear model. The dashed lines show the 5-year average population sizes for the time periods ending in 1990 and 2005 (taken from Gibson *et al.* 2006).



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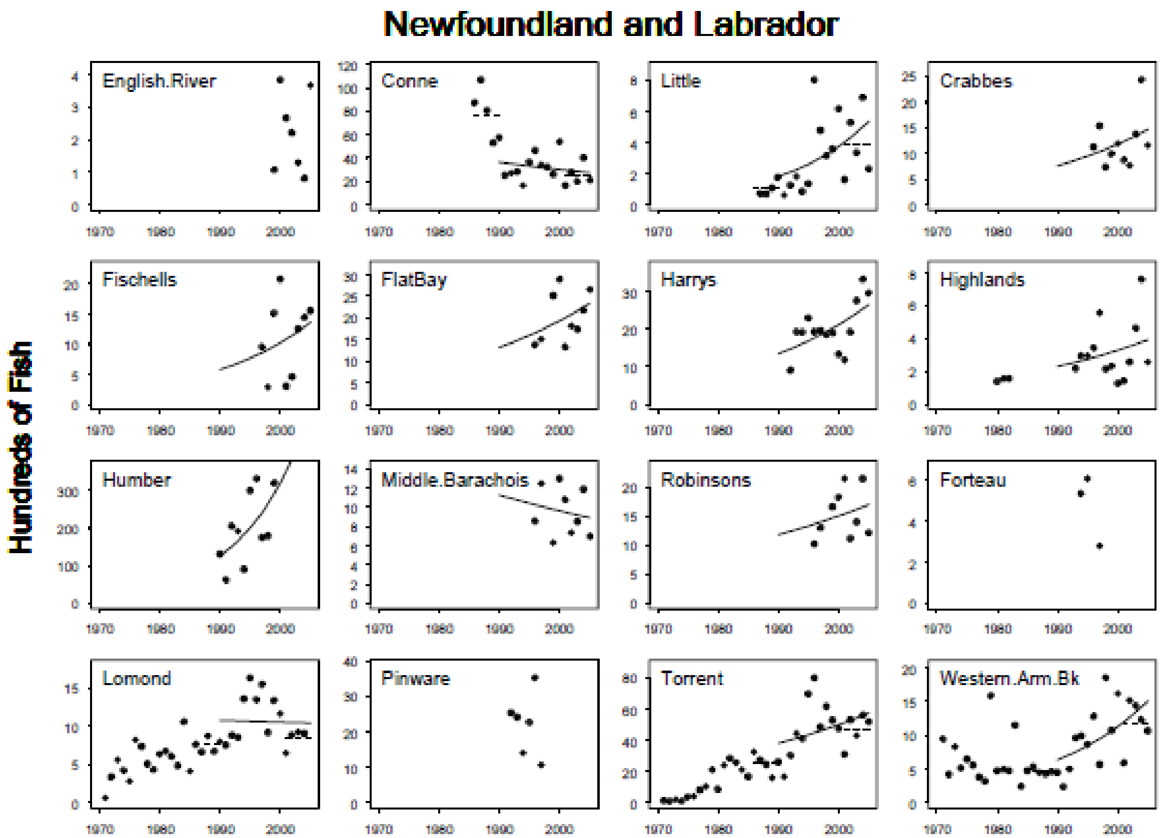
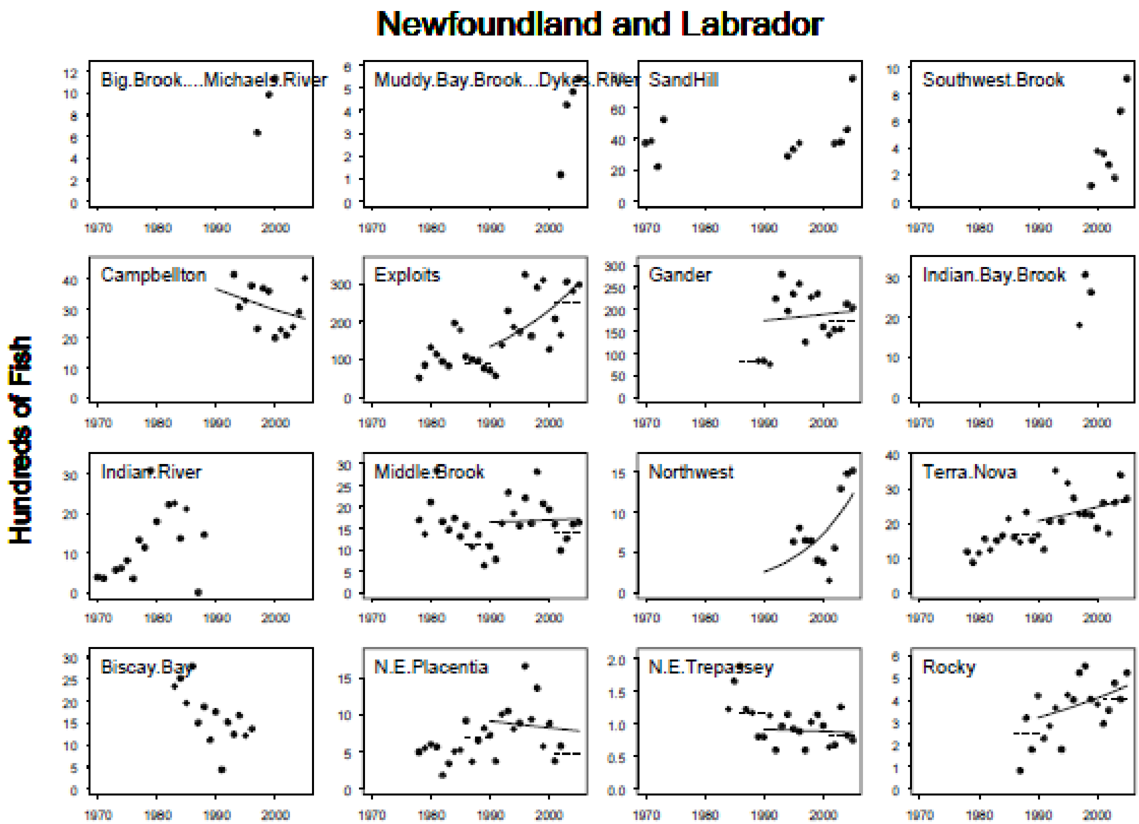


Figure A2. Trends in abundance of salmon populations in Newfoundland and Labrador from 1970 to 1990. The curved solid line shows the trend from 1990 to 2005 obtained from a log-linear model. The dashed lines show the 5-year average population sizes for the time periods ending in 1990 and 2005 (taken from Gibson *et al.* 2006).



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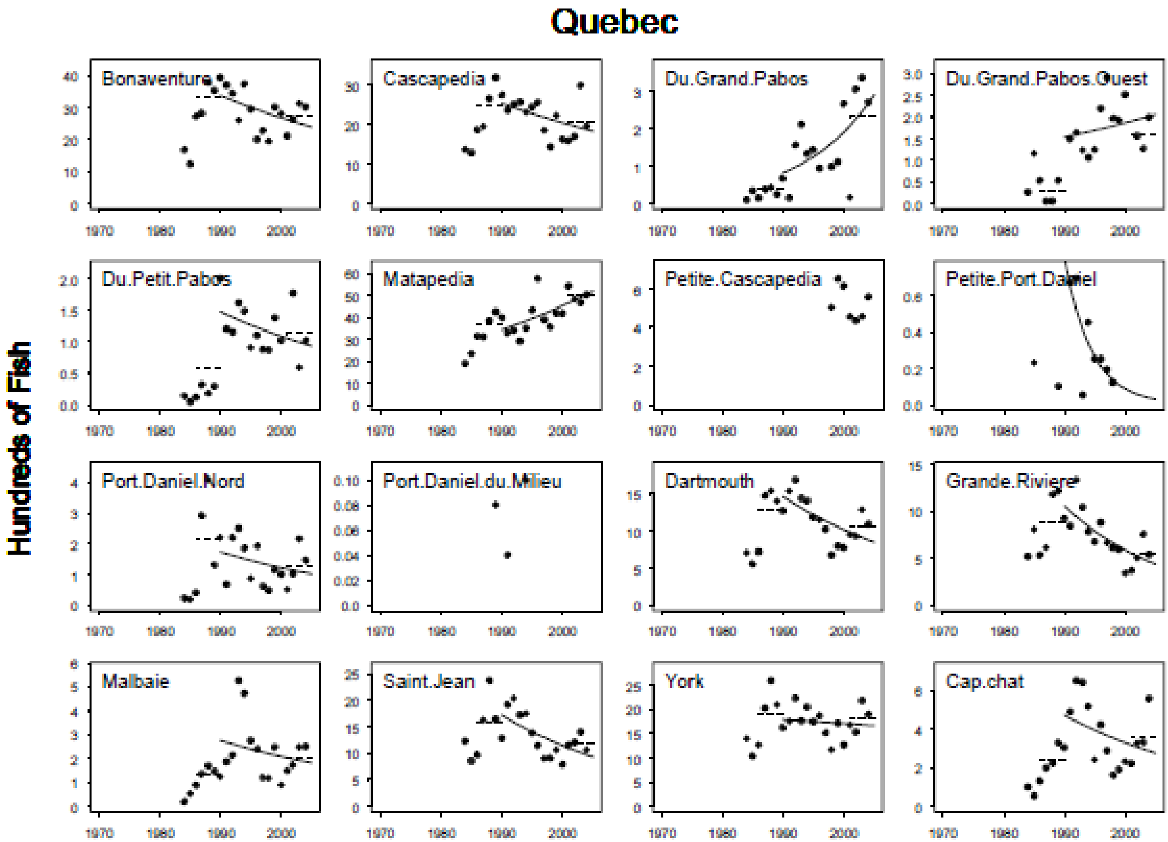
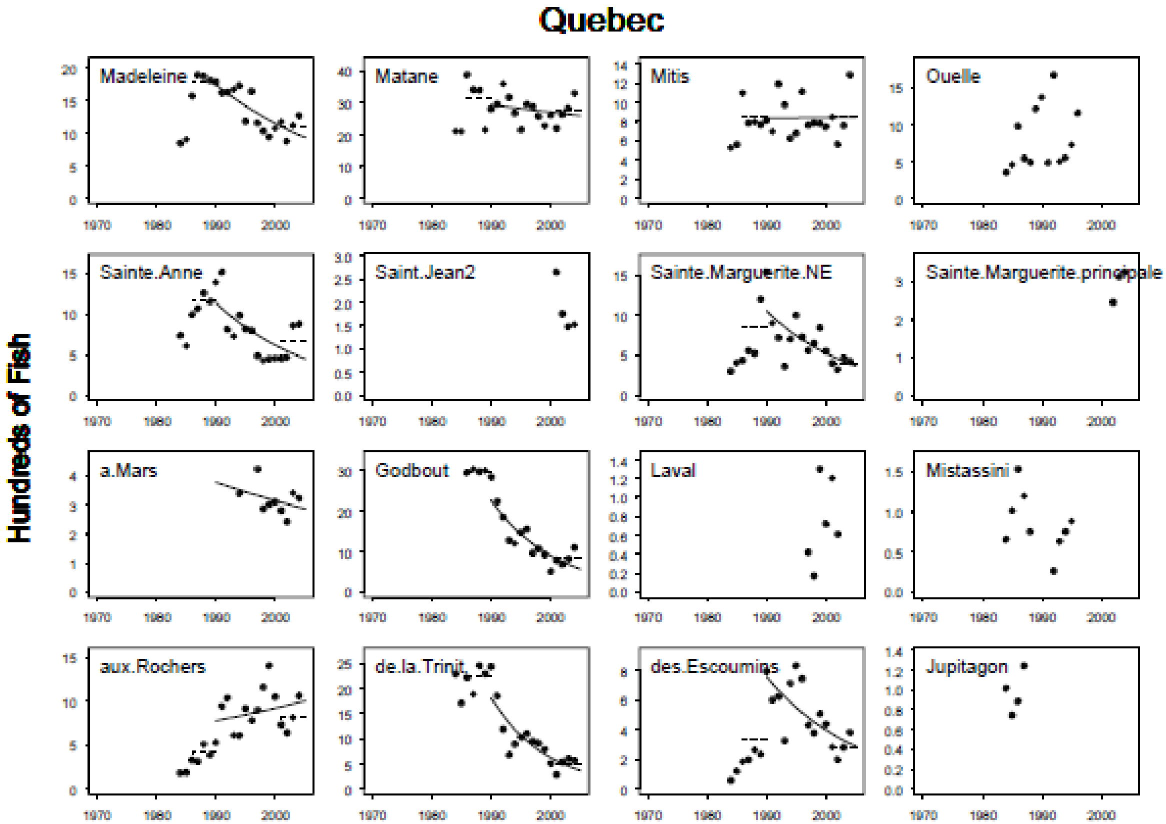


Figure A3. Trends in abundance of salmon populations in Quebec from 1970 to 1990. The curved solid line shows the trend from 1990 to 2005 obtained from a log-linear model. The dashed lines show the 5-year average population sizes for the time periods ending in 1990 and 2005 (taken from Gibson *et al.* 2006).



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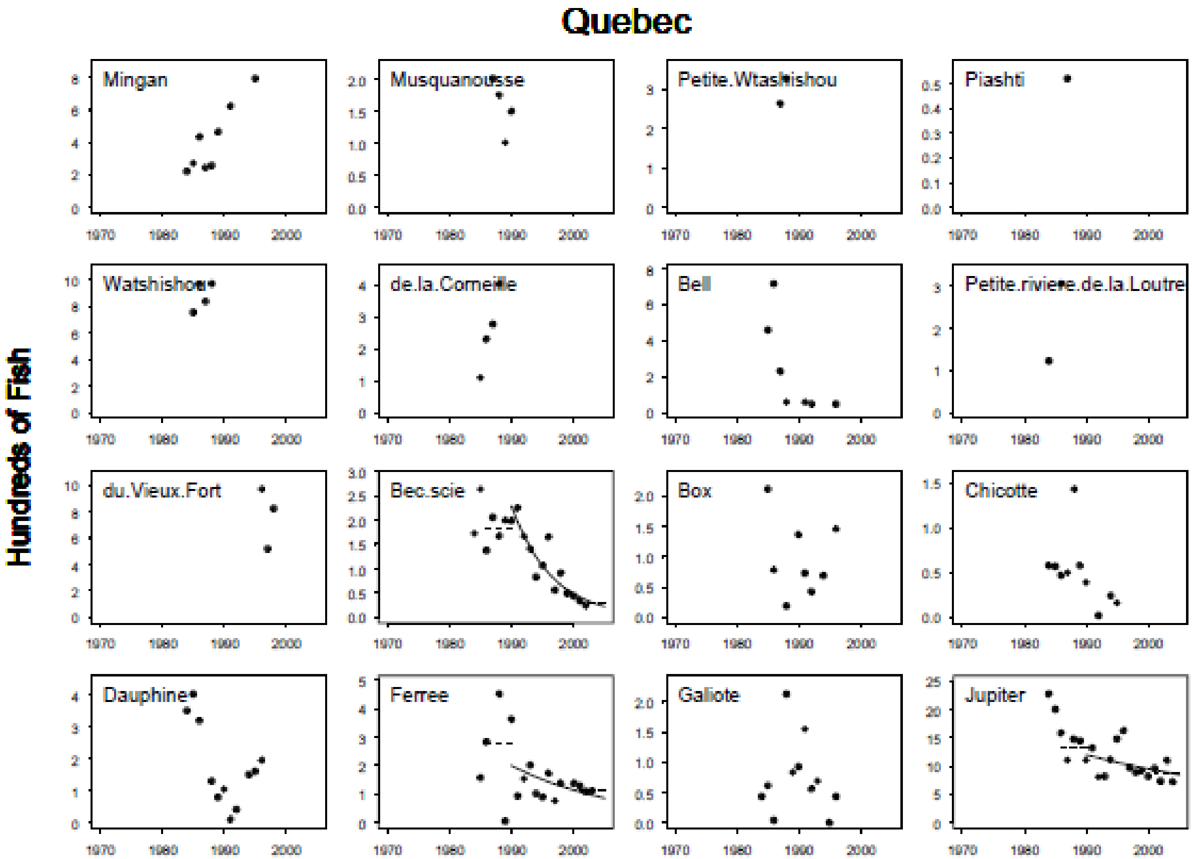

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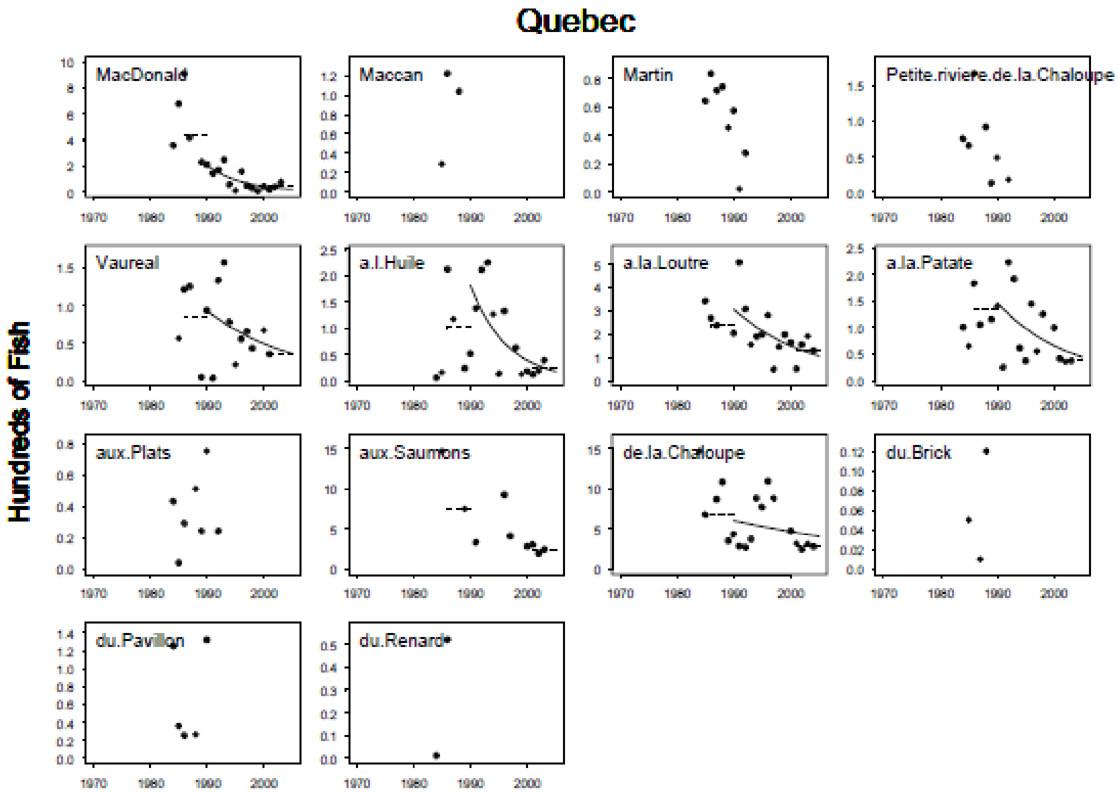

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[i] This section is taken from COSEWIC 2006a.

[ii] Elements of this section are copied, abstracted and/or synthesized from DFO *and* MRNF (2008).

[iii] Elements of this section have been copied, abstracted and/or synthesized from COSEWIC (2006a).

[iv] This section was taken from COSEWIC (2006a).

[v] This section was taken from COSEWIC (2006b).

[vi] Note that the number of salmon rivers presented by the WWF does not correspond with the estimate provided by COSEWIC (2006b) in Figure 2.

[vii] Elements of this section have been copied, abstracted and/or synthesized from DFO (2000), Amiro (2006), COSEWIC (2006a, 2006b) and DFO and MRNF (2008).

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[xii] Elements of this section have been copied, abstracted and/or synthesized from Cairns (2006) and DFO and MRNF (2008).

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[xiv] Elements of this section have been copied, abstracted and/or synthesized from DFO and MRNF (2008), DFO *and* MRNF (2009), Wesley *et al.* (submitted) and COSEWIC (2006a, 2006b).

[xv] Modal smolt ages were derived from Appendix 3 (large and small salmon combined) in Chaput *et al.* (2006a), except for DU 7 (Appendix 1 - small salmon), DU 8 (Appendix 2 - large salmon) and DU 10 (estimated from Figure 3), where data were lacking.

[xvi] This DU was listed as “extirpated” in COSEWIC 2006a; however, current interpretation of the meaning of “DUs” requires that if a DU is lost, its unique elements cannot be recovered. As such, the authors have been advised that “extinct” is a more appropriate description.

[xvii] Elements of this section have been copied, abstracted and/or synthesized from DFO *and* MRNF (2009)

[xviii] Large salmon in DU 3 are comprised almost exclusively of repeat spawning grilse as opposed to maiden multi-sea -winter fish.

[xix] This DU was listed as “extirpated” in COSEWIC 2006a; however, current interpretation of the meaning of “DUs” requires that if a DU is lost, its unique elements cannot be recovered. As such, “extinct” is a more appropriate description.

[xx] Elements of this section have been copied, abstracted and/or synthesized from Cairns (2001), Dempson *et al.* (2008), COSEWIC (2006a, 2006b), DFO *and* MRNF (2008) and DFO *and* MRNF (2009).

[xxi] Elements of this section have been copied, abstracted and/or synthesized from COSEWIC (2006b).

[xxii] Elements of this section have been copied, abstracted and/or synthesized from COSEWIC (2006a).

COSEWIC
Assessment and Status Report

on the

Horned Grebe
Podiceps auritus

Western population
Magdalen Islands population

in Canada

Western population – SPECIAL CONCERN
Magdalen Islands population – ENDANGERED
2009

COSEWIC
Committee on the Status of Endangered Wildlife in Canada

COSEPAC
Comité sur la situation des espèces en péril au Canada

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

COSEWIC. 2009. COSEWIC assessment and status report on the Horned Grebe *Podiceps auritus*, Western population and Magdalen Islands population, in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 42 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

Production note:
COSEWIC would like to acknowledge Alexandre Rivard and François Shaffer for writing the provisional status report on the Horned Grebe *Podiceps auritus* in Canada. COSEWIC also gratefully acknowledges the financial support of Environment Canada for the preparation of this report. The COSEWIC report review was overseen by Marty Leonard, Co-chair, COSEWIC Birds Specialist Subcommittee, with input from members of COSEWIC. That review may have resulted in changes and additions to the initial version of the report.

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur la grèbe esclavon (*Podiceps auritus*) population de l'Ouest et population des îles de la Madeleine au Canada.

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Horned Grebe — Provided by author.

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COSEWIC
Assessment Summary

Assessment Summary – April 2009

Common name
Horned Grebe - Western population

Scientific name
Podiceps auritus

Status
Special Concern

Reason for designation
Approximately 92% of the North American breeding range of this species is in Canada and is occupied by this population. It has experienced both long-term and short-term declines and there is no evidence to suggest that this trend will be reversed in the near future. Threats include degradation of wetland breeding habitat, droughts, increasing populations of nest predators (mostly in the Prairies), and oil spills on their wintering grounds in the Pacific and Atlantic Oceans.

Occurrence
Yukon Territory, Northwest Territories, Nunavut, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario

Status history
Designated Special Concern in April 2009. Assessment based on a new status report.

Assessment Summary – April 2009

Common name
Horned Grebe - Magdalen Islands population

Scientific name
Podiceps auritus

Status
Endangered

Reason for designation
The small breeding population of this species has persisted on the Magdalen Islands for at least a century. It has recently shown declines in both population size and area of occupancy. The small size of the population (average of 15 adults) makes it particularly vulnerable to stochastic events.

Occurrence
Quebec

Status history
Designated Endangered in April 2009. Assessment based on a new status report.

COSEWIC
Executive Summary

Horned Grebe
Podiceps auritus

Western population
Magdalen Islands population

Species information

The Horned Grebe (*Podiceps auritus*) is a member of the *Podiceps* genus. There are two known subspecies of the Horned Grebe: (*P. a. auritus*), which breeds in Eurasia, and (*P. a. cornutus*), which breeds in North America. The Horned Grebe is a relatively small waterbird with breeding plumage characterized by a patch of bright buff feathers behind the eye, which extends into tufts that contrast with its black head.

The present status report covers two designatable units of *P. auritus* that breed in Canada, the Western Population, which includes birds breeding from British Columbia to northwestern Ontario, and the Magdalen Islands Population, which includes a long-standing breeding population found on the Magdalen Islands in Quebec. The birds of these two populations show some genetic differences and their breeding ranges are separated by more than 2,000 km. Birds from both populations may, however, overlap on the wintering grounds on the east coast of Canada.

Distribution

Approximately 92% of the North American breeding range of the Horned Grebe is in Canada. It breeds in British Columbia, Yukon, the Mackenzie River Valley in the Northwest Territories, the extreme southern part of Nunavut, all of the Prairies, northwestern Ontario and the Magdalen Islands (Quebec), where a small isolated population has been breeding for at least a century. In the United States, it breeds in central and southern Alaska, as well as locally in some northwestern states. Most of the North American population winters along the coasts of the continent.

Habitat

The Horned Grebe breeds primarily in temperate zones such as the Prairies and Parkland Canada, but can also be found in more boreal and subarctic zones. It generally breeds in freshwater and occasionally in brackish water on small semi-permanent or permanent ponds, but it also uses marshes and shallow bays on lake borders. Breeding areas require open water rich in emerging vegetation, which provides nest materials, concealment and anchorage, and protection for the young.

Biology

The Horned Grebe is generally a solitary nester, although it can nest in loose colonies if the breeding pond is sufficiently large and there are abundant food resources. The Horned Grebe is aggressive when defending its territory, rarely leaving its nest unguarded. Its diet consists primarily of aquatic insects and fish in the summer, and fish, crustaceans and polychaetes in the winter.

Population sizes and trends

The Western Population of the Horned Grebe is estimated at between 200,000 and 500,000 individuals, with most of the birds found in Saskatchewan and Alberta. Long-term trend analyses based on Christmas Bird Counts show a significant decline of 1.5%/year between 1966 and 2005. At this rate of decline, the population will have decreased by approximately 45% since the mid-1960s. Short-term trend analyses based on the same survey methods show a significant annual rate of decline of 1.25%/year between 1993 and 2005 (three generations). At this rate, the population will have decreased by 14% over the last three generations.

The Magdalen Islands Population in Quebec is estimated at an average of 15 adults. Since 1993, no more than 25 adults have been seen during the same breeding season and only five adults were observed in 2005. Analyses based on annual surveys on the Magdalen Islands suggest that the population has declined by approximately 22% over the last three generations.

Limiting factors and threats

Permanent loss of wetlands to agriculture and development threaten Horned Grebe populations. Temporary loss of wetlands during droughts can also negatively impact Horned Grebe populations, as can eutrophication and degradation of nesting sites from the accumulation of fertilizers used in agriculture. The expansion of predators on the Prairies, Type E Botulism on the Great Lakes and oil spills on the wintering grounds can also threaten Horned Grebe populations.

The very small size of the Magdalen Islands Population makes it vulnerable to demographic, environmental and genetic factors.

Special significance of the species

Horned Grebes occupy the upper trophic level and all of their life stages are tied to water. They may, therefore, be useful indicators of changes in wetland habitat. Furthermore, their striking nuptial plumage, spectacular courtship displays and approachable nature make them popular among bird watchers and ecotourists. On the Magdalen Islands, and by extension in eastern Canada, this small population is unique among the natural heritage.

Existing protection or other status designations

Both the Northern Prairie and Parkland Waterbird Conservation Plan and the North American Waterbird Conservation Plan (NAWCP) have identified the Horned Grebe as a species of high concern. Canada's Waterbird Conservation Plan (Wings Over Water) placed the Horned Grebe population in the "Moderate concern" category. NatureServe, considers the Horned Grebe as globally abundant, widespread and secure in the United States and Canada. However, the species is ranked as vulnerable in Alberta and Washington State, imperiled in Oregon, South Dakota and Minnesota and critically imperiled in Idaho, Ontario and Quebec.

The species is protected under the *Migratory Birds Convention Act*, 1994. Given the precariousness of the Magdalen Islands population in Quebec, the Horned Grebe was designated as a threatened species under Quebec's *Act Respecting Threatened or Vulnerable Species* in 2000. However, this designation does not offer any protection to the species' breeding habitat.

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
(2009)

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

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

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

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

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

Canada

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

COSEWIC Status Report

on the

Horned Grebe
Podiceps auritus

Western population
Magdalen Islands population

in Canada

2009

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SPECIES INFORMATION

Name and classification

Order: Podicipediformes
Family: Podicipedidae
Genus: *Podiceps*
Species: *auritus*
Subspecies: *cornutus*

English name: Horned Grebe
French name: Grèbe esclavon
Other English names: Slavonian Grebe, Hell-diver
Other French name: Grèbe cornu

The Podicipedidae family contains seven genera and 22 species (Fjeldså, 2004). The *Podiceps* genus consists of eight species, three of which breed in Canada: the Red-necked Grebe (*P. grisegena*), Eared Grebe (*P. nigricollis*) and the Horned Grebe (*P. auritus*) (Vlug and Fjeldså, 1990; American Ornithologists' Union, 1998). There are two known subspecies of the Horned Grebe: *P. a. auritus*, which breeds in Eurasia, and *P. a. cornutus*, which breeds in North America (Vlug and Fjeldså, 1990).

Morphological description

The Horned Grebe is a relatively small waterbird (length: 31-38 cm; weight: 300-570 g) (Stedman, 2000), with a short, straight bill with a pale tip. Its breeding plumage includes a distinctive patch of bright buff feathers behind the eye, extending back to the nape of the neck and contrasting sharply with its black head. Its foreneck, flanks and upper breast are chestnut-red, while its back is black and its belly white. Males and females are similar in colouration, although the plumage of the male tends to be brighter (Godfrey, 1986; Stedman, 2000). Its eclipse plumage is black and white and characterized by a black crown and white cheeks, which extend almost around the nape (Stedman, 2000). The juvenile plumage is similar to that of adults in winter, but the upper parts are tinged brown. The demarcation between the black crown and white cheeks is also less defined and the bill is paler (Cramp and Simmons, 1977; del Hoyo *et al*., 1992). Chicks have dark stripes, which are particularly visible on the head and neck (Storer, 1967). *P. a. auritus* is generally darker than *P. a. cornutus,* which has light grey feather edges on the back that are inconspicuous or even absent in *P. a*. *auritus* (Parkes, 1952).

Genetic description

Based on juvenile plumage and courtship displays, the Horned Grebe is believed to be most closely related to the Red-necked Grebe and Great Crested Grebe (*P. cristatus*) (Stedman, 2000). Other phylogenetic analyses suggest that the Horned Grebe is most closely related to the Red-necked Grebe followed by the Great Crested Grebe (Fjeldså, 2004).

A genetic study of the Horned Grebe was carried out using samples from 128 individuals in six Canadian provinces or territories (British Columbia, Alberta, Manitoba, Yukon, Northwest Territories and Magdalen Islands (Quebec)) and in Iceland (Boulet *et al*., 2005). Three types of genetic markers were used: mitochondrial (mt) DNA, the intron of the α-enolase gene and amplified fragment length polymorphism (AFLP).

According to phylogenetic analyses based on mtDNA, the Horned Grebes of Iceland and North America (including the Magdalen Islands) form a single phylogenetic group. The mtDNA haplotypes form a classic "star-shaped" haplotype network (Figure 1), the pattern expected if all populations descended from a single ancestral population that grew fairly rapidly (or alternatively that experienced a selective sweep in mtDNA) (D. Irwin and V. Friesen, pers. comm. 2009).

The Horned Grebe nonetheless demonstrates significant differentiation in its global population at the mtDNA level and in AFLP. Moreover, the moderate but significant genetic differentiation observed in mtDNA is well distributed between the two subspecies (i.e. between Iceland and the other North American sites; 15.7% of variance) and among the three disjunct parts of the range that were analyzed separately (western North America, Quebec, Iceland; 25.6% of variance). Conversely, no significant genetic variation has been observed among sites located in western North America. From the frequency of haplotypes observed (mtDNA), the Quebec population has been identified as being the most divergent after the Iceland population (Table 1 and Figure 2) (Boulet *et al*., 2005).

Results from the AFLP analysis suggest four distinct groups: Iceland, Quebec, British Columbia and the west central sites (Alberta, Manitoba, Yukon and the Northwest Territories); Iceland shows the highest level of differentiation, followed by Quebec and British Columbia (Boulet *et al*., 2005). Results from the analysis of the intron of the α-enolase gene, however, show no evidence of genetic differentiation based on subspecies or according to disjunct areas of the range.

Hence, the Magdalen Islands population would not be "demographically connected" to the population that breeds in Iceland, but certain indices suggest that there may be genetic exchanges with western North American populations. Boulet *et al*. (2005) state that they recorded possible demographic connectivity between Quebec and western North America. It is difficult to precisely estimate the point at which Horned Grebes established themselves on the Magdalen Islands and when the last genetic exchanges with the other population took place. The Magdalen Islands population may be of fairly recent origin (end of the 19th century), like the population in Scotland around 1908 (Fjeldså, 1973a), but they may also be a vestige of the population that bred on the continental shelf during the Pleistocene glaciation and which would have been subject to a relatively recent genetic influx from the other regions (Boulet *et al*., 2005).

Table 1. Paired values of differentiation indices (Fst) calculated between populations of the Horned Grebe surveyed on the basis of three markers (mtDNA, enolase intron and 25 AFLP loci). Source: Boulet *et al*. (2005).

	Alta. (n=13)	**B.C. (n=11)**	**Man. (n=10)**	**N.W.T. (n=14)**	**Y.T. (n=12)**	**Que (n=15)**
B.C. (mt)	–0.02					
(enol)	0.00	-				
(AFLP)	0.03					
Man. (mt)	–0.03	–0.02				
(enol)	–0.03	0.01	-			
(AFLP)	–0.02	0.04*				
N.W.T. (mt)	–0.02	0.00	0.00			
(enol)	–0.03	–0.02	–0.02	-		
(AFLP)	0.02	0.05*	0.03			
Y.T. (mt)	–0.01	0.00	–0.01	–0.02		
(enol)	0.06	–0.02	0.06	0.01	-	
(AFLP)	0.00	0.03	0.01	–0.01		
Que (mt)	0.30*	0.17**	0.22**	0.28*	0.42*	
(enol)	–0.03	0.03	–0.03	–0.01	0.09	-
(AFLP)	0.04*	0.04*	0.02	0.05*	0.01	
IC (mt)	0.22*	0.19*	0.15*	0.21*	0.27*	0.49*
(enol)	0.03	–0.02	0.02	–0.01	–0.02	0.05
(AFLP)	0.07*	0.10*	0.08*	0.08*	0.04*	0.11*

The * symbol corresponds to a significant difference after Bonferroni's adjustment (mtDNA) or after 1000 random (AFLP) randomizations, and the ** symbol corresponds to a value of $P < 0.05$, but is non-significant after adjustments.

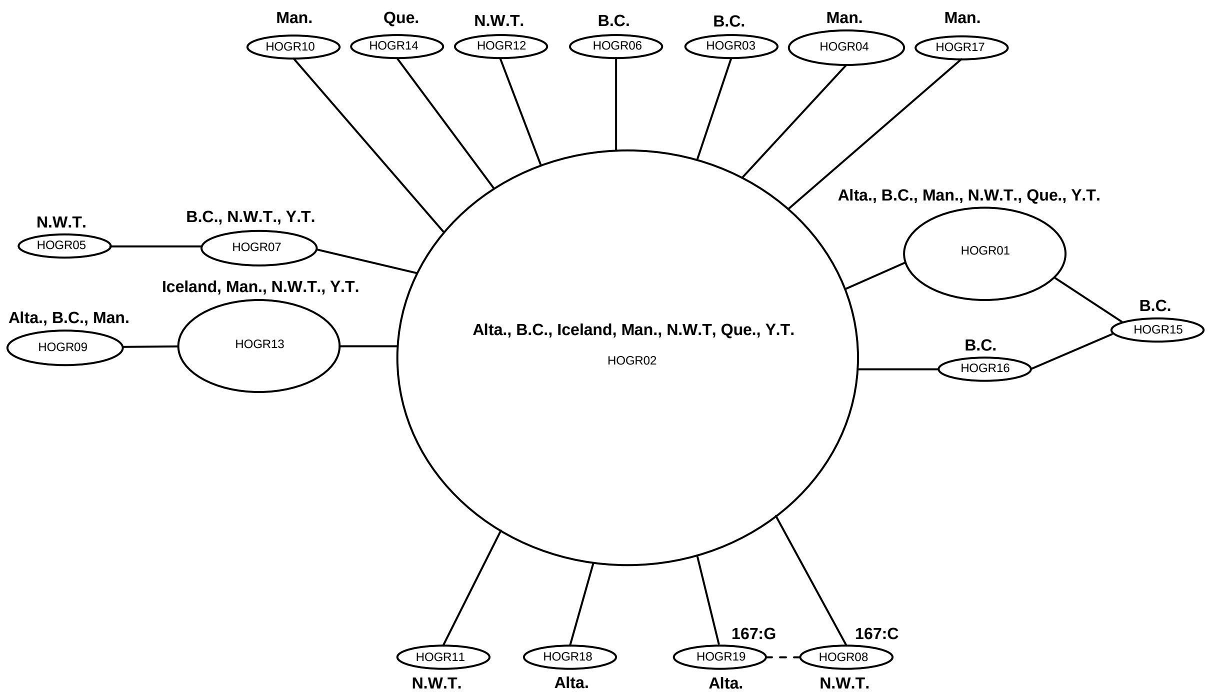

Figure 1. Network of links between haplotypes, the “minimum spanning-network,” showing the relationships between the 19 haplotypes of the mtDNA fragment ND2 of Horned Grebes. Each of the lines connecting the haplotypes (ovals) shows a mutation. The size of the ovals is proportional to the frequency of the haplotypes. Two different mutations figure at locus 167 (HOGR08: A-C; HOGR19: A-G). Source: Boulet *et al*. (2005).

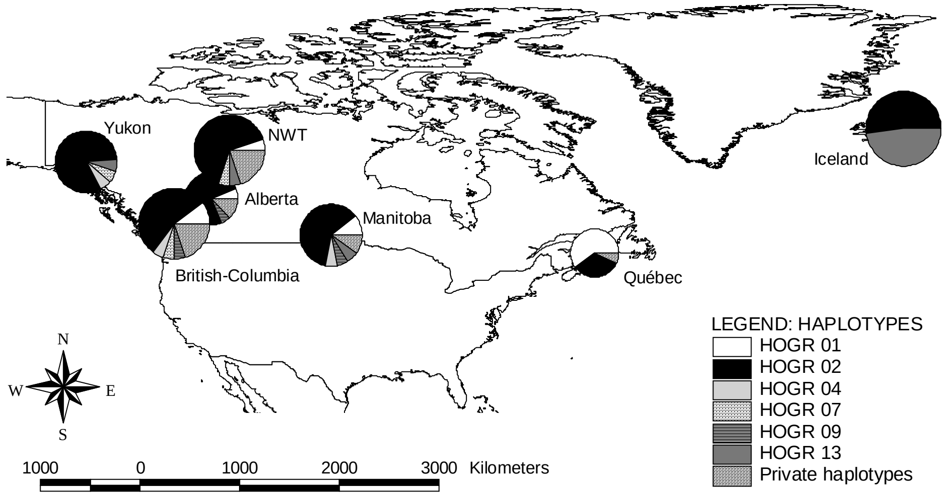

Figure 2. Geographical distribution of Horned Grebe (HOGR) haplotypes. The circles are proportional to the number of samples for each region. Private haplotypes (n=13) correspond to haplotypes observed in a single individual. Source: Boulet *et al*. (2005).

Designatable units

This report covers two designatable units of *P. a. cornutus* that breed in Canada, the Western Population, which includes birds breeding from British Columbia to the extreme northwestern part of Ontario, and the Magdalen Islands Population, which includes birds breeding on the Magdalen Islands (Quebec) and any other sporadic breeders that occur in Quebec. The latter is the only known breeding population in eastern North America and has been well established for at least 100 years.

The rationale for separating the species into two designatable units is based on three criteria. First, there is a natural disjunction in the range of the two units, with more than 2,000 km separating the population on the Magdalen Islands from the nearest populations in Manitoba and northwestern Ontario. Secondly, the populations occupy different eco-geographic zones. Finally, the significant differences in allele frequencies based on mtDNA and AFLP markers between the Magdalen Island population and most of the Western Population suggest some genetic divergence between the two populations (Table 1).

The wintering grounds of the Magdalen Islands Population are unknown, however, it is possible that the two units overlap on the wintering range. If so, some genetic mixing between the two populations could occur.

There is no information on whether the populations show differences in morphology, life history or behaviour.

DISTRIBUTION

Global range

The Horned Grebe is found across Eurasia and North America. In Eurasia, it breeds in a few isolated areas in Iceland, northeastern Scotland, northwestern Norway and extensively (generally between the 50th and 65th parallels north) from southeastern Norway and central Finland to Siberia and southward of central Russia, Lake Baikal, Kamchatka and the extreme west end of China. It is a rare breeder in Greenland and an occasional breeder in the Faroe Islands (Fjeldså, 1973a; O'Donnel and Fjeldså, 1997; Stedman, 2000). Its breeding range in North America is restricted to the northwest part of the continent and is located primarily in Canada (Figure 3), with the core of the population breeding in the Prairies. In the United States, it breeds in central and southern Alaska and locally in a number of northwestern states, namely Washington, Idaho, Montana, North Dakota, South Dakota (irregularly) and Minnesota (irregularly). Some individuals also breed sporadically in certain parts of Oregon (American Ornithologists' Union, 1998; Stedman, 2000).

Winter range

In Eurasia, the species winters mainly on the coasts from Iceland, the British Isles and Norway to the Mediterranean, the Black Sea and the Caspian Sea. In Eastern Asia, the birds winter along the coasts of Japan, Korea and China (Fjeldså, 1973a; Cramp and Simmons, 1977; American Ornithologists' Union, 1998).

In North America, the Horned Grebe winters on the Pacific coast from the Aleutians and south coastal Alaska to northern Baja California (Stedman, 2000). It also migrates overland, following the Mississippi Valley or the Atlantic migration corridors to winter on the Atlantic coast and in the Gulf of Mexico. Many also winter on inland bodies of water (Root, 1988; Stedman, 2000). Based on Christmas Bird Counts (CBC) from 1964 to 2005 for the United States and Canada, an average of 41% of Horned Grebes winter on the west coast of the continent, while 47% winter on the east coast (including Florida) (National Audubon Society, 2006). Only 6% of birds counted were reported in states located on the Gulf of Mexico (Texas, Louisiana, Mississippi and Alabama), and 6% in other inland states of the continent.

The wintering grounds of the Magdalen Islands Population are unknown, but it is presumed that the birds winter along the Atlantic coast of North America.

Canadian range

Approximately 92% of the North American breeding range of the Horned Grebe is in Canada. It breeds from British Columbia to extreme northwestern Ontario. The range includes Yukon, the Mackenzie River Valley in the Northwest Territories, extreme southern Nunavut, all of the Prairies, where it is most abundant, and a disjunct population on the Magdalen Islands (Sugden, 1977; Godfrey, 1986; Stedman, 2000).

In British Columbia, it is considered a rare summer visitor along the coast, whereas it is a widespread breeder east of the coastal mountains. It also occurs in all interior valleys, on the south-central high plateaus, in the Peace River lowlands and in the northern portion of the province. The highest abundances are found in the Chilcotin-Cariboo Basin and the Thompson-Okanagan Plateau regions (Campbell *et al*., 1990).

In Yukon, it is a common to uncommon breeder north to Old Crow Flats. In the Northwest Territories (NWT), the Horned Grebe nests in low densities throughout much of the boreal and subarctic regions. The highest documented densities (>4 birds/km^2) have been observed in the southern NWT. Average grebe population densities throughout the rest of the boreal and subarctic NWT are apparently much lower (probably less than 0.1 bird/km^2 overall) (Stotts, 1988; Fournier and Hines, 1999; Canadian Wildlife Service, 2007a).

In Alberta, the Horned Grebe breeds in the Prairie-parkland ecological region, where it was detected in 31% of the first Atlas of Breeding Birds survey squares. It also bred in the Boreal Forest (21% of the squares), Prairies ecological region (10% of the squares), the Rocky Mountain foothills (5% of the squares) and in the Rockies (3% of the squares) (Semenchuk, 1992). The second Atlas (Semenchuk, 2007) suggests that the distribution of Horned Grebe has decreased in the northwestern part of the province. The second edition also indicated that Horned Grebes were most often found in the Grassland and Parkland and were found only occasionally in the Boreal Forest, Foothills, and Rocky Mountain (Semenchuk, 2007).

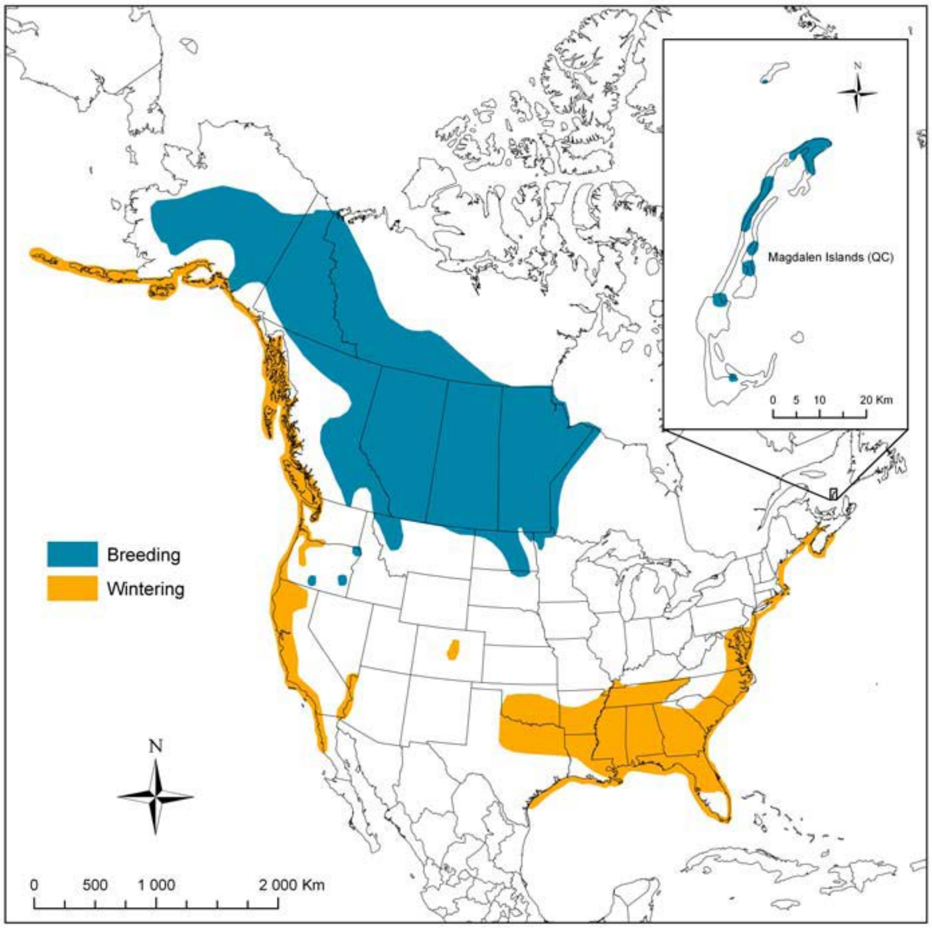

Figure 3. Breeding and winter ranges of the Horned Grebe (*P. auritus*) in North America. Adapted from Stedman (2000).

In Saskatchewan, the Horned Grebe is a common summer resident in the Prairie-parkland and Prairie ecological regions, but less common and localized in the boreal and subarctic regions (Smith, 1996).

In Manitoba, the Horned Grebe breeds throughout the province with the exception of certain eastern regions. It is probably more common in the Minnedosa region, but its abundance in the Prairie region fluctuates according to the water level. The species is generally less abundant in summer in the southeastern part of the province. Some individuals breed in Churchill, mainly in marshes near Akudlik and in the Goose Creek region (Holland and Taylor, 2003).

In Ontario, the Horned Grebe appears to be an irregular, rare breeder. Records of the species before 1938 suggest that it may have occasionally bred in the southern part of the province (Peck and James, 1983; Godfrey, 1986). Work carried out for the first Ontario Breeding Bird Atlas (1981-1985) confirmed Horned Grebe breeding at only one site, which was in the extreme northwestern part of the province (i.e. Fort Severn near Hudson Bay), but there was no evidence of breeding in this area in the second Ontario Breeding Bird Atlas (2001-2005). The second Ontario Breeding Bird Atlas did find breeding evidence from northwestern Ontario adjacent to Manitoba (Opasquia Provincial Park, Pikangikum Lake and the Rainy River sewage lagoons) (Hoar, 2007).

In Quebec, the species breeds annually, but only on the Magdalen Islands, where a small population has been breeding for at least a century (Young, 1897; Shaffer and Laporte, 2003). On this 202-km^2 archipelago, the Horned Grebe is found primarily in the northeastern portion, East Point, the North Dune and the furrows of the South Dune. It also breeds at Brion Island and has previously bred at Baie du Portage (Shaffer and Laporte, 2003). The species breeds sporadically elsewhere in Quebec. Rare breeding records date back more than 40 years, coming from Lake Gamache on Anticosti Island in 1919 (Lewis, 1924; Ouellet, 1969), Lake Saint-Anne on the North Shore in 1959 (Ouellet and Ouellet, 1963) and Lake Perceval at Valcartier in 1960 and 1964 (Larivée, 2006). The breeding records from along the St. Lawrence corridor in the summer season suggest that the species may occasionally breed locally elsewhere in Quebec (Godfrey, 1986; Lepage, 1995).

In the Atlantic Provinces, the only known breeding record for Horned Grebe dates back to 1873 and comes from southwest New Brunswick, near Milltown (Squires, 1976).

In Canada, the Horned Grebe winters on the coast and in the southern interior of British Columbia, on the coasts of Prince Edward Island, Nova Scotia and New Brunswick and occasionally on the lower Great Lakes (Godfrey, 1986).

The Extent of Occurrence (EO) for the Western Population of the Horned Grebe was calculated using the minimum convex polygon method for the breeding range of the species in Canada, excluding the Magdalen Islands Population (Table 2). The Area of Occupancy (AO) was based on the estimated population size range of 100,000 to 250,000 pairs, each occupying an average territory of 0.78 ha (see below; Table 2). The EO for the Magdalen Islands Population was calculated using the minimum convex polygon method and including the Magdalen Islands and Brion Island (Table 2). The Index of Area of Occupancy for the Magdalen Islands Population was calculated by counting all grid cells of 2 km x 2 km (the value was also calculated using a 1 km x 1 km grid) that intersected one of the ponds / marshes used by the Horned Grebe, and the AO was calculated by adding the area of all ponds / marshes above.

Table 2. Extent of Occurrence and Area of Occupancy of the Western and Magdalen Islands Populations of Horned Grebe in Canada. Source: COSEWIC Secretariat.

Population	Extent of Occurrence	Index of Area Occupancy	Area of Occupancy
Western	5,100,000 km^2	>2000 km^2	780–1,950 km^2
Magdalen Islands	772 km^2	100 km^2 (43 km^2 with 1 km x 1 km grid)	12.2 km^2

HABITAT

Habitat requirements

Breeding range

The Western Population of the Horned Grebe breeds primarily in the temperate zone such as the Prairies and Parkland Canada, but it can also be found in more boreal and subarctic zones. It generally nests in freshwater and occasionally in brackish water on small ponds, marshes and shallow bays on lake borders (Cramp and Simmons, 1977; Godfrey, 1986). These ponds are found both in open and forested areas (Sugden, 1977; Campbell *et al*., 1990). In the Prairies, it prefers lakes and permanent or semi-permanent natural ponds which last until autumn. It also uses reservoirs and artificial ponds created by river damming and excavation for road construction or for retaining rain or spring water (Caldwell, 2006).

The Horned Grebe will use a broad range of pond sizes (0.24 to 18.2 ha) but generally prefers ponds ranging from 0.30 to 2 ha (Fournier and Hines, 1999; Gingras and Beyersbergen, 2003; Gingras and Beyersbergen, unpublished data). Ponds must contain areas of open water (over 40%) and beds of emergent vegetation (Faaborg, 1976; Sugden, 1977; Godfrey, 1986; Ulfvens, 1988).

Nests consist of a floating or emerging mass of plant material and are constructed within the fringes of emergent vegetation and in shallow water (Palmer, 1962; Shaffer and Laporte, 2003), between 0 and 140 cm (with average values at around 40 cm) (Fjeldså, 1973b; Sugden, 1977). The Horned Grebe primarily uses eutrophic environments, although it is also able to breed successfully on oligotrophic ponds (Ulfvens, 1988).

In the Magdalen Islands Population, the average pond size used for breeding is 0.7 ha (n=24) and the average maximal depth of the ponds is 89 cm (n=26). These ponds are usually fresh-water, with a few exceptions, in which brackish water habitats are used. On average, 51% of the surface of the ponds is covered by emergent vegetation and the mean water depth near nest locations is 49 cm (Shaffer and Laporte, 2003).

Migration route

Little information is available on the particular requirements of the Horned Grebe during migration, but it has been observed on lakes, rivers and marshes. Some birds follow coastlines as part of their migration.

Winter range

Horned Grebes generally winter in marine habitats, mainly estuaries and bays (Palmer, 1962). Birds are found in greatest numbers in coastal habitats, including areas that offer some degree of protection (Root, 1988). Some birds winter on inland lakes and rivers in areas where the minimum temperature in January is higher than -1°C (Root, 1988; Stedman, 2000).

Habitat trends

In the Prairies, wetlands have been impacted severely by conversion of grassland to cropland and wetland drainage (Sugden and Beyersbergen, 1984; NatureServe, 2006). Recent analyses of habitats included in the Prairie Habitat Joint Venture (PHJV) have quantified wetland loss in these regions between 1985 and 2001 (Watmough and Schmoll, in press). Gross wetland loss over that period was 5% (984 ha) and the results for all ecoregions indicate a declining trend in wetland areas. Low prairies, wet meadows and shallow marshes made up 50% of the total loss, cultivated wetland cover 40% and deep marsh and open water habitats combined almost 4% of lost wetland areas (Watmough and Schmoll, in press). The annual rate of net wetland loss (number of wetlands) between 1985 and 1999 for the three Prairie Provinces is as follows: Alberta 0.48%, Saskatchewan 0.24% and Manitoba 0.32% (Watmough *et al*., 2002). There has been little change in the rate of wetland loss in recent decades. The main causes of loss include agriculture (67%), rural development (10.3%) and other uses (22.7%) (Watmough *et al*., 2002).

In addition to permanent habitat loss, which is part of a long-term habitat trend, Horned Grebes are also facing more short-term or medium-term habitat loss due to drought. For example, the number of ponds in the Prairie Pothole region ranged from good in 1986, to very poor during the 1988-1993 drought, to excellent in 1994-1995 (Austin, 1998). The worst recorded drought in 100 years on the Prairies occurred between autumn 1999 and spring 2004 (Drought Research Initiative, 2007). Dry conditions on the Prairies are not restricted to a particular area and were concentrated in southern regions in 1971, 1973, 1977, 1984, 1985, 1988, 1996, 1997, 2001 and northern regions in 1968, 1969, 1970, 1972, 1981, 1990, 1992, 1998 and 2002 (Agriculture and Agri-Food Canada, 2007).

The number of May ponds, which are used to assess breeding habitat for waterfowl in the Prairies and Parklands, shows no significant long-term trends for the Canadian Prairies (U.S. Fish and Wildlife Service, 2005; Canadian Wildlife Service Waterfowl Committee, 2007). It is not clear, however, that the estimated number of May ponds is a good indicator of Horned Grebe breeding habitat availability.

On the Magdalen Islands, 42 of approximately 250 ponds have been identified as suitable for Horned Grebe breeding. These ponds were identified using a logistic regression model designed following the characterization of 161 ponds and taking into account historical breeding records (Shaffer and Laporte, 2003). The number of existing ponds has been relatively stable over time (Shaffer *et al*., 1994). Nevertheless, other factors, such as the presence of the Pied-billed Grebe (*Podilymbus podiceps*), eutrophication or the drying of certain ponds, have reduced the availability of preferred habitat.

Habitat protection/ownership

The breeding range of the Western Population of the Horned Grebe covers most of the Prairie, Boreal Plains, Taiga Plains, Taiga Cordillera, Montane Cordillera and Boreal Cordillera ecozones (Table 3). Wetlands account for approximately 25% (709,469 km^2) of the area of these ecozones (3.5 to 45.7%, depending on the ecozone). Of this wetland area, 5.9% is strictly protected (IUCN cat. 1, 2 or 3*) and 2.2% is protected to a lesser extent (IUCN cat. 4, 5 or 6). The breeding range of the Horned Grebe also includes a small portion of the vast Taiga Shield and Boreal Shield ecozones. In southern parts of the range, in particular, many of the small wetlands (ponds) used by Horned Grebe are found on private land.

On the Magdalen Islands, almost half of the ponds preferred by the Horned Grebe are located on protected lands. In the île de l’Est sector, there is the Pointe de l’Est National Wildlife Area, which is managed by the Canadian Wildlife Service, and other lands protected by conservation organizations covering an area of 1,049 ha. An additional 1,290 ha adjacent to this reserve form part of the Pointe-de-l’Est Wildlife Preserve. Furthermore, at Brion Island, all the ponds are located within the limits of the Brion Island Ecological Reserve, under the jurisdiction of the Quebec government.

Table 3. Proportion of Canadian wetlands protected by IUCN* conservation category for ecozones that include a significant portion of the breeding range of the Horned Grebe. Source: Wildlife Habitat Canada (2003).

Conservation category	Total area of wetlands (km^2)	Area of protected wetlands (km^2)	% of strictly protected wetlands	% of less protected wetlands	% of ecozone occupied by wetlands
			IUCN 1, 2 and 3	IUCN 4, 5 and 6	
Taiga Plain	231,119	16,525	5.1	2.1	40.2
Taiga Cordillera	21,142	1,361	3.8	2.6	8.4
Boreal Plain	309,644	31,477	8.3	1.9	45.7
Boreal Cordillera	15,732	1,143	6.5	0.7	3.5
Montane Cordillera	28,441	1,582	5.5	0.1	6
Prairie	103,391	5,726	1.1	4.4	22.6
Total	**709,469**	**57,814**	**5.9**	**2.2**	**24.6**

* According to the IUCN protected area classification system (1 = strict nature reserve or wilderness area; 2 = national park; 3 = natural monument/specific natural feature; 4 = habitat/species management area; 5 = protected landscape/seascape; 6 = managed natural resources protected area).

BIOLOGY

Life cycle and reproduction

The Horned Grebe generally breeds in its first year, but a certain number of non-breeding adults may be observed on the breeding grounds (Palmer, 1962). In some areas, 75% of the population arrives on the breeding grounds in pairs (Fjeldså 1973d; Jim Hines, Canadian Wildlife Service, Biologist, NWT). Unpaired Horned Grebes seek mates as soon as they arrive on the breeding grounds. Site and mate fidelity have also been observed in Horned Grebes (Ferguson, 1981). In Alaska, Horned Grebes show fidelity to certain lakes or to the region in which they were banded during the moulting period (July and August) (Stout and Cooke, 2003).

The Horned Grebe is usually a solitary nester (Palmer, 1962), but several breeding pairs may occasionally nest on the same pond when it is sufficiently large and there are abundant food resources (Fjeldså, 1973c; Sugden, 1977). These loose colonies have a maximum of 20 breeding pairs (Campbell *et al*., 1990). The Horned Grebe is known to aggressively defend its territory against conspecifics and other species (Storer, 1969; Fjeldså, 1973d). Ferguson (1977) estimated that the size of the area defended averaged 0.78 ha and ranged from 0.05 to 2.70 ha.

The Horned Grebe's nest is composed of plant matter and is affixed to emergent vegetation. Occasionally, the Horned Grebe builds its nest in areas devoid of vegetation, establishing it on masses of floating algae, shallowly submerged logs, floating branches, or platforms of human origin (Ulfvens, 1988; Campbell *et al*., 1990). Near Yellowknife, nests occurred primarily in cattail (*Typha latifolia*) or flooded willows and sedge (*Carex* spp.). Cattail and *Sphagnum* spp. were present in 83%, 75% and 41% respectively of all Horned Grebe nests (n=236) (Fournier and Hines, 1999).

On the Magdalen Islands, the Horned Grebe uses primarily bulrushes (*Scirpus lacustris*) and more rarely, cattails (*Typha sp.*), bur-reeds (*Sparganium sp.*) and bladderworts (*Utricularia sp.*) for nest construction.

The dates of nest-building and egg-laying initiation can vary considerably from year to year depending on weather conditions (Palmer, 1962; Fjeldså, 1973c; Ferguson, 1977; Fournier and Hines, 1999). High spring temperatures favour early egg laying (Ferguson, 1977). The species is an indeterminate layer and both adults share incubation (Stedman, 2000). It can also rebuild its nest and can lay up to four replacement clutches if previous clutches are destroyed (Fjeldså, 1973c; Ferguson, 1977). Hatching is asynchronous and lasts for several days, with a hatching interval of one to two days. The chicks are dependent on the adults for food for 14 days after hatching, but are normally independent at around 19 to 21 days (Fjeldså, 1973c; Ferguson, 1977).

Reproductive success

In the Western Population, reported clutch sizes vary from an average of 5.3 (n=114 clutches) to 5.9 (n=79) eggs/clutch (Ferguson and Sealy, 1983; Fournier and Hines, 1999) and hatching success from 30.3% (Ferguson and Sealy, 1983) to 60% (Fournier and Hines, 1999). The average number of young produced has been reported at 2.2/ successful nest (i.e. those fledging at least one young, range 1.6–2.6) and 1.4/ breeding pair (range 0.6–2.0) (Fournier and Hines, 1999).

In the Magdalen Islands Population, the average clutch size is 4.4 and ranges from 3 to 6 eggs (n=16) and the hatching success is 54% (n=67) (Shaffer and Laporte, 2003). The minimum productivity estimate based on observations of breeding birds is 0.6 young/pair, although fall counts at East Pond suggest two young/ breeding pair. The latter estimate assumes that the individuals observed in the fall at the East Pond only include those from the local population.

Predators

Horned Grebe eggs are taken by raccoons (*Procyon lotor*), American Crow (*Corvus brachyrhynchos*), Common Raven (*Corvus corax*), Black-billed Magpie (*Pica pica*) and various gull species (*Larus spp.*). Chicks can be subject to predation by the northern pike (*Esox lucius*) and by gulls. Adults may be taken by mink (*Neovison vison*) and possibly foxes (Ferguson, 1977; Fournier and Hines, 1999; Stedman, 2000).

On the Magdalen Islands, the red fox (*Vulpes vulpes*), Great Blue Heron (*Ardea herodias*), Great Black-backed Gull (*Larus marinus*), Common Raven and American Crow represent potential predators (Shaffer *et al*., 1994; Shaffer and Laporte, 2003). The absence of raccoons on the archipelago limits the number of potential predators, but minks have recently escaped from mink-rearing farms on the Magdalen Islands, therefore making them potential predators.

Diet

The Horned Grebe is a diver that catches and eats most of its prey underwater, bringing larger prey items, such as certain fish and amphibians, to the surface before swallowing them (Storer, 1969). It also picks insects from the water surface and from aquatic plants (Stedman, 2000). During the summer, it forages in shallower freshwater and in winter, in fresh or brackish water close to the coast (Stedman, 2000). Its diet consists of fish, insects, crustaceans, leeches, small frogs, salamanders and tadpoles (Palmer, 1962).

Dispersal/migration

The Horned Grebe migrates at night over land towards its wintering sites along the Pacific, Atlantic and Gulf coasts (Palmer, 1962). It does not appear to have specific routes and individuals migrate over a broad front. In fact, the Horned Grebe is regularly observed in various places in the United States and in southern Canada, resting on lakes and rivers. Some individuals can also migrate by day, individually or in loose aggregations, especially along the coasts (Palmer, 1962; Stedman, 2000). Significant diurnal migrations are sometimes observed on the Great Lakes within the Point Pelee Birding Area (Wormington, 2008)

On the Magdalen Islands, adults gather on the East Pond where they gradually moult from breeding to non-breeding plumage before migrating to the wintering areas (Shaffer and Laporte, 2003). The last individuals generally leave the archipelago at the end of September or at the beginning of October (Fradette, 1992; Shaffer and Laporte, 2003; Richard, 2005).

Interspecific interactions

The Horned Grebe defends its territory aggressively and has been observed chasing Mallard (*Anas platyrhynchos*), Green-winged Teal (*Anas crecca crecca*) and Northern Pintail (*Anas acuta*) (Fjeldså, 1973d). Pied-billed Grebes have successfully displaced Horned Grebes from breeding ponds (n=9) (Osnas 2003). Red-necked Grebes also displace Horned Grebes. In southern Manitoba, small- and medium-sized ponds traditionally occupied by Horned Grebes are now mostly used by Red-necked Grebes (K. De Smet, Biologist, Conservation, Manitoba).

Adaptability

The Horned Grebe is vulnerable to changes in water quality near its breeding sites. In particular, it generally occupies small, shallow ponds that are sensitive to eutrophication, drainage and drought.

POPULATION SIZES AND TRENDS

Search effort

There are no national surveys for inland waterbirds in general or Horned Grebes in particular. In North America, the North American Breeding Bird Survey (BBS) and the Christmas Bird Count (CBC) are the two most significant programs monitoring bird population trends. The CBC is the best method for determining Horned Grebe population trends because it surveys most of the North American population, the vast majority of which breed in Canada, while they are on the wintering grounds.

Western Population

The BBS is carried out during the breeding season by volunteers who note the abundance of all bird species detected along randomly selected routes across the continent. Each participant makes three-minute stops every 0.8 km along a 39.4-km long survey route. In 2005, 434 routes were surveyed in Canada, and more than 2,000 in the United States. Fewer than 150 routes in North America can, however, be used to analyze Horned Grebe population trends. The majority of these routes are in Canada.

The BBS provides the only long-term, extensive survey information on Horned Grebe population trends on their breeding range. It has, however, several disadvantages in terms of monitoring Horned Grebe populations. The BBS is a roadside survey, which does not allow for good coverage of a wetland species such as the Horned Grebe. Also, there are very few BBS routes in the northern prairies and in the Northwest Territories. Thus, population abundance and trends for Horned Grebes based on BBS data are biased toward the southern portion of their range.

The CBC is carried out over a three-week period between mid-December and early January each year. Thousands of volunteer observers, in approximately 2,000 locations in North America, note all species observed and the number of individuals in a circular area of 15 km in radius. The main advantage of this method is that it samples most of the Horned Grebe population, predominately birds that breed in Canada, as it winters along the coasts of North America (Sauer *et al*., 1996). One of the disadvantages of this method is that in winter the Horned Grebe occurs mainly on large bodies of water and on the coast, so the birds may be located a fair distance from observers, which makes them difficult to count. However, the areas selected for the CBC are often located close to areas with large concentrations of birds (Sauer *et al*., 1996).

Breeding Bird Atlas projects in different regions (British Columbia, Alberta, Saskatchewan and Ontario) collect information on species distribution during the breeding season. These atlases are produced periodically (generally, every 20 years) so that changes in the species distribution can be monitored over time.

Spring aerial and ground waterfowl surveys are carried out by the Canadian Wildlife Service in association with the U.S. Fish & Wildlife Service and provide data on the abundance of the Horned Grebe in certain Prairie regions. Although these surveys are focused primarily on waterfowl, efforts have been underway since 1999 to count grebes that are present along the survey transects. Currently, this is the most complete data source for estimating Horned Grebe abundance and population trends in the Prairies. The accuracy and precision of the methodology has not, however, been evaluated for this species.

Magdalen Islands Population

The main survey information on the Magdalen Islands Population comes from annual monitoring of Horned Grebe nesting sites on the Magdalen Islands carried out by the Canadian Wildlife Service. Counts are made of the number of nests and adults during the breeding period and also the number of adults and young on East Pond, the largest on the Magdalen Islands and the moulting ground for the Horned Grebe, during weekly visits between early August and early October. In eastern Quebec, Horned Grebe sightings are rare until mid-September or early October and become occasional or frequent mainly from about the second week in October (Otis *et al*., 1993; Larivée, 1993). There is therefore little chance that Horned Grebe counts at the East Pond include migrating individuals coming from elsewhere in North America, but this possibility can not be excluded.

The Breeding Bird Atlas projects done in Quebec and in the neighbouring provinces and the ÉPOQ database (Étude des populations d'oiseaux du Québec) (Larivée, 2006) give some insight on the species distribution.

Abundance

Western Population

The size of the North American population of Horned Grebes is poorly known. A frequently cited estimate from Wetlands International (2002) has a very wide range (100,000 to 1 million individuals) of values, which remains unchanged in recent (2005) drafts of the Waterbirds Population Estimates document (Wetlands International, 2005). The highest Horned Grebe densities are probably found in the wetlands of the Prairies, where densities of 1.5 to 3.3 pairs per km^2 have been observed (Sugden, 1977). High densities have also been recorded near Yellowknife, NWT (2.2 pairs per km^2 average) on similar-sized study areas used by Sugden (1977) (Fournier and Hines, 1999). However, densities near Yellowknife would not be representative of a broad area of Taiga Shield/ Taiga Plains habitat (Fournier and Hines, 1999).

In 2005, 16,000 Horned Grebes were counted in all North American Christmas Bird Counts and the maximum number of individuals recorded in the history of these counts is approximately 20,300 in 1998 (National Audubon Society, 2006). These counts clearly do not constitute an exhaustive inventory of the population and do not cover the species' entire wintering range.

According to data collected from the Canadian Prairies between 2001 and 2005 during the Springtime Waterfowl Surveys (SWS), the average size of the Horned Grebe population for the region covered by the Prairie Habitat Joint Venture (PHJV) is 153,615 (Caldwell 2006). Estimates based on BBS data give similar results to those based on the SWS for Alberta (BBS: 71,665; SWS: 78,090) and Manitoba (BBS: 8,262; SWS: 10,752), but not Saskatchewan (BBS: 325,554; SWS: 69,124) (Peter Blancher, Research Scientist, Environment Canada, unpublished data). It is possible that the survey routes used for the BBS surveys in Saskatchewan are within habitats that are particularly favourable to the Horned Grebe, thereby biasing the estimate (P. Blancher, Research Scientist, Environment Canada).

The Horned Grebe is common in British Columbia and its breeding population probably ranges between 20,000 and 50,000 individuals, while there are 10,000 to 30,000 individuals on wintering grounds (A. Breault, Canadian Wildlife Service, BC). The breeding population for the Yukon is roughly estimated at greater than 10,000 birds (C. Eckert, Yukon Department of Environment; P. Sinclair, Canadian Wildlife Service).

In the Northwest Territories, only approximate numbers are available from the 1980-1982 Waterfowl Breeding Ground Surveys. Stotts (1988) has analyzed non-waterfowl birds data from these surveys and has estimated the Horned Grebe population at 23,042 birds for the 707,592 km^2 area covered.

In Ontario, the first Breeding Bird Atlas assessed the province's breeding population at 10 pairs or less per year (Eagles, 1987). That number did not change much in the second edition, where breeding evidence was reported in four squares compared to three in the first edition (Hoar, 2007). Since most of its potential breeding range lies in remote areas of northwestern Ontario that was not well covered, the Horned Grebe could be more common than either atlas suggests (Hoar, 2007).

On the basis of these estimates, excluding regions with no available estimate (Northern Alberta and Northern Saskatchewan), it is likely that the Western Population of the Horned Grebe totals between 200,000 and 500,000 individuals.

Magdalen Islands Population

According to surveys carried out by the Canadian Wildlife Service from 1993 to 2006 in Quebec, which covered most of the optimal habitats on the Magdalen Islands, no more than 25 adults were ever sighted during the same breeding season, and only five adults were sighted in 2005, for a yearly average of 15 adults. Although there was some variation in search effort between years, the majority of ponds were visited annually. Only part of East Pond on the main island and a pond on Brion Island were excluded on some years.

Fluctuations and trends

Western Population

North American Breeding Bird Survey (BBS)

Based on BBS data, the Horned Grebe population has shown a significant long-term decline of 2.7%/year between 1968 and 2007 (Figure 4, Table 4). This amounts to a loss of 66% of the population over this time period. The population has also shown a significant short-term decline of 5.2%/year over 12 years or three generations (1995-2007; Table 4). At this rate, the population will have decreased by 47% over the last three generations.

Alberta, Saskatchewan and Manitoba have all shown negative long-term trends, as have Alberta and Saskatchewan in the short-term (Table 4). There were not enough routes with the Horned Grebe in Manitoba to calculate a short-term trend or in British Columbia to calculate long or short-term trends.

BBS data also suggest a contraction in the breeding range towards the northwest (Gingras and Beyersbergen, 2003).

Table 4. Horned Grebe population trends in Canada based on data from the Canadian Breeding Bird Survey (Downes *et al*. 2008; Collins pers. comm. 2008).

Area	1968–2007			1995–2007		
	Trend	P	N	Trend	P	N
Canada	- 2.7	**	142	- 5.2		89
Alberta	- 7.3	**	52	- 5.6		41
Saskatchewan	- 2.7		53	- 6.2		24
Manitoba	- 3.8		17	–		–

Trend = average of the annual percentage of change in a bird population; ** indicates P ≤ 0.05, *indicates 0.05<P<0.1; Blank indicates P >0.10). N = total number of routes used in calculating the trend. Not enough routes to calculate a trend for Manitoba from 1995-2007.

Christmas Bird Count (CBC)

The CBC is the best method for determining Horned Grebe population trends because it surveys most of the population while it is on the wintering grounds. CBC data show a significant long-term decline of 1.5%/year between 1966 and 2005 (95% confidence limits -2.4 to -0.8%/yr; Figure 5). Given this rate of decline, the Horned Grebe population will have decreased by 45% over the last 39 years (Niven *et al.,* 2004). CBC data also show a significant decline in the most recent 12-year period (1993-2005) of 1.25%/year (95% confidence limits -1.8% to -24.7%/year; Figure 5), which amounts to a 14% decrease in the population over the last three generations.

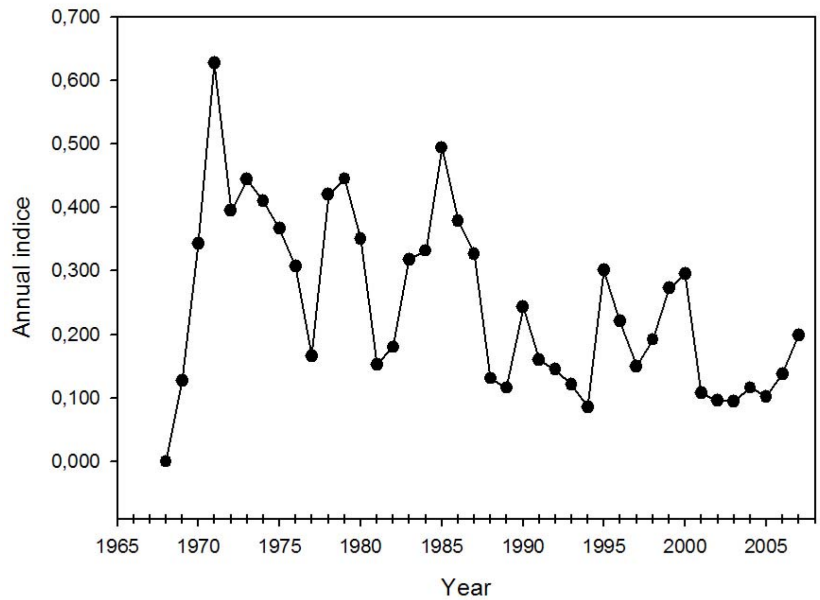

Figure 4. Annual indices of population change for the Horned Grebe in Canada based on Breeding Bird Survey data (1968 - 2007) from Downes *et al*. (2008).

Other information sources

In Alberta, ornithologists have observed an apparent decline in Horned Grebe numbers (G. Beyersbergen, CWS biologist, Alberta). Nevertheless the second edition of the Atlas of Breeding Birds of Alberta reports an increase in relative abundance detected in the Grassland, where the Horned Grebe was observed more frequently in Atlas 2 than in Atlas 1. A decline was, however, detected in the Boreal Forest where it was observed less frequently in Atlas 2 than in Atlas 1. No change was detected in Foothills, Parkland and Rocky Mountain (Semenchuk, 2007).

In Manitoba, Holland and Taylor (2003) note that in the past, the Horned Grebe declined in the south of the province following wetland drainage for agricultural purposes. Since wetland drainage has not been as extensive in the past few decades, the recently noted decline may be due to other factors. Indeed, a species that was abundant and frequently observed for 30 years in the Prairie Potholes region in southern Manitoba is now becoming much rarer.

In southern British Columbia, downward trends were also observed and are likely due in part to the drought which persisted in the south of the province from 2001 to 2005) (A. Breault, Canadian Wildlife Service, BC).

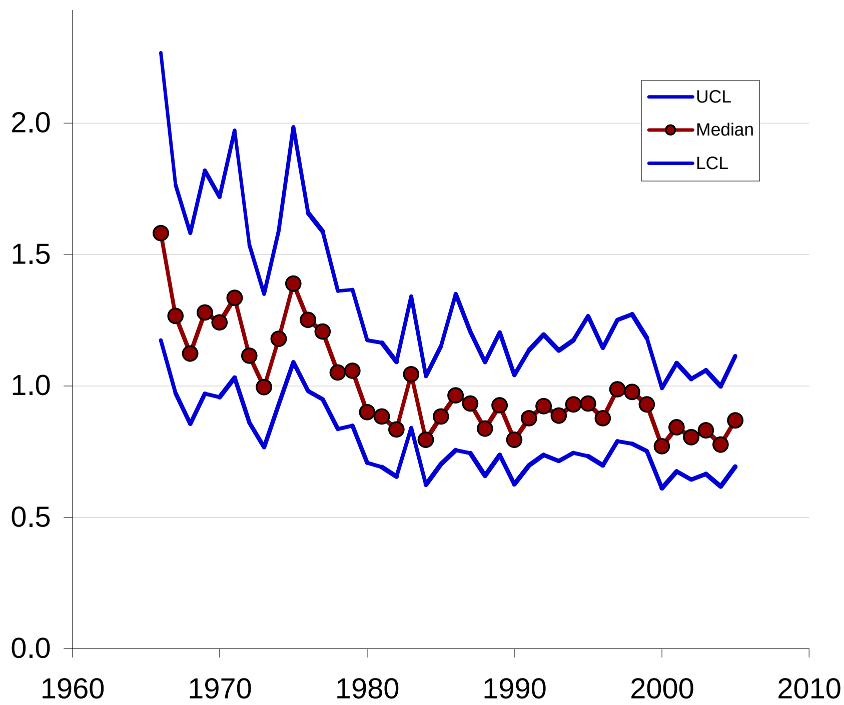

Figure 5. Indices of relative abundance for Horned Grebes observed during all Christmas Bird Counts in the United States and Canada from 1966 to 2005 (data from the National Audubon Society, 2006).

In the Northwest Territories, numbers and productivity of Horned Grebes have been monitored annually from 1986 to 2007 near Yellowknife (Fournier and Hines, 1999; Canadian Wildlife Service, unpublished data). Like other northern areas, the 38-km^2 study area has relatively stable water conditions compared to some other parts of the Horned Grebe range. Breeding populations near Yellowknife show considerable annual variability but no clear long-term trend in population size (Fournier and Hines, 1999; Canadian Wildlife Service, unpublished data). Similarly, annual indices of productivity have varied substantially from year to year without any apparent long-term trend, thus there is no evidence of population decline in NWT (Jim Hines, Canadian Wildlife Service, NWT).

Magdalen Islands Population

The population on the Magdalen Islands has declined by 2%/year between 1993 and 2007 (Figure 6). At this rate, the population will have decreased by 22% over the last 12 years or three generations. Moreover, in recent years (2000-2007), most of the birds and nests found during the breeding season were concentrated on one major pond (East Pond) and on Brion Island. Other breeding areas of the archipelago seem to be deserted (Canadian Wildlife Service, unpublished data).

Records from the previous century suggest that the population was higher than it is today. Job (1902) reported that the Horned Grebe was the only species of grebe nesting on the Magdalen Islands. He also noted that it was abundant, as he found one pair per small pond and several on larger ponds. The abundance indices given by Job (1901, 1906), Philipp (1913) and Bent (1919), as well as reports of 40 individuals on August 11, 1949 (Hagar, 1949) and 41 individuals in the late summer of 1989 (Fradette, 1992), all indicate that the population was higher in previous times.

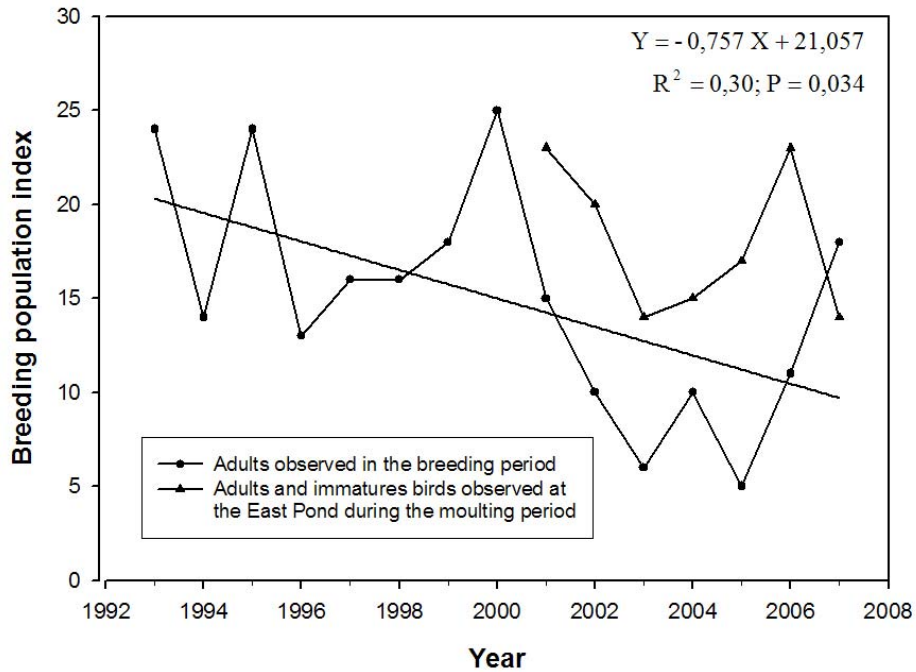

Figure 6. Number of adult Horned Grebes during the breeding season and the number of adults and immatures during the moulting period on the Magdalen Islands (Quebec) from 1993 to 2007 (source: Canadian Wildlife Service, unpublished data).

Rescue effect

Most of the Horned Grebe population is found in Canada, so rescue from the U.S. would be limited, although possible from Alaska.

LIMITING FACTORS AND THREATS

The causes of population decline for this species are not known. The information below includes the most probable threats to this species.

Environmental conditions and habitat loss

The massive destruction and drainage of wetlands on the Prairies primarily occurred before the recent decline in grebe numbers. Nevertheless, the permanent loss of wetlands continues, mainly because of agricultural activity and rural development (Watmough *et al*., 2002; Watmough and Schmoll, in press). Habitat loss can also be temporary. The Prairie region undergoes cycles of drought followed by heavier rainfall, which can result in temporary loss of breeding ponds (Van der Valk, 2005; U.S. Fish and Wildlife Service, 2005). Breeding sites can also be degraded through eutrophication from the accumulation of fertilizers, contamination and other alterations resulting from agriculture and rural development.

The length and frequency of droughts in the Prairies is expected to increase in the future, due to climate change. According to the Canadian Global Climate Model, the southern Prairies could experience serious summer deficiencies in soil moisture by the end of this century. Higher temperatures will intensify drought conditions and also bring about wetter periods, but overall the prediction is that soil moisture will become more variable (Natural Resources Canada, 2007).

Weather conditions can also significantly affect water levels. Heavy rainfall combined with wind and waves during storms can flood nests (Shaffer and Laporte, 2003). Conversely, if rainfall is too low, shallow ponds may dry up and become unsuitable for nesting. Storms encountered during migration can also affect the Horned Grebe, as shown in three documented cases in which 68, 75 and 124 individuals were found on the ground following storms (Hodgdon, 1979; Bell, 1980; Eaton, 1983).

Predation

Nest predation is considered a major factor limiting the reproductive output and population size of waterfowl, although there is wide variation in predation rates among species (Sargeant and Raveling, 1992; Johnson *et al*., 1992). In the Prairies, predation problems are often related to large-scale habitat degradation coupled with changes in predator communities (Sovada *et al*., 2001).

The major expansion of some predators in the Prairies could be a possible limiting factor and cause of population decline in the Western Population of grebes. BBS trends show a substantial increase in Common Raven and Black-billed Magpie since the 1970s (Canadian Wildlife Service, 2008). Raccoons have also expanded their range in the Prairies during the 1900s (Larivière, 2004).

In the Magdalen Islands Population, any predation of adults, chicks or nests can affect the persistence of this small population. Predation of eggs and of one adult has already been reported (Canadian Wildlife Service, unpublished data).

Pollution

At sea, this species is vulnerable to oil pollution, since it spends most of its time on the water. Of 34,717 oiled birds killed in eight spills in the southern USA, 12.3 % were Horned Grebes (del Hoyo *et al*., 1992). In 1976, an oil spill caused the death of more than 4,000 individuals in Chesapeake Bay (Stedman, 2000). During the response to the Cosco Busan oil spill of November 2007, 78 oiled Horned Grebes were collected live and dead (California Department of Fish and Game, 2008). Twelve oiled Horned Grebes were collected after the Selendang Ayu oil spill in Alaska (Alaska Dept. of Environmental Conservation, unpublished data) and 16 were collected during an oiling episode in the winter of 1997-98 in central California (Hampton *et al*., 2003). Horned Grebes were negatively affected by the Exxon Valdez oil spill in Alaska in March 1989 (Day *et al*., 1997), with declines that have continued for years following the oil spill (Stephensen *et al*., 2001).

The large wintering area of this species in North America partially protects this population from catastrophic losses due to isolated oil spills (Stedman, 2000).

Grebes occupy the upper trophic levels of the food chain and are therefore more susceptible to contamination, especially in the case of bioaccumulatable toxic substances. Significant concentrations of DDE and PCB were detected in Horned Grebe eggs collected in Manitoba in 1986 and 1987 (Forsyth *et al*., 1994). In British Columbia, elevated levels of dioxins and furans have been detected in the liver of Horned Grebes collected downstream from a pulp and paper plant outfall (Vermeer *et al*., 1993).

Disease

Type E botulism has been reported in the Great Lakes since the late 1990s and may be an important source of mortality for both resident and migrating waterbirds. Horned Grebes were one of the top five affected species of those collected in 2007, with 354 birds affected by botulism (USGS, 2008). The characteristics of the 2007 event were similar to outbreaks that have occurred annually in at least one of the Great Lakes since 1998. In 2006, 2,600 dead birds including Horned Grebe, Common Loon (*Gavia immer*), mergansers, and Red-necked Grebe were reported to have died from Type E botulism on Lake Michigan (USGS, 2007).

Interspecific competition

Horned Grebes in the Western Population may compete with Pied-billed Grebes for breeding habitat. BBS trends suggest an increase in Pied-billed Grebes in British Columbia, Saskatchewan and particularly in Alberta (14.6% per year) from 1997 to 2007

(Canadian Wildlife Service, 2008). Similarly, the Red-necked Grebe may exclude Horned Grebes from nesting on some ponds.

On the Magdalen Islands, the Pied-billed Grebe was first recorded in the archipelago in 1954 (Gaboriault, 1961) and has since grown to 25 breeding pairs (Shaffer and Laporte, 2003). The Pied-billed Grebe excludes the Horned Grebe from potential productive habitats on the archipelago (Shaffer and Laporte, 2003). Four ponds that were used by the Horned Grebe for nesting had both species occupying the pond at the beginning of the season, but only the Pied-billed Grebe pairs completing their breeding (Shaffer and Laporte, 2003).

Population size

The small size of the population (<25 individuals) breeding on the Magdalen Islands makes it susceptible to demographic, environmental and genetic factors. No reduction in the genetic diversity of this population, at least for the genetic markers that have been studied, has been found, however (Boulet *et al*., 2005).

Human disturbance

On the Magdalen Islands, in particular, disturbance from human visitors may threaten breeding birds. Squatter camps close to breeding ponds is a source of disturbance (Shaffer *et al*., 1994). In addition, tourism has increased considerably on the Magdalen Islands (e.g. 22,000 tourists in 1998 to 37,000 tourists in 2006), which may also be a source of disturbance.

Commercial fishing

Horned Grebes become entangled and drown in nets in some commercial fishing areas (Harrison and Robins, 1992). This is most likely to occur on large lakes during migration (Riske, 1976; Piersma, 1988; Ulfvens, 1989). Bartonek (1965) estimates that 3,000 grebes and loons were netted annually by fishers on the southern part of Lake Winnipegosis (Manitoba) and Horned Grebes were ranked third in abundance of the netted birds. Commercial fisheries occur on large lakes in Manitoba, but bycatch data are not available for Horned Grebes (Ron Bazin, Canadian Wildife Service, MB). On the Great Lakes birds are killed annually in fishing nets during both spring and fall migrations (Alan Wormington, Ornithologist, Ontario). There is little evidence of fishing net mortality occurring at sea in North America. Grebes were not reported from a seabird bycatch assessment of salmon gill net fisheries in British Columbia (Smith and Morgan, 2005); however, grebe species have been reported as bycatch in angel shark/halibut set gillnet fisheries in California (Mills *et al*., 2005).

SPECIAL SIGNIFICANCE OF THE SPECIES

Horned Grebes occupy the upper trophic level and all of their life stages are tied to the water. They, therefore, may be useful indicators of the availability and integrity of wetlands.

Their striking nuptial plumage, spectacular courtship displays and approachable nature also make them popular among bird watchers and ecotourists on the Magdalen Islands (and elsewhere) during the breeding season.

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

The Horned Grebe is on the list of "non-game migratory birds" and is protected under the *Migratory Birds Convention Act, 1994*. This Act protects the Horned Grebe as well as its nest and eggs throughout Canada, but does not accord any specific protection to its habitat.

The two subspecies of the Horned Grebe are globally considered to be facing a small risk of extinction and have been placed in the category of "least concern" by the World Conservation Union (IUCN) (O'Donnell and Fjeldså, 1997; BirdLife International, 2004).

The Northern Prairie and Parkland Waterbird Conservation Plan has identified the Horned Grebe as a species of high concern due to the downward trend in its populations and the contraction in its breeding range towards the northwest (Niemuth *et al*., 2005; Gingras and Beyersbergen, 2003). The North American Waterbird Conservation Plan (NAWCP) also identifies the Horned Grebe as a "species of high concern" (Waterbird Conservation for the Americas, 2006). This status is given to species that are not greatly imperiled, but whose populations appear to be declining and also face other known or potential threats. Canada's Waterbird Conservation Plan (Wings Over Water) has assigned the category "Moderate concern" to the Horned Grebe population (Milko *et al*., 2003).

The General Status of Species in Canada considers the species overall as Secure in Canada, with ranks ranging from At Risk in Quebec to Secure in other provinces (CESCC 2006; Table 5). NatureServe ranks the species overall in Canada as globally abundant, widespread and secure (rank[1] G5), with ranks ranging from Secure in the Yukon and Saskatchewan, apparently secure in British Columbia and Manitoba, vulnerable in Alberta and critically imperiled in Ontario and Quebec (NatureServe 2006; Table 5). In the Northwest Territories the Horned Grebe is considered "secure" (Working Group on General Status of NWT Species, 2006).

In Quebec, the rank of S1 assigned to the Horned Grebe indicates that the species is critically at risk. The Horned Grebe was also designated as a threatened species in 2000 under Quebec's *Act Respecting Threatened or Vulnerable Species* (Government of Quebec, 2000). At the present time this designation does not offer any protection to the species' breeding habitat, but protection measures are scheduled to be implemented in 2009 (Daniel Banville, MRNF Biologist, QC).

Table 5. Ranks assigned to the Horned Grebe in Canada based on NatureServe[1] (2006) and General Status Ranks (CESCC 2006).

Region	Nature Serve	General Status
Alberta	S3B	Sensitive
Manitoba	S4B*	Secure
Newfoundland	SNA	-
Nova Scotia	S4M,S4N	Secure
Ontario	S1B	May be at risk
Quebec	S1B	At risk
Yukon Territory	S5B	Secure
British Columbia	S4B	Secure
New Brunswick	S4M,S4N	Secure
Northwest Territories	SNRB	Secure
Nunavut	SNRB	Undetermined
Prince Edward Island	SNA	Accidental
Saskatchewan	S5B	Secure
Canada	N5B	Secure

* Manitoba breeding population, which was previously ranked S4S5, has recently been assigned the rank S4 by NatureServe.

[1]The status (rank) assigned by NatureServe is made up of a letter which reflects the spatial level for which the status has been granted (G = global, N = national and S = provincial, state or territorial level). The numbers which follow it refer to the following statuses: 1- critically imperiled; 2- imperiled; 3- vulnerable to extirpation or disappearance; 4- apparently secure; 5- demonstrably widespread, abundant and secure. A breeding code is used when a breeding population and a non-breeding population are found within the same province or territory: B = breeding, N = non-breeding, M = migratory. Finally, the code SNA signifies that the definition of a status is not applicable, the code SNR shows that the status has not yet been assessed and the code SX shows that the species is presumed extirpated. Two ranking values next to each other (e.g. S4S5N) show a range of uncertainty regarding the status of the species for the region.

TECHNICAL SUMMARY - Western population

Podiceps auritus

Horned Grebe (Western population) Grèbe esclavon (Population de l'Ouest)

Range of Occurrence in Canada: British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Yukon, Northwest Territories, Nunavut.

Demographic Information

Generation time (average age of parents in the population)	4 yrs
Observed percent reduction in total number of mature individuals over the last 3 generations. Based on Christmas Bird Count data: - decline of 45% between 1966 and 2005 - decline of 14% in last three generations (12 years)	14%
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible?	No
Are the causes of the decline understood?	No
Have the causes of the decline ceased?	No
[Observed, inferred, or projected] trend in number of populations	N/A
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	N/A

Extent and Area Information

Estimated extent of occurrence Calculated from the breeding range of the Horned Grebe in Canada (except for Quebec) shown in Figure 3 in this report using "Minimum convex polygon".	5,100,000 km²
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IOA) Calculated as Index of Area of Occupancy (2 km x 2 km grid)	>2000 km²
Observed trend in area of occupancy	Small decline
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	N/A
Trend in number of locations	N/A
Are there extreme fluctuations in number of locations?	N/A
Trend in area and/or quality of habitat	Declining

Number of mature individuals in each population

Population	**N Mature Individuals**
Total	200,000 - 500,000
Number of populations (locations)	N/A

Quantitative Analysis

None	Ex.: % chance of extinction in 50 years

Threats (actual or imminent, to populations or habitats)

Breeding areas • Permanent loss of breeding habitat from agriculture, development or other land uses • Temporary loss of habitat due to droughts • Increase in predators in the Prairies • Eutrophication and degradation of nesting sites from fertilizers and other agricultural practices Wintering areas and during migration • Exposure to oil spills. • Bycatch in fishing nets

Rescue Effect (immigration from an outside source)

Status of outside population(s)? USA: Most of the population is in Canada	
Is immigration known?	Possible
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	Unlikely, most of the population is in Canada

Current Status

COSEWIC: Special Concern (2009)

Status and Reasons for Designation

Status: Special Concern	**Alpha-numeric code:** None
Reasons for Designation: Approximately 92% of the North American breeding range of this species is in Canada and is occupied by this population. It has experienced both long-term and short-term declines and there is no evidence to suggest that this trend will be reversed in the near future. Threats include degradation of wetland breeding habitat, droughts, increasing populations of nest predators (mostly in the Prairies), and oil spills on their wintering grounds in the Pacific and Atlantic Oceans.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criterion - population decline < 30%.
Criterion B (Small Distribution Range and Decline or Fluctuation): Does not meet criterion **-** Extent of Occurrence > 20,000 km^2 and Area of Occupancy > 2,000 km^2.
Criterion C (Small and Declining Number of Mature Individuals): Does not meet criterion - total population size > than 10,000.
Criterion D (Very Small Population or Restricted Distribution): Does not meet criterion - population size > than 1,000 and Area of Occupancy > than 20 km^2.
Criterion E (Quantitative Analysis): Not done.

TECHNICAL SUMMARY - Magdalen Islands population

Podiceps auritus
Horned Grebe (Magdalen Islands population) Grèbe esclavon (Population des îles de la Madeleine)
Range of Occurrence in Canada: Quebec

Demographic Information

Generation time (average age of parents in the population)	4 yrs
Observed percent reduction in total number of mature individuals over the last 3 generations. Based on trend calculated from data provided by surveys carried out on the Magdalen Islands between 1993 and 2007.	22%
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 or 5 years, or 3 or 2 generations].	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over any [10 or 5 years, or 3 or 2 generations] period, over a time period including both the past and the future.	Unknown
Are the causes of the decline clearly reversible?	No
Are the causes of the decline understood?	No
Have the causes of the decline ceased?	No
Observed trend in number of populations	Stable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	Stable

Extent and Area Information

Estimated extent of occurrence Based on minimum convex and including Brion Island	772 km²
Observed trend in extent of occurrence	Stable
Are there extreme fluctuations in extent of occurrence?	No
Index of area of occupancy (IOA) Calculated as an Index of Area of Occupancy (2 km x 2 km grid): (if using a 1 km x 1 km grid, IAO = 43 km^2)	100 km^2
Observed trend in area of occupancy	Decline
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	One
Trend in number of locations	Stable
Are there extreme fluctuations in number of locations?	No
Trend in area and/or quality of habitat	Stable

Number of mature individuals in each population

Population	**N Mature Individuals**
Total Number of mature individuals observed between 1993 and 2006.	5 – 25
Number of populations (locations)	One

Quantitative Analysis

None	Ex.: % chance of extinction in 50 years

Threats (actual or imminent, to populations or habitats)

Breeding areas • Geographical isolation • Small population size • Interspecific competition from the Pied-billed Grebe Wintering areas and during migration • Exposure to oil spills • Bycatch in fishing nets

Rescue Effect (immigration from an outside source)

Status of outside population(s)? USA: Most of the population is in Canada	
Is immigration known?	Possible
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	Unlikely, most of the population is in Canada

Current Status

COSEWIC: Endangered (2009)

Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code:** B1ab(ii,v)+2ab(ii,v); C2a(i,ii); D1
Reasons for designation: The small breeding population of this species has persisted on the Magdalen Islands for at least a century. It has recently shown declines in both population size and area of occupancy. The small size of the population (average of 15 adults) makes it particularly vulnerable to stochastic events.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Does not meet criterion - population decline < 30%.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered B1ab(ii,v)+2ab(ii,v) with an Area of Occupancy < 500 km², existing at < 5 locations and with an observed decline in area of occupancy.
Criterion C (Small and Declining Number of Mature Individuals): Meets Endangered C2a(i,ii) with a population of < 2,500 and a continuing decline projected in the number of mature individuals and with no population > 250 mature individuals and at least 95% of mature individuals in one population.
Criterion D (Very Small Population or Restricted Distribution): Meets Endangered D1 with a population of < 250 mature individuals.
Criterion E (Quantitative Analysis): Not done.

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

Alexandre Rivard has participated in many bird ecology field studies since 1998. He has a master’s degree in Ecology and wrote his thesis on diet and contamination in riparian passerines. He has participated in the writing of scientific reports such as a technical report on the status of the Nelson’s Sharp-tailed Sparrow in Quebec for the Canadian Wildlife Service. He has also written reports and ornithological columns for the Observatoire d’oiseaux de Tadoussac. He is currently working on issues related to endangered species in cooperation with the Canadian Wildlife Service.

François Shaffer is an endangered species biologist at the Canadian Wildlife Service. He is a member of the national recovery teams for the Piping Plover, Roseate Tern and Peregrine Falcon. He is also a member of the Quebec raptor recovery team. Furthermore, he has taken part in research on many other species, such as the Horned Grebe, Nelson’s Sharp-tailed Sparrow, Caspian Tern, Chimney Swift, Least Bittern, Yellow Rail, and Harlequin Duck. In cooperation with Regroupement Québec Oiseaux, he participates in managing the SOS-POP database, which contains all Quebec data on the breeding ranges of endangered bird species.

COSEWIC
Assessment and Status Report

on the

Barn Swallow
Hirundo rustica

in Canada

THREATENED
2011

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

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Barn Swallow — photo courtesy of Gordon Court.

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COSEWIC
Assessment Summary

Assessment Summary – May 2011

Common name
Barn Swallow

Scientific name
Hirundo rustica

Status
Threatened

Reason for designation
This is one of the world's most widespread and common landbird species. However, like many other species of birds that specialize on a diet of flying insects, this species has experienced very large declines that began somewhat inexplicably in the mid- to late 1980s in Canada. Its Canadian distribution and abundance may still be greater than prior to European settlement, owing to the species' ability to adapt to nesting in a variety of artificial structures (barns, bridges, etc.) and to exploit foraging opportunities in open, human-modified, rural landscapes. While there have been losses in the amount of some important types of artificial nest sites (e.g., open barns) and in the amount of foraging habitat in open agricultural areas in some parts of Canada, the causes of the recent population decline are not well understood. The magnitude and geographic extent of the decline are cause for conservation concern.

Occurrence
Yukon Territory, Northwest Territories, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland and Labrador

Status history
Designated Threatened in May 2011.

COSEWIC
Executive Summary

Barn Swallow
Hirundo rustica

Wildlife species description and significance

The Barn Swallow is a medium-sized songbird that is easily recognized by its steely-blue upperparts, cinnamon underparts, chestnut throat and forehead, and by its deeply forked tail. Sexes have similar plumage, but males have longer outer tail-streamers than females and tend to be darker chestnut on their underparts.

Distribution

The Barn Swallow has become closely associated with human rural settlements. It is the most widespread species of swallow in the world, found on every continent except Antarctica. It breeds across much of North America south of the treeline, south to central Mexico. In Canada, it is known to breed in all provinces and territories. It is a long-distance migrant and winters through Central and South America.

Habitat

Before European colonization, Barn Swallows nested mostly in caves, holes, crevices and ledges in cliff faces. Following European settlement, they shifted largely to nesting in and on artificial structures, including barns and other outbuildings, garages, houses, bridges, and road culverts.

Barn Swallows prefer various types of open habitats for foraging, including grassy fields, pastures, various kinds of agricultural crops, lake and river shorelines, cleared rights-of-way, cottage areas and farmyards, islands, wetlands, and subarctic tundra.

Biology

The Barn Swallow is social throughout the year, travelling and roosting in flocks during migration and on the wintering grounds. It is socially monogamous, but polygamy is common. The Barn Swallow nests in small, loose colonies that usually contain no more than about 10 pairs. Nests are built largely of mud pellets. Egg-laying starts in the second week of May in southern Canada. Two broods are frequently produced each year, except in the far north. This species forages in the air, and specializes on a diet of flying insects.

Population sizes and trends

In Canada, the current Barn Swallow population is estimated at about 2.45 million breeding pairs (about 4.9 million mature individuals). Although the species is still common and widespread, Breeding Bird Survey (BBS) data for the period 1970 to 2009 indicate a statistically significant decline of 3.6% per year in Canada, which corresponds to an overall decline of 76% in the 40-year period. Most of the decline started to occur sometime in the mid-1980s. Over the most recent 10-year period (1999 to 2009), BBS data show a statistically significant decline of 3.5% per year, which represents an overall decadal decline of 30%. Regional surveys, such as breeding bird atlases in Ontario and the Maritimes, and the Étude des populations d'oiseaux du Québec, also show significant declines over the long term, as do surveys from the United States. Despite these losses, the distribution and numbers of this species are acknowledged to be far greater than they were before European settlement created a large amount of artificial nesting and foraging habitat that the species readily exploited.

Threats and limiting factors

Although poorly understood, the main causes of the recent decline in Barn Swallow populations are thought to be: 1) loss of nesting and foraging habitats due to conversion from conventional to modern farming techniques; 2) large-scale declines (or other perturbations) in insect populations; and 3) direct and indirect mortality due to an increase in climate perturbations on the breeding grounds (cold snaps). Other limiting factors include high nestling mortality due to high rates of ectoparasitism; and interspecific competition for nest sites with an invasive species (House Sparrow). Additional threats may also be affecting the species during migration and on the wintering grounds, including loss of foraging habitat and exposure to pesticides.

Protection, status, and ranks

In Canada, the Barn Swallow and its nests and eggs are protected under the *Migratory Birds Convention Act, 1994*. It is ranked as secure in Canada by NatureServe, but is ranked as sensitive in several provinces and territories, including Alberta, British Columbia and most Maritime provinces.

TECHNICAL SUMMARY

Hirundo rustica
Barn Swallow — Hirondelle rustique
Range of Occurrence in Canada : Yukon Territory, Northwest Territories, British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, Newfoundland/Labrador

Demographic Information

Generation time (average age of parents in the population)	2 to 3 yrs
Is there an observed continuing decline in number of mature individuals?	Yes
Estimated percent of continuing decline in total number of mature individuals within 5 years	Unknown
Observed percent reduction in total number of mature individuals over the last 10 years. Long-term BBS data show a significant decline of 3.6% per year between 1970 and 2009, which corresponds to an overall population decline of about 76% over the last 40 years. For the most recent 10-year period (1999 to 2009), BBS data show a significant decline of 3.5% per year which represents a 30% decline over the last 10 years (95% CI = -39.5% to -18.3%).	~30%
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Unknown
[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.	Unknown
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 - Based on a minimum convex polygon	~7.3 million km²
Index of area of occupancy (IAO) - IAO based upon the 2x2 km grid cell method cannot be calculated at this time because precise locations of nesting colonies have not been mapped. However, IAO would be far greater than COSEWIC's minimum threshold of 2000 km^2	Unknown (>2000 km^2)
Is the total population severely fragmented?	No
Number of “locations”	Unknown (but far greater than 10)
Is there an [observed, inferred, or projected] continuing decline in extent of occurrence?	No
Is there an inferred continuing decline in index of area of occupancy? Based on breeding bird atlas results in Ontario and the Maritimes that show significant declines in the number of 10 x 10 km squares occupied.	Yes
Is there an [observed, inferred, or projected] continuing decline in number of populations?	Not applicable

Is there an [observed, inferred, or projected] continuing decline in number of locations?	Unknown
Is there an [observed, inferred, or projected] continuing decline in [area, extent and/or quality] of habitat?	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)

Population	N Mature Individuals
Total = about 2.45 million breeding pairs. The estimate incorporates an estimated 55% decline that occurred between the mid-1990s and 2009 (see **Abundance** section)	~ 4.9 million
Number of populations	1

Quantitative Analysis

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

Threats (actual or imminent, to populations or habitats)

Threats are not well understood, but are thought to include:

- loss of nesting and foraging habitats on the breeding grounds due to conversion from conventional to modern farming techniques;
- large-scale decline or some other change in populations of flying insects;
- increased mortality of adults and/or young due to a possible increase in climate perturbations (cold snaps that are out of phase with the species' annual cycle);
- issues on the wintering grounds and/or during migration (pesticides, habitat loss);
- high levels of inter-specific competition for nests with an invasive species (House Sparrow);
- high loads of ectoparasites that reduce nesting success; and
- human persecution (e.g., removal of nests from bridges and other structures).

Rescue Effect (immigration from outside Canada)

Status of outside population(s)? USA: significant rangewide decline of 1.0% per year (1980-2007); declines are greatest for many states bordering Canada.	
Is immigration known or possible?	Yes
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes, but nesting and foraging habitats continue to be lost
Is rescue from outside populations likely?	Yes, but tempered somewhat by population declines in states bordering Canada

Current Status

COSEWIC: Threatened (May 2011)

Status and Reasons for Designation

Status: Threatened	**Alpha-numeric code:** A2b
Reasons for designation: This is one of the world's most widespread and common landbird species. However, like many other species of birds that specialize on a diet of flying insects, this species has experienced very large declines that began somewhat inexplicably in the mid- to late 1980s in Canada. Its Canadian distribution and abundance may still be greater than prior to European settlement, owing to the species' ability to adapt to nesting in a variety of artificial structures (barns, bridges, etc.) and to exploit foraging opportunities in open, human-modified, rural landscapes. While there have been losses in the amount of some important types of artificial nest sites (e.g., open barns) and in the amount of foraging habitat in open agricultural areas in some parts of Canada, the causes of the recent population decline are not well understood. The magnitude and geographic extent of the decline are cause for conservation concern.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Threatened A2b, because the population decline is at the threshold level of 30% over the most recent 10-year period.
Criterion B (Small Distribution Range and Decline or Fluctuation): Does not meet criterion; exceeds thresholds for extent of occurrence and area of occupancy.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable; exceeds thresholds for population size.
Criterion D (Very Small or Restricted Total Population): Not applicable; exceeds thresholds for population size, area of occupancy and number of locations.
Criterion E (Quantitative Analysis): Not done

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.

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

Canada

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

COSEWIC Status Report

on the

Barn Swallow
Hirundo rustica

in Canada

2011

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and classification

The common name of *Hirundo rustica* Linnaeus (1758) is Barn Swallow in English and Hirondelle rustique in French. The taxonomy of the Barn Swallow is as follows:

Class:	Aves
Order:	Passeriformes
Family:	Hirundinidae
Genus:	*Hirundo*
Species:	*Hirundo rustica*
Subspecies:	*erythrogaster*

Morphological description

The Barn Swallow (*Hirundo rustica)* is a medium-sized passerine (total length: 15-18 cm). Adults have steely-blue upperparts, cinnamon underparts, and a chestnut throat and forehead. The tail is deeply forked and the outer feathers are elongated. A white band appears across the tail. Sexes are similar in plumage, but males have longer outer tail-streamers than females (79-106 mm in males versus 68-84 mm in females; Pyle 1997) and tend to have darker chestnut colouration on their underparts (Brown and Brown 1999a).

Barn Swallows can be easily distinguished in all plumages and ages from all other North American swallows by their long and deeply forked tails, the white spots on the inner webs of the tail feathers, and extensive cinnamon underparts (Godfrey 1986; Brown and Brown 1999a).

Population spatial structure and variability

Six subspecies are known to occur in the world, but only one breeds in North America (*H. r. erythrogaster*; Brown and Brown 1999a). Few studies have compared genetic variation among subspecies, but the level of differentiation (in morphology and behaviour) found between Eurasian and North American populations suggests that more than one species may exist (Zink *et al.* 1995). Phylogenetic analysis of mtDNA haplotypes on worldwide subspecies of Barn Swallow revealed four main genetic clades: Europe, Asia, North America and the Baikal region of Asia (Zink *et al.* 2006). It appears that the North American subspecies shares a common population history and ancestry with the Baikal clades in Asia (Zink *et al.* 2006). No information is available on population structure or variability within Canada or North America.

Several species that are very similar to Barn Swallows in their appearance, behaviour and ecology are found in sub-Saharan Africa, Malaysia, and Australia, but the genetic relationship of these to the Barn Swallow is currently unclear (Brown and Brown 1999a).

Designatable units

The Barn Swallow breeds across a large portion of Canada. There are no large disjunctions in range, nor any known genetic differences, that would merit a treatment of more than one designatable unit.

Special significance

As a consequence of both its wide distribution and its capacity to nest on accessible artificial structures near human populations, the Barn Swallow is well known to the general public and has been studied extensively throughout the world. It has figured prominently in studies on the costs and benefits of group-living (Snapp 1976; Møller 1987; Shields and Crook 1987), and has served as a model organism for detailed studies on the mechanisms of sexual selection (Møller 1994) and the effects of climate change and ectoparasites on breeding ecology (Brown and Brown 1999a). However, most of the research has been done on European populations, and relatively few studies have been conducted in North America (Brown and Brown 1999a).

The Barn Swallow is perhaps the only northern temperate breeder that commonly winters in South America and occasionally also breeds there during the boreal winter (Brown and Brown 1999a). No Aboriginal Traditional Knowledge is currently available (but see **Habitat requirements**).

DISTRIBUTION

Global range

The Barn Swallow is the most widespread swallow in the world, found on every continent except Antarctica (American Ornithologists' Union 1998). Its current breeding range in North America includes south-coastal and southeastern Alaska, all Canadian provinces and territories, the conterminous United States (except most of Florida), most of northern and central Mexico, and a few areas in Argentina (Brown and Brown 1999a; Figure 1).

There is no overlap between the breeding and winter ranges except in portions of Central Mexico (Brown and Brown 1999a; Figure 1). The Barn Swallow winters from Mexico southward throughout Central America (Howell and Webb 1995). The bulk of the North American population winters in lowlands across South America (including the Galápagos Islands; Brown and Brown 1999a). Vagrants are known from Tierra del Fuego and the Falkland Islands, and the species is rare in eastern Brazil and south of central Chile and northern Argentina (Paynter 1995; Ridgely and Tudor 2009; Figure 1). Based on Christmas Bird Count results, small (but apparently increasing) numbers of Barn Swallows are recorded in the winter in parts of the U.S. and Canada, including British Columbia (D. Fraser pers. comm. 2011).

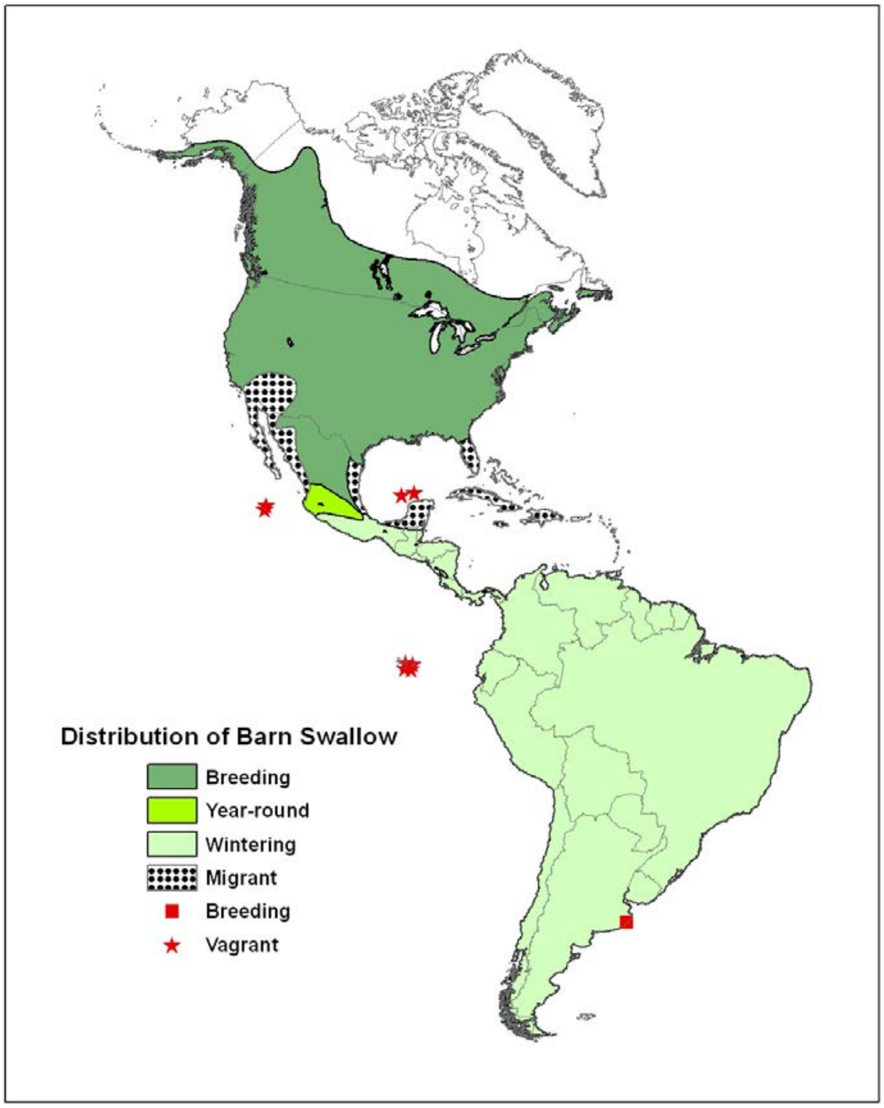

Figure 1. Range of the Barn Swallow in the Western Hemisphere (data provided by NatureServe in collaboration with Robert Ridgely, James Zook, The Nature Conservancy – Migratory Bird Program, Conservation International – Centre for Applied Biodiversity Science, World Wildlife Fund – US, and Environment Canada – WILDSPACE; modified from Ridgely *et al.* 2007).

Canadian range

In Canada, the Barn Swallow breeds in all provinces and territories (Figure 2), from the southern part of the Yukon (widespread across the region north to Ross River but also breeding occasionally on the Arctic coast; Sinclair *et al.* 2003) and the central part of the Northwest Territories, and south through British Columbia and the prairies (Godfrey 1986; Smith 1996; Campbell *et al.* 1997; American Ornithologists' Union 1998; Manitoba Avian Research Committee 2003). It breeds rarely and sporadically in Nunavut, where it is considered a vagrant (Richards and White 2008). Farther east, it breeds throughout most of Ontario, including the Hudson Bay Lowlands (where it is very local and rare), but is absent from most of the forested and muskeg-covered areas of the Boreal Shield Ecozone (Peck and James 1987; Cadman *et al*. 2007). It breeds throughout southern Quebec (Landry and Bombardier 1996), and east through the Maritime provinces and southern Newfoundland (Godfrey 1986).

Following European settlement, humans constructed buildings and other structures that were readily adopted by Barn Swallows as suitable nesting sites. At the same time, the amount of open habitat needed for foraging also greatly increased. In response, Barn Swallows expanded their breeding populations and extended their breeding range into areas where they formerly did not occur; most of these documented range expansions occurred in the second half of the 19^{th} century (Brown and Brown 1999a). In Canada, such range expansion (mostly northward) has been noted in Alberta (Erskine 1979), Quebec (Landry and Bombardier 1996), and Ontario (Cadman *et al.* 2007).

The Barn Swallow's current distribution has remained largely static since about 1980 in most provinces, but in the last two decades its occurrence has grown more sparse in the Southern Shield region of Ontario (Cadman *et al.* 2007) and across the Maritimes (Bird Studies Canada 2010a). In British Columbia, its current distribution (based on the first 3 years of breeding bird atlas data) is similar to that given for the period 1923-1994 (Campbell *et al.* 1997; Bird Studies Canada 2010b).

The extent of occurrence in Canada is about 7.3 million km^2 as measured using a minimum convex polygon based on Figure 2 (A. Filion pers. comm. 2011). An index of area of occupancy (IAO) in Canada based upon the 2x2 km grid cell method cannot be calculated at this time, because coordinates of the vast number of nesting sites are impossible to map. Nevertheless, any estimate of IAO would be far greater than COSEWIC's minimum threshold of 2000 km^2.

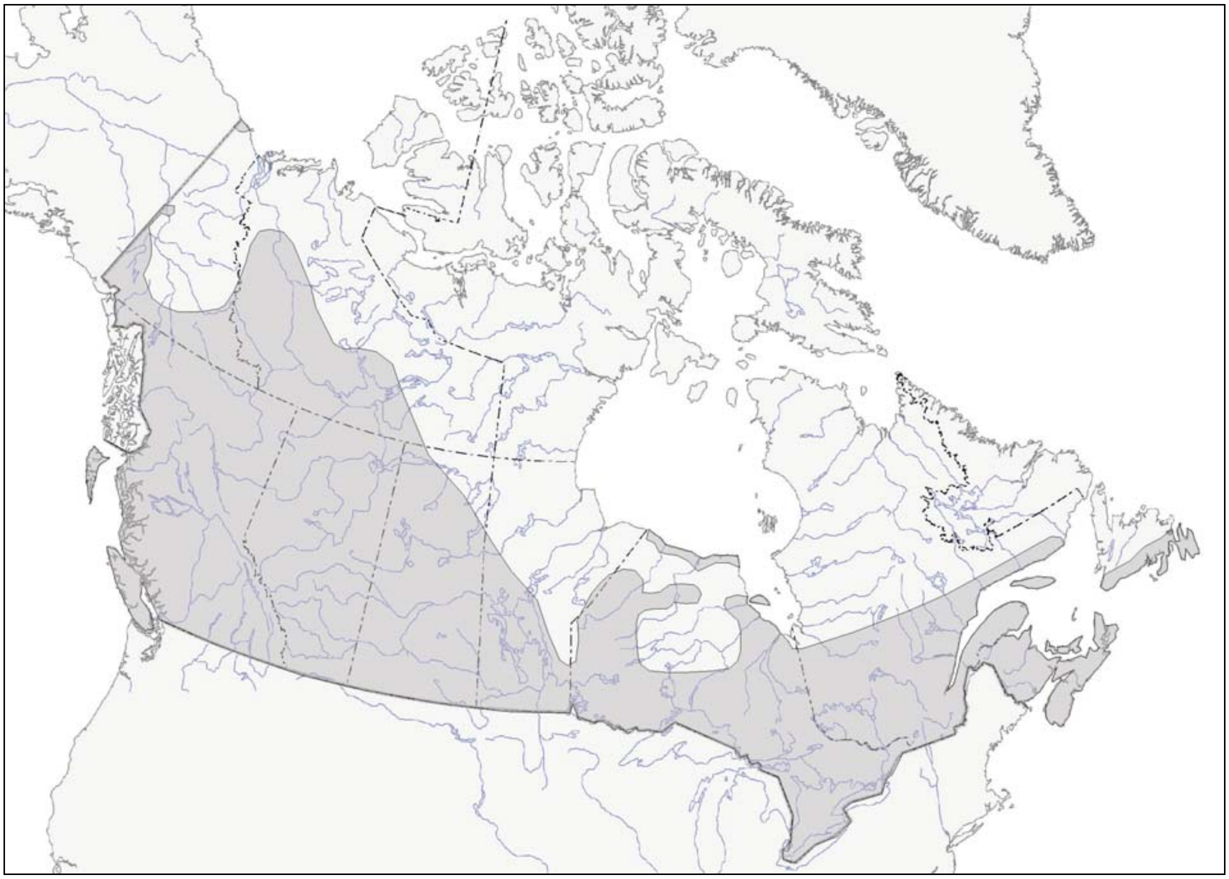

Figure 2. Canadian breeding range of the Barn Swallow (based on Godfrey 1986; Landry and Bombardier 1996; Campbell *et al.* 1997; Manitoba Avian Research Committee 2003; Cadman *et al.* 2007; Federation of Alberta Naturalists 2007; Bird Studies Canada 2010a,b,c). Areas inhabited in northern extremities of the range are mostly localized to human settlements and are less continuous than depicted.

Search effort

Search effort that yields distributional data on Barn Swallows mainly comes from intensive breeding bird atlas work conducted in the 1980s and in the 2000s in several provinces: Ontario (Cadman *et al.* 1987, 2007), Quebec (Gauthier and Aubry 1995), Alberta (Federation of Alberta Naturalists 2007), the Maritimes (Erskine 1992; Bird Studies Canada 2010a), and British Columbia (Bird Studies Canada 2010b). Distributional information on Barn Swallows is also provided by published summaries of historical observations compiled in the Northwest Territories (Bird Studies Canada 2010c), British Columbia (Campbell *et al.* 1997), Alberta (Semenchuk 1992), Saskatchewan (Smith 1996), Manitoba Avian Research Committee, Quebec (Cyr and Larivée 1995), and Nova Scotia (Tufts 1986).

HABITAT

Habitat requirements

Before European settlement, the Barn Swallow's nesting habitat was mainly characterized by natural features such as caves, holes, crevices, and ledges associated with rocky cliff faces (Speich *et al.* 1986; Peck and James 1987; Campbell *et al.* 1997). While there was undoubtedly a large shift in nesting site types following European settlement in North America (see below), Barn Swallows were probably already making use of First Nations habitations well before then. There are accounts of swallows nesting on Native American wooden habitations in the early 1800s (Macoun and Macoun 1909, cited in Brown and Brown 1999a). D. Fraser (pers. comm. 2010) notes that there were extensive First Nations villages along the entire coast of British Columbia prior to European contact, and that extensive clearings around these village sites are depicted in early illustrations. In eastern Canada, other First Nations peoples built wooden structures as well. For example, the Seneca, Cayuga, Onondaga, Oneida and Mohawk are collectively referred to as the *Haudenosaunee* or 'People of the Long House'. Some also practised burning and agriculture, thus creating open landscapes that Barn Swallows would presumably have found attractive.

With rapid expansion of the human population since European settlement, Barn Swallows have shifted largely from natural to artificial nesting sites (Speich *et al.* 1986). In Canada, it has been suggested that only about 1% of Barn Swallows now use natural nesting sites (Erskine 1979; Campbell *et al.* 1997). However, no systematic studies have ever been conducted to confirm this supposition. Indeed, the species persists in relatively "pristine" natural areas in at least some regions of Canada. For example, in British Columbia, D. Fraser (pers. comm. 2010) notes that Barn Swallows still nest in numbers on cliff faces, river edges and canyon walls.

Although Barn Swallows continue to nest in traditional natural situations, they are now most closely associated with human situations in rural areas. Such nesting sites include a variety of artificial structures that provide either a horizontal nesting surface (e.g., a ledge) or a vertical face, often with some sort of overhang that provides shelter. Nests are most commonly located in and around open barns, garages, sheds, boat houses, bridges, road culverts, verandahs and wharfs (e.g., Campbell *et al.* 1997), and are situated on such things as beams and posts, light fixtures, and ledges over windows and doors.

Barn Swallows typically select nesting and foraging sites close to open habitats such as farmlands of various description, wetlands, road rights-of-way, large forest clearings, cottage areas, islands, sand dunes, and subarctic tundra (Peck and James 1987). Because their nests are constructed of mud pellets, Barn Swallows require wet sites that have a source of nearby mud (Brown and Brown 1999a). In the tall-grass prairies of Oklahoma, Barn Swallows used habitats containing creeks and grasslands that have been annually burned (Coppedge *et al.* 2008). In the mixed-grass prairies of southern Alberta, Barn Swallows were positively associated with large fields and long wetland edges (Koper and Schmiegelow 2006). In British Columbia, Barn Swallows have been recorded from near sea level to elevations of at least 2400 m and are frequently observed in suburban areas of cities and in towns and villages where they forage in gardens, parks, fields, and other similar open spaces. In the British Columbia countryside, they forage in and around coastal bays, lagoons, estuaries, beaches and harbours, powerline rights-of-way, forest and woodland glades, streams, sloughs, marshes, orchards, vineyards, farmyards, and feed lots (Campbell *et al.* 1997). In the Yukon, the species nests at low elevation, but has also been reported nesting to the treeline in alpine areas and even on the Arctic coast (Sinclair *et al.* 2003).

During migration, Barn Swallows gather in large numbers over marshes, lakes and sloughs to feed on aerial insects (Tufts 1986; Campbell *et al.* 1997). Roosting sites during fall migration in Canada are characterized by alder groves and cattail and bulrush marshes (e.g., Tufts 1986; Campbell *et al.* 1997).

On the wintering grounds, Barn Swallows are associated with various open, low vegetation habitats such as sugar cane fields (Hilty and Brown 1986; Ridgely and Tudor 2009), savannahs and ranch lands. In Latin America, they may be attracted to insects associated with burned or harvested sugarcane fields and the waste from the cane (Richard 1991; Hilty 2003; T. Salvadori pers. comm. 2010).

Habitat trends

There has been no net change in the availability of historic, natural nesting habitat provided by cliff faces and caves. However, the Barn Swallow benefited greatly by massive changes in the amount and diversity of anthropogenic nest sites and associated foraging habitats following European settlement.

In the 1800s and early 1900s, there was a significant increase in the amount of suitable anthropogenic habitat for Barn Swallows, especially in eastern North America. This was due to the large-scale removal of forests for agriculture, which not only provided suitable foraging habitat, but also greatly increased the availability of nest sites because of the wide-scale construction of barns and other wooden structures (Brown and Brown 1999a). Construction of bridges and culverts since the mid-1900s is also thought to be responsible for the species' range expansion (e.g., into areas of boreal forest; C. Machtans pers. comm. 2009).

Following this large pulse of expansion, the Barn Swallow's nesting habitat in rural regions has subsequently been decreasing in recent decades, primarily owing to the widespread conversion of old wooden farm buildings to more modern structures that often lack nesting structures for swallows and/or are typically sealed against their entry (Brown and Brown 1999a).

The amount of open foraging habitat in many parts of Canada (especially the east) has also been declining in recent decades due to conversion of dairy farms (pastures and hayfields) and wetlands to intensive agriculture such as row crops (Jobin *et al.*

1996; Latendresse *et al.* 2008). For example, in the St. Lawrence Lowlands of Quebec, the number of dairy farms fell by half from 1971 to 1988 due to farm abandonment, industrialization and urbanization (Jobin *et al.* 1996). The total area planted to row crops increased by 23% since 1960, due to, among other things, new policies favouring grain production for livestock (Jobin *et al.* 1996; Bélanger and Grenier 2002; Jobin *et al.* 2007). Loss of Barn Swallow foraging habitat has also occurred in Ontario (Cadman *et al.* 2007) and in the Maritime provinces (Stewart 2009), again owing to economic forces.

BIOLOGY

Many aspects of the biology of the Barn Swallow have been studied intensively in Europe for more than 30 years (Møller 1994 and others). In contrast, the biology of this species has been investigated in North America only recently (see Brown and Brown 1999a; Safran *et al.* 2005; Neuman *et al.* 2007).

Reproduction

Barn Swallows are socially monogamous, but extra-pair copulations are common, making this species genetically polygamous (Møller 1994). Females first breed at 1 year old; some males remain unpaired until 2 years old (NatureServe 2010).

Breeding pairs form each spring after arrival on the breeding grounds. Pairs that have nested together successfully may remain mated for several years (Shields 1984).

The Barn Swallow often nests solitarily, but is more frequently a colonial or semi-colonial species. Colonies in Canada contain up to 83 pairs (n = 135 colonies; Campbell *et al.* 1997), but generally average no more than 10 nests (n = 161 colonies; Peck and James 1987). Adult fidelity to breeding sites varies greatly among studies, ranging between 12 and 88% in eastern North America (Brown and Brown 1999a).

Nest construction starts in mid-May in Ontario (Peck and James 1987). Construction typically begins from 5 days to 2 weeks after spring arrival (Smith 1933; Barclay 1988). The cup-shaped nests are made principally of mud pellets, lined with grasses and feathers (Brown and Brown 1999a). From two studies in West Virginia and British Columbia, nest building takes an average of 6 to 15 days (Samuel 1971; Campbell *et al.* 1997), but takes less time if old nests are reoccupied and repaired (Brown and Brown 1999a). Indeed, old nests from previous years are commonly reused (Barclay 1988; Brown and Brown 1999a). In New York, 36% of returning birds used the same nests from the previous year (Shields 1984). In Oklahoma, 16% of returning birds reused the same nest, while most other returning birds moved within an average of only 12 m from their previous year’s nest (Iverson 1988). Reusing old nests allows earlier breeding, which increases reproductive success owing to the ability to produce more than one brood per year (Safran 2006, 2007).

In Canada, most nests with eggs can be found from May through mid-July, but some nests still contain eggs into August (Peck and James 1987; Landry and Bombardier 1996; Campbell *et al.* 1997). Incubation, which is performed mainly by the female (Smith and Montgomerie 1991), lasts 13-14 days in Ontario (Peck and James 1987) and 12-17 days in British Columbia (Campbell *et al.* 1997).

Two broods are commonly produced each year in the southern part of the Barn Swallow's Canadian range, but these are rare in the far North (NatureServe 2010). In British Columbia, 37% of pairs laid a second clutch (Campbell *et al.* 1997). In Ontario, a second brood is common and is usually produced in the first nest (Peck and James 1987). In Manitoba, 90% of females initiated a second clutch (Barclay 1988).

Generally, first clutches are significantly larger than second clutches (Campbell *et al.* 1997; Brown and Brown 1999a). Clutch size may also be age-related. For example, in Europe, male Barn Swallows that reached at least 5 years of age (considered old birds) usually mated with females that produced larger clutches than those produced by the mates of younger males (Møller *et al.* 2005).

In Canada, clutch size is generally four to five eggs in the east (Ontario: range: 1-7 eggs, n = 467 nests; Peck and James 1987), and three to five in the west (British Columbia: range: 1-10 eggs, n = 1705; Campbell *et al.* 1997). Hatching success (≥ 1 fledgling) in British Columbia is 70% (n = 609 nests; Campbell *et al.* 1997). Both parents equally tend nestlings (Brown and Brown 1999a). The nestling period is 19-24 days in British Columbia and extends from 10 May to 22 September, with 51% of nestling records being between 26 June and 30 July (Campbell *et al.* 1997).

In Ontario, an average of 3.1 fledglings survived in first broods (n = 20 nests) and annual reproductive success (including second broods) was estimated at 4.2 fledglings/pair (n= 201; Smith and Montgomerie 1991). In Manitoba, average annual reproductive success for birds with two broods was 6.9 ± 0.5 SD (range 3-11) fledglings/pair (Barclay 1988). Reasons for the differences in fledgling success between these two studies are unknown. After leaving the nest, fledglings stay together and are fed by parents for about a week (NatureServe 2010).

Survival

Few data exist on rangewide survival of Barn Swallows in North America. The mean annual apparent survival probability of adults in one large colony in Nebraska was estimated at 0.350 ± 0.054 SE (n = 300; Brown and Brown 1999a). In this study, survival probability did not differ between sexes. The apparent survival of adult Barn Swallows across the MAPS (Monitoring Avian Productivity and Survivorship) network in North America was estimated at 0.483 (SE 0.060; DeSante and Kaschube 2009). In Europe, studies of Barn Swallows reported a mean survival rate of 0.284 for adult males and 0.255 for adult females (Møller 1994). More recent European studies based on mark-recapture analyses report similar adult survival rates for males (0.343) and females (0.338; Møller and Szép 2002).

The Barn Swallow has a maximum reported life span of about 8 years (Clapp *et al.* 1983) and an average life span of 4 years (Turner and Rose 1989). With an annual survival rate of between 0.35 and 0.48 in North America (see above), and after accounting for delayed breeding by some males into their second year, the estimated generation time or average age of breeders is roughly 2-3 years (P. Blancher pers. comm. 2010).

Movements/dispersal

Barn Swallows are diurnal, long-distance migrants that winter in Central and South America (Brown and Brown 1999a). Most migrating Barn Swallows follow the Central American isthmus, but trans-Gulf and trans-Caribbean migrants have also been reported (Hailman 1962; Yunick 1977).

In Europe, there was a significant positive relationship between the mean first arrival date of Barn Swallows and mean March temperature (Sparks and Tryjanowski 2007). Migrating male European Barn Swallows with heavy infestations of ectoparasites arrived later than other males on the breeding grounds (Møller *et al.* 2004). There are no current indications if similar patterns occur in the North American Barn Swallow population.

In southern Canada, adults start to return in the spring by the end of April and the first week of May, but the main influx occurs in mid-May, tailing off in early June (Landry and Bombardier 1996). In the Fraser River delta in British Columbia, Barn Swallows have been reported throughout the year, and spring migrants can start to appear as early as late March (Campbell *et al.* 1997). In northern regions such as Yukon, they start to arrive between the second and third week of May (Sinclair *et al.* 2003).

In eastern Canada, fall migration generally starts by the end of August and extends until the first week of November (Landry and Bombardier 1996; Cyr and Larivée 1995). In the west, it begins in early August in British Columbia and peaks in late August or early September (Campbell *et al.* 1997).

After the breeding season and during fall migration, Barn Swallows gather in large numbers, often in association with other species of swallows, to forage and roost around marshes, lakes and sloughs. Roosting flocks often consist of several thousand birds (e.g., Tufts 1986; Weir 2008), whereas movements of actively migrating birds often consist of 200 or more birds (Campbell *et al.* 1997).

In Central and South America, the species can be found mainly from August to May, though some birds linger throughout the year (Hilty and Brown 1986; Brown and Brown 1999a; Ridgely and Tudor 2009).

Adults display a high-degree of fidelity to nest sites (Brown and Brown 1999a). Iverson (1988) reported that female Barn Swallows moved an average of 1.6 km from the previous year's nesting site (n=5). Yearlings often return to within 30 km of their natal sites (Shields 1984; Turner and Rose 1989). In Kansas, 95% of returning first-year birds (n=20 birds) were males, suggesting greater natal philopatry among males than among females (Mason 1953). No information is available on site attachment to wintering areas.

Diet and foraging behaviour

Barn Swallows feed on the wing, almost entirely on flying insects (99.8% of their diet during the breeding season; Beal 1918). In North America, the main insect groups are Diptera, but insects from many other families are consumed (Brown and Brown 1999a). Generally, the species prefers to feed on single, large insects rather than on swarms (Brown and Brown 1999a). Nestlings are fed a great variety of insects, but primarily flies; the most frequent families recorded in a study in Nebraska include members of the fly families Empididae, Dolichopodidae, and Syrphidae (Brown and Brown 1999a).

Barn Swallows forage individually or in small groups over open land and water. They forage at lower heights than most other North American swallows, usually <10 m above ground and often within 1 m (Brown and Brown 1999a). Most foraging takes place within a few hundred metres from the colony and usually within 500 m (Møller 1987). During the haying season, Barn Swallows are known to chase insects that flush up behind mowers. They also feed on insects flushed by farm animals, dogs, and humans moving through tall grass (Brown and Brown 1999a). The species will occasionally land on the ground to feed on dead insects or pick insects off plants as well as pick insects off the water surface (Brown and Brown 1999a). During bouts of cold weather, Barn Swallows often concentrate their foraging just above the surface of ponds and lakes (Brown and Brown 1999a), where the warmer water temperatures keep flying insects active.

Interspecific interactions

During the breeding season, interspecific interactions often involve other passerine species competing for the same nesting sites. For example, Barn Swallow numbers were reported to have decreased in the late 1800s in New England following the increase of House Sparrows (*Passer domesticus*) that usurped swallow nests (Brewster 1906 in Brown and Brown 1999a). Weisheit and Creighton (1989) reported a 45% reduction in Barn Swallow fledgling success at one site in Maryland due to competition with House Sparrows. In the Guelph area of Ontario, Barn Swallow nests are also usurped fairly frequently by sparrows, especially those nesting near barn entrances (M. Cadman pers. comm. 2010).

Competition for nest sites with other species of swallows has been reported in Nebraska, where Cliff Swallows (*Petrochelidon pyrrhonota*) usurped Barn Swallow nests (Brown and Brown 1999a). On the other hand, Barn Swallows sometimes use old nests of other bird species that also nest on human-made structures, such as Eastern Phoebe (*Sayornis phoebe*) and American Robin (*Turdus migratorius*; Peck and James 1987).

Avian predators of nestlings and/or eggs include several raptor species, corvids, House Wrens (*Troglodytes aedon*), and European Starlings (*Sturnus vulgaris*), while mammalian predators include feral cats, squirrels and mice (Campbell *et al.* 1997; Brown and Brown 1999a).

Home range and territory

Barn Swallows are not territorial while foraging. In West Virginia, breeding adults will venture out to within 1.2 km of their nest site (equivalent to a foraging home range of 4.5 km^2; Brown and Brown 1999a). Adults do not defend breeding “territories” per se, but do have minimum separation distances around active nests – ranging from 1.7 m in British Columbia (Campbell *et al.* 1997) to 3.7 m in Mississippi and Oklahoma (Grzybowski 1979; Lohoefener 1980).

Behaviour and adaptability

Across their global range, Barn Swallows have proven themselves to be highly adaptable to changes in the availability of different types of nesting sites, as demonstrated by their propensity to nest in and on a variety of human-made structures. On the other hand, it is unknown the extent to which the species may be able to compensate for the recent decrease in the numbers of wooden farm buildings in many rural regions. In addition to wooden outbuildings, Barn Swallows have adapted to the increase of human infrastructure along road systems such as bridges and culverts. The species is capable of colonizing regions away from open agricultural areas as a result (e.g., logging roads in boreal forests; C. Savignac, pers. obs. 2009; C. Machtans pers. comm. 2009).

In Europe, Barn Swallows are responding to climate change by nesting earlier due to warmer temperatures in spring (Møller 2008).

POPULATION SIZES AND TRENDS

Sampling effort and methods

North American Breeding Bird Survey (BBS)

The BBS is a program that has been monitoring North American breeding bird populations since 1966 (Sauer *et al.* 2011). Breeding bird abundance data are collected by volunteers at 50, 400-m radius stops spaced at 0.8 km intervals along permanent 39.2 km roadside routes (Environment Canada 2010). In Canada, the surveys are generally conducted in June, at the height of the breeding period of most bird species. Surveys start one half hour before sunrise and last 4.5 hours. In Canada, BBS data give the most reliable estimations of the Barn Swallow's population size and trends.

The main advantages of the BBS are that data from across much of North America are collected according to a single standardized method and the surveys employ random start points, thus enhancing regional representation of the avifauna (roadside bias notwithstanding; Blancher *et al.* 2007). BBS is a suitable method for surveying Barn Swallows because the species is easily detected, most survey routes are located in suburban and rural regions where the species is most common, and the BBS covers most of the species' range in Canada (except extreme northern regions where it is far less abundant). One limitation of the BBS is that it probably does not wholly track colonial and semi-colonial species like the Barn Swallow. It also does a poor job of monitoring populations in remote, natural situations associated with cliff faces. Another limitation is that the database extends back only to the late 1960s, and therefore does not provide a full historical context.

Breeding Bird Atlases

Breeding bird atlas projects cover most of the Barn Swallow's breeding range in Canada. Atlas projects that were completed in the 1980s and repeated in the 2000s in Ontario, Alberta and the Maritimes provide 20-year comparisons of changes in breeding distribution (Cadman *et al.* 2007; Federation of Alberta Naturalists 2007; Bird Studies Canada 2010a). A second atlas project in Quebec began in 2010, while British Columbia's first 5-year breeding bird atlas started in 2007 and another was launched in Manitoba in 2010.

In addition to distributional information, population estimates of Barn Swallows can also be derived from recent atlas projects that incorporate large numbers of point counts that are conducted both on and off roadsides. Relative abundance mapping from this type of work provides an excellent depiction of species abundance patterns across large landscapes (see Cadman *et al.* 2007).

A major limitation of atlas projects is that they are typically conducted only at 20-year intervals. In addition, changes in species occurrence (based on presence/absence data within 10 x 10 km squares) of widespread, common species like the Barn Swallow underestimate changes in actual population size (Francis *et al.* 2009).

Étude des populations des oiseaux du Québec (ÉPOQ) / Study of Quebec Bird Populations (SQBP)

In Quebec, the SQBP database, which manages the bird checklists produced by thousands of volunteers since 1969 (totalling more than 500,000 checklists), is an additional reference for determining the Barn Swallow's regional population trend (G. Falardeau pers. comm. 2009). The SQBP database covers all regions south of the 52nd parallel and all seasons (Cyr and Larivée 1995). The abundance index is one of the two abundance measures produced by ÉPOQ and is a measure of the number of birds observed relative to the number of checklists produced.

The strength of this survey method lies in the fact that it covers most of the breeding range of the species in Quebec (Cyr and Larivée 1995). However, the current analysis method does not take into account the number of observers per checklist, weather conditions, or spatial variations in observation effort, but simply the number of hours of observation (Cyr and Larivée 1995). Nonetheless, the trends produced by the SQBP database are correlated with those of the BBS and generate adequate trend assessments (Cyr and Larivée 1995; Dunn *et al.* 1996).

Abundance

Numbers of Barn Swallows increased with the arrival of European settlers due to increased availability of suitable nest sites (Brown and Brown 1999a). The global population of Barn Swallows in the 1990s was estimated at 190 million adults (PIF LPED 2007), whereas the North American population was estimated at 51 million adults and the Canadian population at roughly 10.9 million (Table 1). Hence, Canada supports about 22% of the North American population and about 6% of the global population. The above abundance estimates are based on BBS count data from the mid-1990s; the current species' abundance in Canada is about 55% lower when declines that have occurred since then are taken into account (see **Fluctuations and trends**). Factoring in these declines yields a current population estimate of about 4.9 million mature individuals (equivalent to about 2.45 million breeding pairs).

Table 1. Population estimates and relative abundance of the Barn Swallow in Canada based on 1990-1999 Breeding Bird Survey data (PIF LPED 2007). Population estimates in this table do not take recent population declines into account (see text).

Province / Territory	Population estimate (birds)*	Relative BBS abundance (birds/route)	Standard deviation of relative abundance	Number of BBS routes	Number of routes with detections of Barn Swallows
SK	2,000,000	9.73	0.48	62	61
AB	1,800,000	7.18	0.41	131	127
ON	1,700,000	4.65	0.23	131	114
BC	1,600,000	4.44	0.50	100	75
QC	1,501,000	2.99	0.22	99	77
MB	1,500,000	6.33	0.54	59	52
NT	305,000	0.86	0.35	8	5
NB	200,000	7.83	1.09	30	27
NS	190,000	8.84	1.60	32	31
YT	60,000	0.36	0.14	29	7
PE	6,000	2.77	0.67	4	4
NL	4,000	0.03	0.01	29	4
Total	**10,866,000**			**1,363**	**587**

* Details of the methods are presented in Blancher *et al.* 2007.

Fluctuations and trends

As noted elsewhere in this report, there was a large increase in Barn Swallow populations across Canada following European colonization (Landry and Bombardier 1996; Campbell *et al.* 1997). Since the 1980s, however, data from BBS, breeding bird atlas projects and ÉPOQ all point to a significant and persistent decline of Barn Swallow populations. In North America, population trends tend to be slightly positive or stable in the southern regions of United States, but become progressively negative northward and eastward through the species' breeding range. As such, Barn Swallow declines tend to be most pronounced in the northeastern states and eastern Canada (Nebel *et al.* 2010).

North American Breeding Bird Survey

In Canada, long-term BBS data show a statistically significant decline of 3.6% per year between 1970 and 2009 (Environment Canada 2010; Figure 3; Table 2), which corresponds to an overall population decline of about 76% over the last 40 years. For the most recent 10-year period (1999 to 2009, or roughly three generations), BBS data show a significant decline of 3.5% per year (Table 2), which represents a 30% decline over the decade (95% CI = -39.5% to -18.3%).[1]

1 BBS data for Canada have recently been re-analyzed by the United States Geological Survey using a hierarchical approach (Sauer *et al.* 2011). This analysis method results in a significant decline of 4.1% per year for the most recent 10-year period (34% overall). The 95% Confidence Intervals around this estimate are -5.0% to -3.3%. The lower value produces an overall decline of 40%.

BBS results suggest that the species' decline started sometime in the mid-1980s (see Figure 3), which coincides with that seen in many other species of aerial insectivores (Nebel *et al.* 2010). In keeping with the latitudinal and longitudinal patterns suggested by Nebel *et al.* (2010), Barn Swallow populations in Canada have decreased most profoundly in the Maritimes, where the annual decrease over the most recent 10-year period was 8.1% and 11.8% in New Brunswick and Nova Scotia, respectively (Table 2).

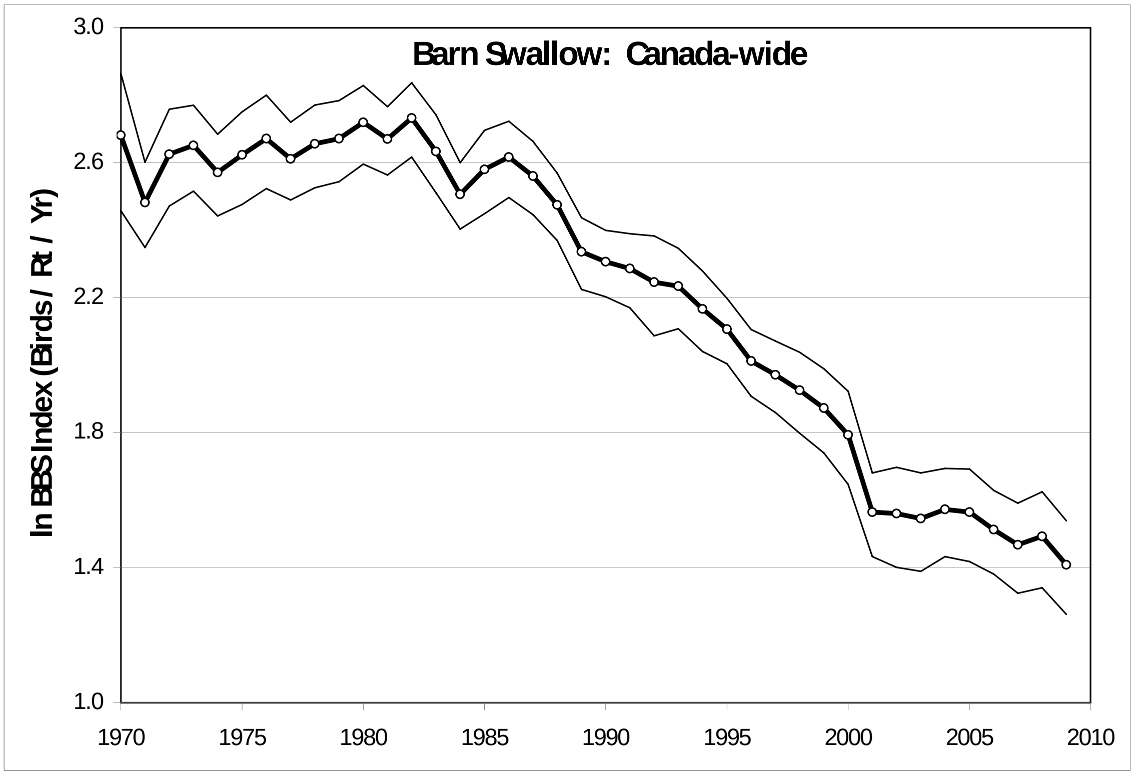

Figure 3. Trend in Barn Swallow annual abundance indices in Canada from 1970 to 2009, based on Breeding Bird Survey data (from Environment Canada 2010, courtesy P. Blancher). Indices are plotted on a log scale, showing 95% Confidence Intervals.

Table 2. National and regional annual average estimates of percent population change (including 95% Confidence Intervals) for the Barn Swallow in Canada over the long- and short-terms, based on Breeding Bird Survey results (from Environment Canada 2010).

Region	Long-term Trend (1970-2009)					10-year Trend (1999-2009)				
	%/yr[a]	Lower CI	Upper CI	P	n[b]	%/yr[a]	Lower CI	Upper CI	P	n[b]
CANADA	**-3.6**	-4.1	-3.0	0.000	708	**-3.5**	-4.9	-2.0	0.000	603
BC	**-4.7**	-6.6	-2.8	0.000	103	-3.5	-9.3	2.8	0.269	85
AB	**-3.4**	-4.4	-2.4	0.000	139	**-5.1**	-8.2	-1.9	0.002	123
SK	**-2.9**	-3.9	-1.8	0.000	76	-3.9	-7.8	0.3	0.065	56
MB	**-2.0**	-3.1	-0.8	0.001	64	0.4	-2.7	3.5	0.814	64
ON	**-2.5**	-4.1	-1.0	0.002	134	**-3.5**	-6.6	-0.3	0.031	119
QC	**-5.8**	-6.7	-5.0	0.000	102	**-4.3**	-7.3	-1.3	0.006	80
NB	**-7.7**	-9.4	-6.1	0.000	35	**-8.1**	-13.8	-2.1	0.011	29
NS	**-5.8**	-7.1	-4.4	0.000	32	**-11.8**	-16.7	-6.6	0.000	29

[a] Statistically significant values (P<0.05) are highlighted in grey
[b] n = number of survey routes used in the analysis.

Breeding Bird Atlases

A comparison of the Barn Swallow's probability of occurrence in Ontario between the first (1981-1985) and second (2001-2005) atlas periods shows an overall significant decline of 35% (Cadman *et al.* 2007). Declines appear to have been strongest in the Northern Shield (51%), the Southern Shield (32%) and the Lake Simcoe-Rideau region (7%; Cadman *et al.* 2007; Figure 4).

In the Maritimes, the number of atlas squares where Barn Swallows occur declined over the 20-year period between 1989 and 2010 (Figure 5). Based on results of preliminary unpublished analyses conducted by P. Taylor, who took survey effort into account, the probability of detection for Barn Swallow decreased significantly in all three Maritime provinces between atlas periods – from 0.87 to 0.53 (New Brunswick), from 0.90 to 0.67 (Nova Scotia), and from 0.93 to 0.48 (Prince Edward Island; B. Whittam pers. comm. 2010).

Barn Swallow populations have also declined substantially in several National Parks in the Maritimes (Fundy, Kouchibouguac, Kejimkujik and Cape Breton Highlands). The species might already be extirpated from Prince Edward Island National Park and possibly from Cape Breton Highlands National Park, two sites where it was fairly common in the late 1970s (S. Blaney pers. comm. 2009).

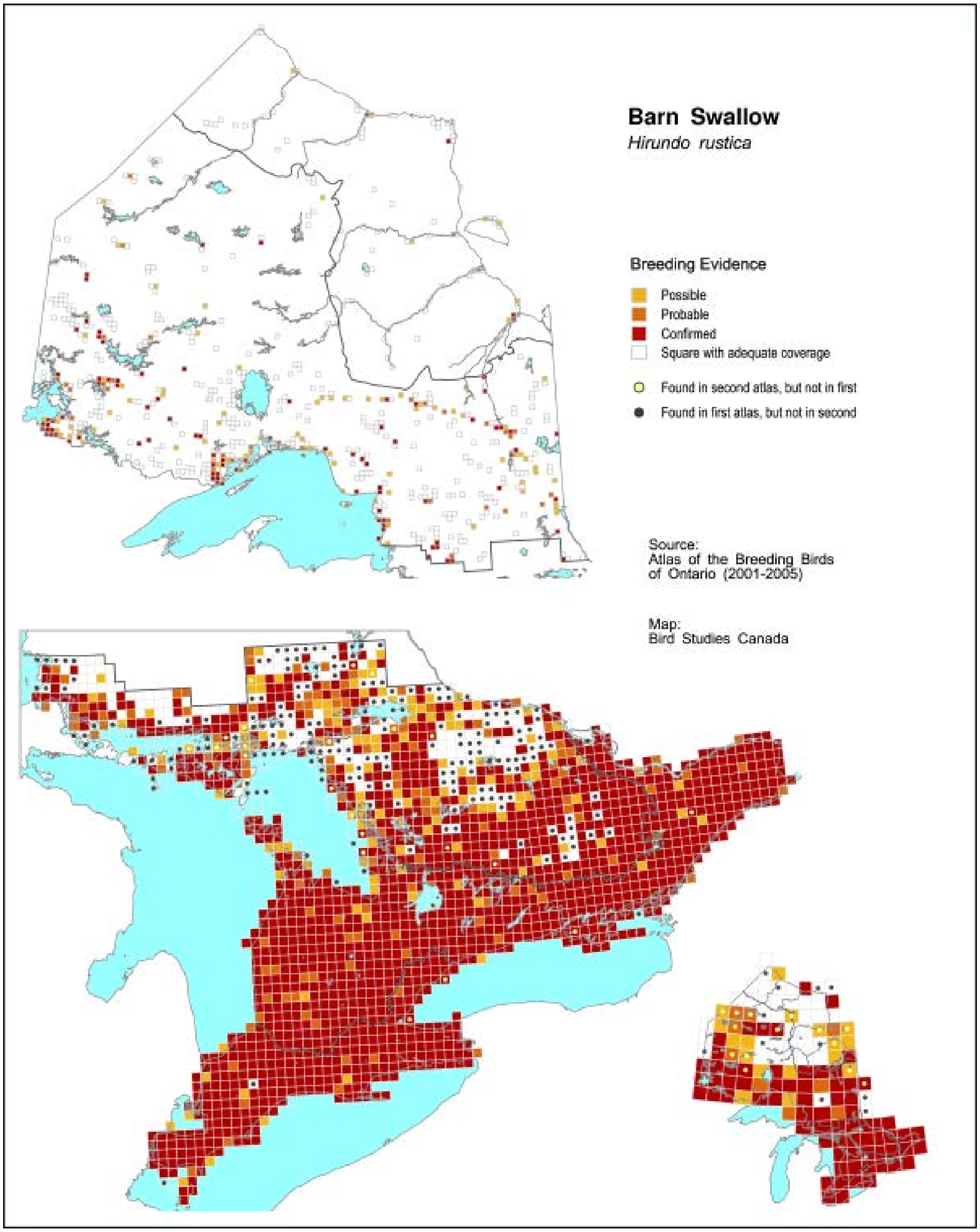

Figure 4. Ontario distribution of the Barn Swallow during the period 2001-2005 (reproduced with permission from Cadman *et al.* 2007). In the map of southern Ontario, squares with black dots are those in which the species was found in the first atlas period (1980-1985), but not in the second atlas (2001-2005). In the north, blank squares “with adequate coverage” are those that received at least 20 person-hours of survey coverage.

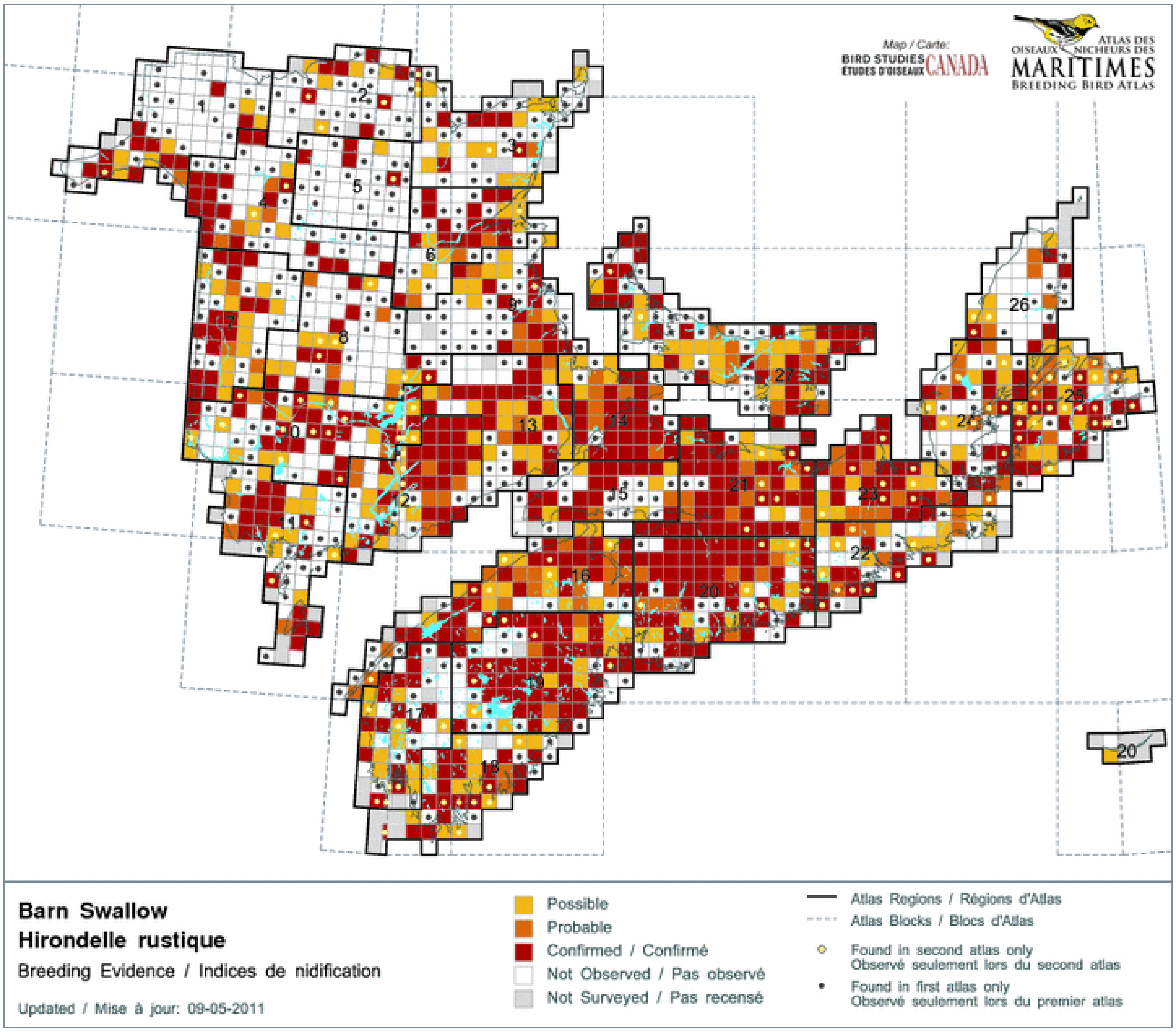

Figure 5. Maritimes breeding bird atlas distribution of the Barn Swallow during the period 2006-2010 (reproduced with permission from Bird Studies Canada 2010a). Squares with black dots are those in which the species was found in the first atlas period (1986-1990), but not in the second. Conversely, squares with yellow dots are those that were not occupied by Barn Swallows in the first atlas, but were occupied in the second.

In Alberta, comparison of the two atlas periods indicates that the Barn Swallow's relative abundance has declined in all Natural Regions of the province since the first atlas period that began in 1986 (Federation of Alberta Naturalists 2007).

Étude des populations des oiseaux du Québec (ÉPOQ) / Study of Québec Bird Populations (SQBP)

For the period 1970-2008, the ÉPOQ database shows a significant long-term decline in Barn Swallow abundance in Quebec of 2.4% per year ($P < 0.001$; Larivée 2009; Figure 6), representing a 60% decline over 38 years.

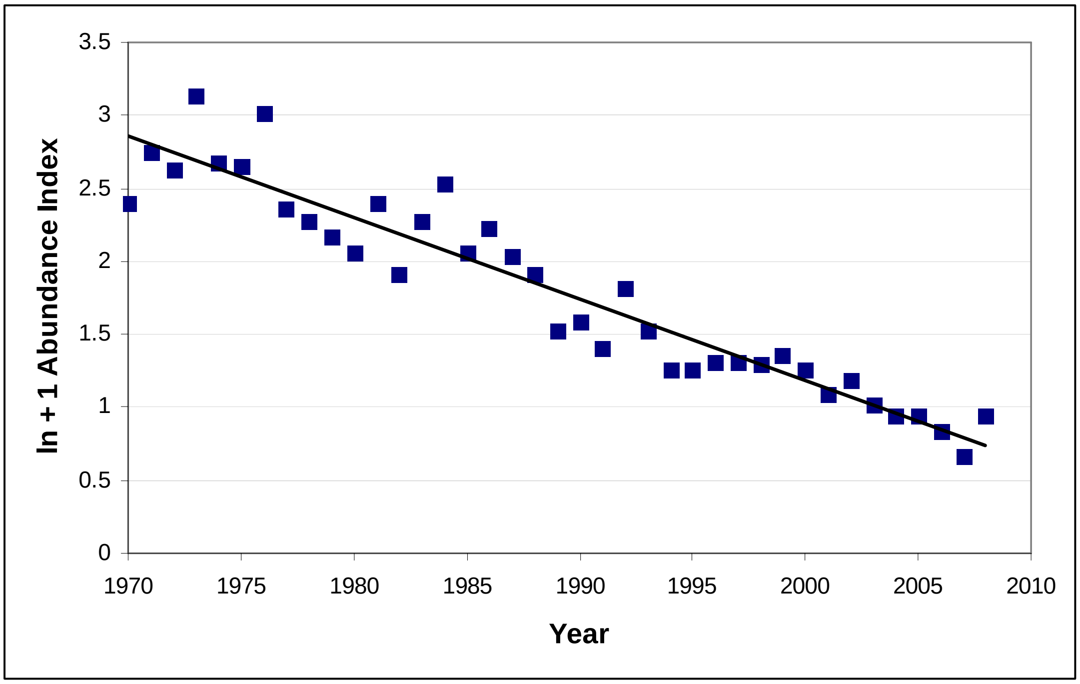

Figure 6. Annual indices of population change for the Barn Swallow in Quebec between 1970 and 2008 based on ÉPOQ data (Larivée 2009). Indices are plotted on a log scale,

Population trends in Europe

Burfield and van Bommel (2004) reported that the Barn Swallow's European breeding population underwent a moderate decline between 1970 and 1990. Although declines abated or even reversed in some countries during 1990–2000, the species continued to decline across much of Europe, and underwent a small decline overall. They concluded that "its population has clearly not yet recovered to the level that preceded its initial decline, and consequently it is evaluated as Depleted."

Population trend summary

In summary, BBS data show significant declines in Barn Swallow populations in Canada in recent decades, beginning sometime in the mid- to late 1980s. Evidence for this decline is supported by results from a variety of other types of regional surveys, including the Alberta, Ontario and the Maritimes breeding bird atlas projects and from Étude des populations des oiseaux du Québec surveys. Despite these losses, both the current distribution and abundance of the Barn Swallow in Canada (and North America) are still greater than they were before European settlement created large amounts of artificial nesting habitat and foraging opportunities that were readily exploited by the species. Nevertheless, declines are pervasive across most of the species' North American range, including the northern U.S. (see below).

Rescue effect

In the event of the extirpation of the Canadian population, immigration of individuals from the US could be viewed as likely, considering that the species is currently still common in most American states bordering Canada (NatureServe 2010). Despite the seemingly robust US population, recent (10-year) declines are apparent for virtually all states bordering southern Canada (Sauer *et al.* 2011; Table 3) – a pattern that diminishes the long-term potential for rescue.

Table 3. Barn Swallow population trends in adjacent jurisdictions of the United States, from west to east, for the period 1999-2009, based on Breeding Bird Survey results (Sauer *et al.* 2011).

State	Trend (average annual % change)	95% CI (lower)	95% CI (upper)	N (# of routes)
Washington	-3.8	-5.5	-2.1	83
Montana	-1.6	-4.0	0.8	54
Idaho	0.2	-2.9	3.6	48
North Dakota	-2.9	-5.3	-0.8	47
Wisconsin	-1.3	-3.0	0.4	95
Minnesota	-1.4	-3.1	0.2	79
Michigan	-1.5	-3.7	0.2	87
Pennsylvania	-1.2	-2.4	0.0	125
Ohio	-0.4	-2.0	1.0	78
New York	-1.8	-3.2	-0.4	123
Vermont	-4.2	-6.6	-2.5	26
New Hampshire	-4.7	-6.5	-3.4	25
Maine	-6.4	-8.4	-4.4	65

THREATS AND LIMITING FACTORS

The causes of the recent Barn Swallow declines, and indeed of those for many other aerial insectivore birds in Canada, are recent and poorly understood (Nebel *et al.* 2010). Something appears to have happened sometime in the mid- to late 1980s that seems to have triggered a sharp decline. The threats listed below are possible causes, and they are likely acting additively in unknown ways. As such, it is difficult to assign them in terms of priority. More research is necessary to determine the extent to which population bottlenecks are occurring on the breeding grounds versus the wintering grounds.

Habitat loss and degradation on the breeding grounds

In the last few decades, loss of nesting habitat due to the replacement of older-style wooden farm structures by modern buildings that lack easy access to suitable nesting sites has been cited as a principal reason for recent Barn Swallow declines in North America (Erskine 1992; Campbell *et al.* 1997; Brown and Brown 1999a; Cadman *et al.* 2007; Federation of Alberta Naturalists 2007). Even when newer structures remain open and accessible to Barn Swallows, Tate (1986) noted that nestlings are far more subject to heat-induced mortality in modern metal-roofed barns than in older barns with wooden roofs.

The extent to which declines in the availability of artificial nesting sites is actually limiting the Canadian population is unclear. There are growing numbers of reports of suitable buildings, which were formerly heavily used by Barn Swallows, now standing empty. Moreover, the timing of the onset of Barn Swallow declines in the mid- 1980s does not appear to coincide well with changes in the availability of artificial nest sites.

The decline of Barn Swallows has also been attributed to loss of foraging habitat due to a reduction in the amount of open, grassland types of agricultural habitats (Cadman *et al.* 2007). Several studies, mainly conducted in Europe, have shown a strong link between maintaining farming activities with domestic animals (especially cattle) in the landscape and the occurrence of large colonies of Barn Swallows (Møller 2001; Ambrosini *et al.* 2002a,b; Evans *et al*. 2007). Generally, the removal of cattle from pastures causes a decline in aerial invertebrate abundance, which has been reported to be more than twice as abundant over pasture fields compared to cereal fields and silage (Ambrosini *et al.* 2002a,b; Evans *et al.* 2007). This directly affects swallow reproductive output and can cause the total disappearance of the species from local areas (Møller 2001a; Ambrosini *et al.* 2002a,b; Evans *et al.* 2007). There are currently no similar studies for North America, but the rapid conversion of cattle pastures and dairy farms to cereal crops in at least some regions (e.g., Jobin *et al*. 2007; Latendresse *et al*. 2008) could play an important role in the decline of Barn Swallows in parts of eastern Canada. Loss of foraging habitat is also occurring due to reforestation of large tracts of eastern Canada (Jobin *et al.* 2007; Latendresse *et al.* 2008), such as in the southern Shield region of Ontario, where it has been suggested that declines of Barn Swallows are linked to abandoned, non-productive farmlands returning to forest conditions (Cadman *et al.* 2007).

Elsewhere in Canada, however, the area of suitable foraging habitat may even be increasing, even in regions where Barn Swallow populations are in decline. For example, the area of open foraging habitat in the prairies is increasing due to the conversion of cropland to non-native grassland for pasture and hay (cattle numbers are increasing in the prairies) and to the conversion of forest to farmland (D. Duncan pers. comm. 2010). Watmough and Schmoll (2007) examined trends in habitat in the prairies during the period 1985 to 2001. While they did find a small decrease in the amount of natural grassland cover (from 24.2 to 23.6% of the landscape), they also found that the area of row cropland decreased, and that the area of planted pasture and hayfield increased from 9 to 16% of the landscape. This suggests that loss of foraging habitat does not, by itself, explain Barn Swallow population declines.

Large-scale changes in insect prey

It has been suggested that the decline of Barn Swallows in Canada, as for several other aerial-foraging avian insectivores, could be related to large-scale declines in the abundance of flying insects and/or a change in their seasonal phenologies (see Nebel *et al.* 2010). Light pollution in and around urban centres, climate change (see below), loss and degradation of wetlands, acid precipitation and resulting calcium depletion, changes in agricultural landuse practices (e.g., loss of pastureland in some regions), large-scale use of pesticides, and the recent genetic development of insect-resistant row crops are among the many factors that could be affecting insect abundance (McCracken 2008; Nebel *et al.* 2010; M. Cadman pers. comm. 2010).

Climate change

Studies of the effect of climate change on reproductive success of Barn Swallow have shown contrasting results between Europe and North America. In Europe, for example, climate change has been found to enable Barn Swallows to reproduce earlier in spring and to increase reproductive success (Møller 2008). On the other hand, climate change has been proposed as an important limiting factor affecting several species of aerial insectivores, including Barn Swallows, in North America (Nebel *et al.* 2010). This hypothesis is based on studies conducted in the northeastern United States and Europe where the El Niño Southern Oscillation and the North Atlantic Oscillation are suggested to have significantly reduced fecundity and survivorship in several species of insectivorous birds (Sillett *et al.* 2000; Stokke *et al.* 2005). By nesting earlier, insectivorous species could face greater risk of mortality and increased energetic costs during bouts of inclement weather (cold snaps) that occur in early spring and/or during the breeding season because of suppression of insect prey (Anthony and Ely 1976; Newton 1998; Brown and Brown 1999a). More studies are needed to test this hypothesis, and particularly how it might be operating across the Barn Swallow's range.

Interspecific competition for nest sites from invasive species

As noted earlier (see **Interspecific interactions**), Barn Swallow nests are frequently usurped by non-native House Sparrows, which can reduce swallow fledging success. While this threat could indeed have negative population-level effects, House Sparrow populations have been declining significantly in Canada and across most of North America persistently over the past several decades (Sauer *et al*. 2011; Environment Canada 2010). Not only has the level of this threat been diminishing over time, its timing does not overlap with the onset of recent decline in Barn Swallow populations. Nevertheless, House Sparrows remain numerous and widespread, and the threat they pose is likely additive.

Parasitism

Unlike many other songbird species, Barn Swallows are rarely exposed to nest parasitism by Brown-headed Cowbirds (Brown and Brown 1999a). Nestlings are, however, frequently exposed to high rates of ectoparasitism (mites, fleas, feather lice, blowflies), which can limit productivity. In British Columbia, the majority of mortality in nestlings resulted from nest infestation with the larvae of the parasitic blowfly (*Protocalliphora*), which often results in the young falling from the nest or the death of the young in the nest (Campbell *et al.* 1997).

Barn Swallows often reuse their nest sites from one year to the next and often within the same season. Hence, nests are often infested with a large number of ectoparasites (Barclay 1988; Møller *et al.* 2001a). Ectoparasitism by mites and blowflies causes delayed breeding, reduces the incidence of second clutches, induces nest failure, reduces reproductive success (up to 33%), slows the growth rate of young, reduces the condition of offspring produced, and decreases fledging success in Barn Swallows (Shields and Crook 1987; Barclay 1988; Campbell *et al.* 1997; Brown and Brown 1999a; Saino *et al.* 1999; Saino *et al.* 2002). Little information on the effect of parasites is available for North America, nor is there any information as to whether rates or severity of infestations has been increasing.

Human persecution

Although not quantified, unknown numbers (perhaps many) of Barn Swallow nests are intentionally destroyed, because the droppings that accumulate beneath them create sanitary and aesthetic issues (Brown and Brown 1999a). Nests are also disturbed or removed from bridges and other infrastructure during routine maintenance activities (Brown and Brown 1999a; N. Mahony and M. Chutter pers. comms. 2010). There is also the potential for harvest of Barn Swallows for food at large wintering roosts in South America (Brown and Brown 1999a). Whether there has been any recent increase in the intensity of human persecution, which might correspond to the timing of recent declines in Barn Swallow populations, is unknown.

Other threats and limiting factors

Very little is known about the Barn Swallow's ecological needs or threats on its Latin American wintering grounds. More research is needed in this large region, where the bird spends most of its life.

Other threats potentially affecting Barn Swallows include mortality due to increased numbers and intensity of hurricanes encountered during migration (e.g., Newton 1998), water contamination (Custer *et al.* 2006), and poisoning by pesticides (Turner 1991; Basili and Temple 1999; Nebel *et al.* 2010). Another threat is increased nest predation from non-native predators such as Fox Squirrels (*Sciurus niger*) in western Canada, rats in barns, and possibly increased predation of adults from increasing populations of several native species of diurnal raptors.

PROTECTION, STATUS, AND RANKS

Legal protection and status

In Canada, the Barn Swallow and its nests and eggs are protected under the *Migratory Birds Convention Act, 1994* (Environment Canada 2004), and related provincial legislation governing native species of migratory birds.

Non-legal status and ranks

At the global level, the Barn Swallow is considered 'Secure' (G5, Table 4). It is considered as 'Least Concern' according to the IUCN Red List (BirdLife International 2009). In Europe, it is 'Depleted' (Burfield and van Bommel 2004). In the United States, it is not listed under the *Endangered Species Act* and is considered 'Secure' (N5B). It is not considered a 'Watch List Species' or a 'Stewardship Species' in the North American Landbird Conservation Plan (Rich *et al.* 2004). In Canada, it is identified as being 'Secure' in six provinces/territories and as 'Sensitive' in six (Canadian Endangered Species Conservation Council 2006; Table 4).

Habitat protection and ownership

In Canada, most suitable Barn Swallow breeding habitat is located on private land, which for the most part is not protected. Little information is currently available on the amount of suitable habitat and the level of habitat protection for Barn Swallows on public lands in Canada. There is no doubt that they occur widely on public lands that are protected as federal and provincial protected areas, such as national parks (the Barn Swallow is present in at least 44 protected areas managed by Parks Canada; Parks Canada 2009), Migratory Bird Sanctuaries, National Wildlife Areas, and provincial parks.

Table 4. Ranks assigned to the Barn Swallow in North America, based on NatureServe (2010) and General Status Ranks (CESCC 2006).

Region	Rank*	General Status
Global	G5	---
United States	N5B	---
Canada	N5B	Secure
British Columbia	S3S4B	Sensitive
Alberta	S5	Sensitive
Newfoundland & Labrador	S1S2B	Secure**
New Brunswick	S3B	Sensitive
Nova Scotia	S4B	Sensitive
Prince Edward Island	S3B	Sensitive
Saskatchewan	S5B, S5M	Secure
Manitoba	S4B	Secure
Ontario	S4B	Secure
Quebec	S4B	Secure
Yukon Territory	S4B	Secure
Northwest Territories	SNRB	Sensitive

* G = is a global status rank; S = rank assigned to a province or state; N = is a national status rank. S1 indicates that a species is critically imperiled because of extreme rarity (often 5 or fewer occurrences) or because of some factor(s) such as very steep declines, making it especially vulnerable to extirpation; S2 indicates that a species is imperiled because of rarity or other factors making it very vulnerable to extirpation, usually with 6 to 20 occurrences or few individuals remaining (i.e., 1000 to 3000); S3 indicates that a species is vulnerable at the subnational level because it is rare or uncommon, or found only in a restricted range, or because of other factors making it vulnerable to extirpation; S4 indicates a species is apparently secure; S5 indicates that a species is secure because it is common, widespread, and abundant in the state/province.

** Despite small numbers of individuals, the general status for Newfoundland & Labrador was recently changed from “May be at risk” to “Secure” owing to current population stability (*fide* Shelley Pardy Moores 2010).

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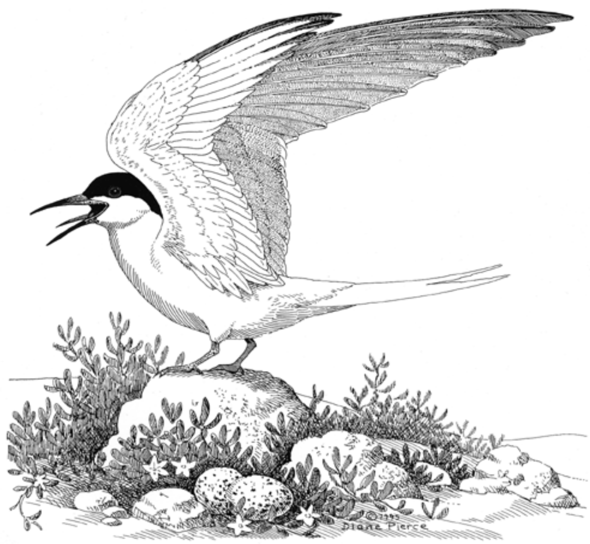
COSEWIC
Assessment and Update Status Report

on the

Roseate Tern
Sterna dougallii

in Canada



Roseate Tern. Diane Pierce © 1995

ENDANGERED
2009

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

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COSEWIC
Assessment Summary

Assessment Summary – April 2009

Common name
Roseate Tern

Scientific name
Sterna dougallii

Status
Endangered

Reason for designation
In Canada, this colonial species is part of the northeastern population that breeds on small islands off the Atlantic coast from the Magdalen Islands in the Gulf of St. Lawrence south to Long Island, New York. It winters in South America, from Colombia to eastern Brazil. The most recent (2007) population estimate for Canada was 200 mature individuals occupying 7 locations (approximately 98% are in only 2 locations). The number of mature birds has been fairly stable over the past decade despite recovery efforts. Rescue through immigration of birds from the United States is unlikely since the species is endangered in New England and the population there is also small (circa 7600 mature individuals in 2007). The primary factors limiting the population are predation of eggs, young and adults, low adult survival rates, and stochastic events (e.g. hurricanes).

Occurrence
Quebec, New Brunswick, Nova Scotia

Status history
Designated Threatened in April 1986. Status re-examined and designated Endangered in April 1999. Endangered status re-examined and confirmed in October 1999 and in April 2009. Last assessment based on an update status report.

COSEWIC
Executive Summary

Roseate Tern
Sterna dougallii

Species information

The Roseate Tern (*Sterna dougallii*) is a medium-sized, pale seabird, closely related to gulls, with a long and deeply forked tail. During breeding, adults are mostly white with a black cap, have long white tail streamers, and a white breast suffused with pale pink. The bill of the Roseate Tern is black with red appearing at the base later in the breeding season. Recent genetic analyses suggest two subspecies, *S. d. dougallii* in Europe, North America and the Caribbean, and *S. d. gracilis* in western Australia.

Distribution

The Roseate Tern occurs on six continents in the Atlantic, Indian, and Pacific oceans. In North America, two populations of Roseate Tern breed on the Atlantic coast in distinct locations. The northeastern population breeds from the Magdalen Islands in the Gulf of St. Lawrence south to New York. The second population breeds from Florida and the Bahamas to the Lesser Antilles. Both populations winter in South America, from Colombia to eastern Brazil. The Canadian population of Roseate Tern constitutes approximately 2.6% of the northeastern population and breeds almost exclusively on coastal islands in Nova Scotia, although small numbers of birds also breed on islands in Quebec and New Brunswick. The location of small colonies changes unpredictably between years and only two colonies in Nova Scotia have maintained relatively large numbers of Roseate Tern since the 1980s.

Habitat

Roseate Terns nest in colonies almost exclusively on small islands, frequently vegetated with beach grass and herbaceous plants. In northeastern North America, Roseate Terns always nest in association with Common or Arctic terns, which help provide protection from diurnal predators through communal mobbing (Nisbet and Spendelow 1999). Roseate Terns nest under cover, usually in the form of dense vegetation or under and among strewn rocks, boards, driftwood, and artificial structures like boxes and half-buried tires. Roseate Terns have specialized foraging habitat requirements, preferring shallow areas close to shore near shoals and tide rips.

Biology

The majority of Roseate Terns breed first at three years, and the average age of breeding adults in the northeastern population is estimated at 7.8 years. Roseate Terns usually lay 1-2 eggs and in the absence of predation they fledge at least one chick per pair. About 32% of fledglings are estimated to survive to breeding age, and about 83.5% of adults survive annually. Site fidelity is high, with 88-98% of surviving adults returning to the same site to breed each year. Movement of birds between major breeding colonies in the U.S. and Canada has been recorded, but it is not extensive. After the breeding season, Roseate Terns stage at a number of specific sites in the Gulf of Maine and around Cape Cod. They then migrate south in late August and early September, arriving at wintering sites ranging from western Colombia to eastern Brazil in October. Roseate Terns forage on small fish such as Sand Lance, herring and hake.

Population sizes and trends

The number of Roseate Terns breeding in Canada has remained relatively stable at around 100 pairs since the 1980s when detailed data collection began. The number of colonies used by Roseate Terns has fluctuated annually with a high of 14 colonies in 1999 and a low of four in 2003. Numbers at the two major Nova Scotia colony sites (The Brothers and Country Island) continue to be relatively high, although recent declines have been noted at Country Island (from 53 pairs in 2000 to 25 pairs in 2007). The small colony on Machias Seal Island, New Brunswick, which has been occupied since 1979, was abandoned by terns in 2006, 2007 and 2008. As of 2007, the Canadian population consisted of an estimated 200 mature individuals nesting at 7 locations.

Limiting factors and threats

Roseate Terns in Canada are limited by the number of predator-free breeding sites in close proximity to suitable foraging areas. The following threats have been identified: 1) high levels of predation and displacement by large gulls; 2) increased predation by other species, especially American Mink; 3) erosion of North Brother Island leading to loss of breeding habitat; 4) human disturbance, especially in Mahone Bay, Nova Scotia; 5) industrial development and associated increases in large ship traffic, especially in Country Harbour, where undersea natural gas pipelines and a liquefied natural gas receiving plant are in development; 6) severe weather events such as hurricanes; 7) natural biological factors including low adult survival rates, a short overall breeding lifetime, and specialized foraging habitat requirements; 8) a skewed sex ratio (127 females:100 males) that lowers estimates of the effective size of the adult breeding population; and 9) unidentified sources of wintering mortality.

Special significance of the species

The Roseate Tern has become a symbol of coastal conservation in North America, as evidenced by its inclusion in the logo of at least four conservation organizations ranging from international to local.

Existing protection or other status designations

The Roseate Tern is currently designated as *Endangered* in Canada and is protected under Schedule 1 of the *Species At Risk Act* and the *Migratory Birds Convention Act.* In the United States, the northeastern population of Roseate Tern is listed as *Endangered*, and the Caribbean population is listed as *Threatened*. It is also *Endangered* as of 2000 in Nova Scotia and protected under the Nova Scotia *Endangered Species Act*. It is designated globally by the IUCN (World Conservation Monitoring Centre) as Least Concern.

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
(2009)

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

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

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

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

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

Canada

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

Update
COSEWIC Status Report

on the

Roseate Tern
Sterna dougallii

in Canada

2009

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SPECIES INFORMATION

Name and classification

Scientific name: *Sterna dougallii*
English name: Roseate Tern
French name: Sterne de Dougall

Two genetically valid subspecies are recognized, *S. d. dougallii* (Europe, North America and Caribbean) and *S. d. gracilis* in western Australia (Indo-Pacific Basins; Lashko 2004; Szczys *et al.* 2005a; Figure 1). This report deals with *S. d. dougallii*.

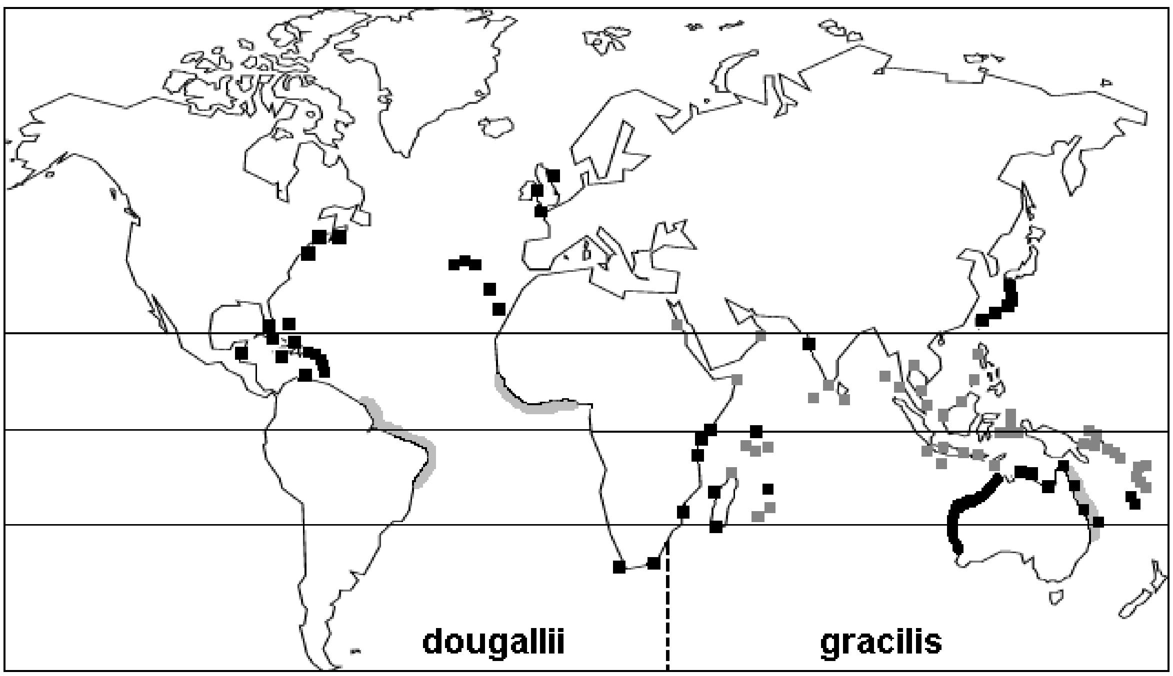

Figure 1. Global range of Roseate Tern. Black squares are known breeding sites, grey squares are putative range or historic records and pale grey shading indicates the temperate breeding populations' wintering areas. The dotted line indicates the line of separation between *dougallii* and *gracilis* (Source: N. Ratcliffe and I. Nisbet unpublished data).

Morphological description

The Roseate Tern is a medium-sized, pale tern with a long and deeply forked tail (Gochfeld *et al.* 1998). Males and females are outwardly identical in appearance. During breeding, adults are mostly white with a black cap. They have long white tail streamers and a white breast suffused with pale pink. The wings and mantle are pale grey, and the outer 2-4 primaries appear blackish on the upper wing. Roseate Terns are very similar to Common and Arctic terns and are best distinguished from them by their shorter wings, longer tail and paler plumage with no grey or black on tail streamers, less black on the outer primary feathers and complete lack of black on the underwings. An adult

Roseate Tern in non-breeding plumage has a black mask, a white forehead and a shorter tail than during breeding, but it can still be distinguished from other terns by its all-white underwing, compared with the black trailing primary edge on the underwing of Common and Arctic terns (Gochfeld *et al*. 1998). The bill of the Roseate Tern is all black with progressively more red appearing at the base as the breeding season advances (Gochfeld *et al.* 1998). The bill of the Arctic Tern is all red, and the Common Tern's bill is red with a black tip, similar to the bill of the Roseate Tern late in the season. Roseate Tern is also distinguished from Common and Arctic tern by its "chi-vik" call given in flight or raspy "craaak" call when mobbing predators (Gochfeld *et al.* 1998). To a trained ear, these calls allow a single Roseate Tern to be picked out of a mixed species colony.

Genetic description

No genetic research has been done on the Canadian population alone, but two recent genetic studies (Lashko 2004; Szczys *et al.* 2005a) have included data from northeastern U.S. colonies which are considered the same population as Canadian colonies (Gochfeld *et al.* 1998). There is no reason to suspect barriers to gene flow in the Canadian population, because band resighting data have indicated movement of individuals between Canadian and U.S. colonies (see **Dispersal/migration**).

Lashko (2004) used mitochondrial DNA to examine historical relationships among global Roseate Tern colonies, including one colony in the U.S. (Bird Island, MA), Ireland, the Azores, South Africa, the Seychelles, Japan, and Australia. Mitochondrial DNA revealed two strongly supported clades, one comprised of the Atlantic Ocean breeding colonies, and a second including the Indian and Pacific Ocean breeding colonies, with a high inter-oceanic corrected sequence divergence of 4% corresponding to a genetic separation of up to one million years. None of the six haplotypes present within the Atlantic lineage were present in Roseate Terns from the Indo-Pacific, with analyses showing strong evidence for isolation by distance (using the correlation coefficient for genetic versus geographic distance: $r = 0.96$, $P = 0.001$). Based on sequences of the two mitochondrial DNA genes, ND6 and ND2, Lashko (2004) found minimal phylogenetic structure within the Atlantic lineage. There was a single fixed nucleotide difference ($G \rightarrow A$) between the east and west Atlantic lineages, with the Azores and Ireland (east Atlantic) sharing the fixed difference that differentiates them from the U.S. colony (west Atlantic; but see contrasting microsatellite results below).

Szczys *et al.* (2005a) identified four novel microsatellite markers and one other marker using blood samples from two U.S. colonies (Bird Island, MA and Falkner Island, CT) and two colonies in Western Australia. These markers were used to determine population genetic structure within and between the two populations. Four of the five markers showed greater Allelic Richness (R_S) in Western Australia than in the North Atlantic, ranging from 1.5 to 4 times higher. Szczys *et al.* (2005a) found significant population differentiation at the global scale ($F_{ST} = 0.48$, $P < 0.05$), and Lashko (2004), using the same four microsatellites, also found strong differentiation between the Atlantic and the Indo-Pacific populations: 38.7% of the observed genetic variation was distributed between the two ocean basins ($F_{ST} = 0.43$, $R_{ST} = 0.52$ $P< 0.001$). Szczys *et* *al.* (2005a) found no evidence for differentiation between the two northern U.S. colonies (F_{ST} = 0.03). However, Lashko (2004) found that breeding colonies in Ireland and the U.S. have diverged from the Azores (R_{ST} = 0.28-0.36, $P < 0.05$). Colonies in Ireland and the U.S. were not significantly divergent from one another, which may be due to true genetic homogeneity, or could be a result of low sample sizes or recent population declines in the U.S. (40-50% in the 1970s) and Ireland (40% in the 1960s) leading to reduced genetic diversity in these colonies relative to the Azores, making them appear more genetically homogeneous (Lashko 2004).

The relative reduction in genetic diversity in the North Atlantic population relative to western Australia is likely a result of smaller population size, but inbreeding was not apparent at the two colonies studied by Szczys *et al.* (2005a; F_{IS} = 0.05). The lower F_{ST} values in pairwise comparisons of the North Atlantic populations indicated higher gene flow between North Atlantic colonies compared with those in the Azores or Western Australia; this result was validated by band resighting data indicating movement of individuals between U.S. colonies (Spendelow *et al.* 1995; Lebreton *et al.* 2003). In addition, limited band recovery data supports the possibility of greater gene flow between the U.S. and Ireland, than between the U.S. and the Azores or Ireland and the Azores (Lashko 2004). Roseate Terns banded on Rockabill Island in Ireland have been found at breeding colonies in the U.S. (Nisbet and Cabot 1995; Hays *et al.* 2002) and two individuals banded as chicks at colonies in the U.S. have been reported from Rockabill Island (Newton and Crowe 2000).

Lashko (2004) identified two evolutionarily significant units (ESU) of Roseate Tern: the Indo-Pacific ESU and the Atlantic ESU. Africa has served as a barrier to gene flow between these two ESUs and is considered a zone of secondary contact between them (Lashko 2004). Within the Atlantic ESU, there was insufficient data to identify separate management units, but the two proposed (potential) management units are the Azores and the North Atlantic (Canada, U.S. and Ireland; Lashko 2004).

Designatable units

There is only one designatable unit in Canada, because all birds belong to one population of one subspecies, and are found in one ecozone. There is no reason to believe that Canadian birds are genetically distinct from the adjacent U.S. population.

DISTRIBUTION

Global range

The Roseate Tern occurs on six continents in the Atlantic, Indian, and Pacific Oceans (Figure 1). In North America, two populations of Roseate Tern breed on the Atlantic coast in distinct locations. The northeastern population breeds from the Magdalen Islands in the Gulf of St. Lawrence south to Long Island, New York. The second population breeds from Florida and the Bahamas to the Lesser Antilles (Cramp 1985). Both populations winter in South America, from Colombia to eastern Brazil (Nisbet 1984; Hays *et al.* 1997).

Canadian range

The Canadian population of Roseate Tern constitutes approximately 2.6% of the northeastern population and breeds almost exclusively (98%) in Nova Scotia, with small numbers of birds (1-2 pairs) known to breed in the Magdalen Islands, QC and until recently on Machias Seal Island, NB (Figure 2).

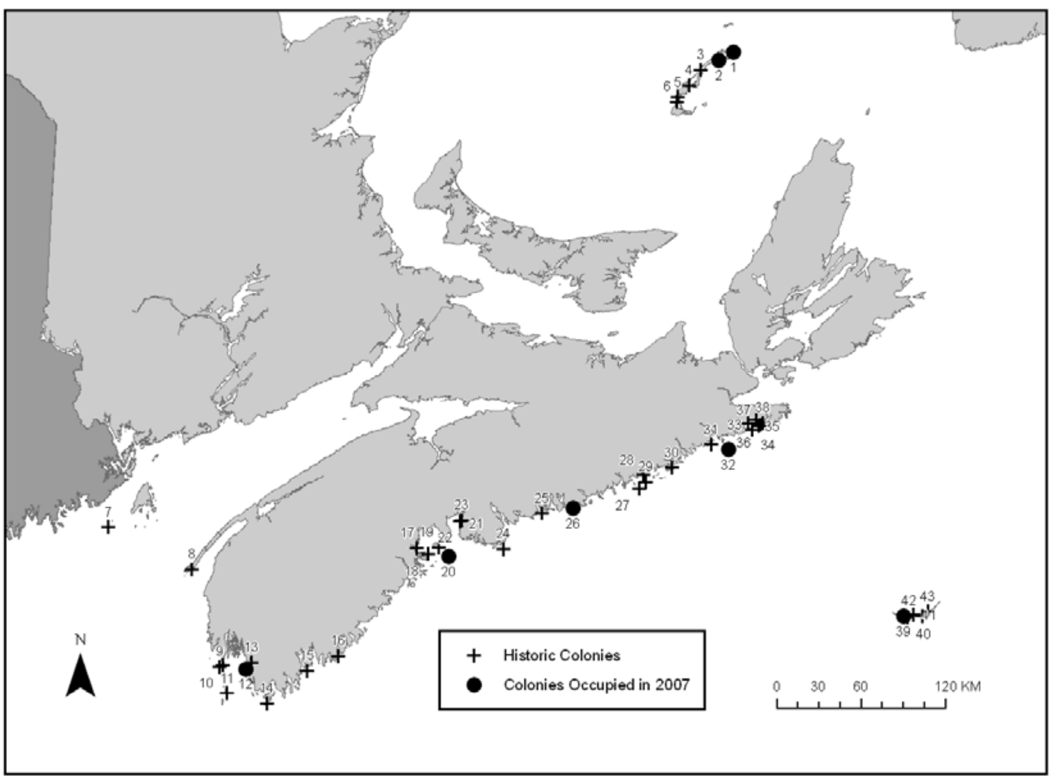

Figure 2. Canadian Roseate Tern breeding locations. Historic colonies had at least one pair of Roseate Terns at least once since 1982 but not in 2007. For colony names and details see Appendix 1.

Since 1982, Roseate Terns have occupied 43 distinct sites, 26 of which are coastal islands, and five of which are coastal headlands, in Nova Scotia. The remainder include five separate colony sites on Sable Island, NS, six small islands in Quebec's Magdalen Islands, and a single island in New Brunswick (Figure 2). The location of small colonies changes unpredictably between years (Appendix 1). Over the last three generations (~23-24 years for Roseate Tern), the number of occupied colonies has fluctuated from four to 14 annually (Table 3, p. 17), with only two colonies maintaining relatively large numbers of Roseate Terns since the 1980s (Appendix 1).

In the Magdalen Islands, QC, at least six sites have been known to support small numbers of Roseate Terns since the 1980s (Figure 2) although only three of these sites have had Roseate Terns in more than two years (Appendix 1). Similarly, on Sable Island, NS at least five sites have been known to support Roseate Terns since the 1980s (Figure 2, Appendix 1).

In New Brunswick, Roseate Terns have nested in small numbers (1-2 pairs) on Machias Seal Island since 1979. The entire tern colony (Common, Arctic and Roseate terns) abandoned this site in July 2006 and again in June 2007 (Appendix 1) and June 2008 (A. Diamond pers. comm. 2008). Roseate Terns have not bred at this site since at least 2004 (Appendix 1).

The Extent of Occurrence (EO) of Roseate Terns in Canada is estimated at 98,707 km^2, based on the area of a polygon joining four colonies (The Brothers, Sable Island and two colonies on the Magdalen Islands) and including within them the additional three colonies (Country, Duck and Pearl islands) occupied in 2007. The EO has decreased from a historic maximum of 145,035 km^2 in 1982-85, a difference of 46,328 km^2 or 32%. However, abandonment of the small colony on Machias Seal Island (colony #7 in Figure 2) is the primary driver of this change.

The current Area of Occupancy of Roseate Terns in Canada is estimated at less than 25 km^2, using the area of the breeding colony for biological AO. Using the 2 x 2 km grid system, the figure would be between about 20 and 100 km^2. Both these figures fluctuate based on the number of colonies occupied in any given year (maximum of 14 in 1999, 12 three generations ago, 7 in 2007).

HABITAT

Habitat requirements

Foraging habitat of breeding Roseate Terns

Roseate Terns generally forage in shallow areas close to shore, near shoals and tide rips (Safina 1990; Rock *et al.* 2007). At some colonies, Roseate Terns travel up to 30 km round trip to find food (Heinemann 1992). The only study of Roseate Tern foraging habitat in Canada found that Roseate Terns foraged up to 23.9 km from the colony on Country Island, with an average distance of 6.9 ± 1.5 km from the colony, with

90% of observations made over water < 5 m deep (Rock *et al.* 2007). Common Terns forage under a wider range of habitat conditions, and are less restricted by physical oceanography (Safina 1990). Arctic Terns forage farther from land in deeper water (Rock 2005). As a result, Roseate Terns prey on a limited number of fish species, whereas Common and Arctic terns have a more diverse diet (Richards and Schew 1989; Safina *et al.* 1990; Rock 2005).

<u>Staging and wintering habitat</u>

Roseate Tern staging habitat has been identified in Saco Bay, ME (Stratton Island; Shealer and Kress 1994) and on Cape Cod (Trull *et al.* 1999). At Stratton Island, terns stage on the southern end of the island as well as on a sandy beach at nearby Proutt's Neck. During the day they feed in shallow water areas (<10 m depth) and over sandy substrates on abundant Sand Lance (*Ammodytes* spp.; Shealer and Kress 1994). In Cape Cod, at least 20 discrete sites consisting of beaches or sand flats at or near the end of barrier islands or barrier beaches, or near tidal inlets or tide rips, were reported to have staging Roseate Terns (Trull *et al.* 1999).

Little is known about wintering habitat. The largest concentration of wintering Roseate Terns was located at Mangue Seco, Bahia, Brazil (11°27'S 37°21'W) between December 1996 and February 1997. The area is a sandy point on the south side of the mouth of the Rio Real. At low tide, extensive sandbars and mudflats lie west of the point; Cayenne (*S.* [*sandvicensis*] *eurygnatha*),Yellow-billed (*S. superciliaris*) and Least (*S. antillarum*) terns gather during the day. Roseate and Common terns were found roosting only at night (Hays *et al.* 1999).

<u>Breeding habitat</u>

Roseate Terns nest in colonies almost exclusively on small islands, frequently vegetated with beach grass and other herbaceous plants (Nisbet 1981). They will occasionally (though not consistently) nest on mainland spits (Whittam 1999, Appendix 1: site numbers 23, 25, 31, 34, 35).

In northeastern North America, Roseate Terns always nest in association with Common or Arctic terns, presumably because the presence of large numbers of congenerics elevates communal colony defence. In fact, the presence of Common Terns is the most important habitat feature (summarized in Gochfeld *et al.* 1998). Terns require colony sites that are relatively free from predators, and will abandon a colony after a season of heavy predation (Nisbet 1981; Whittam and Leonard 1999). Roseate Terns breeding in North America are limited by the number of available predator-free (or predator-controlled) colony sites that are also in close proximity to good foraging sites (Whittam 1999). Within a colony, Roseate Terns nest at sites that provide more cover than nest sites of Arctic or Common terns (Burger and Gochfeld 1988; Ramos and del Nevo 1995; Whittam 1997). This cover is usually in the form of dense vegetation or strewn rocks, boards, or driftwood (Nisbet 1981; Spendelow 1982; Environment Canada 2006). Roseate Terns will also nest in boxes, half-buried tires, or other artificial shelters provided by humans (Spendelow 1982, 1991b). Reproductive success is greater under artificial shelters than in natural sites (Spendelow 1996). Table 4 in Whittam (1999) provides specific information on the type of nesting habitat used by Roseate Terns at major Canadian breeding colonies. Similar descriptions of nest sites at U.S. colonies can be found in Nisbet (1981, 1989).

Habitat trends

In Canada, Roseate Terns nest only in association with large breeding colonies of Arctic and Common terns. The number of tern colonies in the region is therefore an important factor in an assessment of Roseate Tern habitat trends. While overall tern numbers have increased in Nova Scotia and stayed about the same in New Brunswick between the 1980s and present (Figures 3, 4), the number of tern colonies in the Maritimes has fluctuated since the early 1980s. In Nova Scotia, the number of mixed-species tern colonies has varied from a low of 15 in 1987 to a high of 104 in 1995 and appears relatively stable in 2007 at 78 colonies (Figure 3). In New Brunswick, the number of colonies has undergone a steep decline, from 26 in 1983 to only 14 in 2001 and 10 in 2005 (Figure 4). In the Magdalen Islands, the number of tern nests has remained relatively stable, but the number of colonies has fluctuated from a low of four in 1999 to a high of 11 in 1993 (Figure 5).

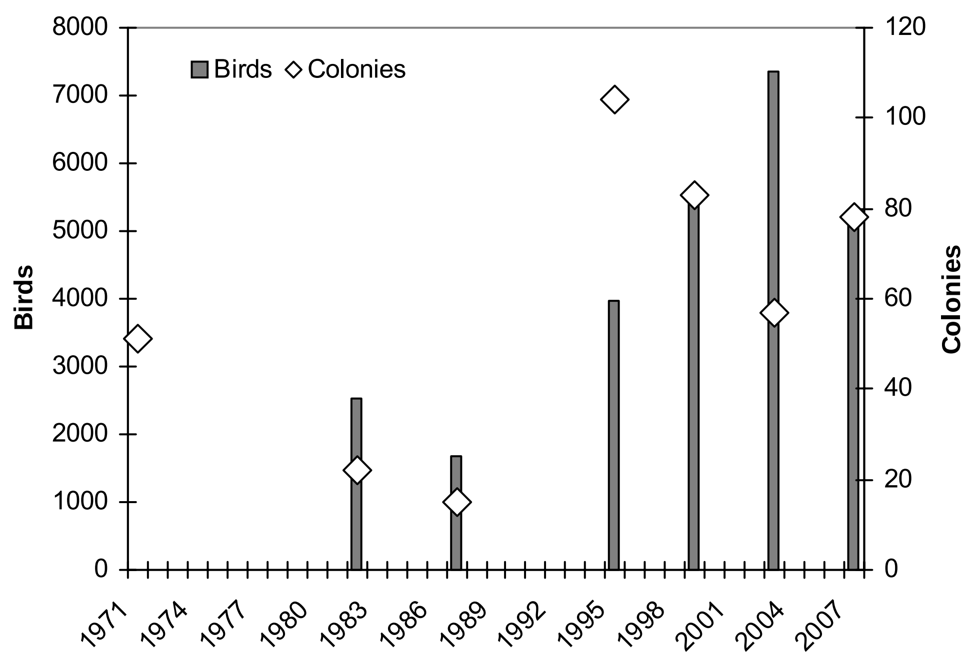

Figure 3. Numbers of terns and tern colonies (all species combined) counted in Nova Scotia between 1971 and 2007 (Source: Lock 1971, 1983; Boyne unpublished data).

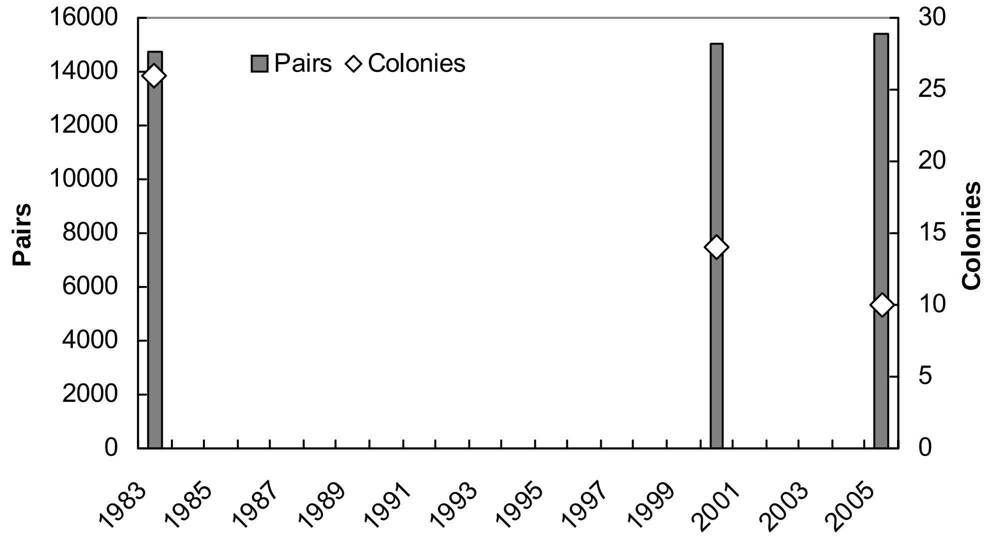

Figure 4. Numbers of tern pairs and tern colonies (all species combined) counted in New Brunswick between 1983 and 2006 (Source: Lock 1984; Boyne *et al.* 2006).

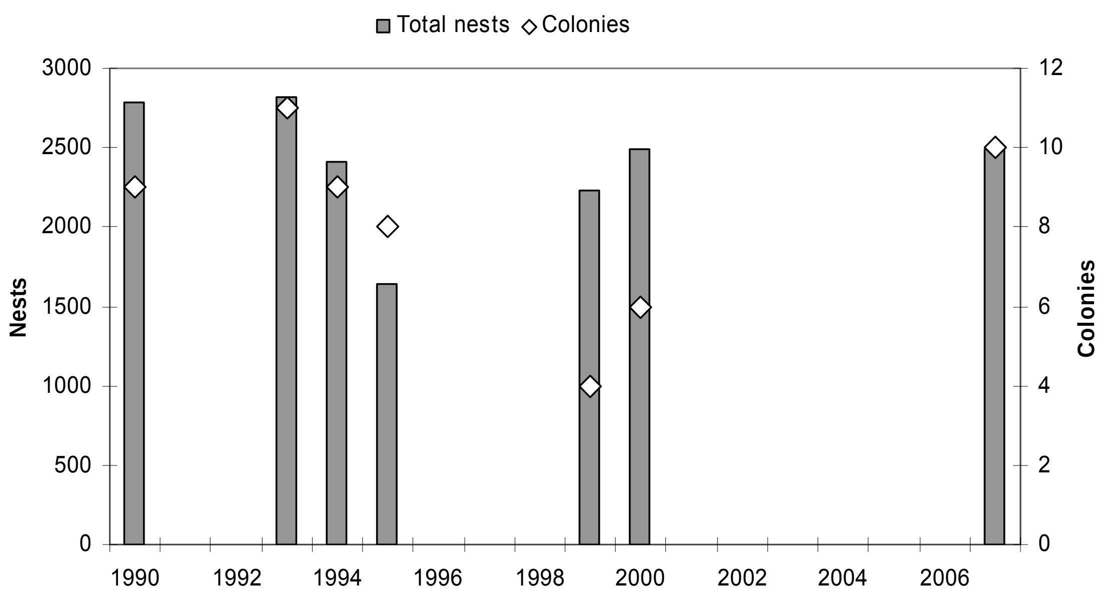

Figure 5. Numbers of tern nests and tern colonies (all species combined) counted in the Magdalen Islands between 1990 and 2007 (Source: Shaffer unpublished data).

Many tern colonies have been abandoned this century due to the presence of gulls (Crowell and Crowell 1946; Kress 1983; Howes and Montevecchi 1993). In 1997 Roseate Terns abandoned Country Island, almost certainly due to gull predation (Whittam and Leonard 1999). The number of gulls in the region, and the availability of gull-free breeding habitat are, therefore, important factors in an assessment of Roseate

Tern habitat trends. In general, the number of large *Larus* gulls in the Maritimes, especially Herring Gulls (*L. argentatus*), appears to be lower than estimates from the 1970s, but populations of all species do not appear to be undergoing continued declines (Table 1). In the Magdalen Islands, surveys between 1990 and 2007 indicate steady declines in Herring Gulls but recent stabilization of Great Black-backed Gulls (*L. marinus*; Table 1).

Table 1. Historic and current estimates of the number of pairs of Great Black-backed Gulls, Herring Gulls, and Ring-billed Gulls breeding in the Bay of Fundy, mainland Nova Scotia, the Gulf of St. Lawrence coast of New Brunswick, and the Magdalen Islands.

	1971	1979	1986	1987	1990	1998	2000	2001	2002	2005	2007
Bay of Fundy[1]											
Great Black-backed Gull		600				1771		602			
Herring Gull		13800				5367		11809			
Mainland Nova Scotia[2]											
Great Black-backed Gull	9547			16608					11393		
Herring Gull	8720			11569					6434		
New Brunswick[3]											
Great Black-backed Gull			1134				910			1025	
Herring Gull			5950				2330			2406	
Ring-billed Gull			1534				3544			3947	
Magdalen Islands[4]											
Great Black-backed Gull					1169				753		779
Herring Gull					1664				1152		545

1. Lock unpublished data; Mawhinney *et al.* 1999; Ronconi and Wong 2003
2. Not including Cape Breton Island; Lock 1971; Boyne and Beukens 2004
3. Lock unpublished data; Boyne *et al.* 2006; Bond *et al.* 2006
4. Shaffer unpublished data

Non-lethal predator control (destruction of gull and corvid nests, scaring of gulls using noise makers) is carried out at the two major Canadian Roseate Tern colonies (The Brothers and Country Island). At Country Island, the number of successful predator intrusions (where an egg or chick was taken) has declined from 0.84/hour to 0.09/hour between 1996 and 2007 (Toms *et al.* 2008). The number of gull nests initiated on both The Brothers and Country Island has also declined over the last decade (D'Eon 2007; Toms *et al.* 2008). These results suggest that the quality of habitat in terms of predation risk has been enhanced at these sites over the last decade.

At The Brothers, the amount of physical habitat available to terns is declining due to erosion. Between 2007 and 2008, North Brother Island lost about 0.7 m of land mass at its southern tip and about 0.3 m along the south-west edge (D'Eon 2008), which is a significant one-year loss considering that the island is only about 100 m x 200 m in size.

Recent efforts by the Bluenose Coastal Action Foundation (BCAF) to restore a colony of Roseate, Arctic and Common terns in Mahone Bay (Quaker Island) have been unsuccessful, most likely due to human disturbance (BCAF 2006, and see below under Threats).

Habitat protection/ownership

Critical habitat for Roseate Tern has been identified at Sable Island, The Brothers, Country Island and the Magdalen Islands (Paquet Island, Deuxième Îlet and Chenal Island; Environment Canada 2006). New critical habitat may be identified if it is occupied by Roseate Terns for three consecutive years (Environment Canada 2006). Protection and ownership of sites occupied in 2007 are described below.

Sable Island is protected as a Migratory Bird Sanctuary under the *Migratory Birds Convention Act*.

The Brothers Islands are owned by the province of Nova Scotia and this site has been designated a Wildlife Management Area under the provincial *Wildlife Act* (s. 113).

Country Island is federal crown land administered by the Department of Fisheries and Oceans. The Department of Fisheries and Oceans and Environment Canada are currently engaging in discussions on how best to protect the critical habitat at this site.

A single pair of Roseate Terns was located on Duck Island in a colony of about 270 other terns for the first time in 2007. This island is owned by the province of Nova Scotia and is currently zoned “Category 2” for wildlife under the Department of Natural Resource’s Integrated Resource Management Crown Land classification system because Common Eiders (*Somateria mollissima*) are also known to nest there. This means that the island must be managed with the natural resource (in this case, nesting Common Eiders) in mind (see http://www.gov.ns.ca/natr/irm/introduction.html for details). An extension of the Eastern Shore Islands Wildlife Management Area is being considered, and if such an extension occurs Duck Island would become part of this management area (Archibald pers. comm. 2008).

Pearl Island has had Roseate Terns present (breeding unconfirmed) in 1992 (Kress and Duley 1992), 1999-2001 (Stevens pers. comm. 2008) and in 2007 (Rodenhizer pers. comm. 2008). Pearl Island is owned by the province of Nova Scotia and is designated as a Wildlife Management Area under their *Wildlife Act* (s. 113).

Environment Canada is working in collaboration with the province of Quebec to ensure the effective protection of Roseate Tern critical habitat located in Quebec’s Magdalen Islands archipelago. In Quebec, islands or peninsulas inhabited by colonial birds are protected as “wildlife habitat” under Quebec’s *Loi sur la conservation et la mise en valeur de la faune* (s. 128.6). Individual sites in Quebec are discussed below.

Deuxième Îlet and Chenal Island

These islands are owned by the government of Quebec and protected as wildlife habitat under section 128.6 of *Loi sur la conservation et la mise en valeur de la faune* (Shaffer pers. comm. 2008).

Paquet Island

This island is partially private and partially the property of the government of Quebec. The Government of Quebec's parcel of land is protected as wildlife habitat under section 128.6 of *Loi sur la conservation et la mise en valeur de la faune*. In an effort to protect the private part of the island, stewardship activities will be pursued (Shaffer pers. comm. 2008).

Pointe de l'Est

Roseate Terns were observed here for the first time in 2006 and again in 2007 (1 individual). The site is owned by the Government of Quebec and is designated as a provincial wildlife refuge (Refuge faunique de la Pointe-de-l'Est; Shaffer pers. comm. 2008). In addition, the provincial refuge is surrounded by the Pointe-de-l'Est National Wildlife Area.

BIOLOGY

The most comprehensive sources of information on Roseate Tern biology include Gochfeld *et al.* (1998) and several recent northeastern U.S. metapopulation studies (Spendelow *et al.* 2002; Lebreton *et al.* 2003).

Life cycle and reproduction

Several cases of Roseate Terns breeding at age two have been recorded (Donaldson 1971; Spendelow 1991a), although the majority of birds breed first at age three (Lebreton *et al.* 2003). For example, 77% of birds surviving to breeding age at Falkner Island, CT bred first at age three (Spendelow *et al.* 2002). Age-specific breeding probabilities of Roseate Tern estimated from capture-recapture modeling using data from three U.S. colonies indicate that 1.0-4.5% of birds breed by age two, 45%-67% by age three, 62%-100% by age four, and 100% by age five or six (Lebreton *et al.* 2003). Some pairs may forego breeding in poor food years but the proportion of non-breeders is not known (Gochfeld *et al.* 1998). Generation time (average age of breeding adults in the population) is estimated at 7.8 years (median = 7 years; Spendelow unpublished data). This is two to three years less than the known generation time for Common Tern (median = 9-10 years; Nisbet 2002) and four to five years shorter than for Least Tern (*Sterna antillarum*, breeding lifetime estimated at 9.63 years after reaching maturity; Massey *et al.* 1992). Longevity estimates for Roseate Tern are hindered by band loss, but the oldest known bird (banded as a chick in Massachusetts) was 25.6 years (Gochfeld *et al.* 1998).

Clutch size ranges from one to four eggs with a mode of two, which is somewhat smaller than the typical clutch size for Common Tern (2-3 eggs; Nisbet 2002). The proportion of one versus two egg clutches varies depending on phenology, parental quality, food supply and other environmental factors (summarized in Gochfeld *et al.*

1998). In Canada on Country Island, mean annual clutch size ranged from 1.0 to 1.66 between 1997 and 2007 (Toms *et al.* 2008). Supernormal clutches (i.e., ≥3 eggs) are primarily associated with multi-female associations (mostly pairs) that appear to be the result of a skewed sex ratio (1.27 females per 1 male at Bird Island, MA; Nisbet and Hatch 1999). Eggs are laid two to four days apart (Nisbet 1981). Both weather and food constrain the first and peak dates of egg-laying (Gochfeld *et al.* 1998). Eggs hatch after about 23 days but this incubation period can be prolonged by up to 13 days at colonies where adults desert at night to avoid nocturnal predation (owls, night-herons; Nisbet 1981). There is no evidence that adults attempt to produce second broods (Gochfeld *et al.* 1998). Hatching success is generally high in the absence of predation (i.e., greater than 80% at Bird Island, MA) but is lower in nests without males that are attended by female pairs or trios (Nisbet and Hatch 1999). There may be a slight female-biased sex ratio at hatching (Szczys *et al.* 2001; Szczys *et al.* 2005b). On Country Island, mean annual hatching success has varied from 0.0 to 1.0 between 1997 and 2006 (Toms *et al.* 2007). It is noteworthy that predator control began in 1998 at Country Island, and hatching success has been greater than 0.57 eggs hatched/eggs laid in all years since then, except in 2001 when only one Roseate Tern nest was found and the eggs did not hatch (Toms *et al.* 2007).

Annual reproductive success for the U.S., Culebra and Puerto Rico is summarized in Appendix 2 of Gochfeld *et al.* (1998). Reproductive success can vary from 0.0 to 1.6 fledglings/nest, depending on food supply, egg size, parental performance, year, colony, and predation rates (reviewed in Gochfeld *et al.* 1998). In the northeast, reproductive success is generally more than 1.1 fledglings/pair, with productivity lower than 1.0 fledgling/pair seen only at small colonies or colonies experiencing predation (Gochfeld *et al.* 1998). Information on reproductive success at Canadian colonies is limited to rough estimates from Country Island. Reproductive success is generally low at this site, ranging from 0.0 to 0.3 fledglings/nest between 1999 and 2007 when estimated at chick age 20 days, and ranging from 0.0 to 0.72 fledglings/nest when estimated at chick age 15 days (Toms *et al.* 2008). Challenges associated with estimating reproductive success of Roseate Terns (nests inaccessible, chicks hide in dense vegetation or under rocks often far from the nests; Gochfeld *et al.* 1998) suggest Canadian estimates should be considered minimums, yet they are clearly well below the 1.1 fledglings/nest seen on average at relatively large U.S. colonies.

Research in the U.S. has shown that, in the absence of predation, 97% of first-hatched (A) chicks survive to fledging, and survival of second-hatched (B) chicks is lower, more variable between years, and strongly dependent on hatching date, with earlier-hatched B chicks more likely to survive (Nisbet *et al.* 1995, 1998; Burger *et al.* 1996). Survival of B chicks can be predicted based on growth during the first four days of life (Nisbet *et al.* 1998), which in itself is predicted by egg size and hatching date, both factors attributable to parental quality (Nisbet *et al.* 1998).

In most years, about 32% of fledglings from the northeastern population are estimated to survive to breed at age three (Lebreton *et al.* 2003, with estimate obtained by multiplying average 2-year survival of fledgings, 0.3762, with average adult survival, 0.8501, Spendelow pers. comm. 2008). Survival to first breeding varies with the year of fledging and can be impacted by single large events such as Hurricane Bob, which hit the coast of Cape Cod in August 1991 and led to reduced survival to breeding age of birds fledged in 1991 (only 6% survival; Lebreton *et al.* 2003; Spendelow pers. comm. 2008). Annual adult survival probability is estimated at 0.84 (range 0.81-0.85; Spendelow *et al.* 2008), which reflects a higher annual mortality than other marine birds (i.e., Common Tern annual adult survival estimated at 0.88-0.91; Nisbet and Cam 2002; California Least Tern annual adult survival estimated at 0.78-0.93 with an average of 0.89; Akçakaya *et al.* 2003).

Predation

See below, under **Limiting Factors and Threats**.

Physiology

The only relevant information available on Roseate Tern physiology relates to temperature regulation of adults and chicks. By age three days, chicks are able to maintain a nearly stable body temperature independent of ambient temperature but still slightly lower than the 40.9–43.6°C temperature of adults (LeCroy and Collins 1972). Both chicks and adults rest in the shade during hot periods. Adults and chicks (1–2 d old) gular-flutter when air temperatures are high (Gochfeld *et al.* 1998). Newly hatched second chicks may succumb to chilling when adults are away catching food for the larger first-hatched chick (LeCroy and Collins 1972).

Food

Sand Lance are commonly taken on Sable Island (Whittam 1999). On The Brothers, Roseate Terns have been observed feeding on Atlantic Silversides (*Menidia menidia*), Butterfish (*Peprilus triacanthus*) and Atlantic Herring (*Clupea harengus;* D'Eon 1994, 1996, 2007). Roseate Terns on Country Island were found to prey primarily on Sand Lance (82% of deliveries in 2003) and hake (*Urophycis* spp.; 72% of deliveries in 2004) along with smaller numbers of herring and Atlantic Cod (*Gadus morhua;* Rock *et al.* 2007). The strong reliance on Sand Lance is consistent with other studies of foraging in the United States (Richards and Schew 1989; Safina *et al.* 1990; Heinemann 1992; Nisbet and Spendelow 1999).

Dispersal/migration

Results of capture-recapture modelling from three major U.S. colony sites indicate that 88-98% of surviving adults return to the same site to breed each year (Lebreton *et al.* 2003). In addition, 58-91% of birds hatched at one of these three sites are likely to return to that site to breed in future (Lebreton *et al.* 2003). The rate of dispersal away from a colony that was suffering from high predation was greater than the rate of dispersal away from sites where predation was not an issue (Lebreton *et al.* 2003).

In Canada, birds are known to disperse between major breeding colonies (Country Island to The Brothers; Table 2) from one breeding season to the next. In addition, movement has been noted between U.S. colonies and The Brothers (Table 2). However, the amount of movement noted between birds nesting in the warmwater areas south and west of southern Cape Cod (i.e., the bulk of the northeastern Roseate Tern population), and those nesting in the coldwater-influenced areas north and east of Cape Cod in the Gulf of Maine and Canada, is low compared with movement within the warm and cold water groups (Spendelow *et al.* in review). Relatively little standardized effort has been made to resight banded birds at either The Brothers or Country Island, and it is likely that more movement than that depicted in Table 2 occurs.

Table 2. Roseate Terns of foreign origin resighted at North Brother Island, 2002-2007[1].

Date of resighting	Band number	Origin of banded bird	Date banded
7-7-07	34C1 [1182-65634 L-U]	Eastern Egg Rock, ME	7-13-02
7-18-07	5V77 [9822-80577 L-U]	Stratton Island ME	6-17-99
7-24-07	1V51 [0802-69901 L-U]	South Brother	7-03-02
7-4-02	IL44 [0802-98688]	Petit Manan ME as a chick	6-30-99
7-16-06			
7-24-07			
7-24-07	070E [1172-77674]	Country Island as a chick	7-03-05
7-4-02	2K70 [892-94270]	Bird Island, MA as a chick	6-24-96
7-4-02	V507	Petit Manan, ME as a chick	6-23-95

1. D'Eon 2002, 2007

Table 3. Estimated number of Roseate Tern pairs and colony sites recorded between 1982 and 2007 in Nova Scotia, New Brunswick and Quebec. Because the majority of Roseate Terns are found in Nova Scotia, this table reports only numbers for years in which full surveys of the Nova Scotia coastline were done. Colony details are found in Appendix 1.

	1982-85	1995	1999	2003	2007
Nova Scotia[1]					
Pairs	91-106	96	119-143	130	98
Colonies	10	5	12	3	5
New Brunswick[2]					
Pairs	1	2	Present, non-breeding	Present, non-breeding	0
Colonies	1	1	0	0	0
Quebec[3]					
Pairs	2	2	2	1	2
Colonies	1	2	2	1	2
TOTAL					
Pairs	94-109	100	121-145	131	100
Colonies	12	8	14	4	7

1. Kirkham and Nettleship 1985; Leonard *et al.* 2004; Boyne unpublished data
2. Kirkham and Nettleship 1985; Whittam 1999; Bernard *et al.* 1999; Charette *et al.* 2004; Kennedy pers. comm. 2008
3. Shaffer unpublished data

After fledging in early August, juvenile Roseate Terns from the northeastern population disperse with their parents to staging areas located from Long Island to Nantucket and Cape Cod (Trull *et al.* 1999), and in the Gulf of Maine (e.g., Stratton Island; Shealer and Kress 1994). Little is known about staging areas used by Canadian birds, but in 2002 two Roseate Terns banded as chicks on The Brothers were sighted at Great Gull Island, New York within a month of fledging (Environment Canada 2006). At Stratton Island from 1989-1992, banded Roseate Terns were identified from at least eight breeding colonies in Maine, Massachusetts and Connecticut (Shealer and Kress 1994). It was estimated that at least 4.9% of all adult Roseate Terns in the U.S. visited Stratton Island in 1991 and at least 10.4% visited the island in 1992 (Shealer and Kress 1994). At nine of 20 known staging sites in Cape Cod, numbers of Roseate Terns ranged from 100-1500 (Trull *et al.* 1999). Only two of the Cape Cod sites hosted night-roosting Roseate Terns, one with between 3000 and 4000 individuals (half of the northeast population at a single site; Trull *et al.* 1999). The largest numbers of Roseate Terns were reported at Cape Cod sites between 26 August-19 September (Trull *et al.* 1999). At least one of these Cape Cod staging areas includes birds marked from all major breeding sites in the northeast and with the proportion of juveniles equal to the numbers of chicks banded at these breeding sites (Trull *et al.* 1999).

Roseate Terns migrate south in late August and early September. They arrive in South America by October, where they have been recovered along the north coast from western Colombia to eastern Brazil, between 11° and 18° S (Hays *et al.* 1997). A large concentration of about 10,000 terns, including up to 3000 Roseate Terns, was discovered in 1997 at Mangue Secco, Bahia, Brazil (Hays *et al.* 1999). This concentration contained banded Roseate Terns from the Caribbean population as well as from every major breeding colony in the northeastern U.S. (Hays *et al.* 1999).

Interspecific interactions

In northeastern North America and Europe, Roseate Terns always associate with large colonies of Common and/or Arctic terns (Gochfeld *et al.* 1998). In Nova Scotia between 1995 and 2007, based on aerial estimates, tern colonies with Roseate Terns averaged 532 individuals (mixture of Arctic, Common and Roseate terns); tern colonies without Roseate Terns averaged only 58 individuals (Toms unpublished data), illustrating the dependence that Roseate Terns exhibit for large breeding colonies of other tern species.

Interbreeding between Roseate and Common terns (Robbins 1974; Hays 1975; Zingo *et al.* 1994) and Roseate and Arctic terns (Whittam 1998) does occur. Nisbet estimates one of every 800 Roseate Terns on Bird Island, MA to be a hybrid Roseate-Common tern, and also notes that hybridization appears most common at small peripheral colonies, perhaps due to lack of conspecific mates (Nisbet pers. comm. 1997). On the Magdalen Islands, copulation between Roseate and Common terns has been observed during three different breeding seasons (Shaffer pers. comm. 2008).

Adaptability

Roseate Terns, like other tern species, are sensitive to human and other disturbance and may desert colony sites especially if disturbed early in the breeding cycle (Nisbet and Drury 1972). Roseate Terns usually move to other sites within one to two years of the disturbance event, whereas Common Terns are slower to move (Nisbet and Spendelow 1999). Roseate Terns choose nest sites with greater cover (vegetation or human-made nest structures) than Common Terns (Gochfeld and Burger 1987) and they are known to benefit from the aggressive behaviour of Common and Arctic terns against diurnal predators (Nisbet and Spendelow 1999). Dispersal to new or historic breeding sites is likely an adaptation to disturbance and may partly explain why small Roseate Tern colonies in Nova Scotia are so ephemeral.

Roseate Terns exhibit a relatively narrow range of years for recruiting to the breeding population compared to other seabirds (age 3-5 years), an adaptation which is expected in a species with relatively low adult survival probabilities (Spendelow *et al.* 2002).

POPULATION SIZES AND TRENDS

Search effort

Nova Scotia

The Nova Scotia Department of Natural Resources (NSDNR) conducted aerial surveys of approximately 60% of the Nova Scotia coastline in 1995, 1999, 2003 and 2007. The same observer conducted the surveys and the same route was flown each year. Coastal aerial surveys are limited in that they do not easily differentiate between species of terns. Hence, the NSDNR (1995) or the Canadian Wildlife Service (1999, 2003, 2007) conducted follow-up ground surveys in June or July at all tern colonies estimated aerially to have more than 100 terns present as well as at a subset of smaller colonies (Leonard *et al.* 2004; Boyne pers. comm. 2008). The ground surveys consist of a systematic survey of nests (each nest is marked to avoid double counting), ensuring that the entire area of the colony is surveyed. After 1999, in years that fell between these “full” surveys, the colonies considered critical Roseate Tern habitat (Country Island, The Brothers) were surveyed as part of ongoing studies at those sites. Between 1982 and 1985, a compilation of surveys was done of the coastline (Kirkham and Nettleship 1985) and these results are compared to the more recent surveys for the purposes of this report. Additional observations, usually made by local naturalists and/or members of the Nova Scotia Bird Society, are also included in Appendix 1 when available.

New Brunswick

Machias Seal Island has been surveyed annually since 1995 as part of the Atlantic Cooperative Wildlife Ecology Research Network's ongoing studies of seabirds breeding there (Bond *et al.* 2007). The intensive work at this site makes it possible in most years to state whether Roseate Terns were breeding or present but not breeding (see Appendix 1). Prior to 1995, terns on Machias Seal Island were surveyed by various researchers (summarized by Bond *et al.* 2007).

Quebec

Since 1990, tern surveys on the Magdalen Islands have been conducted using the following protocol: in 1990, 1993, 1994, 1995, 1999, 2000, and 2007 all tern colonies were visited on the ground and nest counts were done. The surveys were conducted during the last 10 days of June, just before the hatching period, at historic colonies as well as new colonies. No special effort was made to find Roseate Tern nests in order to avoid undue disturbance to the colonies. However, Roseate Terns were counted if present at any colony. The largest known tern colonies were visited at least once a year since 1990 to check for Roseate Terns and efforts were made at these sites to find evidence of breeding (Shaffer pers. comm. 2008).

Abundance

In 2007, 100 pairs of Roseate Terns were estimated breeding at seven colonies in Canada, with 98 of these pairs found at five colonies in Nova Scotia (Table 3, p.17).

Fluctuations and trends

The number of Roseate Terns breeding in Canada has remained relatively stable over the last three generations (~24 years) at around 100 pairs. In 1999, more birds were detected (between 119-145) due to the presence of birds at several previously unused sites (Table 3, p. 17, Appendix 1). Historically, the number of Roseate Terns in Canada has probably always been relatively low, although there is some speculation that numbers were greater in the first half of the last century than they are now, at least in Nova Scotia (Leonard *et al.* 2005). In 1970-71, up to 200 pairs were suspected to breed at six sites in Nova Scotia (Lock 1971).

The number of colonies used by Roseate Terns has fluctuated annually, with a high of 14 colonies occupied in 1999 and a low of 4 colonies occupied in 2003 (Table 3, p. 17). New sites continue to be found in any given year; for example Salmon Island had 16 Roseate Terns in 1999 (but none since then) and Duck Island had a single pair of Roseate Terns in 2007 (Appendix 1).

Numbers at the two major colony sites (The Brothers and Country Island) continue to be relatively high. At The Brothers, Roseate Terns increased from just 20 pairs in 1991 to a high of 90 pairs in 2002, but then declined and have remained steady at 67-68 pairs since 2005 (D'Eon 2007, Appendix 1). At Country Island, Roseate Terns reached a high of 53 pairs in 2000, dropped to just 1 pair in 2001, remained steady at around 40 pairs from 2002-2005, but then dropped to 29, 25 and 20 pairs in 2006-2008, respectively (Toms *et al.* 2008, Appendix 1).

In 2007, Sable Island had the highest number of Roseate Terns (4 pairs suspected, 2 nests confirmed) since 1993 (also 4 pairs; Appendix 1). Two nests with chicks were found (Dillon pers. comm. 2008). Historically, Sable Island was believed to have had many more Roseate Terns, with 250 individuals estimated in 1971, albeit based on extrapolations made from birds trapped after the breeding season (McLaren 1981).

Roseate Terns were known to breed in small numbers (1-3 pairs) on Machias Seal Island in 1994, 1995, 1996 (Whittam 1999), 2001 (Devlin and Diamond 2001) and 2002 (Devlin *et al.* 2003). In 2003, an attempt was made to attract larger numbers of Roseate Terns to nest at this colony using a sound system and Roseate Tern decoys. Small numbers were observed for 19 days between 10 May and 17 August but they did not nest (Charette *et al.* 2004). In 2006, the terns abandoned Machias Seal Island midway through the breeding season (Bond *et al.* 2007). In 2007, some terns were seen flying over the colony site in May and June (up to 100), half a dozen nests were initiated but not incubated, and Roseate Terns were not seen (Kennedy pers. comm. 2008). Terns abandoned the colony in early June 2008 (Diamond pers. comm. 2008). The reasons for the abandonment of Machias Seal Island in the last three years may include a decline in food quality, bad weather during chick hatching, increased gull predation, disturbance due to construction activities (solar panels, wind turbine; Diamond pers. comm. 2008) or increased fishing next to the island with an associated increase in gulls feeding on offal (MacKinnon pers. comm. 2008). The loss of Machias Seal Island as a tern breeding colony for three years straight is unprecedented and does not appear to be part of a regular cycle; terns were known to completely abandon Machias Seal Island only once previously, in 1944, but since that time have occupied this site every year until 2006 (MacKinnon and Smith 1985).

Rescue effect

An estimated 3803 pairs of Roseate Terns nested in the northeastern U.S. in 2007, down from a peak of 4310 pairs in 2000 but higher than the low of 2743 in 1992, the year following Hurricane Bob (Figure 6). Numbers of Roseate Terns in the U.S. appeared to be on the rise between 1992 and 1999 but then declined between 2000 and 2007 (Figure 6). The entire northeastern population declined by about 20% between 2007 and 2008 (Nisbet pers. comm. 2008; U.S. Roseate Tern Recovery Team unpubl data). The Canadian population of 100 pairs makes up only about 2.6% of the northeastern North American population.

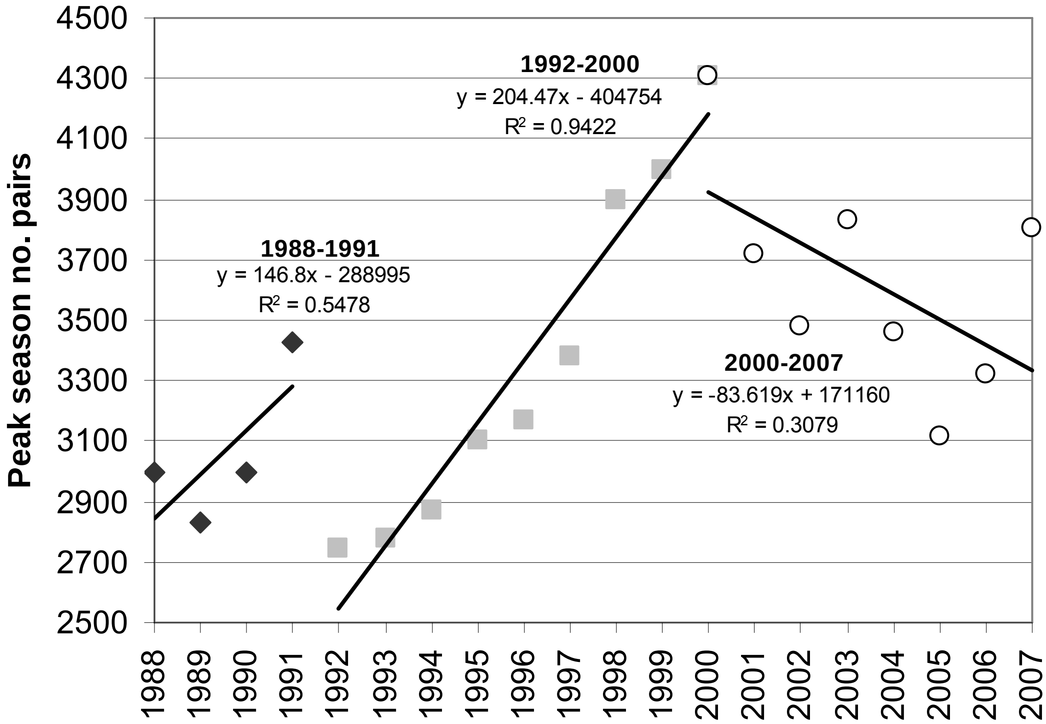

Figure 6. Roseate Tern abundance (peak season count of pairs) in the northeastern United States from 1988-2007 (Source: U.S. Roseate Tern Recovery Team unpubl. data). Abundance has fluctuated over the years.

A small number of birds banded in U.S. colonies have been resighted at The Brothers (Table 2), suggesting that dispersal from the U.S. to Canada does occur and could lead to the recolonization of a Canadian site in the event of local extirpation. It should, however, be noted that there is relatively little interchange of breeding adults between birds in the warm-water colony sites (containing more than 90% of the North American population) and the coldwater colony sites (including Canadian sites). For example, only five of 1520 individuals colour banded in Buzzard's Bay, MA between 2004 and 2006 were resighted as breeding adults at coldwater-influenced colony sites from 2005-2007 (Spendelow *et al.* 2008). Moreover, the potential for rescue in Canada is constrained by the fact that the northeastern U.S. population is itself small and Endangered.

LIMITING FACTORS AND THREATS

Predation and displacement by gulls

The major avian predators at Canadian tern colonies are Herring and Great Black-backed gulls. Gulls prey on tern eggs, chicks, and adults (Hatch 1970; Nisbet 1981; Whittam and Leonard 1999; Toms *et al.* 2008). Roseate Terns will abandon a colony after a season of heavy predation (Nisbet 1981; U.S. Fish and Wildlife Service 1998;

Whittam and Leonard 1999). Gulls are currently controlled using non-lethal methods at both major Canadian colonies (Country Island and The Brothers), and predation rates have decreased as a result (D'Eon 2007; Toms *et al.* 2008). As long as gull control continues at these sites, this threat should be relatively low, although gulls continue to take small numbers of tern chicks annually at Country Island (nine, 12 and six chicks were observed taken over the last three years; Toms *et al.* 2008).

In 2007, at least 200 tern nests (mixture of species) were counted on Pearl Island in Mahone Bay and six Roseate Terns were reported flying overhead on a boat survey. The colony abandoned the site in July (Rodenhizer pers. comm. 2008). About 400 pairs of gulls breed on Pearl Island (Boyne and Beukens 2004) and prey on terns (Kress and Duley 1992) and are the likely reason why terns have not been successful at this site in recent years.

In general, the numbers of large *Larus* gulls in eastern Canada are somewhat lower now than they were in the 1970s (Table 1); however, gulls are not continuing to decline and it is likely that they are still displacing terns from potential colony sites and preying on terns at unmanaged, chronically unsuccessful colonies such as those in Mahone Bay, NS. In the U.S., between Long Island, NY and Cape Cod, MA, the major effect of gulls is that they displace Roseate Terns from secure offshore islands to inshore sites where they are subject to other types of mainland-based predators such as Great Horned Owls (*Bubo virginianus)* and foxes (Nisbet and Spendelow 1999).

Predation by other species

Red Foxes (*Vulpes vulpes*) are major predators of tern eggs on the Magdalen Islands (Shaffer and Laporte 1996), and Northern Ravens (*Corvus corax*) and American Crows (*Corvus brachyrhynchos*) have been known to take tern eggs (including Roseate eggs) at several Nova Scotian colonies (Whittam 1997; D'Eon 1997). Great Horned Owls are major predators of Roseate Tern adults, chicks, and fledglings in the U.S. (reviewed in Nisbet and Spendelow 1999). Hunting owls cause adult terns to abandon their nests at night, leading to exposure of embryos and chicks, and greater predation by nocturnal species such as Black-crowned Night-Herons (*Nycticorax nycticorax*) and ants (Nisbet and Spendelow 1999). Nothing is known about potential Black-crowned Night-Heron predation on Roseate Terns in Canada. There are few Black-crowned Night-Heron colonies in Atlantic Canada, none of which are located near Roseate Tern colonies (Chardine unpublished data), although night-herons have been seen near The Brothers (D'Eon 2004). Ants are a known cause of mortality for hatching or recently hatched Common Tern chicks on the Magdalen Islands and may also impact Roseate Terns (Shaffer pers. comm.).

Great Horned Owl predation on adult Common Terns has been reported in Pubnico Harbour, Nova Scotia (D'Eon 1997, 2005, 2007, 2008). In 2008, a Great Horned Owl was trapped on The Brothers but only after it had killed at least 11 adult Roseate Terns, eight adult Common Terns and one adult Arctic Tern (D'Eon 2008). On the Magdalen Islands, Snowy Owls (*Nyctea scandiaca*) have been present in the summer months during seven of the last 20 years; they are known to roost near tern colonies and their pellets have been found to contain remains of Common Terns (Shaffer pers. comm.). A Merlin (*Falco columbarius*) preyed upon terns at The Brothers in 2006 and 2007 but Roseate Terns did not appear to be affected (D'Eon 2007). A Northern Harrier (*Circus cyaneus*) was observed preying on a tern chick on Country Island in 2007 (Toms *et al.* 2008), and Merlins and Bald Eagles (*Haliaeetus leucocephalus*) were also noted in predator watches there over the last two years (Toms *et al.* 2008). Coyotes (*Canis latrans*) recently moved onto the Magdalen Islands and likely now prey on terns (Shaffer pers. comm.).

American Mink (*Neovison vison*) have been noted as serious predators at tern colonies in the northeast over the last decade. Predation by mink appears to be increasing, although there are no data available to assess the degree or cause of this increase. Mink predation at tern colonies not only causes direct mortality but can also lead to nocturnal abandonment by adult terns and subsequent chick death (Burness and Morris 1993).

Mink have been found preying on tern adults and chicks at The Brothers, Country Island, and Westhaver and Quaker Islands in Mahone Bay (BCAF 2003, 2006). At least eight adult Roseate Terns and many more chicks were found dead on The Brothers in July 2003 due to mink (D'Eon 2003), and again in 2004 about 10-12 adult Roseate Terns and many more Common and Arctic terns were killed (D'Eon 2004). No Roseate Tern chicks were believed to fledge from The Brothers in these two years. Late in the breeding season in 2004 a mink was captured on The Brothers. Since then, no additional mink predation has been noted there (D'Eon 2005-2007). On Country Island, mink predation was noted for the first time in 2007. A large number of Leach's Storm Petrels (*Oceanodroma leucorhoa*) and Common Eider eggs were eaten. Dead adult terns including six Roseate Terns, 26 Common Terns and 71 Arctic Terns (in total, 9.4% of the colony) were found from May 28 until June 14. The mink was eventually trapped on July 17. Despite heavy adult mortality, the colony did not abandon and the terns had a productive breeding season (Toms *et al.* 2008).

The Mahone Bay Tern Restoration Project also trapped mink at Quaker Island in 2005 and 2006 (BCAF 2006). Mink have also been documented recently at U.S. colonies, especially in the Gulf of Maine. For example, in 2005 a mink swam up to 5 km to Outer Green Island where it decimated a colony including up to 42 pairs of Roseate Terns before it was trapped (Hall pers. comm. 2008).

Occasionally young terns are caught in mink traps (D'Eon 2004), so the trapping process itself is a potential threat (although the benefits of catching a mink which is preying on hundreds of terns far outweighs the risk of bycatch). It is important that researchers and stewards at major colony sites continue to watch for mink predation, and respond with quick and efficient trapping. More also needs to be done to determine why mink predation appears to be on the rise at tern colonies.

Productivity at Country Island, the only site where (albeit rough) productivity estimates are available, is nowhere near the 1.1 fledglings/nest seen in the U.S., suggesting that even at this managed site productivity is still limited by predation. Spendelow *et al.* (2002) have documented that site fidelity (in the form of proportion of unmarked, first-time breeders that become residents) is lowest in years when severe nocturnal disturbance, predation and low productivity (due in the specific case of Falkner Island to Black-crowned Night-Herons) are experienced. Indeed, in the last five years, almost 10% of the adult population of Roseate Terns has been killed by mink at two major colony sites (Country Island and The Brothers), and the population has declined from 130 to 100 pairs over this same period (Table 3). It is likely that continued predation by various avian and mammalian predators at Country Island and The Brothers is negatively impacting site fidelity and recruitment in Canada.

Erosion of The Brothers

As noted above under habitat trends, North Brother Island is eroding and tern breeding habitat is being lost (D'Eon 2008). The potential exists for the island and/or its associated tern habitat to be lost rapidly should one or several severe winter storms hit. The level of concern is great enough that the Canadian Wildlife Service has begun to examine potential alternative sites for this tern colony should restoration become necessary (Toms 2007).

Erosion is recognized in the U.S. Roseate Tern Recovery Plan as a threat to the long-term viability of nesting colonies, and has been implicated in the abandonment of 20% of colonies known to have been abandoned between 1920 and 1979 (USFWS 1998). Many islands currently used by Roseate Terns from Maine to Long Island, NY include low areas exposed to some erosion and tidal overwash which reduces the amount of nesting area available and sometimes results in major losses of eggs and young to flooding (USFWS 1998). The U.S. Roseate Tern Recovery Plan (USFWS 1998) recommends that dredged material from approved projects be used to enhance breeding islands currently facing issues of erosion, with any such work limited to the non-nesting portion of the year. In addition, riprap material along the periphery of these islands could help protect them from continued erosion, although permits issued for such projects should include specific conditions regarding fill material, grading, vegetation plantings, and a firm completion date (USFWS 1998). At Great Gull Island, NY, most Roseate Terns nest in rock crevices created when the Island was riprapped for storm damage protection. These nesting sites offer the benefit of protection from most predators (USFWS 1998). At Falkner Island, CT, concerns over erosion leading to instability of the historic lighthouse led to construction of a rock revetment wrapping around a large proportion of the island (Spendelow and Kuter 2001). The construction of the main revetment at Falkner Island has had a negative impact on Roseate Tern productivity due to loss of chicks in the revetment labyrinth (Rogers and Spendelow 2005). The question of whether erosion should be controlled through such measures is clearly a difficult one and impacts on birds cannot always be predicted.

In 2008, consideration is being given to the creation of additional Roseate Tern habitat in an area of North Brother Island that has never been used by Roseate Terns by placing tarps covered with gravel and nest shelters prior to the terns' arrival. Similar habitat manipulations were conducted about 10 years ago with great success; the manipulated area has been used by Roseate Terns for breeding in every year since (D'Eon pers. comm. 2008).

Human disturbance

Recreational use of coastal areas in Nova Scotia is increasing and may be responsible for the loss of Roseate Terns breeding in Mahone Bay over the last 30 years. In the past, Roseate Terns were known to breed on Grassy Island and have also been found (albeit in small numbers and with no knowledge of productivity) on Westhaver, Pearl, Mash and Wedge islands (Appendix 1). Since 2003, the Bluenose Coastal Action Foundation (BCAF) has been attempting to create a third managed colony for Roseate Terns on Quaker Island in Mahone Bay as recommended in the Roseate Tern Recovery Strategy (Environment Canada 2006), but without success. Two pairs of Roseate Terns were observed circling and landing on Quaker Island in 2004 and 2005 but they did not nest. The project has used methodologies developed and used successfully elsewhere (Kress and Hall 2004) but efforts have been hampered by poor weather, predators (owls, mink and falcons; BCAF 2003, 2006) and human disturbance. The situation on Quaker Island appears to be representative of how terns are doing throughout Mahone Bay; terns have apparently not nested successfully anywhere in the Bay since BCAF began monitoring terns in 2004. Colonies have been established at various sites but have always been abandoned prior to fledging (BCAF 2004, 2005, 2006). Anecdotal information suggests that human disturbance is the most likely cause for many of these abandonments. People have been observed picnicking, walking dogs and even mowing grass within active colonies in Mahone Bay (BCAF 2006).

Human disturbance at other Nova Scotian Roseate Tern breeding sites is minimal. Country Island is located 5 km offshore, is difficult to land on, and is thus rarely visited by people. The Brothers is easier to access but is carefully watched by a local steward. A potential new source of disturbance has been noted in Pubnico Harbour: the landing and take-off of a float plane several times per week about 1 km from The Brothers. Thus far, no adverse effects on the terns have been documented, but there is no information on the reaction of the birds (D'Eon pers. comm. 2008).

On the Magdalen Islands, human disturbance may be a limiting factor at some sites (Shaffer pers. comm. 2008). At Paquet Island, a cottage on the island, as well as a nearby wharf and marina, attract people to the area, and some people land on the island for swimming and strawberry picking (Shaffer pers. comm. 2008). Chenal Island is close to a large lobster fishing wharf, though activities at the wharf do not appear to disturb the tern colony. Clam diggers may cause some disturbance, but more importantly this island is next to a large shipping lane which occasionally requires dredging. This lane is partially within the 200 m buffer zone established around the island as critical habitat, but thus far there has been no observed impact to the Roseate Tern colony (Shaffer pers. comm. 2008). Deuxieme Ilet and other colonies occasionally used by Roseate Terns on the Magdalen Islands are all easily accessible by foot as they are surrounded by less than 1 m of water. Kite surfing is a popular activity at many lagoons and is sometimes practised near tern colonies; kite surfers who rest on tern colony islands may disturb the terns (Shaffer pers. comm. 2008).

Industrial development

Industrial activities in the coastal zone are intensifying in the Maritimes, and the cumulative effects on Roseate Terns may be difficult to foresee (Environment Canada 2006; Rock *et al.* 2007). An example is the increase in aquaculture sites in coastal Nova Scotia. In Country Harbour, six aquaculture operations (Blue Mussel *Mytilus edulis*, and Sea Scallops *Placopecten magellanicus*) are currently mapped, and in Pubnico Harbour near The Brothers four operations (including Blue Mussel, Rainbow Trout *Oncorhynchus mykiss*, Sea Scallops, Eastern or American Oyster *Crassostrea virginica*, European Oyster *Ostrea edulis*, Bay Quahog *Mercenaria mercenaria*, Bay Scallop *Argopecten irradians*, Atlantic Cod and Atlantic Halibut *Hippoglossus hippoglossus*) are mapped (http://www.gov.ns.ca/fish/aquaculture/aquamap.shtml) though not all are active.

Increasing aquaculture operations may pose a threat if they reduce fish populations or disrupt habitat where terns forage (Environment Canada 2006). In New Brunswick, seabirds (including Common Terns) use oyster aquaculture cages for perches, which leads to fecal contamination of the product (Comeau *et al.* 2006). Bird scaring at aquaculture sites is not currently conducted but if it is implemented it may pose a threat to seabirds breeding nearby. Currently, the aquaculture industry is considering low-cost gear modifications that could effectively deter birds from using the gear without having to resort to bird-scaring devices (Comeau *et al.* 2006).

The Sable Offshore Energy Project (SOEP) laid a natural gas pipeline 5 km from Country Island in 1999, though no ill effects on terns were detected (CEF Consultants Ltd. 2000). Several new development projects for the Country Harbour area are planned in 2008-2010:

- A pipeline will be laid from the Deep Panuke gas field within 5 km of Country Island, with landfall in Country Harbour (next to the SOEP landfall) at a site known to be used by foraging terns (Rock 2005).
- Construction of a large wharf and liquefied natural gas (LNG) receiving terminal at the mouth of Isaac's Harbour, next to the landfall site of the pipelines.
- Construction of a large petrochemical plant in Goldboro, NS that will consist of ethylene, polyethylene, propylene and polypropylene plants as well as a supporting cogeneration plant. Large ships will bring LNG to the plant's receiving terminal.

Roseate, Arctic and Common terns could be impacted by these projects through disruption of foraging (i.e., disturbance to foraging habitat and prey species, displacement from foraging areas) and stochastic events such as spills from rigs/vessels, especially in light of the additional shipping traffic that will result from the LNG receiving terminal at Goldboro. Another LNG receiving terminal near Port Hawkesbury, NS is proposed, which would further increase large shipping traffic in northeastern Nova Scotia, thus increasing the cumulative-effects risk to Roseate Terns and other seabirds in the region. The April 2003 oil spill in Buzzard's Bay, MA, where terns (including hundreds of Roseate Terns) had to be hazed to prevent them from landing on Ram Island until the oil was cleaned up, and at least three adult Roseate Terns were found dead (Buzzard's Bay National Estuary Program 2008), provides strong incentive to minimize risks of shipping accidents in the vicinity of Roseate Tern breeding colonies.

The company constructing the gas pipeline has indicated that it will not conduct construction activities in the vicinity of Country Island from May 1 to June 20, or fly over, disembark on, or approach within 2 km of the island unless an emergency requires it (Kopperson 2006). In addition, the petrochemical and LNG companies will avoid Roseate Tern critical breeding habitat during their activities, and will develop a spill response plan that identifies specific protocols for avoiding and managing exposure of migratory birds (especially Roseate Tern) to spilled substances. However, because critical foraging habitat for Roseate Terns has yet to be identified, it is not known how these development projects might impact the birds. All three companies have contracted biologists to study tern foraging in the Country Harbour area in 2008-2009 to determine if these projects have any impact on terns. The project is also being designed to meet the needs of the Recovery Team to identify critical foraging habitat for Roseate Terns in the Country Harbour area.

Wind turbines have been placed near Roseate Tern colonies on three occasions in the last five years. These include the Pubnico Point wind farm, the Sable Island turbine, and a turbine on Machias Seal Island (Gautreau pers. comm. 2008). The 17-turbine wind farm at Pubnico Point opened in 2005 and a bird monitoring program has thus far shown no ill effects on terns (Gautreau pers. comm. 2008). No information is available for the other two sites, although the Sable Island turbine was placed immediately adjacent to a large tern colony and could thus potentially affect Roseate Terns.

Weather

Major storms, such as Hurricane “Bob” which passed through the principal staging area for Roseate Terns in August 1991, can hinder population recovery (Nisbet and Spendelow 1999). “Bob” appeared to be responsible for the crash in the U.S. Roseate Tern population between 1991 and 1992 (Spendelow *et al.* 2002; Lebreton *et al.* 2003; and see Figure 6). Adult survival probability decreased from 0.83 to 0.62 on Falkner Island between 1990 and 1991. Furthermore, it was estimated that only 4% of fledglings from Falkner Island in 1991 (equal to one-quarter of the expected number) survived to breeding (Spendelow *et al.* 2002). Interestingly, both young and adult survival probabilities increased to above pre-hurricane levels on Falkner Island in the two years following Hurricane Bob (Spendelow *et al.* 2002).

In Canada, sites such as those used by terns in Mahone Bay, which are already subject to high levels of human disturbance, may be more likely to be abandoned after severe weather impacts. For example, in 2004 a small number of terns attempted to nest on Quaker Island as a result of the tern restoration activities conducted by BCAF; however, the terns abandoned the site when a severe thunderstorm flooded all nests in June (BCAF 2004).

Biologically limiting factors

Roseate Terns have a low annual adult survival rate for a seabird (average 0.835; Spendelow *et al.* 2008), lay one small clutch per year, and do not generally breed until their third year (Spendelow *et al.* 2002). Survival to breeding (age 3) is relatively low, averaging 32% (Lebreton *et al.* 2003). There is some evidence that there has been a reduction in postfledging survival and recruitment of young Roseate Terns in Buzzard’s Bay, MA since 1999 but a formal analysis has yet to be conducted (Spendelow *et al.* 2008). The median age of breeding adults is 7 years, and median age at first breeding is 3-4 years, suggesting that the median breeding lifetime (number of years of reproduction) of the Roseate Tern is only 3-4 years, which is short for a seabird (Nisbet pers. comm. 2008). First-hatched A chicks generally survive to fledging in the absence of predation, but survival of second-hatched B chicks is more variable and can, in some years, be limited by food supply (Nisbet and Spendelow 1999).

The specialized nature of Roseate Tern foraging habitat may partially explain why this species is both less abundant and less widely-distributed than Common Tern (Safina 1990; Nisbet and Spendelow 1999). Roseate Terns are known to travel long distances (up to 30 km) to their preferred foraging sites (Heinemann 1992). In the U.S., a single foraging site near Bird Island, MA has been used by 20-25% of the Roseate Tern population since 1970 (Heinemann 1992). Furthermore, because Roseate Terns in given colonies prey primarily on only one or two fish species, they are vulnerable to environmental perturbations affecting these fish (Safina *et al.* 1988, 1990; Rock *et al.* 2007). It is therefore extremely important to ensure that essential foraging habitat is identified and protected at major Canadian colony sites.

Skewed sex ratio

A shortage of males may limit the productivity of Roseate Terns at some colonies in northeastern North America (Nisbet and Hatch 1999). The sex-ratio of breeders on Bird Island, MA is 127 females:100 males. Twenty per cent of breeding females do not obtain male mates, and instead pair together to produce supernormal clutches of three to four eggs. Fertilization is achieved through extra-pair copulations. Female-female pairs produce 75% fewer fledglings per female than male-female pairs. As a result, average colony productivity at Bird Island is reduced by at least 20%, compared to the value expected if all females had male mates (Nisbet and Hatch 1999). This sex-ratio bias has been found to be present at hatching at Bird Island in a single season (Szczys *et al.* 2001), but not at Falkner Island across five breeding seasons (Szczys *et al.* 2005b). Research thus far has not been able to differentiate between the possibility of a slight female-biased sex ratio at hatching versus an equal sex ratio with sporadic deviations according to site and year (Szczys *et al.* 2005b). The female-biased sex ratio at breeding is believed to be at least partially caused by sex-specific differences in adult survival rate (Nichols *et al.* 2004), the cause(s) of which remain unknown.

Wintering mortality

The average adult survival rate of Roseate Terns (0.85) is low compared to other species of seabirds in the orders Procellariiformes, Pelecaniformes, and Charadriiformes (Table 3 in Spendelow and Nichols 1989). Because adult mortality is rarely observed at breeding colonies, Roseate Terns are probably dying during migration or at their wintering grounds (Spendelow and Nichols 1989; Spendelow *et al.* 1995). Roseate Terns were trapped intensively between 1968-1981 in Guyana for sale at local markets, but this practice has since reportedly stopped (Nisbet 1984). More information is required to determine the causes of winter mortality (Spendelow *et al.* 1995).

SPECIAL SIGNIFICANCE OF THE SPECIES

Canada represents the northern edge of the Roseate Tern's range in North America. While numbers are low and have probably always been relatively low, the species is still an important component of Canada's avian and marine biodiversity. Recently the Roseate Tern has become an icon for coastal conservation efforts; its image forms the logo of several conservation organizations including Bird Life International, the Association of Field Ornithologists, the Atlantic Canada Conservation Data Centre and the Bluenose Coastal Action Foundation (Environment Canada 2006).

EXISTING PROTECTION OR OTHER STATUS DESIGNATIONS

The Roseate Tern is currently designated as *Endangered* in Canada (COSEWIC 1999) and is protected under the *Species At Risk Act*. The Roseate Tern is a non-game species, and is therefore also protected in Canada under the *Migratory Birds Convention Act* (1994)*.* The Canadian General Status rank for Roseate Tern is At Risk (CESCC 2006). In the United States, the northeastern population of Roseate Tern is listed as *Endangered* and is protected under the U.S. *Endangered Species Act* (1973), and the Caribbean population is listed as *Threatened* (USFWS 1987). It is also *Endangered* as of 2000 under the Nova Scotia *Endangered Species Act* (*Endangered Species Act 1998, c. 11, s. 1.*). In Quebec, the Roseate Tern is presently considered “Likely to be designated as threatened or vulnerable” under the *Loi sur les espèces menaces ou vulnérables du Québec* (Quebec’s *Act Respecting Threatened or Vulnerable Species,* Quebec Department of Natural Resources and Wildlife 2008). NatureServe’s Global Status for Roseate Tern is G4 (Apparently Secure) and provincial statuses are as follows: New Brunswick (S1B = Extremely rare: may be especially vulnerable to extirpation, with typically 5 or fewer occurrences or very few remaining individuals), Nova Scotia (S1B), Quebec (S1). State rankings are available on NatureServe’s website at www.natureserve.org. The Roseate Tern is designated globally by the IUCN (World Conservation Monitoring Centre) as Least Concern.

TECHNICAL SUMMARY

Sterna dougallii
Roseate Tern — Sterne de Dougall
Range of Occurrence in Canada: QC, NB, NS

Demographic Information

Generation time (average age of parents in the population)	7.8 yrs
Observed percent change in total number of mature individuals over the last 10 years or 3 generations.	stable
Projected or suspected percent change in total number of mature individuals over the next 10 years or 3 generations.	Unknown
Observed, estimated, inferred, or suspected percent change in total number of mature individuals over any 10 or 5 years, or 3 or 2 generations period, over a time period including both the past and the future.	Not applicable
Are the causes of the decline clearly reversible?	Not applicable
Are the causes of the decline understood?	Not applicable
Have the causes of the decline ceased?	Not applicable
Trend in number of populations	Not applicable
Are there extreme fluctuations in number of mature individuals?	No
Are there extreme fluctuations in number of populations?	Not applicable

Extent and Area Information

Estimated extent of occurrence Based on area of polygon joining 4 colonies (The Brothers, Sable Island and 2 colonies on Magdalen Islands) and including three additional colonies (Country Island, Duck Island and Pearl Island) occupied in 2007	98,707 km^2
Observed trend in extent of occurrence	Declined from maximum over last three generations of 145,035 km^2 in 1982-85
Are there extreme fluctuations in extent of occurrence?	Not “extreme” but fluctuations have occurred over last three generations: the maximum (above) differs from the current EO by 46,328 km^2 or 32%. However, the non-use of Machias Seal Island is the primary driver of this change.
Index of area of occupancy (IAO) AO calculations are based on the size of the breeding colonies.	Biological AO < 25 km^2 IAO between 20 and 100 km^2
Observed trend in area of occupancy	Decline since 1982-85 (over 3 generations), when 12 colonies were occupied, to 7 colonies in 2007
Are there extreme fluctuations in area of occupancy?	No
Is the total population severely fragmented?	No
Number of current locations	7

Trend in number of locations	Decline from 12 colonies in 1982-85 to 7 in 2007 (but increased to 14 in between)
Are there extreme fluctuations in number of locations?	No
Trend in area and/or quality of habitat	Relatively stable as long as gull control continues at two major colony sites.

Number of mature individuals in each population

Population	N Mature Individuals
Total	200
Number of populations (locations)	1 population (7 colonies in 2007)

Quantitative Analysis

	Not done

Threats (actual or imminent, to populations or habitats)

Predation and displacement by gulls (in the absence of gull control), predation by mink and Great Horned Owls, erosion of at least one major breeding island, human disturbance, and industrial development. The population is also subject to stochastic events (e.g., hurricanes).

Rescue Effect (immigration from an outside source)

Status of outside population(s)? USA: Endangered	
Is immigration known?	Yes, but not extensive
Would immigrants be adapted to survive in Canada?	Yes
Is there sufficient habitat for immigrants in Canada?	Yes
Is rescue from outside populations likely?	Possible but limited by small size of Endangered northeastern population

Current Status

COSEWIC: Endangered (1999, 2009)

Additional Sources of Information: none

Status and Reasons for Designation

Status: Endangered	**Alpha-numeric code:** D1
Reasons for designation: In Canada, this colonial species is part of the northeastern population that breeds on small islands off the Atlantic coast from the Magdalen Islands in the Gulf of St. Lawrence south to Long Island, New York. It winters in South America, from Colombia to eastern Brazil. The most recent (2007) population estimate for Canada was 200 mature individuals occupying 7 locations (approximately 93% are in only 2 locations). The number of mature birds has been fairly stable over the past decade despite recovery efforts. Rescue through immigration of birds from the United States is unlikely since the species is Endangered in New England and the population there is also small (circa 7600 mature individuals in 2007). The primary factors limiting the population are predation of eggs, young and adults, low adult survival rates, and stochastic events (hurricanes).	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable.
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Threatened B2ab(i, ii, iii, iv) because area of occupancy is <2000 km^2, breeds at < 10 locations, and there have been observed declines in extent of occurrence, area of occupancy, quality of habitat, and number of locations.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable.
Criterion D (Very Small Population or Restricted Distribution): Meets Endangered D1 (<250 mature individuals)
Criterion E (Quantitative Analysis): Not done.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Becky Whittam obtained her B.Sc. in Biology from Queen's University and her M.Sc. in Biology from Dalhousie University, where she completed a Master's thesis on the effects of predation on Roseate, Arctic and Common terns on Country Island, Nova Scotia. Whittam has worked for Bird Studies Canada since 1998, first as Volunteer Projects Coordinator in Port Rowan, Ontario, and currently as the Atlantic Canada Program Manager in Sackville, New Brunswick. She has extensive experience studying Canadian Species At Risk, including Hooded Warbler and Barn Owl in Ontario, and Roseate Tern and Bicknell's Thrush in Atlantic Canada.

COLLECTIONS EXAMINED

No physical collections were examined; however, the following data sets were reviewed as needed:

Nova Scotia Tern Survey database (provided by B. Toms and A. Boyne, Canadian Wildlife Service, with data collected by NS Department of Natural Resources and Canadian Wildlife Service). Cited as Boyne unpublished data in text.

Nova Scotia and New Brunswick gull survey summarized data (provided by A. Boyne, Canadian Wildlife Service). Cited as Boyne unpublished data in text.

Magdalen Island tern and gull survey summaries (provided by F. Shaffer, Canadian Wildlife Service). Cited as Shaffer unpublished data in text.

A summary of element occurrences of Roseate Tern (1930-2001; provided by S. Gerriets, Atlantic Canada Conservation Data Centre).

Summary of number of pairs and productivity of Roseate Terns at all colony sites in the northeastern U.S. and Canada (provided by C. Mostello, U.S. Roseate Tern Recovery Team). Cited as U.S. Roseate Tern Recovery Team unpublished data in text.

Atlantic Canada Waterbird Colony Database (provided by J. Chardine, Canadian Wildlife Service). Cited as Chardine unpublished data in text.

Appendix 1. Site number, name, location and numbers of Roseate Tern pairs present per year from 1982-2007.

P = Roseate Tern(s) present but number of pairs unknown (and breeding questionable). P,NB = present but confirmed non-breeding. Blank cells indicate years in which surveys were not done at particular sites.

#	Site Name	Year																						Refs[C]
		82-85	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	
	QUEBEC																							
1	Pointe de l'Est								0	0	0					0			0	0	0	1	1	1
2	Île du Chenal		1		1	1	0	0	1	0	0	0	0	0	0	1	0	0	0	0	0	0	1	1
3	Deuxième Îlet					0				1	1	0	1	1	1	1	1	1	0	0	1	0	0	1
4	Île Paquet			3	1	1-2	1	1	2-3	0	1	1-2	1-2	1	1	1-2	1	0	1	0	0	0	0	1
5	Îlot du Nord-Ouest (Havre aux Basques)	1				0			0	0	0		0			0		0	0	0	0	0	0	1
6	Île de Travers										0								0	1	0	0	0	1
	NEW BRUNSWICK																							
7	Machias Seal Island	1		1				0	7	1	2	2	2-3		P,NB	P,NB	1	1	P,NB	P	0	P,NB	0	2-10
	NOVA SCOTIA																							
8	Peter Island	1		1							1	0	0		2				0				0	2-3 10,11
9	Holmes Island						1		1	0	0	0	0	0	0				0		0		0	13-19, 12
10	Tusket Island[A]	6									0		0						0	0	0		0	2, 11, 18, 19
11	Mud Island	2					0									0					0			2,11,12,13, 19, 20
12	The Brothers	55-60					20	23	30	34	33	48	54	59	61	86	70	90	86	76	68	67	68	21
13	Chesapeake Island										0	2	0	0	0	0			0				0	11, 12 17, 18, 20, 22,
14	Salmon Island	0									0				16				0				0	11, 12
15	McNutt's Island	0									0				1-2				0				0	11,12
16	Hughes Island	0									0				5 - 10				0				0	11,12
17	Westhaver Island	8									0				P				0	0	0	0	0	11, 12, 23, 24
18	Mash Island	0									0				10-20				0	0		0	0	11, 12, 24
19	Grassy Island	0							20	20	30		12		0				0			0	0	3, 11, 12, 24
20	Pearl Island					0		P					0	0	P	P	P					0	P	25, 26, 24, 27
21	Wedge Island	6									0				5-10				0				0	11, 12
22	Neil's Island										0				3-6				0				0	12
23	Macdonald Point	0									0				3-6				0				0	11,12
24	Sambro Island	3									0				0				0				0	11, 12
25	Fisherman's Beach	P									0				0				0				0	11, 12
26	Duck Island																						1	12
27	Beaver Island		P								0				0				0				0	12, 28
28	Lobster Island	0									0				0				1				0	11, 12
29	Western Bird Island		P										P											12
30	Thrumcap Island	P									0				0				0					11, 12

#	Site Name	Year 82-85	87	88	89	90	91	92	93	94	95	96	97	98	99	00	01	02	03	04	05	06	07	Refs[C]
31	Fisherman's Harbour										0		5		0				0				0	29, 12
32	Country Island	0	25								30	45	1	3	16	53	1	41	43	40	41	29	25	3, 30
33	Charlos Cove, unnamed I.												4											29
34	Berry Head		1																					28
35	Cole Harbour		1																					28
36	Gravel bar E of Cook's I. (off Port Felix)		P																					28
37	Dort's Island													P										12
38	Hog Island		P																					28
39	Sable Island Main Station																							31
40	Sable I. - Lake Wallace																							28
41	Sable I - unnamed colony																							28
42	Sable I. - Green Plains																							28
43	Sable Island East Light																							32
	Sable Island (General)[B]	10-20				1			4	3	2	1				2	1	0				2	4	12, 28, 31, 32

A. There are many islands in the Tusket Island system and it is not known which of these Roseate Terns were found on in 1982-85. Kirkham and Nettleship reference C. Allen, a reputable birder (now deceased), for 6 pairs present on Tusket Island in 1983 but do not specify which island. They also mistakenly reference Nova Scotia Birds 1984 (Vol 26 no 1) for "15-20 pairs on N. Twin I., Tusket Is." which upon checking the original reference is actually just The Brothers (aka Twin Islands). After 1983, all records of "0" Roseate Terns in this row are for Little Half Bald Tusket Island made by Ted D'Eon. In the calculation of Area of Occupancy for 1982, the location for Roseate Tern breeding was assumed to be Outer Bald Island based on Bird Society records indicating Roseate Terns present at this site prior to the 1980s.

B. At least 5 locations on Sable Island have been known to have Roseate Terns since 1982 (sites 39-43). Details for which sites were used in what years are incomplete, however, so data on numbers of birds seen per year are lumped under the category "Sable Island (General)".

C. References for Appendix:

1- Shaffer unpublished data
2- Kirkham and Nettleship 1985
3- Whittam 1999
4- Bernard *et al.* 1999
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6- Devlin and Diamond 2001
7- Devlin *et al.* 2003
8- Charette *et al.* 2004
9- Bond *et al.* 2006
10- Bond *et al.* 2007
11- Leonard *et al*. 2004
12- Boyne unpublished data
13- D'Eon 1991
14- Boates *et al.* 1993
15- D'Eon 1994
16- D'Eon 1995
17- D'Eon 1996
18- D'Eon 1997
19- D'Eon 2005
20- D'Eon 2000
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COSEWIC
Assessment and Status Report

on the

Butternut
Juglans cinerea

in Canada

ENDANGERED
2017

COSEWIC
Committee on the Status
of Endangered Wildlife
in Canada

COSEPAC
Comité sur la situation
des espèces en péril
au Canada

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

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COSEWIC 2003. COSEWIC assessment and status report on the butternut *Juglans cinerea* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 32 pp. (www.sararegistry.gc.ca/status/status_e.cfm)

Nielsen, C., M. Cherry, B. Boysen, A. Hopkin, J. McLaughlin, T. Beardmore. 2003. COSEWIC status report on the butternut *Juglans cinerea* in Canada *in* COSEWIC assessment and status report on the butternut *Juglans cinerea* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-32 pp.

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COSEWIC
Assessment Summary

Assessment Summary – April 2017

Common name
Butternut

Scientific name
Juglans cinerea

Status
Endangered

Reason for designation
This widespread early-successional tree of the Eastern Deciduous Forest occurs throughout southern Ontario and Québec, and locally in New Brunswick. The species was formerly a significant source of wood for cabinetry and instrument making and continues to hold cultural significance for some Indigenous communities in eastern Canada. The fungal disease Butternut Canker has infected almost all Canadian trees, is causing rapid mortality, and is projected to cause a near 100% decline from the pre-canker population of this species within one generation. There is evidence that some trees may be showing resistance. Ornamental introductions in Manitoba, Nova Scotia, and Prince Edward Island are not included in the assessment.

Occurrence
Ontario, Quebec, New Brunswick

Status history
Designated Endangered in November 2003. Status re-examined and confirmed in April 2017.

COSEWIC
Executive Summary

Butternut
Juglans cinerea

Wildlife Species Description and Significance

Butternut (*Juglans cinerea*) is a medium to large, deciduous tree of the walnut family reaching a height of up to 30 m. Its leaves are densely hairy, alternate, and composed of 11-17 pinnately-arranged, stalkless leaflets. The twigs are stout and hairy with a central pith divided into chambers. The Butternut fruit is a sticky-hairy, egg-shaped husk enclosing a single two-chambered nut within a hard, jagged-ridged shell.

Butternut is one of only two walnut species native to Canada, where it is at the northern limit of its native global distribution. The New Brunswick subpopulation is an outlier with noteworthy genetic divergence from the species elsewhere. The species is prized for its wood and edible nuts and was an important source of food and medicine for First Nations people. Butternut supports numerous specialist insect species, including the weevil *Eubalus parochus* and the metallic wood-boring beetle *Agrilus juglandis*, possible Butternut-obligate species that may be threatened in Canada by Butternut decline.

Distribution

Butternut occurs across much of the central and eastern United States and small portions of southeastern Canada, occurring south to Arkansas, Mississippi, Alabama and Georgia. Within this latitudinal range, the species occurs in all states west to Minnesota, Iowa and Missouri. Butternut's native Canadian range is restricted to southern Ontario and Quebec (primarily south of the area bounded by Georgian Bay, the Ottawa Valley and the Quebec City region), and western and southern portions of New Brunswick.

Habitat

Butternut occurs primarily in neutral to calcareous soils of pH 5.5 to 8, often in regions with underlying limestone, and is generally absent from acidic regions. It tends to reach greatest abundance in rich well-drained mesic loams in floodplains, streambanks, terraces and ravine slopes, but can occur in a wide range of other situations. In closed-canopy stands, it must be in the overstory to thrive. Seedling establishment, growth and survival to maturity are most frequent in stand openings, riparian zones and forest edges.

Biology

Butternut is a shade-intolerant deciduous tree that rarely lives more than 100 years. It flowers from April to June with separate male and female flowers on the same tree maturing at different times to encourage out-crossing. It is wind-pollinated and can hybridize with Japanese, English, Little and Manchurian walnuts. The fruit matures in September and October in the year of pollination. Seed bearing starts about age 20 and peaks at age 30 to 60. Generation time is estimated at 45 years, the median of this range. Good seed crops occur irregularly with light crops in intervening years. The seeds typically germinate the spring following seed fall and do not survive more than 2 years in the soil. Younger Butternut is capable of vegetative propagation from stump sprouting. Seed dispersal over land is primarily animal-mediated, and seeds may travel long distances by water flow. Pollen may be disseminated over distances exceeding 1 km.

Population Sizes and Trends

Population size is not well documented. Remaining occurrences are still very incompletely documented and it is unclear how many of the 863 occurrences compiled by Canadian conservation data centres are still extant. Experts estimate that from tens of thousands to 100,000+ live trees remain in Ontario and Quebec and thousands to 10,000+ are in New Brunswick, but numbers are declining rapidly. Monitoring data from 1,221 trees in 60 sites across the Ontario range show 99.7% Butternut Canker infection rate, 5.43% annualized mortality from 2008 to 2014-2015, limited seedling recruitment and almost no recruitment into mature age classes. Canker infection in Quebec is also almost complete and mortality is significant. In New Brunswick, the last region reached by the disease, canker infection was 70% in 2013-2014 and dead trees are now common. Population decline from pre-canker levels is probably already well over 50%. The well documented (but single time interval) decline rate in Ontario translates to 91% loss from current levels in one generation and 100% in just short of two generations. Population declines have been estimated to exceed 90% in Michigan, Wisconsin and the southeast.

Threats and Limiting Factors

The foremost threat is Butternut Canker, a lethal disease caused by the fungal pathogen *Ophiognomonia clavigignenti-juglandacearum*, thought to be introduced in North America, likely from Asia. Butternut Canker kills trees of all ages. Saplings are often quickly killed, while mature trees may survive up to 30 years before dying from severe crown loss and girdling by coalescing stem cankers. Seeds from infected trees can be internally infected, and recruitment into mature age classes may have nearly ceased in Canada.

In Canada, Butternut Canker was first detected in Quebec in 1990, Ontario in 1991 (where it was present by 1972 based on canker age) and New Brunswick in 1997. It now occurs throughout Butternut’s native range, affecting nearly all trees in Ontario and Quebec and 70+% of trees in New Brunswick. Putatively tolerant trees are rare, genetically-based long-term disease tolerance is not well demonstrated anywhere, and some observed tolerance is associated with hybridization with the exotic Japanese Walnut.

Additional threats to Butternut include wood harvesting, forest conversion to other uses, and hybridization with Japanese Walnut. Naturally low genetic diversity may be a limiting factor.

Protection, Status and Ranks

Butternut was initially assessed as Endangered by COSEWIC in 2003. It is presently listed as federally Endangered and protected under Schedule 1 of the *Species at Risk Act*. It is protected under the provincial *Endangered Species Act* in Ontario, and it is listed under the *New Brunswick Species at Risk Act* but with no prohibitions in place. It is not protected through provincial legislation in Quebec. Butternut is globally ranked as Apparently Secure (G4) and nationally ranked as Vulnerable in the United States (N3N4) and Imperilled to Vulnerable (N2N3) in Canada, though these ranks are outdated and do not account for current knowledge of Butternut Canker. It is Imperilled in Quebec (S2) and Ontario (S2?) and Critically Imperilled (S1) in New Brunswick.

TECHNICAL SUMMARY

Juglans cinerea

Butternut

Noyer cendré

Range of occurrence in Canada (province/territory/ocean): Ontario, Quebec, New Brunswick

Demographic Information

Generation time (*average age of parents in the population*)	45 years; Estimate is the median of the published peak reproductive age of 30 to 60. Following COSEWIC / IUCN guidelines, no adjustment is made for reduced longevity caused by Butternut Canker
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes – observed and projected declines primarily from Butternut Canker, also from land development
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	90+% over 2 generations (90 years) based on the known ON and QC prevalence of, and mortality from, Butternut Canker (extirpation predicted 84 years into future based on documented ON mortality rate), and knowledge of US mortality rates.
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Likely well over 50% decline in past three generations (135 years) based on documented rates of decline, the time since arrival and prevalence of Butternut Canker, and knowledge of US mortality and declines.
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	90+% decline projected in 3 generations (135 years) based on the known ON and QC prevalence of, and mortality from, Butternut Canker, and knowledge of US mortality and declines.
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. * 20+ year old canker detected in 1992 in southern Ontario	90+% decline projected from current levels within one generation (45 years) into the future with extirpation ~84 years into the future, based on documented rates of decline and knowledge of US mortality and declines. Inclusion of estimated decline since arrival of Butternut Canker (~1972*, about one generation ago) would greatly increase total decline.
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. No b. Yes c. No
Are there extreme fluctuations in number of mature individuals?	No

Extent and Occupancy Information

Estimated extent of occurrence	266,920 km^2 (if based exclusively on definitely native occurrences) 399,440 km^2 (if all observation records are considered)

Index of area of occupancy (IAO) (Always report 2x2 grid value).	Unknown. Less than 159,700 km^2 (total area of grid squares intersected by core Canadian range, rounded to nearest 100 km^2).
Is the population "severely fragmented" i.e., is >50% of its total area of occupancy in habitat patches that are (a) smaller than would be required to support a viable population, and (b) separated from other habitat patches by a distance larger than the species can be expected to disperse?	a. No b. No
Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	1 (all occurrences of the species are affected by Butternut Canker with no evidence of substantial variation in how the disease will proceed, and are therefore considered as a single location)
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Yes – Projected loss of small peripheral occurrences based on documented and anticipated widespread major declines. Some loss has likely already occurred.
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes (loss from sparsely occupied 2 x 2 km squares is inferred based on ~90% inferred population loss in southwestern Ontario (see **Fluctuations and Trends,** re: Cambridge District), and major declines throughout range. Loss is projected to continue based on documented rates of infection and mortality.
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Yes (observed, inferred and projected losses). Local losses observed (CDC extirpated sites and other observations). Losses inferred based on known major declines throughout range. Losses projected based on documented rates of infection and mortality.
Is there an [observed, inferred, or projected] decline in number of "locations"*?	No. All subpopulations are considered one location because all are subject to Butternut Canker.
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes (Observed and inferred decline in area, extent and quality with forest, old field and hedgerow loss to a large range of development)
Are there extreme fluctuations in number of subpopulations?	No
Are there extreme fluctuations in number of "locations"∗?	No. All subpopulations are considered one location because all are subject to Butternut Canker.
Are there extreme fluctuations in extent of occurrence?	No
Are there extreme fluctuations in index of area of occupancy?	No

* See Definitions and Abbreviations on COSEWIC website and IUCN (Feb 2014) for more information on this term

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	N Mature Individuals
Known occurrences in both Ontario and Quebec are not comprehensively compiled, and many undocumented occurrences exist. About 1,300 occurrences documented (excluding historical occurrences and using a 1 km separation distance), but this may include many occurrences now extirpated. Ontario About 800 sites documented. 346 occurrences ranked as Verified Extant (observed in past 20 years, but not necessarily actually still extant because of canker mortality), 61 ranked as Historical (not observed in over 20 years, but may still be present) and one considered Extirpated. Quebec At least 378 occurrences documented, but some portion of these are likely now extirpated by canker. New Brunswick 139 occurrences documented. Many undocumented occurrences exist.	Not known precisely, but experts estimate tens of thousands to 100,000+ live trees in Ontario and Quebec, and thousands to 10,000+ in New Brunswick.

Quantitative Analysis

Probability of extinction in the wild is at least [20% within 20 years or 5 generations, or 10% within 100 years].	No quantitative analysis done

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

Was a threats calculator completed for this species? Yes, see Appendix 1

i. Invasive Non-native Pathogen: Butternut Canker
ii. Habitat Conversion
iii. Logging and Wood Harvesting
iv. Introduced Genetic Material: Hybridization with Japanese Walnut

Less Significant Threats (Unknown rating)
v. Problematic Native Species: White-tailed Deer
vi. Climate Change

What additional limiting factors are relevant?
i. Low Genetic Diversity
ii. High Levels of Seed Predation

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Michigan (S3), Ohio (S4), Pennsylvania (S4), New York (S4), Vermont (S3), New Hampshire (S3), Maine (S3). These ranks do not reflect declines and threats from Butternut Canker, which are significant in all above jurisdictions.
Is immigration known or possible?	Yes, not known but possible
Would immigrants be adapted to survive in Canada?	No – no resistance to Butternut Canker known in United States, though adjacent American occurrences would presumably be suited to Canadian environmental conditions
Is there sufficient habitat for immigrants in Canada?	Yes
Are conditions deteriorating in Canada?[+]	Yes
Are conditions for the source population deteriorating?[+]	Yes
Is the Canadian population considered to be a sink?[+]	No. The population is not dependent upon or significantly influenced by immigration from outside Canada
Is rescue from outside populations likely?	No. Limited rescue potential through water-borne or animal dispersal. Potential source populations are in poor health due to Butternut Canker and are unlikely to provide a meaningful source of uninfected or resistant seeds. Natural dispersal potential is low.

Data Sensitive Species

Is this a data sensitive species? No

Status

COSEWIC: Designated Endangered in November 2003. Status re-examined and confirmed in April 2017.

Status and Reasons for Designation:

Status: Endangered	**Alpha-numeric codes:** A2ae+3e+4ae
Reasons for designation: This widespread early-successional tree of the Eastern Deciduous Forest occurs throughout southern Ontario and Quebec, and locally in New Brunswick. The species was formerly a significant source of wood for cabinetry and instrument making and continues to hold cultural significance for some Indigenous communities in eastern Canada. The fungal disease Butternut Canker has infected almost all Canadian trees, is causing rapid mortality, and is projected to cause a near 100% decline from the pre-canker population of this species within one generation. There is evidence that some trees may be showing resistance. Ornamental introductions in Manitoba, Nova Scotia, and Prince Edward Island are not included in the assessment.	

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

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Endangered A2ae+3e+4ae. Reduction over past three generations estimated at over 50 percent. Ongoing declines due to Butternut Canker projected to cause near 100% decline from pre-canker population within one generation.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not met.
Criterion C (Small and Declining Number of Mature Individuals): Not met.
Criterion D (Very Small or Restricted Population): Not met.
Criterion E (Quantitative Analysis): No data to conduct analysis.

PREFACE

Butternut (*Juglans cinerea*) was initially assessed by COSEWIC in 2003 (COSEWIC 2003) and subsequently listed as Endangered under SARA. Since the 2003 report, considerable new occurrence data have been collected. Conservation data centres in Ontario, Quebec and New Brunswick have compiled over 7,600 observation records for the species, representing 863 separate occurrences. These data allow for better assessments of distribution, extent of occurrence, and area of occupancy. The COSEWIC (2003) Canadian population estimate of 13,600, noted in the report as being very conservative, is now known to have been a substantial underestimate, and an inaccurate citation of a value that was never intended as a comprehensive population estimate.

Butternut Canker, a fungal disease (caused by the fungal pathogen *Ophiognomonia clavigignenti-juglandacearum*) representing the primary threat to Butternut's survival, has spread significantly over the last decade to occupy all of Butternut's Canadian range. Reliable data on the disease's prevalence has shown 90-100% infection rates in Ontario and Quebec and 70% infection rates in New Brunswick. The Ontario Ministry of Natural Resources and Forestry established 60 monitoring plots in 2006 across the southern Ontario range, on which 100% canker infection (excluding one hybrid with Japanese Walnut—*Juglans ailantifolia*) and 39% mortality was documented from 2008 to 2014-2015 on the 1,221 trees initially assessed. The Forest Gene Conservation Association (FGCA) has conducted extensive fieldwork relating to Butternut recovery from 1995-2017 and continues to expand its Butternut recovery work. The FGCA has searched for putative tolerance to Butternut Canker, and has archived the genetic material of over 70 potentially tolerant, DNA-confirmed, pure Butternut trees since 2008 by grafting them onto canker-resistant Black Walnut (*Juglans nigra*) root stock. The grafted trees are maintained in managed, protected seed orchards with the goal to conserve the genetic diversity of Ontario subpopulations and produce seed for reintroduction. Over 50 additional trees await grafting and many others are expected to be found.

Research and propagation efforts elsewhere have shown little evidence of genetically-based disease resistance or tolerance in genetically pure Butternut, and have discovered that hybridization with Japanese Walnut is frequent in wild subpopulations (though generally infrequent in Canada, <10% of trees) and is often the source of some disease resistance.

Recent research into the genetic diversity of Butternut has suggested that New Brunswick occurrences exhibit a higher level of divergence than any other sampled subpopulations in the U.S. However, comparison with Ontario subpopulations does not demonstrate major divergence and the species occurs on similar habitat throughout its range. As such, the species is treated as a single designatable unit in Canada**.**

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
(2017)

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

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

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

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

Environment and Climate Change Canada
Canadian Wildlife Service

Environnement et Changement climatique Canada
Service canadien de la faune

Canada

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

COSEWIC Status Report

on the

Butternut
Juglans cinerea

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2017

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Species: *Juglans cinerea* L.

Synonym: *Wallia cinerea* (L.) Alef.

Common names: English: Butternut, American Butternut, White Walnut, Oilnut, Lemonnut

French: Noyer cendré, Arbre à noix longues, Noix longues, Noix tendre
Mohawk: Akiehwa'ta
Maliseet: Pokanewimus
Mi'kmaq: Epganmosi

Tribe: Juglandeae

Family: Juglandaceae

Order: Fagales

Superorder: Rosanae

Class: Magnoliopsida

Subdivision: Spermatophytina

Division: Tracheophyta

Morphological Description

Butternut (*Juglans cinerea*) is a relatively short-lived, medium to large, early-successional, deciduous tree (Figure 1). Although it can reach 30 m (Rink 1990; Whittemore and Stone 1997), average mature individuals are more typically 12 to 18 m high with trunk diameters of 30 to 60 cm at breast height (Clark 1965). The trunk, which is often divided (Farrar 1995), branches into a broad, open crown up to 15 m wide in open conditions (Woeste and Pijut 2009). The light grey or grey-brown bark is smooth on young trees, gradually becoming shallowly to deeply fissured. Leaves are 30 to 60 cm long, composed of 11 to 17 ovate leaflets each 5 to 11 cm long (Figure 2). Leaves, branchlets and fruit are densely sticky-hairy, especially when young. Twigs are stout (to almost 1 cm wide near the tips) with a chambered dark brown pith and conspicuous large leaf scars. Butternut is monoecious, with drooping male catkins occurring on second-year twigs and inconspicuous female flowers in groups of 2 to 8 at branch tips. The fruit is a two-chambered nut with a hard jagged-ridged shell enclosed within a sticky-pubescent egg-shaped husk 5 to 10 cm long. The common name "White Walnut" refers to the species' light coloured wood. See Farrar (1995), Whittemore and Stone (1997), and Gleason and Cronquist (1991) for more complete technical descriptions.

Butternut is similar to Black Walnut (*Juglans nigra*) which is native in southwestern Ontario and widely planted and occasionally escaped elsewhere in Butternut's Canadian range. In contrast to Butternut's strongly pubescent leaves with large terminal leaflets, pubescent twigs, pubescent leaf scars, dark brown pith and hairy egg-shaped fruits with jagged-ridged inner shells, Black Walnut has smooth or only slightly hairy leaves and twigs, terminal leaflets that are absent or noticeably smaller than the lateral leaflets, hairless leaf scars, orange-yellow pith and nearly hairless globose fruits with inner shells bearing rounded ridges (Farrar 1995; Whittemore and Stone1997; COSEWIC 2003). Distinctions between Butternut and its hybrids with non-native walnut crosses are given in Table 1. Catling and Small (2001) provide a complete key to all native and introduced walnut species and hybrids occurring in Canada.

Figure 1. Butternut (*Juglans cinerea*) at edge of floodplain meadow, Nashwaak River, New Brunswick. Photo: David Mazerolle, AC CDC.

Figure 2. Compound leaf and bark of Butternut (*Juglans cinerea*) at Plymouth, New Brunswick. Photo: David Mazerolle, AC CDC.

Table 1. Summary of characteristics distinguishing Butternut from hybrids of Butternut and non-native species (most frequently Japanese Walnut). Contents are adapted from Woeste *et al.* (2009).

Character	Butternut	Hybrid Butternut
Current-year stem	Olive green, changing to red-brown near terminal buds, glossy, and with few hairs except immediately beneath terminal buds	Bright green to copper brown or tan, changing to pale green near terminal bud, often densely covered with russet or tan hairs, especially near terminal buds
Terminal bud (1-yr twigs)	Beige in colour, longer and narrower than in hybrids, with outer fleshy scales more tightly compact	Pale green to tan or yellowish in colour, wider and squatter than in *J. cinerea*; outer fleshy scales more divergent than Butternut and often deciduous
Lateral bud (1-yr twigs)	Vegetative buds are elongated (sometimes stalked) and somewhat angular, creamy white to beige in colour	Vegetative buds are rounded and green to greenish brown in colour
Lenticels (1-yr twigs)	Small, round, abundant, evenly distributed, and sometimes elongating horizontally across the branch (perpendicular to the stem axis)	Large, often elongating laterally down the branch (parallel to the stem axis) on 1-yr wood, patchy distribution; on 3 and 4-yr wood, lenticels often form a diamond pattern as they become stretched both transversely and longitudinally
Leaf scar (1-yr twigs)	Top edge almost always straight or slightly convex; scar usually compact	Top edge almost always notched; often with large, exaggerated lobes
Pith (1-yr twigs)	Dark brown	Dark brown, medium brown or even light brown
Bark (mature tree)	Varies from light grey and platy to dark grey and diamond patterned in mature trees; in older trees, fissures between bark ridges may be shallow or deep but are consistently dark grey in colour	Silvery or light grey, rarely darker; fissures between bark ridges moderate to shallow in depth and often tan to pinkish tan in colour
Leaf senescence	Leaves yellow and brown by early mid-autumn, dehiscing in early to mid-autumn	Leaves often green until late autumn, dehiscing in late autumn or may freeze green on the tree
Catkins	5-12 cm in length at peak pollen shed	13-26 cm in length at peak pollen shed
Nut Clusters	One or two nuts in most clusters, sometimes three to five, rarely more	Usually three to five per cluster, sometimes as many as seven

Taxonomy

Butternut has always been considered a distinct species since its description by Linnaeus in 1753.

Juglans L. is a principally New World genus of about 21 extant species occurring in North America, South America, the West Indies, southeastern Europe, mainland Asia, and Japan (Manning 1978; Aradhya *et al.* 2005, 2006). The most recent genetic analyses have placed Butternut with other North American *Juglans* in section Rhysocaryon (Aradhya *et al.* 2006, 2007; Zhao and Woeste 2010), rather than with Asian species in section Cardiocaryon (Fjellstrom and Parfitt 1995) or in its own section Trachycaryon (Manning 1978; Ostry and Pijut 2000; Aradhya *et al.* 2006).

Population Spatial Structure and Variability

Several recent studies have described phylogeographic structure within the native range of Butternut. Laricchia *et al.* (2015) investigated chloroplast genetic diversity throughout its range (14 study sites, eight regions of the chloroplast genome, 197 individuals sampled) and found ten chloroplast haplotypes. The three most common haplotypes were not closely related to one another and were each restricted to a western, southern or eastern portion of the range, suggesting separate post-glacial migration pathways. Of 51 Canadian individuals sampled (14 from one Ontario site and 37 from three New Brunswick sites), 50 shared the most common eastern haplotype and one, from Keswick, New Brunswick on the Saint John River, exhibited a highly divergent haplotype found nowhere else, providing no evidence that New Brunswick trees are a uniformly divergent population.

Within-population genetic diversity in Butternut is generally inversely correlated with latitude, with subpopulations north of the last glacial maximum exhibiting much lower levels of heterozygosity, isozyme diversity and nuclear microsatellite polymorphisms (Morin *et al.* 2000; Ross-Davis *et al.* 2008a; Hoban *et al.* 2010; Laricchia *et al.* 2015; Boraks and Broders 2016). In a range-wide study, Hoban *et al.* (2010) conducted Bayesian cluster analysis and a principal components analysis of pairwise F_{ST} (a fixation index, quantifying genetic differentiation between subpopulations), finding evidence of lower gene flow and higher levels of population structure and genetic drift in northern peripheral subpopulations. Lower diversity and higher differentiation at the northern range edge are most likely a result of founder effects during range expansion following glacial retreat (Hoban *et al.* 2010; Laricchia *et al.* 2015).

Boraks and Broders (2016) investigated variation in six neutral microsatellite markers in 206 individuals from 16 subpopulations in New York, Vermont, New Hampshire and southern Maine, including two sites along the Quebec border. They found weak subpopulation differentiation (F_{ST}=0.084), an absence of regional genetic structure and no sign of a recent bottleneck. Population statistics and Bayesian analysis indicated significant historical gene flow among their subpopulations and they concluded that surviving Butternut in the northeast United States could be considered a single broadly distributed population, though they noted that could change rapidly because of fragmentation caused by mortality. They also found significantly greater allele differentiation in riparian subpopulations compared to upland ones.

Hoban *et al.* (2010) described, using microsatellite markers, some genetic divergence in three New Brunswick subpopulations, in comparison with two in Ontario and one in Quebec, though it is difficult to assess the significance of the differences with such a limited sample size (Beardmore pers. comm. 2016). In contrast with the Laricchia *et al.* (2015) study above which found limited genetic difference between New Brunswick and Ontario-Quebec individuals, there is good evidence that New Brunswick subpopulations are distinct from those in the United States (Hoban *et al.* 2010, see Figure 3; Romero-Severson 2012; Hoban pers. comm. 2015). Jeanne Romero-Severson of Notre Dame University (2012) conducted a range-wide assessment of 39 subpopulations including 13 New Brunswick and 26 United States subpopulations, using 11 gSSR (genomic simple sequence repeat) markers, 10 developed from Butternut (Hoban *et al.* 2008) and one from Black Walnut (Woeste *et al.* 2002). Her results show that New Brunswick has at least two unique gene pools (Romero-Severson 2012). Principal component analysis showed a difference between New Brunswick Butternut and the other subpopulations from across the range in the United States greater than that between any other non-New Brunswick subpopulations, and differences among New Brunswick subpopulations (13 subpopulations; of 78 pairwise F_{ST} values, eight were less than 0.03, 35 were 0.03 to 0.049, and 35 were 0.05 or greater, of which eight were 0.08 to 0.099). This differentiation suggests genetic isolation over a long period of time, possibly via persistence in an unknown northern refugium different from the rest of the species (Beardmore pers. comm. 2015; Hoban pers. comm. 2015), as has also been speculated for genetically distinct populations of Black Spruce (*Picea mariana*), Red Pine (*Pinus resinosa*) and Jack Pine (*Pinus banksiana*) elsewhere in Atlantic Canada (Jaramillo-Correa *et al.* 2004; Boys *et al*. 2005; Godbout *et al.* 2010).

Additionally, during 2015-16, as part of an ongoing study, the Canadian Forest Service and Jeanne Romero-Severson have evaluated 425 trees in 25 subpopulations throughout Butternut's range in New Brunswick for general health and genetic diversity (Beardmore pers. comm. 2016). Eleven gSSR markers and two chloroplast CAPS (cleaved amplified polymorphic sequences) markers were used to evaluate the genetic diversity of New Brunswick Butternuts relative to the rest of the native range in the US and to detect evidence of Japanese Walnut (*Juglans ailantifolia*) ancestry. Their results further supported the Romero-Severson (2012) finding that New Brunswick Butternuts are highly divergent from those in the United States (Beardmore pers. comm. 2016), and seven samples were identified as Japanese Walnuts, mostly from anthropogenic sites, but including one from a remote and undisturbed site in which pure Japanese Walnut would be improbable[1]. Six samples were identified as introgressed hybrids.

[1] This site, Butternut Island in the Little River, Sunbury County, New Brunswick, is remote (5 km to the nearest residence, 9 km to the nearest settlement), is unlikely to have ever been farmed and supports a completely native community of rich floodplain herbs typical of native Butternut habitat (Blaney pers. obs. 2002). The genetic identification of trees here as Japanese Walnut and hybrids seems questionable.

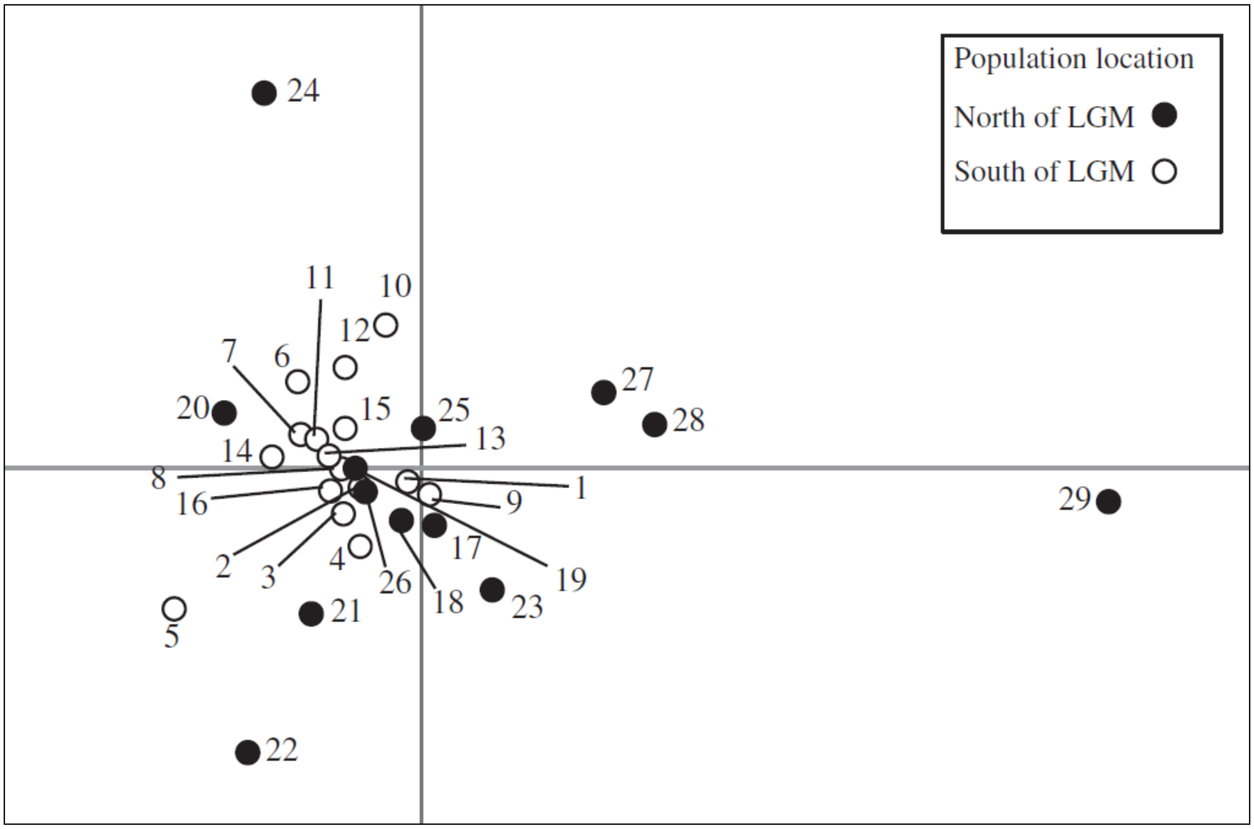

Figure 3. Principal component analysis based on F_{ST}, illustrating levels of genetic divergence within the global range of Butternut. Populations labelled 27, 28 and 29 are located in New Brunswick, population 24 is situated in Quebec and populations labelled 25 and 26 are situated in Ontario. LGM refers to the ice limit at the last glacial maximum. From Hoban *et al.* (2010), with permission.

Designatable Units

There is some evidence of the discreteness of the Ontario/Quebec and New Brunswick occurrences of Butternut; however, the significance is questionable.

As described in **Population Spatial Structure and Variability**, there is limited information on the divergence of New Brunswick Butternut from subpopulations in Ontario and Quebec, but significant levels of divergence in New Brunswick compared with United States subpopulations, suggesting origin from different glacial refugia and perhaps separation predating glaciation (Severson-Romero 2012; Hoban pers. comm. 2015).

There may be a modest disjunction between the Butternut occurrences that straddle the New Brunswick – Maine border in the vicinity of Woodstock, New Brunswick and Houlton, Maine, and the rest of its range. Butternut is reported from all Maine counties in Kartesz (2015); however, some of that distribution is probably based on planted or naturalized occurrences, as much of the northern portion of Maine lacks native subpopulations (Cameron pers. comm. 2015; Haines pers. comm. 2016). Apparently native herbarium records extend northeast in Maine at least to the Bangor area about 180 km southeast of the nearest New Brunswick records (Consortium of Northeastern Herbaria 2016). The actual disjunction may be less than this. Arthur Haines (pers. comm. 2016), author of *Flora Novae Angliae* (Haines 2013) suggests that Butternut was "almost without a doubt" present historically on the Penobscot River (extending within about 75 km of known occurrences along the Maine-New Brunswick border) based on habitat and the fact that there is a Penobscot word for the species (pakά́nosi). He also notes that the Passamaquoddy also had this word (pokanimùs for the tree and pokan for the nut), suggesting the possibility of occurrence into that nation's territory in southeastern-most Maine near the New Brunswick border. Suitable habitat for Butternut exists between the Penobscot River and known New Brunswick occurrences in the Mattawamkeag and the upper Meduxnekeag watersheds and undocumented subpopulations could be present there, meaning that at least historically there may not have been disjunctions of Butternut range in Maine and New Brunswick exceeding 50 km. Additionally, there are undoubtedly some planted occurrences in the zone between southern Maine and New Brunswick.

New Brunswick occurrences are clearly separated by about 200 km between the Grand Falls, New Brunswick and city of Québec areas. This distance is likely beyond the typical range of pollen movement (see **Dispersal and Migration**) and distances are large enough that there is unlikely to be sufficient dispersal between Ontario/Quebec and New Brunswick to prevent local adaptation (COSEWIC 2014).

The New Brunswick and Ontario/Quebec occurrences of Butternut are in almost entirely separate COSEWIC National Ecological Areas (NEAs; COSEWIC 2014). The New Brunswick occurrences are in the Atlantic NEA, while the Ontario/Quebec occurrences are within the Great Lakes Plains NEA, except for very limited areas extending into the Atlantic NEA (Figure 4) in southeastern-most Quebec and into the Boreal NEA north of the Ottawa River. Because Butternut occurrence is not comprehensively databased in Quebec, there may be somewhat more occurrence outside the Great Lakes Plains NEA than is mapped in Figure 4.

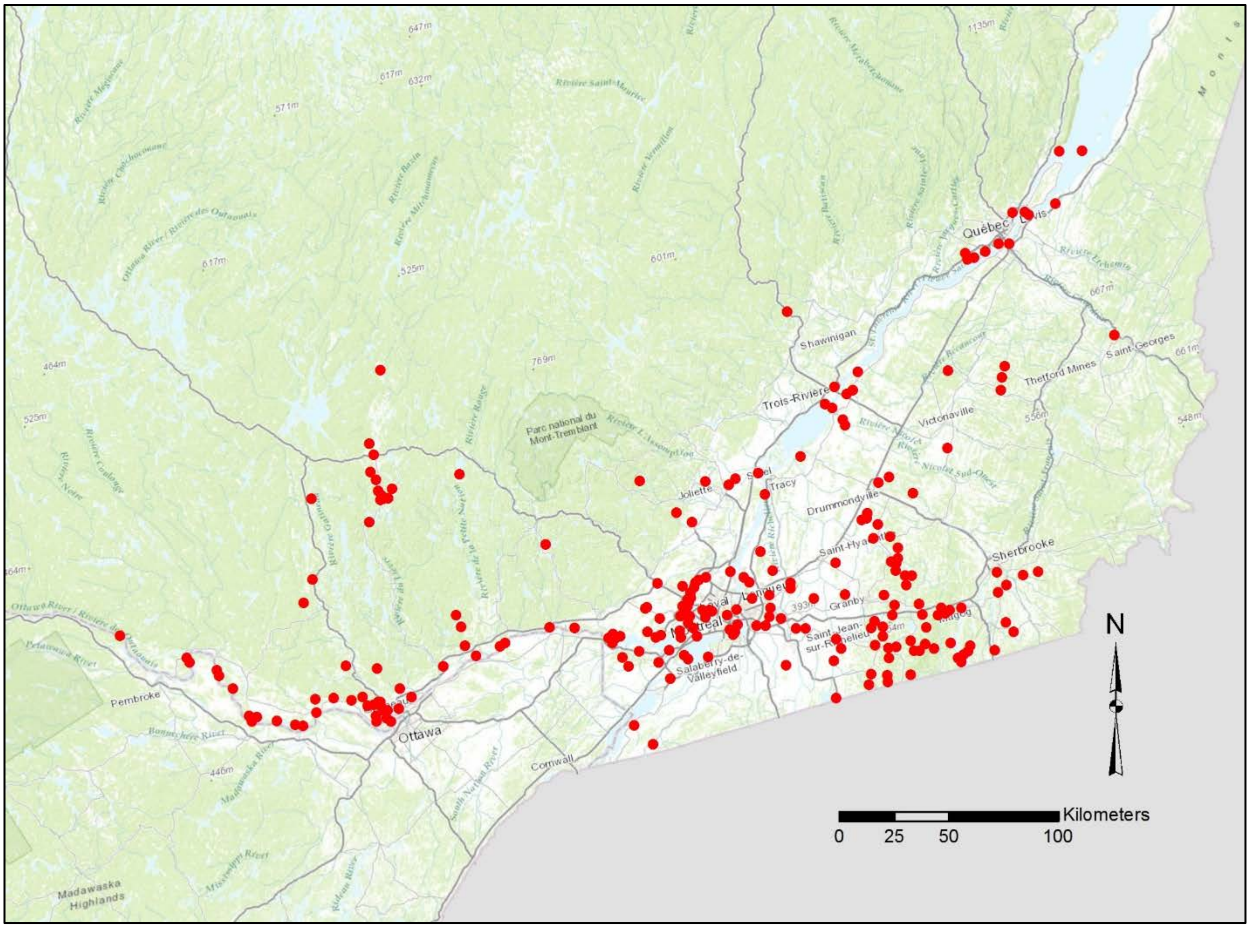

Figure 4. Quebec Butternut observation records compiled in the CDPNQ database. The native origin of some outlying occurrences is uncertain. Basemap from OpenStreetMap, containing data from GeoBase, GeoGratis (Department of Natural Resources Canada), CanVec (Department of Natural Resources Canada), and StatCan (Geography Division, Statistics Canada).

The “relevance to the species” (COSEWIC 2014) of the differing eco-regions is questionable, as climate and ecological setting of occurrences (which would drive local adaptation) are very similar. The ecological settings of the New Brunswick occurrences and those in Ontario/Quebec are in predominantly deciduous forests on calcareous soils, with the associated tree and understory plant species in New Brunswick occurrences being very similar to those in Ontario/Quebec (Blaney pers. obs. 1989-2015 in Ontario and New Brunswick; Doyon *et al.* 1998). The New Brunswick subpopulations are, however, sufficiently separated that natural dispersal is unlikely to occur. Their loss would result in a significant reduction in the Canadian range, but would not produce an “extensive disjunction” (COSEWIC 2014) within the Canadian range. The evolutionary significance of the New Brunswick occurrences is harder to demonstrate. There is evidence of comparatively deep phylogenetic divergence by the standards of the species. This is, however, based on microsatellite frequency which is noted in COSEWIC (2014) as generally being insufficient to demonstrate significance because of the rapid evolution of microsatellites.

In this status report, Butternut is treated as a single designatable unit.

Special Significance

Butternut is one of only two species of the walnut genus *Juglans* that are native to Canada. The Canadian population is at the northern and northeastern peripheries of the species' native global range. Populations at the edge of a species' geographical range often occupy less favourable habitats, exhibit lower densities, tend to be more fragmented, and are less likely to receive immigrants from other populations (Channel and Lomolino 2000). Through isolation, genetic drift and natural selection, peripheral populations can give rise to genetic, ecological and morphological divergence, increasing their conservation significance as sources of adaptive genotypes and as source populations for range recolonization or migration; they can also be important as final refuges (Lesica and Allendorf 1995; Garcia-Ramos and Kirkpatrick 1997; Gibson *et al.* 2009). Canadian Butternut subpopulations are known to exhibit significantly higher differentiation than core United States or southern peripheral subpopulations (Hoban *et al.* 2010). New Brunswick occurrences, which are isolated from the species' main native range by about 180 km, show a level of genetic differentiation far greater than that seen in any other subpopulations across the species' range (Hoban *et al.* 2010; Hoban pers. comm. 2015, see **Population Spatial Structure and Variability**). These genetically distinct occurrences may therefore be of particularly high conservation significance.

Butternut supports a wide range of insects (see **Interspecific Interactions**), many of which are specialists of walnuts, occurring on few or no other tree species. At least a few of these, most notably the weevil (*Eubalus parochus,* family Curculionidae) and the Butternut Agrilus wood-boring beetle (*Agrilus juglandis,* family Buprestidae), may be entirely dependent on Butternut (Halik and Bergdahl 2002, 2006; Anderson 2008; Paiero *et al.* 2012) and may warrant COSEWIC status assessment because of Butternut decline. In New Brunswick, the owlet moths (family Noctuidae) Gray-edged Hypena (*Hypena madefactalis*) and The Bride Underwing (*Catocala neogama*) are very rare provincially and presumed entirely dependent on Butternut (Webster *et al.* 2005; Webster pers. comm. 2016). The provincially rare Banded Hairstreak butterfly, *Satyrium calanus* (family Lycaenidae) is also primarily or exclusively reliant on Butternut as a food plant in New Brunswick (Webster pers. comm. 2016).

Butternut wood is lightweight, soft and coarse-grained. Its qualities once made it favourable for cabinetwork, interior finishing, carving, musical instruments and boats (Woeste *et al.* 2009). It does not have high economic value in Canada, but was valued in the U.S. as a timber species, although its widely-scattered growth habit within stands and relatively soft wood limit its commercial importance (Ostry and Pijut 2000). The species is also valued economically for its edible nuts (Woeste and Pijut 2009), which have a delicious buttery flavour and an oil content of up to 60% at peak ripeness (Rupp 1990). More than 70 Butternut cultivars have been described with a few genotypes exhibiting good nut qualities for commercial production (large size and ease of cracking) (Millikan *et al.* 1990; Ostry and Pijut 2000; Woeste 2004). Nut growers value Butternut as a cold-hardy, nut-producing species. Nuts have been especially popular in New England for making maple-Butternut candy. Additionally, there are reports that Butternut trees were tapped by the pioneers and yielded an excellent syrup (Lauriault 1989), though the ratio of sap to syrup is estimated to be four times higher than that of maple trees (Rupp 1990).

Juglone, an organic compound derived from walnuts, including Butternut, is antiseptic and herbicidal with some antitumour properties reported. An animal study suggests that juglone possesses sedative activity comparable with diazepam (the prescription drug Valium; Girzu *et al.* 1998). The inner bark of the root has a mild cathartic property, and may be used as a habitual laxative, as well as for toothaches, dysentery and hepatic congestions (Lauriault 1989; Schultz 2003). The expressed oil of the nut is also said to combat tapeworms (Schultz 2003).

The First Nations of North America had many medicinal and cultural uses for Butternut (Smith 1923, 1928, 1933; Gilmore 1933; Hamel and Chiltoskey 1975; Herrick 1977; Chandler *et al.* 1979; Talalay *et al.* 1984). It was likely used by all First Nations within its Canadian range. For example, the Ojibwe (Smith 1932), Haudenosaunee (Herrick 1977), Algonquin (Black 1980), Maliseet (Mechling and Rioux 1958) and Mi'kmaq (Chandler *et al.* 1979) are reported to have used it for food, dyes and medicine. Its nuts were prized for their high nutritional value and its sap was boiled to produce syrup (Goodell 1984).

DISTRIBUTION

Global Range

Butternut is a widespread species found across much of the central and eastern United States and small portions of southeastern Canada. The species ranges from southern Ontario, southern Quebec and New Brunswick in the north to Arkansas, Mississippi, Alabama, and Georgia in the south (Rink 1990; Whittemore and Stone 1997; BONAP 2015). Within this latitudinal range (roughly latitudes 32^o to 47^o), the species occurs in all states from the Atlantic Coast west to Minnesota, Iowa and Missouri. Most of the species' range, containing the highest density of occurrences, is found in the Appalachian Region, southern Great Lakes Region, Upper Mississippi River watershed and Ohio River watershed. Disjunct occurrences are found in New Brunswick and several states at the southern limit of the species' range (BONAP 2015). The native global range of Butternut is illustrated in Figure 5.

The importance of Butternut as a source of food and medicine for Indigenous peoples is well-documented (Smith 1923; Gilmore 1933; Hamel and Chiltoskey 1975; Herrick 1977; Chandler *et al.* 1979; Talalay *et al.* 1984), and First Nations likely played a role in disseminating the species prior to European settlement (Wykoff 1991). Butternut is also frequently planted outside its native range, with 72 cultivars (65 specific, 7 hybrid) registered by the U.S. Department of Agriculture Forest Service (Woeste 2004). As a result, the boundaries of the species' natural range are difficult to accurately define.

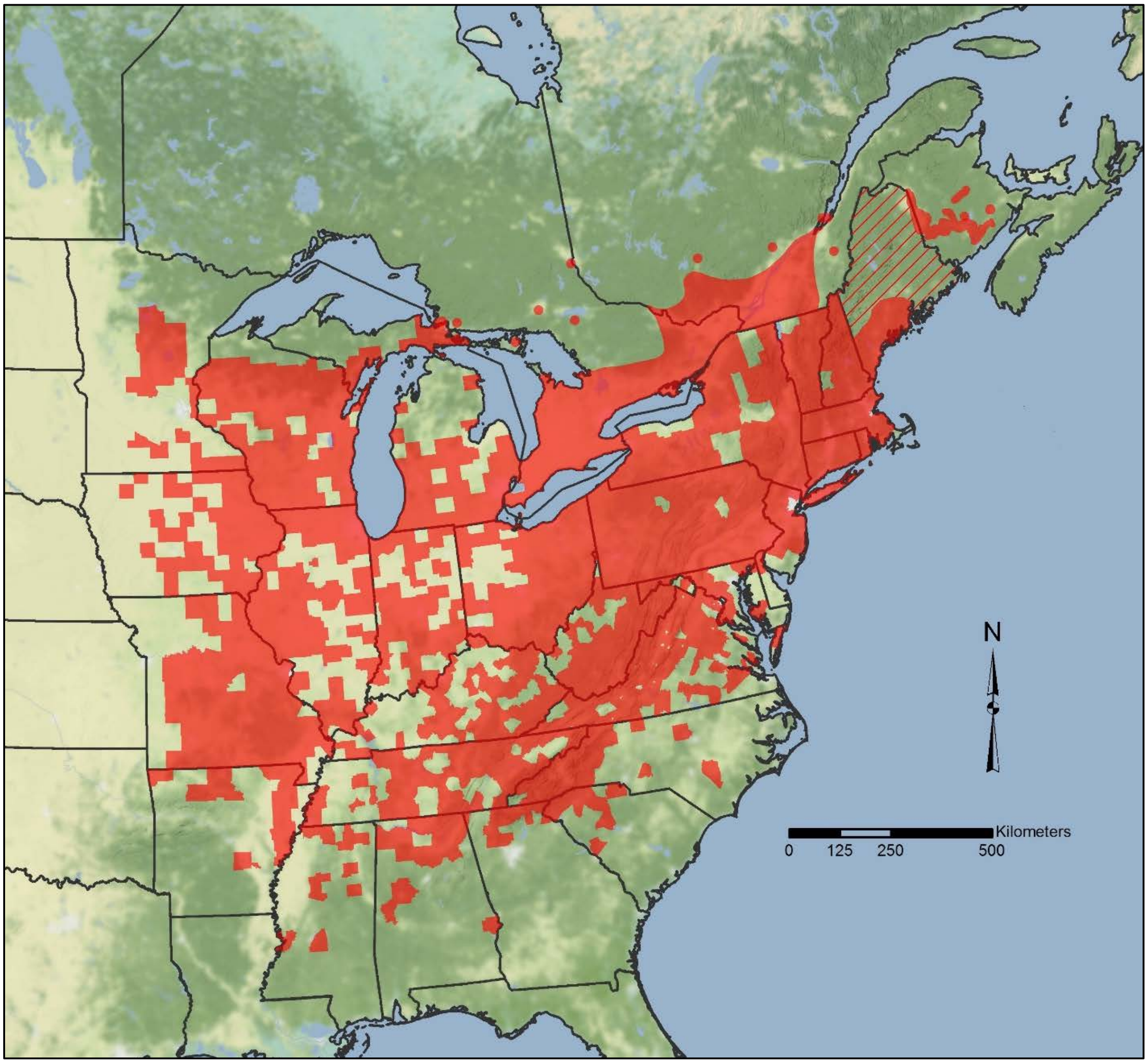

Figure 5. Global range of Butternut. Shading indicates forest cover. Canadian range is adapted from Farrar (1995) based on data from ONHIC (2015), AC CDC (2016) and CDPNQ (2015). Range in the United States is based on county-level data from BONAP (2015), except for Maine. Hatched area in Maine indicates range mapped by BONAP (2015), but distribution in northern Maine (and perhaps northern New Hampshire) counties may represent planted individuals or establishment from planted individuals outside the original native range (see discussion under Designatable Units). Maine distribution is based on Consortium of Northeast Herbaria (2016) records and Bergdahl (pers. comm. 2016). Some other disjunct peripheral occurrences, especially those in northern Ontario (see Canadian Range), may represent plantings or establishment from plantings outside the native range. Basemap from Stamen, based on OpenStreetMap data.

Canadian Range

Butternut's native Canadian range is restricted to southern Ontario, southern Quebec, and portions of western and southern New Brunswick (Figure 6). In Ontario and Quebec, the species is limited to an approximately 1,100 km band extending from Windsor to the city of Québec and is almost entirely contained within the Great Lakes Plains National Ecological Area but also extends into the Boreal National Ecological Area (COSEWIC 2014).

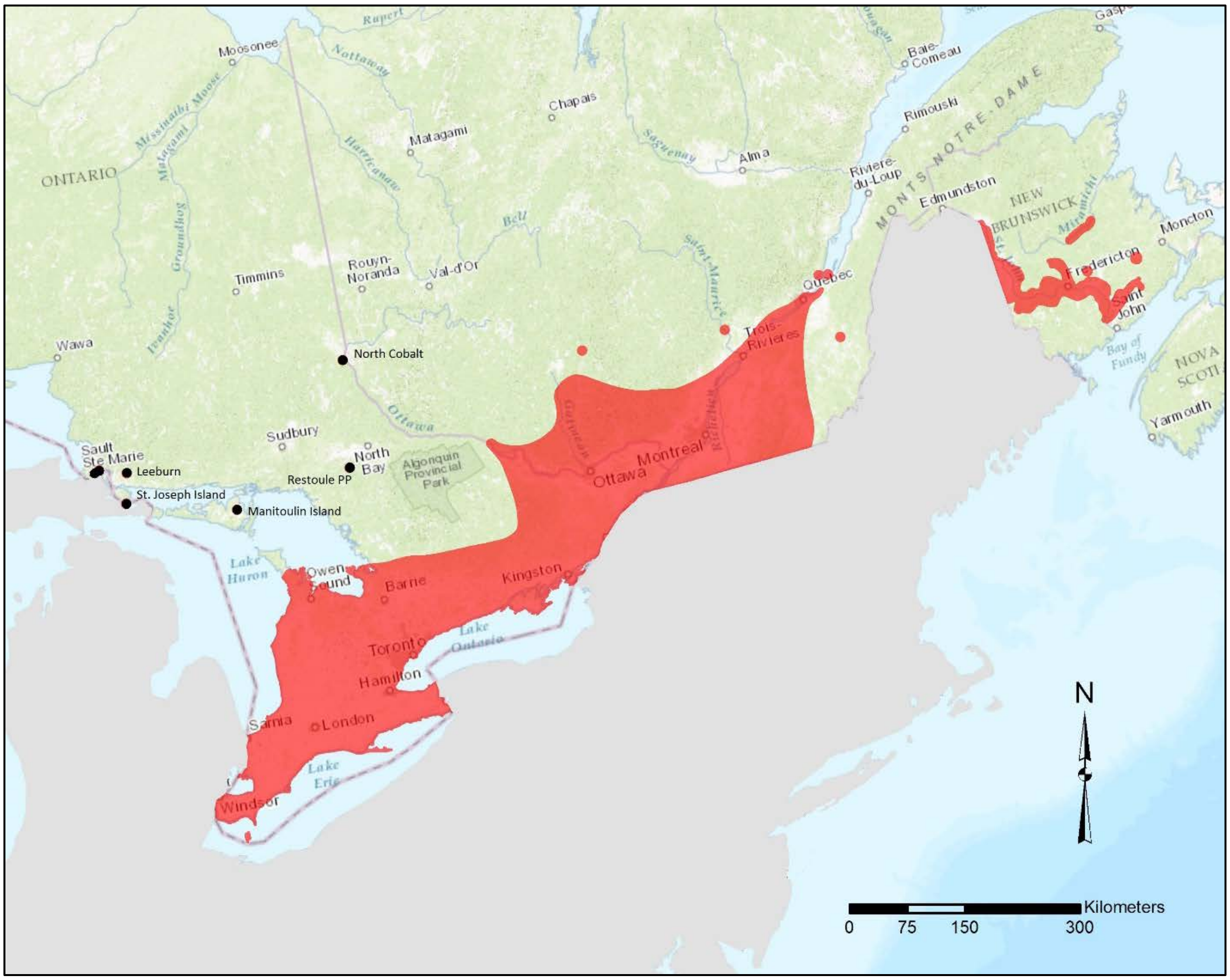

Figure 6. Canadian native range of Butternut (adapted from Farrar 1995; ONHIC 2015; AC CDC 2015; CDPNQ 2015). Black dots in Ontario are probably non-native occurrences (see Canadian Range), although the Sault Ste. Marie, Leeburn, St. Joseph Island and possibly the Manitoulin Island records might be close enough to presumed native range in adjacent Michigan (see Figure 5) that they could be considered as not extra-limital and therefore relevant for status assessment. Basemap from Stamen, based on OpenStreetMap data.

In Ontario (Figure 7), the area in which Butternut is unquestionably native extends as far north as the southern Bruce Peninsula (Bruce County) in the west and Chalk River along the Ottawa River in the east. Scattered additional occurrences are documented further north between Sault Ste. Marie in the west eastward to North Cobalt in the upper Ottawa River watershed in the district of Timiskaming (Farrar 1995; OMNR 2011; ONHIC 2015). All of these occurrences are near human settlement (ONHIC 2015), and most or all likely represent plantings into natural or semi-natural habitat, or establishment in the wild from planted trees (Wilson pers. comm. 2016; see Figure 7). St. Joseph's Island records likely originate with a local nursery that grows Butternut (Meades pers. comm. 2017), but regardless of origin, the Sault Ste. Marie, St. Joseph Island and Leeburn records might be argued to occur within Butternut's natural range based on Reznicek *et al.* (2011) stating that some, if not all, Butternut occurrences in Michigan's Upper Peninsula (immediately across the border from Sault Ste. Marie and St. Joseph Island) appear to involve native trees. Butternut was considered non-native on Manitoulin Island and was noted as commonly planted in Morton and Venn's (1984) *The Flora of Manitoulin Island*.

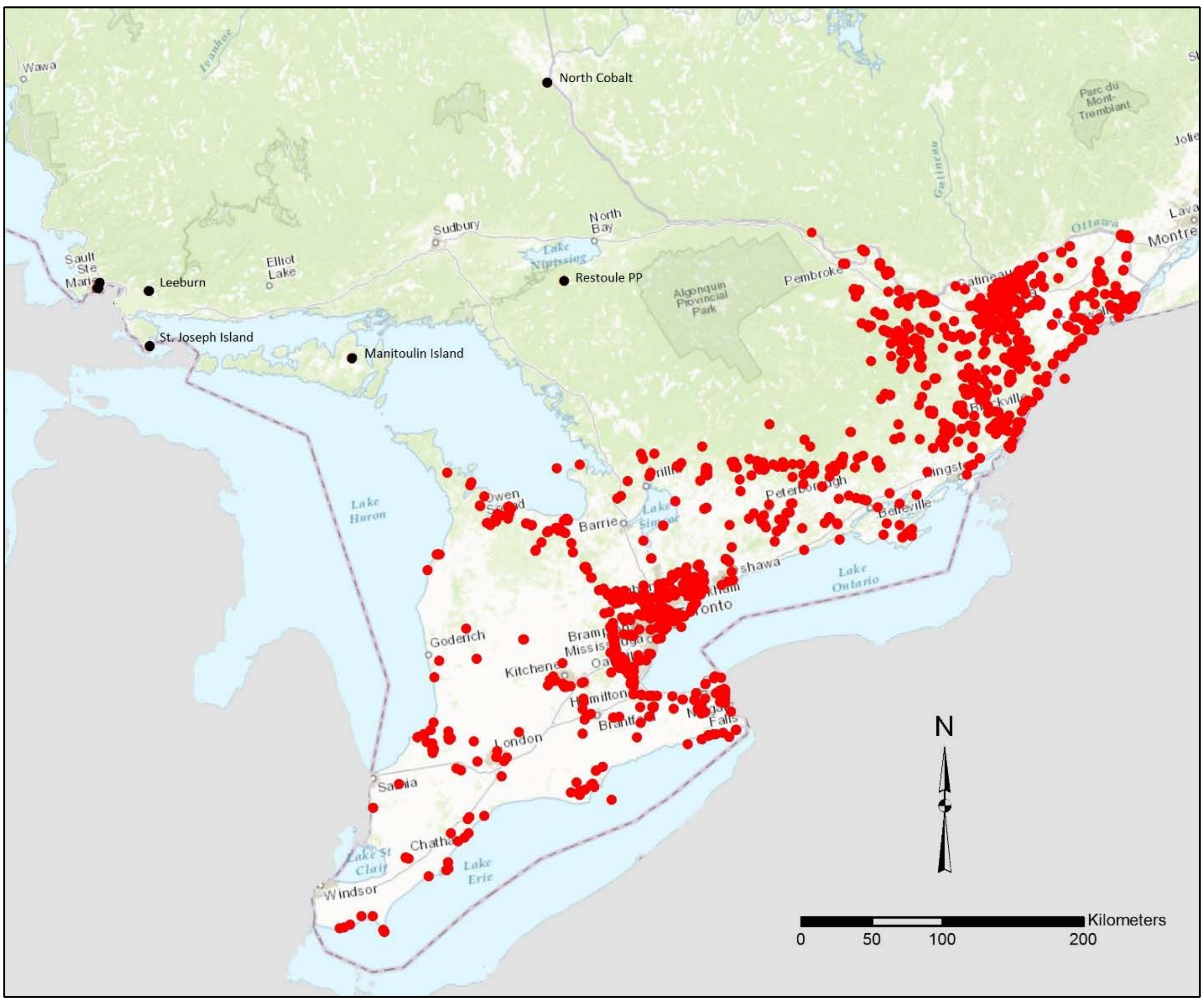

Figure 7. Ontario Butternut observation records compiled in the ONHIC database. The dataset does not contain Ontario Tree Atlas data (see Figure 8). The native origin of the outlying northern occurrences (black dots) is uncertain (see Figure 6, and **Canadian Range**). Basemap from OpenStreetMap, containing data from GeoBase, GeoGratis (Department of Natural Resources Canada), CanVec (Department of Natural Resources Canada), and StatCan (Geography Division, Statistics Canada).

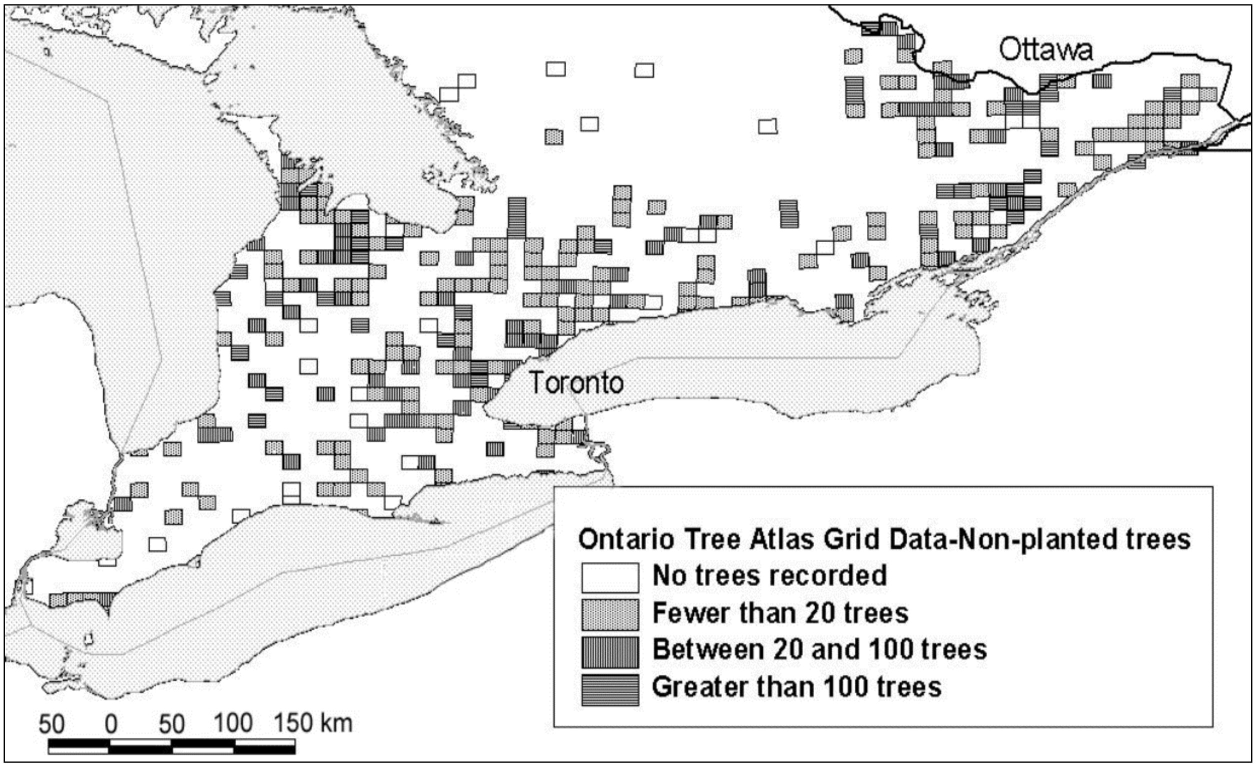

Figure 8. Ontario Tree Atlas data for non-planted Butternut. Tree Atlas volunteers recorded abundance by class for each tree species within an assigned 10 km x 10 km square during the period 1995 to 1999 (from COSEWIC 2003).

In Quebec (Figure 4), the species reaches its northern limit in the northern Rivière des Lièvres watershed (Antoine-Labelle County) and in the city of Québec region, both at roughly 47^{o} latitude (FloraQuebeca 2009; CDPNQ 2015). Distribution of the species in Quebec is, however, strongly concentrated below latitude 45.8^{o} along the Ottawa River, the St. Lawrence River and in the Eastern Townships as far east as the Sherbrooke Region (FloraQuebeca 2009; CDPNQ 2015).

Occurrences in New Brunswick (Atlantic National Ecological Area, COSEWIC 2014) are found primarily along a 300 km section of the Saint John River watershed from Grand Falls in Victoria County to Browns Flats in Kings County (Figure 9; AC CDC 2015). Smaller somewhat isolated subpopulations are also found in the upper Kennebecasis River watershed (Kings County), in the Petitcodiac River watershed (Westmorland County), and a 35 km section of the Southwest Miramichi River from Priceville to Upper Blackville in Northumberland County (AC CDC 2015). There is a single specimen from St. Stephen in southwestern-most New Brunswick along the Maine border (Consortium of Northeastern Herbaria 2016). No other records are known from nearby despite extensive recent searches of suitable habitat along the St. Croix River and elsewhere (AC CDC 2016). This record is assumed to represent either a planted individual or a misidentification of another species of walnut. Several unidentified naturalized saplings of a walnut species (not believed to be Butternut) were found along the St. Croix River during AC CDC fieldwork in 2011 (AC CDC 2016)

Butternut has been introduced as an exotic ornamental in Manitoba, Nova Scotia, and Prince Edward Island, with some establishment outside of cultivation. All reported occurrences in these jurisdictions are outside the species' natural range and are therefore excluded from status assessment as extra-limital introductions (COSEWIC 2010). Figure 6 shows the native range of Butternut in Canada, while figures 4, 7 and 9 show provincial distributions in Quebec, Ontario, and New Brunswick respectively.

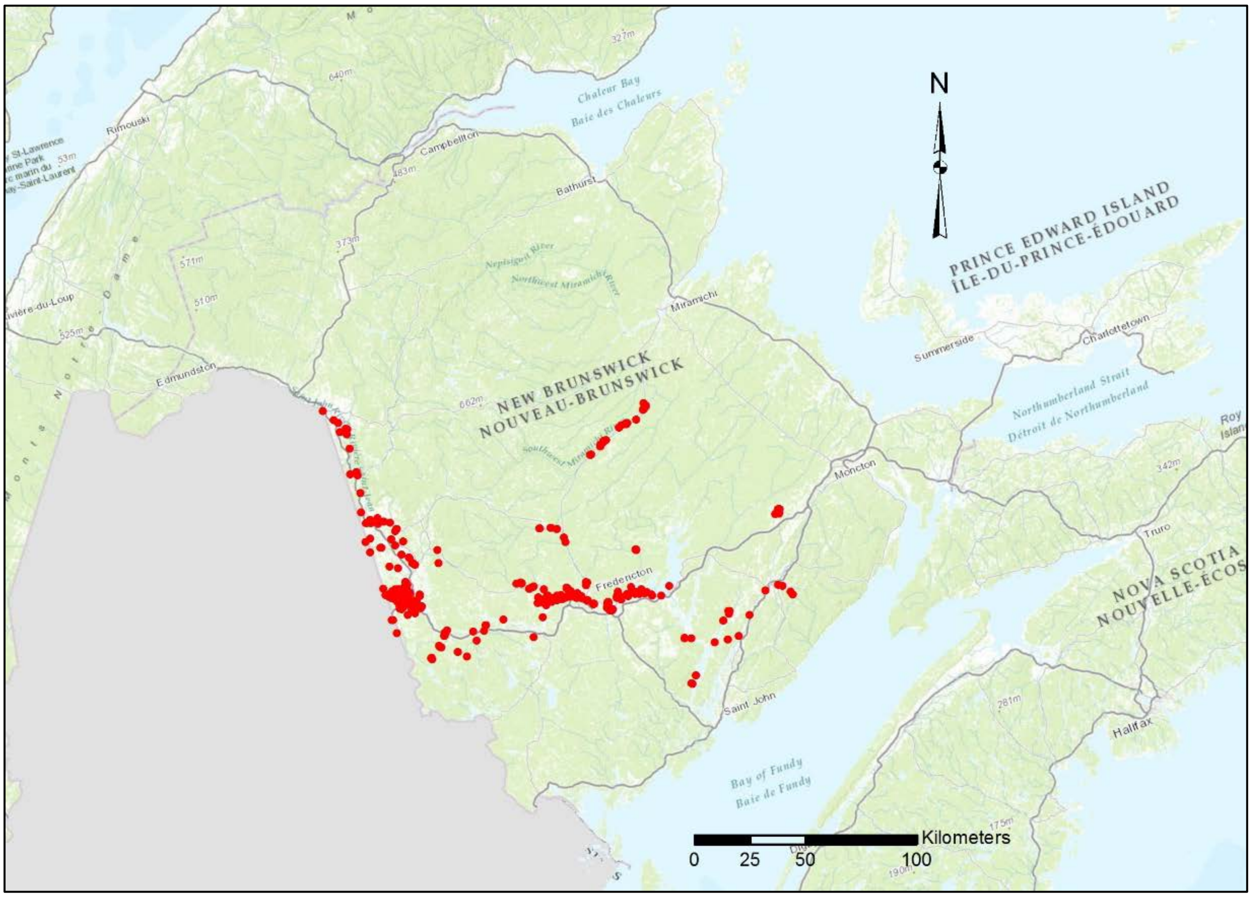

Figure 9. New Brunswick Butternut observation records compiled in the AC CDC (2016) database and documented through Canadian Forest Service fieldwork. Basemap from OpenStreetMap, containing data from GeoBase, GeoGratis (Department of Natural Resources Canada), CanVec (Department of Natural Resources Canada), and StatCan (Geography Division, Statistics Canada).

Extent of Occurrence and Area of Occupancy

Based on data obtained from Ontario Natural Heritage Information Centre (ONHIC), Centre de données sur le patrimoine naturel du Québec (CDPNQ), Atlantic Canada Conservation Data Centre (AC CDC) and Canadian Forest Service (CFS), total extent of occurrence (EOO) is 399,440 km^2 if all observation records are considered and 266,920 km^2 if outlying occurrences (i.e., northern occurrences identified as potentially introduced points in Figure 6) are excluded. The calculated EOO includes a considerable area of unsuitable aquatic habitat.

Index of area of occupancy (IAO) is difficult to quantify because occurrences are far from completely documented and the extent to which formerly occupied 2 km x 2 km grid squares have lost their subpopulations is unclear. The IAO prior to the arrival of Butternut Canker in the Ontario-Quebec area was likely a significant proportion of the 2 x 2 km squares intersected by its core range, which represents roughly 148,000 km^2.

IAO based solely on occurrences available for this status report is 5,684 km^2. This total significantly underestimates current IAO because of incomplete documentation of actual occurrence. The actual current IAO has likely declined fairly significantly from pre-canker levels, especially in regions with limited forest cover, where the number of Butternut trees in many 2 x 2 km grid squares would have been small even prior to Butternut Canker.

HABITAT

Habitat Requirements

Climatic conditions within Butternut's natural range vary significantly, with mean annual temperatures ranging from nearly 18^{o}C in Warren County, Mississippi (NCEI 2015) to slightly over 4^{o}C in Victoria County, New Brunswick (Environment Canada 2015). Frost-free periods within this region range from 105 days in the north to more than 210 in the south (Rink 1990). Butternut is the most winter hardy of the *Juglans* species (Ostry and Pijut 2000). Most of the Butternut's range has an annual precipitation of 800 to 1,200 mm, with averages up to 1,600 to 2,000 mm in the southern Appalachians and as low as 600 to 800 mm at the northwestern limit of its range in Minnesota (CEC 2010). The species occurs up to an elevation of 1,500 m in the Virginias (Clark 1965).

Butternut occurs predominantly in neutral to calcareous soils of pH 5.5 to 8, often in regions with underlying limestone, and is generally absent from acidic regions in Canada. It tends to reach greatest abundance in rich, neutral to calcareous, mesic loams and sandy loams (Schultz 2003; Lupien 2006) in floodplains, streambanks, terraces, hardwood coves and ravine slopes, but can occur in a wide range of other situations (Rink 1990; Ostry *et al.* 1994; Farrar 1995; Ostry and Pijut 2000; Brosi 2010; AC CDC 2015; CDPNQ 2015; ONHIC 2015). Butternut is seldom found on dry, compact and infertile soils (Rink 1990) but can occur on drier rocky soils, particularly those of limestone origin (Rink 1990; Farrar 1995; Ostry and Pijut 2000). In Ontario, there is a notable concentration of records where limestone is present at the soil surface along the Niagara Escarpment and in alvar regions just south of the southern margin of the Canadian Shield (OMNR 2011; ONHIC 2015). In a four year experiment in southern Quebec examining seedling performance in a variety of old field conditions, Butternut growth did not vary significantly by soil type. However, survival was significantly reduced in wetter soils (>30% soil water content) in which the surficial materials were marine sediments (Cogliastro *et al.* 1997). In Canada, however, it is frequently found in seepy, rich hardwood forest sites (Blaney and Mazerolle pers. obs.

1999-2015) that appear relatively moist. Rink (1990) and Brosi (2010) also note its affinity for moist loamy floodplain sites in the United States.

Butternut is a shade-intolerant tree (Rink 1990; St. Jacques *et al.* 1991; Doyon *et al.* 1998). In closed-canopy stands, it must be in the overstory to thrive (Ostry *et al.* 1994, 2003). Seedling establishment, growth and survival to maturity are largely restricted to stand openings, riparian zones and forest edges (Ostry *et al.* 1994; Hoban *et al.* 2012a). It has been called an early successional species (e.g., Rink 1990), and does occur in old field habitats (e.g., ONHIC 2015; AC CDC 2016); however, Brosi (2010) considered it predominantly a species of mature forest gaps and edges and Hoban (2010) found that although upland habitats facilitated more frequent colonization, upland populations were also more frequently extirpated compared to those in riparian forests.

In Canada, tree species most often found occurring in association with Butternut include (in alphabetical order) American Beech (*Fagus grandifolia*), American Elm (*Ulmus americana*), Basswood (*Tilia americana*), Bitternut Hickory (*Carya cordiformis*), Black Cherry (*Prunus serotina*), Bur Oak (*Quercus macrocarpa*), Eastern Hemlock (*Tsuga canadensis*), Hackberry (*Celtis occidentalis*), Northern Red Oak (*Quercus rubra*), Red Maple (*Acer rubrum*), Sugar Maple (*Acer saccharum*), White Ash (*Fraxinus americana*), White Oak (*Quercus alba*) and Yellow Birch (*Betula alleghaniensis*) (Rink 1990; Doyon *et al.* 1998; Ostry and Pijut 2000; Schultz 2003). In Ontario and extreme southwestern Quebec, Butternut also co-occurs with a suite of other deciduous trees of southeastern North America, including several Carolinian Forest species which have very limited Canadian ranges.

Habitat Trends

Total habitat available for Butternut in Canada has declined significantly from pre-European settlement conditions. Forest cover within the Ontario and Quebec range of Butternut, representing >75% of the total Canadian range, is less than 30% compared to about 80% forest cover prior to settlement (National Forest Inventory 2013; but note caveats about unforested and edge habitat use below). The portion of this loss that has occurred since 1881 (within the past three generations) would probably be less than half given that most farming settlement within Butternut's Canadian range had occurred by 1871 (Dominion Bureau of Statistics 1951). In assessing Butternut habitat loss to forest clearance it is important to note that closed canopy mature forest is less suitable for Butternut than more sunlit forest edges, regenerating stands and hedgerows (see **Habitat**). Thus lower intensity farming may have neutral or locally beneficial effects on Butternut numbers even if amount of habitat is reduced. As farming intensifies, these potentially positive effects may be reduced. Since 1881, the best regions for annual crop cultivation, such as southwestern-most Ontario west of London, have seen non-plantation forest cover continue to decline through agricultural conversion (Larson *et al.* 1999; decline from 6.7% forest cover in 1967 to 4.5% in 2014 for Kent County, Bacher 2014), with intensive cultivation and few remaining hedgerows leaving little Butternut habitat. Urbanization has also permanently removed large areas of Butternut habitat, with a high proportion of that having occurred within the last 135 years. Overall, forest cover in southern Ontario and

Quebec increased since the 1920s and 1930s with abandonment of marginal agricultural land (Larson *et al.* 1999; Ministère des Ressources Naturelles 2013). Abandoned agricultural land is only accessible for Butternut if seed sources are nearby because of its slow rate of terrestrial dispersal (<100 m per generation; see **Dispersal and Migration**) but does represent a significant portion of occupied habitat in central and eastern Ontario, especially in rocky areas with limestone close to the surface (Boysen pers. comm. 2016; Brunton pers. comm. 2016).

The majority of the Canadian range of Butternut lies in the most densely populated and heavily industrialized region of Canada (Statistics Canada 2009) between the city of Québec and Windsor. Habitat loss from a wide variety of development continues, especially from urban sprawl and rural housing development (see **Threats** – **Habitat Conversion**). These losses are no longer necessarily compensated for by farmland abandonment elsewhere. For example, Li and Beauchesne (2003) documented a net forest loss of 412 km^2 in four administrative regions (Chaudière-Appalaches, centre-du-Québec, Montérégie and Lanaudière) from 1990 to 1998 and a net loss of 320 km^2 from 1999 to 2002 (a 30% higher rate than in the preceding period). Ongoing small habitat losses could become significant over one or more generations into the future.

The habitat trend for Butternut in New Brunswick is likely a small decline. The ecodistricts forming the majority of Butternut's range in New Brunswick remain strongly forested (> 60%) in comparison to Ontario and Quebec. However, most occurrences are found in the more agricultural and deforested portions of western Carleton and Victoria counties where conversion of forest to cropland (especially for potato cultivation) is still an issue (Blaney and Mazerolle pers. obs. 1999-2015). There is a longer-term provincial trend in New Brunswick of declining agricultural land associated with abandonment of marginal farms (COSEWIC 2003). However, the total area of land on farms in New Brunswick increased 1.8% between 2001 and 2006 (Statistics Canada 2006), then decreased 4.0% between 2006 and 2011 (Statistics Canada 2011). Effects on Butternut are unclear, but its occurrence is concentrated in the highly productive farmlands in the western part of the province that are least likely to be abandoned. Rural residential development is also locally affecting Butternut habitat on the Saint John River, especially near Fredericton where riverfront properties (frequently in areas of high Butternut abundance) are highly valued (Beardmore pers. comm. 2016).

Given Butternut's affinity for river shores and floodplains, the damming of watercourses has clearly caused localized habitat loss in all three provinces. The large number of dams and run-of-the-river generating stations along the Saint Lawrence River (Iroquois, Long Sault, Moses Saunders, Les Cèdres, Beauharnois, Rivière-des-Prairies), Ottawa River (Lac-des-Chats, Hull, Carillon) and many of their tributaries have cumulatively flooded a considerable area of highly suitable habitat for the species in which denser stands likely occurred historically (Butternut is or was a dominant species on some remaining Ottawa River islands, Brunton pers. comm. 2016). In New Brunswick, Butternut occurrences, especially stands in which it is a dominant species, are mainly concentrated along the Saint John River and its tributaries (Blaney and Mazerolle pers. obs. 1999-2015; AC CDC 2015). Two large dams on the Saint John River have flooded extensive ideal

Butternut habitat within the region of its densest occurrence in New Brunswick: Beechwood Dam (constructed 1955, flooding 34 km upstream to the Aroostook River) and Mactaquac Dam (constructed 1968, flooding 82 km to Woodstock).

Butternut Canker may be effectively reducing Butternut habitat because trees become more susceptible to canker with increased canopy closure (Brosi 2010), though recruitment may now be so reduced (Parks *et al.* 2013) and expected future mortality may be so high that this is not demographically significant over the longer term.

BIOLOGY

Life Cycle and Reproduction

Butternut is a relatively short-lived deciduous tree, rarely living more than 80-100 years (Rink 1990; Ostry *et al.* 1994; Ostry and Pijut 2000; Forest Gene Conservation Association 2012). It flowers from April to June. The species is monoecious (separate male and female flowers on the same tree), and wind-pollinated. In spring, male flower catkins emerge from small cone-like axillary buds on the previous year's branches and female flowers emerge on two- to eight-flowered spikes in the axils of new leaves on the current year's shoots (Dirr 1990). Male and female flowers on a given tree usually mature at different times, encouraging out-crossing (Rink 1990; Young and Young 1992; Ostry and Pijut 2000). Butternut is considered to be almost exclusively out-crossing (Young and Young 1992; Ross-Davis *et al.* 2008b). Butternut can hybridize with Japanese Walnut, English Walnut (*Juglans regia*), Manchurian Walnut (*Juglans mandshurica*) and Little Walnut (*Juglans microcarpa*) (Rink 1990; Michler *et al.* 2005; Ross-Davis *et al.* 2008b; Woeste and Pijut 2009). Hybridization with Japanese Walnut is now known to be fairly common across the native range of Butternut (Hoban *et al.* 2009; McLaughlin and Hayden 2012; Beardmore pers. comm. 2015; Rioux pers. comm. 2015). See **Morphological Description** (above), **Threats** (below) and Table 1 for more information on hybridization.

The fruit matures in September and October in the year of pollination. Fruits occur singly or in clusters of two to seven and usually remain on the tree until mid- to late October, after leaf fall (Talalay *et al.* 1984; Rink 1990; Zurbrigg pers. comm. 2017). Although the embryo can remain dormant for two years (OMNR 2000) it usually germinates in the spring following seed fall (Rink 1990). Dormancy can be broken by cold stratification at 1 to 5°C for 90 to 120 days (Brinkman 1974; Young and Young 1992). Seeds reportedly do not survive more than two years in the soil (Woeste *et al.* 2009).

Seed bearing starts around age 20 and peaks at age 30 to 60 (Ostry *et al.* 1994; Ostry and Pijut 2000). For this report, generation time (the average age of reproductive individuals) is thus roughly estimated at the median point within this range, 45 years. Good seed crops occur irregularly (maximum frequency every two to three years) with light crops during intervening years. Low viable seed yields may be caused by insect damage, spring frost or lack of pollination (Rink 1990).

Younger trees and saplings are capable of re-sprouting from stumps (Rink 1990).

Physiology and Adaptability

Butternut tolerates a wide range of climatic conditions, as evidenced by its large latitudinal range. Soil pH appears to be a physiologically limiting factor in Canada, where the species occurs mostly on soils of pH 5.5 to 8 (Schultz 2003; Lupien 2006) and is largely or entirely absent from acidic regions. Butternut is the most cold-tolerant of the North American walnuts and occurs in USDA hardiness zones 3 to 7 (Ostry and Pijut 2000). Its northern and southern range limits are several hundred kilometres north of those of Black Walnut. Although it is frequently found in river floodplains and forested seeps, it is not a wetland species. In a Quebec study of seedling performance in calcareous old field soils of various textures and moisture levels, growth was not significantly affected by soil type but survival was significantly reduced in imperfectly drained sites having soil moisture content of 49% (Cogliastro *et al.* 1997). In a study comparing the physiological tolerances of Butternut, Japanese Walnut, Buartnut (*Juglans* × *bixbyi*) and Black Walnut, Crystal and Jacobs (2014) found that Butternut was negatively affected by flooding but exhibited a relatively high tolerance to drought.

Butternut is an early-successional tree (Rink 1990; St. Jacques *et al.* 1991; Doyon *et al.* 1998). It is fast-growing, particularly as a seedling, and can grow despite considerable lateral competition (Rink 1990; Ostry *et al.* 1994). The species does not tolerate shade and maturing individuals must reach the overstory to thrive (Ostry *et al.* 1994). If source populations remain nearby, the species can benefit from various natural and anthropogenic disturbances that create openings in the forest canopy, including insect pest outbreaks, blow-down and timber harvesting. Fires can also create openings for seedling establishment, although Clark (1965) states that Butternut does not sprout following top-killing fires, and fire disturbance is currently rare in the Canadian range of Butternut.

The nut is considered intolerant of long-term storage and remains viable for three to five years if stored in sealed containers at temperatures just above freezing (USDA 1948). Satisfactory storage can be obtained for at least two years if stored in closed containers at 80% to 90% relative humidity and +5 to 0°C. The nuts cannot tolerate drying to low water contents (e.g., 5% water content) and are sensitive to temperatures below -40°C (Wang *et al.* 1993).

Butternut is commonly and easily propagated by seed and through grafting onto Black Walnut rootstock, which is more readily available (Ostry and Pijut 2000). Vegetative propagation via rooted cuttings is ineffective except possibly on saplings under 12 years old (Pijut and Moore 2002; Pijut 2004; Zurbrigg pers. comm. 2017). Micropropagation through the induction of somatic embryogenesis (Pijut 1993, 1997) and cryopreservation of embryonic axes (Beardmore 1998; Beardmore and Vong 1998) have both been shown to be potentially viable tools for the propagation and long-term preservation of Butternut germplasm.

Dispersal and Migration

No published studies have investigated pollen dispersal potential in Butternut, but the documented dispersal potential of other wind-pollinated temperate tree species suggests that a considerable portion of Butternut pollen may be disseminated over distances exceeding 1 km (Sork and Smouse 2006; Craft and Ashley 2007; and Robichaud 2007, for Black Walnut). Pollen dispersal could therefore potentially allow for genetic exchange to take place between subpopulations separated by several kilometres. However, a parentage analysis carried out by Hoban *et al.* (2012a) showed that the majority of parent to parent distances were less than 100 m and found no signs of cross-pollination occurring over distances greater than 500 m. This suggests that cross-pollination potential over longer distances may be low and that cross-pollination over distances on the order of hundreds of kilometres is unlikely. Subpopulations in New Brunswick are therefore likely to be genetically isolated from those in Quebec and New England.

Due to their considerable weight, nuts typically fall directly beneath the parent tree, where they may be carried further down-slope by gravity. Where Butternut occurs in riparian and floodplain habitats, water flow could represent an important vector for dispersal, as the nut falls while still encased in a buoyant husk (Laricchia *et al.* 2015). During spring freshet and other high-water events, nuts could be carried downstream over considerable distances.

Seed-caching rodents, particularly squirrels, are known to seek out Butternuts and play an important role in dispersal (Ostry *et al.* 2003; Moore 2005; Moore *et al.* 2007; Woeste *et al.* 2009; Hoban *et al.* 2012a). Squirrel caches are typically not more than 40–60 m from the seed source (Ivan and Swihart 2000; Hewitt and Kellman 2002a,b in southern Ontario; Goheen and Swihart 2003; Moore *et al.* 2007), though they have been documented dispersing other species of walnut up to 168 m (Stepanian and Smith 1986; Tamura *et al*. 1999; Tamura and Hiyashi 2008). In Canada, the predominant disperser would be Grey Squirrel, *Sciurus carolinensis,* abundant through most of Butternut's Canadian range but uncommon or absent in parts of the New Brunswick range where it is a relatively recent arrival (Woods 1980). Red Squirrel (*Tamiasciurus hudsonicus*) also co-occurs across Butternut's Canadian range and caches the seeds of both native walnuts (Laricchia *et al.* 2015; Hanrahan 2016) but is uncommon or absent in purely deciduous stands in southernmost Ontario (iNaturalist 2016; Blaney pers. obs. 1989-2015). Eastern Chipmunk (*Tamias striatus*), which occurs commonly throughout the Canadian range of Butternut, may also be important in dispersal, although some references suggest Butternuts are too large to be consumed by the species (Rosell 2001). Fox Squirrel (*Sciurus niger*) is an important disperser in the United States (Laricchia *et al.* 2015), but within Butternut's Canadian range is restricted to Pelee Island in southernmost Ontario (Schneider and Pautler 2009).

Butternuts are probably too large and hard-shelled for most birds, but American Crow (*Corvus brachyrhynchus*) could be a significant disperser. Cristol (2005) found that American Crows dispersed English Walnuts in northern California. About 77% of the nuts transported away from parent trees were cached in surrounding fields, most within 1-2 km of the source but 5% at a distance > 2 km. Crows cached an estimated 2,000 nuts/km^2/year in fields 1-2 km away.

Hoban *et al.* (2012a) found that genetically inferred parent-offspring distances in a regenerating Butternut population indicated limited seed dispersal. All maternal parent-offspring distances were less than 100 m, with most being less than 40 m. Due to its limited seed-dispersal capacity, Butternut rarely colonizes openings not adjacent to seed sources and distances as little as 50 m may represent isolating barriers (Hewitt and Kellman 2002). Stochastic long-distance water-borne seed dispersal events could allow for rescue to take place between subpopulations joined by water flow, but would not allow for rescue to occur in non-riparian environments or across watersheds.

An investigation of chloroplast haplotypes by Laricchia *et al.* (2015) found results consistent with the eastern portion of Butternut's range having been colonized from a single southern refugium, potentially in the vicinity of southern Georgia or Florida. They noted, however, that northward migration rates produced by squirrel dispersal were insufficient to cover the 2,300 km northeastward to New Brunswick in 18–20,000 years. They suggested that Pleistocene megafauna such as mammoths and ground sloths may have been significant in the early recolonization northward to New England, and that First Peoples may have played a significant role in dispersal thereafter, consistent with evidence in Wykoff (1991). Humans also presently act as important long-distance dispersal vectors through movement and cultivation of the species, both within and beyond its natural range.

Interspecific Interactions

As in other *Juglans* species, Butternut exudes the naphthoquinone compound juglone through its root system (Rink 1990; Schultz 2003). This substance is toxic to many other tree species, ornamentals and crop plants and also inhibits the growth of Butternut seedlings (Rietveld 1983; Schultz 2003; see also an extensive listing of species reported as affected or unaffected by *Juglans nigra* in Willis 2000). Allelopathy may play an important role in reducing interspecific competition for soil nutrients and sunlight, though there remains significant uncertainty regarding the significance of *Juglans* allelopathy in natural communities (Willis 2000).

Butternut can represent an important food source for wildlife, especially in areas without other high-quality mast sources (Ostry *et al.* 1994). The highly nutritious nuts are eaten by many animals including mice, squirrels, chipmunks and deer and the developing nuts are consumed by Common Grackles (*Quiscalus quiscula*), (Rink 1990; Ostry *et al.* 2003; Waldron 2003) and likely other birds. Seed caching rodents such as squirrels and chipmunks also act as seed dispersal agents (Ostry *et al.* 2003; Woeste *et al.* 2009; Hoban *et al.* 2012a).

White-tailed Deer (*Odocoileus virginianus*) may impact Butternut regeneration by browsing leaves and twigs and through antler-rubbing (Ostry *et al.* 2003; Woeste *et al.* 2009; Boysen pers. comm. 2015) and Butternut is reported as a favoured deer browse (Van Dersal 1938, as cited in Woeste *et al.* 2009).

Butternut trees support a diverse insect fauna including many specialists of walnut species that occur on few or no other genera (Ostry and Pijut 2000). A few of these (most notably the weevil *Eubulus parochus*, family Curculionidae, and the Butternut Agrilus beetle, *Agrilus juglandis*, family Buprestidae), may be entirely dependent on Butternut (Halik and Bergdahl 2006; Anderson 2008; Paiero *et al.* 2012; Webster pers. comm. 2016). Both these species are known from Ontario, Quebec and New Brunswick. In Wisconsin and Vermont, Katovich and Ostry (1998) identified 87 insect species on Butternut in the orders Coleoptera (beetles), Thysanoptera (thrips), Hemiptera (in the broad sense, true bugs), Diptera (flies), Lepidoptera (moths) and Hymenoptera (sawflies, wasps, ants and bees). Handfield (2011) listed 31 butterfly and moth species that use Butternut in Quebec as a host plant. A few Butternut specialist insects highlighted in the forest or agricultural pathology literature and considered native to Canada are described below.

Butternut Curculio (*Conotrachelus juglandis*) is a weevil (family Curculionidae) occurring throughout the Canadian range of Butternut (Bousquet *et al.* 2013) and is likely important in spreading Butternut Canker (Halik and Bergdahl 2006). Adults and larvae create feeding and oviposition wounds on new shoots and young fruit in the tree crown (Rink 1990; Ostry and Pijut 2000; Halik and Bergdahl 2002) and can cause severe damage to nuts, young stems, petioles and branches (Johnson and Lyon 1988). The Walnut Shoot-borer moth (*Acrobasis demotella*, family Pyralidae) has been considered an important pest species for commercial growers, capable of causing serious damage to both Butternut and Black Walnut in Ontario (Syme and Nystrom 1988). A single larva of this species can kill a shoot or leader and result in a crooked tree (Martinat and Wallner 1980). Walnut Caterpillar (*Datana integerrima*, family Notodontidae), a common species in southern Ontario, southern Quebec and the northeastern U.S. (USDA 1985; Troubridge and Lafontaine 2007), is considered an important defoliator of *Juglans* species (Farris and Appleby 1979). Butternut Wooly Sawfly (*Eriocampa juglandis*, family Tenthredinidae), although not considered a serious pest, can sometimes become locally abundant (Schultz 2003). In Canada, this species is known to occur throughout the native range of Butternut (Smith 1979). Striped Caterpillar (*Datana angusi*, family Notodontidae) and the micro-moth *Gretchena amatana* (family Tortricidae) have also been noted as pest species of minor importance in Ontario (Nystrom and Britnell 1994). *Gretchena concitatricana*, known from Black Walnut (Miller 1987) and documented in Ontario (North American Moth Photographers Group 2015), may also occur on Butternut. Larvae of the fruit fly *Rhagoletis suavis* (family Tephritidae) feed in developing walnut and Butternut husks and can cause significant damage to nuts (Beck 1932). Several other *Rhagoletis* species are known from commercial walnuts (Boyce 1934) and likely also occur on Butternut. The Walnut Aphid (*Chromaphis juglandicola*, family Aphididae), a European species known from Ontario, is an external phloem feeder on leaflets that can cause leaflet curling (Favret and Eades 2015). Leafhoppers (family Cicadellidae) of unknown species are reported to transmit a virus that causes a condition called Hopper Burn (Zurbrigg pers. comm. 2017).

In addition to Butternut Canker there are a number of fungal and bacterial diseases known to affect Butternut. Only those considered to cause significant damage are included here.

Walnut Bunch Disease, believed to be caused by a mycoplasma-like bacterium (Rink 1990), instigates normally dormant axillary and adventitious buds to develop prematurely, causing a “witch’s-broom” of sucker-like shoots and undersized chlorotic leaves on large limbs and trunks (Seliskar 1976; Meador *et al.*1986). This abnormal growth lacks cold-hardiness and suffers winter-kill, and affected branches do not produce normal nut crops (Berry 1973).

Aside from *Ophiognomonia clavigignenti-juglandacearum* (Oc-j), the causal agent of Butternut Canker, the most notable fungal pathogen of Butternut is *Melanconis juglandis*, which often secondarily infects dead or dying portions of trees affected by *Oc-j* (Nicholls *et al.* 1978; Loo *et al.* 2007; see discussion of Butternut Canker under **Threats**). Other fungal cankers noted as significant in young Butternut plantations in Quebec are caused by the genera *Fusarium* and *Phomopsis* (COSEWIC 2003). *Armillaria gallica*, a species of honey mushroom, has been reported as causing root disease on Butternut (McLaughlin 2001). This species favours hardwood hosts and infects and kills stressed trees. Among foliage diseases the most damaging is an anthracnose leaf spot caused by *Marssonina juglandis*, the anamorph or imperfect stage of the ascomycete *Gnomonia leptostyla*. This pathogen reportedly infects and kills young shoots as well as foliage (Black *et al.* 1977; Myren 1991; CFS 1994), in some cases blighting most of the leaf and causing it to fall prematurely (Hepting 1971, as cited in Schultz 2003).

Although they are relatively minor threats, these pathogens and several other minor diseases can accelerate the decline of trees already suffering from Butternut Canker.

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

No fieldwork was carried out specifically for the preparation of this status report. Because Butternut is not a commercially significant lumber species and tends to be a minor component of forest communities, provincial government forest inventories provide limited data. In all, 863 occurrences (1 km separation distance) were compiled for this status report, and the Ontario Tree Atlas (Figure 8; OMNR 2011, not yet digitized) and FGCA have hundreds of additional records, but many more sites remain undocumented. There have been no efforts to systematically assess the abundance of Butternut in Canada.

Abundance

The previous status report (COSEWIC 2003) estimated the Ontario population to be approximately 13,000, stating that this was a very conservative estimate. One of the report’s writers has since noted that the estimate represented only the number of trees on eastern Ontario properties reported to the Forest Gene Conservation Association (a very small fraction of the actual number of occurrences) rather than the total Ontario population (Boysen pers. comm. 2015). ONHIC (2015) has databased 7,000+ Ontario observation records representing 408 element occurrences[2] (Figure 7). Ongoing discovery of new sites clearly shows knowledge of fine-scale distribution to be far from complete (Oldham pers. comm. 2016). The high rate of tree mortality in Ontario populations (40% per decade based on Wilson pers. comm. 2016) makes it very difficult to extrapolate records of mixed age into a current population total.

Population size has never been estimated in Quebec. The CDPNQ does not actively track Butternut occurrences, meaning that efforts to compile all potentially available records have been limited. Its database includes 233 occurrence records for Butternut (Figure 4). Forest plot inventories carried out by the Ministère des Resources Naturelles du Québec have detected the species in 378 plots in southern Quebec, 39 of which had Butternut as a dominant or co-dominant species (>25% canopy cover or basal area). The extent of duplication between CDPNQ data and forest inventory plots is unknown in the province.

The current population of mature trees in Ontario and Quebec may still be in the tens of thousands to 100,000+ (Brunton pers. comm. 2016; based primarily on high abundance observed in the Ottawa region, which exceeds that found by the Forest Gene Conservation Association (FGCA) in other regions in Ontario; Boysen pers. comm. 2016), but much more systematic work would be required to produce a more precise population estimate.

No recent New Brunswick abundance estimates are available but provincial population size was estimated in the previous status report (COSEWIC 2003), for which experienced New Brunswick Department of Natural Resources (NB DNR) field staff identified roughly 370 discrete stands in 50 sites and estimated numbers of mature trees by site in exponential categories: 1-10 (11 sites), 11-100 (23 sites), 101-1,000 (10 sites), and 1,000+ (6 sites). This totalled between 7,000 and 18,000 mature trees (rounded to nearest thousand, and assuming the six sites of 1,000+ had exactly 1,000 trees). This process would have missed large numbers of trees in isolated private woodlots in Carleton and Victoria counties and smaller numbers elsewhere, in addition to underestimating any sites actually over 1,000 trees. Whatever the 2003 New Brunswick population, it is clearly now reduced. In the Saint John River valley, where most New Brunswick Butternut occurs, dead trees are almost as common as living ones (Blaney and Mazerolle pers. obs. 1999-2015), almost all living trees are visibly unhealthy, and recruitment is likely significantly depressed as in the remainder of the range (Hoban *et al.* 2012a; Boraks and Broders 2014; Wilson pers. comm. 2016). Extensive field observation suggests that the current population of mature trees in New Brunswick may still be in the high thousands to 10,000+ (Blaney and Mazerolle pers. obs. 1999-2015; Beardmore pers. comm. 2016), but much more systematic work would be required to produce a precise population estimate.

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[2] In theory, element occurrences are sites supporting a subpopulation that could contribute to the survival or persistence of the species, though in practice for this species they simply represent sites with at least one living Butternut at the time of observation, separated from other occurrences by at least 1 km (Oldham pers. comm. 2016). Ontario element occurrences include 346 ranked as Verified Extant (observed in past 20 years, but not necessarily actually still extant because of canker mortality), 61 ranked as Historical (where the species has not been observed in over 20 years) and one considered Extirpated. Roughly 44% of observation records, however, lack any indications of abundance, tree age or tree health.

Fluctuations and Trends

In the absence of disease, Butternut matures around 20 years of age in good growing conditions and has a life expectancy of 70-100 years (Ostry 1998; Forest Gene Conservation Association 2012). As a long-lived organism with a generation time estimated at 45 years, it would not exhibit significant fluctuations in total population size across the Canadian range.

Butternut Canker has caused dramatic declines in the global Butternut population and is the foremost threat to the survival of the species (see **Threats**). The disease has been in the United States somewhat longer than in Canada and its progression there can inform what can be expected in Canada in the coming 20 years. Rates of Butternut Canker infection are near 100% in the United States (Schultz 2003 as cited in LaBonte *et al.* 2015). Total mortality in the United States is not well quantified but USDA Forest Service (1995) estimated 77% of Butternut trees in the southeast were dead by 1995, and mortality in the United States since that time has been substantial (e.g., 60% mortality from 2001 to 2012 in a Wisconsin site initially hoped to have genetically resistant individuals, LaBonte *et al.* 2015). Michigan is believed to have lost 90+% of individuals and Wisconsin had lost 80+% of individuals by 2004 (Ostry, in Freedman 2016; Cummings-Carlson and Guthmiller 1993; Cummings-Carlson *et al*. 2004).

In Ontario and Quebec, the species has also suffered dramatic losses. Cumulative mortality is probably now well above 50%. Mortality in 1992 was already 27% in the OMNRF Cambridge District (southwestern Ontario), and although mortality was not found at that time in eastern Ontario, infection rates there were already 90% (CFS Forest Insect and Disease Survey unit data, as cited in COSEWIC 2003). Very roughly estimating ongoing mortality since 1992 based on the 5.43% annualized rate from 2008 to 2014-15 measured by Wilson pers. comm. (2016; see **Threats** – **Butternut Canker**) would translate to a 93.2% reduction from pre-canker levels in Cambridge District and a 77% reduction in eastern Ontario. The rate of infection in surviving trees in Ontario now appears near 100%, and mortality continues to proceed rapidly. Wilson pers. comm. (2016) found 99.7% infection in 1,221 trees examined in 60 plots across southern Ontario, and recorded 38% mortality between 2008 and 2014-2015. Seedling establishment and survival to maturity is also reduced (only three plots out of 60 with any seedlings or saplings in 2014-2015 and almost no recruitment into reproductive age classes from 2008 to 2014-2015; Wilson pers. comm. 2016, but see discussion in **Threats** – **Butternut Canker**). Canadian recruitment is otherwise not well documented, but low recruitment rates would be expected in Canada based on an extensive demographic study that showed recruitment essentially ended in Great Smoky Mountains National Park (Kentucky and Tennessee) in 1980 at or near the time of Butternut Canker's arrival (Parks *et al.* 2013). Quebec data paints a similar overall demographic picture to Ontario, with 80 to 95% of trees infected and extensive mortality observed, though not generally well quantified (Blais 2011; Tanguay 2011; Nadeau-Thibodeau 2015b; Rioux pers. comm. 2015).

Disease progression is less advanced in New Brunswick (70% infection in 403 trees examined in 2013 to 2015, Beardmore pers. comm. 2016) but total canker mortality may already be in the range of 20-50% and is increasing significantly, with dead or nearly dead trees common and the majority of mature trees exhibiting significant crown die-back presumed to be associated with canker infection (Blaney and Mazerolle pers. obs. 1999-2015; see **Threats**).

Diseased trees are often killed in the span of a few years, but larger trees (which are not girdled as rapidly by cankers) can sometimes live as long as 30 years (Ostry *et al.* 1994). Cankers can be aged by growth rings, and ages of 20+ years are known (CFS data cited in COSEWIC 2003). Disease tolerance and survival has been associated with more open habitats (Parks *et al.* 2013) and with drier, upland habitats on thin soils (LaBonte *et al.* 2015), though Wilson (pers. comm. 2016) did not observe this association in a study of 1,221 trees in 60 plots in southern Ontario. Putatively disease-tolerant trees are only 1-5% of the current population (Boysen pers. comm. 2015; Rioux pers. comm. 2015), some of which may represent hybrids with non-native species that are questionably countable as Butternut by COSEWIC standards (Michler *et al.* 2005; Hoban *et al.* 2009, 2012a; McCleary *et al.* 2009; COSEWIC 2010; Zhao and Woeste 2010; Wilson pers. comm. 2016). Efforts to find resistant trees have yet to produce strongly resistant cultivars. For example, although Ostry and Moore (2008) found some genetic basis for canker resistance, LaBonte *et al.* (2015) found that there was little genetic basis for resistance in a formerly large Wisconsin subpopulation in which resistance has been investigated since 2001. Barring identification and propagation of resistant genotypes, rates of infection and mortality documented in Canada (especially via Ontario monitoring plot data, Wilson pers. comm. 2016), suggest that current numbers will follow the trajectory observed in the United States and decline further by significantly more than 50% within one generation (45 years), and that Butternut could be at or near to extinction within three generations (135 years). The extensive population declines that have already occurred make projected losses relative to pre-canker populations significantly higher than the estimates above.

Population losses from Butternut Canker are on top of population reductions resulting from habitat conversion in the past three generations (135 years). As noted in **Habitat Trends**, forest cover will not perfectly correlate with Butternut population because some landscape clearance could increase populations, and because much of current forest cover is regenerated from formerly cleared areas that differ in tree species composition compared to primary forest (Flinn and Marks 2007), and may lack poorly dispersed tree species like Butternut (which has a terrestrial dispersal rate estimated at under 100 m per generation, see **Dispersal and Migration**). However, total population reductions in Ontario and Quebec prior to Butternut Canker as compared to pre-settlement levels (going back further than 135 years) can be roughly estimated by loss of forest cover. Forest cover has been reduced from more than 80% to about 37% within Butternut range (Butt *et al.* 2005, see **Threats**). The portion of this loss that has occurred since 1881 (within the past three generations) would probably be less than half given that most farming settlement within Butternut's Canadian range had occurred by 1871 (Dominion Bureau of Statistics 1951). The many hydroelectric dams on river and stream systems have likely been a fairly significant additional factor causing population reductions in the past 135 years because they tend to affect the riparian sites with the densest Butternut populations (see **Habitat Trends**). Pre-canker losses to forest clearance are substantial in New Brunswick as well, but are likely somewhat less than in Ontario and Quebec because of less intensive agriculture and settlement.

Rescue Effect

Water-borne dispersal might allow for movement of seeds between the United States and Canada across the lower Great Lakes and the Saint Lawrence River in Ontario. Current-borne seeds would be especially likely to enter Canada across the Quebec border along major rivers and streams in the Lake Champlain – Richelieu River and Saint-François River watersheds. River transport of seeds could also occur very locally via watercourses flowing into western New Brunswick from Maine (Meduxnekeag River, Presque Isle Stream and several smaller brooks), though the population in eastern Maine is believed to be much smaller than that in New Brunswick (Cameron pers. comm. 2015). In non-riparian habitats, the seeds of Butternut are mainly dispersed by small seed-caching rodents, which typically do not carry them over distances greater than 100 m (see **Dispersal and Migration**). Animal-mediated international dispersal would be possible in Quebec and New Brunswick, but of limited occurrence in Ontario because the international border is almost entirely water within Butternut range. The value of seed dispersal in rescuing the Canadian population would be limited because there is no evidence of greater canker resistance in adjacent United States populations.

Documented pollen dispersal potential of other temperate wind-pollinated tree species suggests that Butternut pollen may commonly travel over distances greater than 1 km (Sork and Smouse 2006; Craft and Ashley 2007). This would allow for genetic exchange (i.e., a genetic rescue effect) to occur between populations in the U.S. and those in southern Ontario and southern Quebec, but this would be of significance primarily if it were to confer greater resistance to Butternut Canker and there is no evidence of increased resistance in the adjacent United States population.

Deliberate human dispersal from the United States is also possible as there is a community of tree nut enthusiasts, in addition to general horticulturalists, who could transport seeds across the border (Wilson pers. comm. 2017).

THREATS AND LIMITING FACTORS

Threats

Direct threats to Butternut assessed in this report are organized and evaluated based on the IUCN-CMP (World Conservation Union-Conservation Measures Partnership) unified threats classification system (Master *et al.* 2009). Threats are defined as the proximate activities or processes that directly and negatively affect the Butternut population. Results on the impact, scope, severity, and timing of threats are presented in tabular form in Appendix 1. The overall calculated and assigned threat impact is Very High for Butternut.

Narrative descriptions of the threats are provided below in the general order of highest to lowest overall impact threats.

Invasive Non-native Pathogen: Butternut Canker Fungus (IUCN Threat 8.1)

The foremost threat to Butternut is Butternut Canker, a lethal fungal disease caused by *Ophiognomonia clavigignenti-juglandacearum* (Broders and Boland 2011). A thorough review of Butternut Canker across the North American range of Butternut is given below, but the most valuable data for purposes of assessment are presented first.

In 2008, Richard Wilson, Forest Program Pathologist, Ontario Ministry of Natural Resources and Forestry (pers. comm. 2016) developed 60 monitoring sites on public lands in a wide variety of habitats (mature upland forest, old field forest, riparian forest, open parkland) across the southern Ontario range of Butternut, in accordance with the Canadian Butternut Monitoring Strategy protocol. Each plot included a variably sized but fairly extensive area, generally with a minimum of 25 Butternut trees. Plots were resampled in 2008 and 2014-2015 and over those six to seven years, there was 38% mortality of mature trees. Of the 1,221 monitored trees in the plots in 2008, by 2014-2015 only one large tree and four small trees of 3 cm to 11 cm diameter retained vigour scores of 1 (meaning no visible evidence of disease; Millers *et al.* 1991). The single large tree was subsequently genetically confirmed as a Butternut × Japanese Walnut hybrid. Richard Wilson reports a greater frequency of trees having better vigour scores in the Ottawa River Valley, but major declines in vigour in that region and throughout Ontario between 2008 and 2014-2015. Contrary to observations elsewhere suggesting open-grown trees were more resistant to canker, there was little pattern in mortality by habitat, with mortality frequent in both highly competitive forest habitat and fully open parkland. Wilson's study sites also showed very little regeneration, with saplings and seedlings observed in only 14 sites in 2008 and three plots in 2014-2015 and no evidence of significant recruitment into reproductive size classes. Assuming that recruitment to maturity is minimal or no longer occurring (see **Fluctuations and Trends**), and the rate of decline documented by Wilson (38% over 7 years, or 5.43% annually) continued, there would be 91% decline from the initial population within one generation (45 years) and 100% decline by year 84, well short of three generations (135 years). Documented rates of infection in Quebec are between 80+% (Blais 2011) and 95% (of 163 individuals in the Eastern Townships, Tanguay 2011), and are slightly lower in New Brunswick (70% of 403 trees in 2013 to 2015, Beardmore pers. comm. 2016), presumably because of the disease's later arrival there. There is no evidence to suggest that rates of decline and ultimate loss in Quebec and New Brunswick are likely to be less than those documented in Ontario and elsewhere in Butternut's range outlined below.

Based primarily on field observations that have yielded records of 14,000 trees on 500 sites in eastern Ontario (Renfrew, Lanark, Leeds and Grenville counties to the Quebec border), the FGCA (Boysen pers. comm. 2016; Fleguel pers. comm. 2017) notes the following, which may temper some conclusions or extrapolations above:

- Throughout southern Ontario some individual trees remain vigorous though diseased, despite steady decline of other trees in the same population. This may be the result of genetic tolerance to the canker, micro-site effects, minimal stresses (Butternut Curculio, drought, shading) or a combination of these factors. Signs of canker tolerance include: trees callusing over cankers or other wounds; trees with healthy canopy but a cankered bole; or single healthy trees surrounded by heavily cankered trees.

- Butternut regeneration in eastern Ontario is relatively uncommon, but in some situations, considerable regeneration (e.g., 252 seedlings and saplings less than 9 cm DBH on a 5 ha site) has been observed. Recruitment into reproductive sizes on these sites has not been evaluated.

- Landowner education, conservation and intervention to provide the conditions for regeneration could result in persistence of an Ontario Butternut population beyond 84 years, the time of extirpation roughly extrapolated above from observed mortality rates.

Significant disease-caused damage in Butternut was first reported in New York in the early 1920s (Graves 1919, 1923) and initially attributed to the fungus *Melanconis juglandis* (Graves 1923). It is now believed that these early reports of die-back and mortality in Butternut may have been the first documented cases of what came to be called Butternut Canker (Broders *et al.* 2012, 2015). The first reports recognizing Butternut Canker came from Wisconsin in 1967 (Renlund 1971), although the cause was not fully understood until extensive research by Nair *et al.* (1979), who successfully isolated the fungus in pure culture and described it as a new taxon, *Sirococcus clavigignenti-juglandacearum*. Later phylogenetic study determined that the fungus is a member of the genus *Ophiognomonia* and not *Sirococcus*, and it was subsequently reclassified as *Ophiognomonia clavigignenti-juglandacearum* (henceforth referred to as *Oc-j*) (Broders and Boland 2011).

Although the origin of *Oc-j* is not clear and the fungus is not known from outside North America, its sudden appearance, high level of virulence and rapid spread suggest that it was most likely introduced (Furnier *et al.* 1999; Woeste *et al.* 2009). The sexual stage of the fungus is unknown (Nair *et al.* 1979). Low genetic variability observed throughout the range of the fungus in North America led to suggestions that its presence stemmed from a single introduction event (Furnier *et al.* 1999), but more extensive investigation by Broders *et al.* (2012) found three genetically distinct groups, indicating that there were likely at least three independent introduction or emergence events. Broders *et al.* (2012) suggest that *Oc-j* is either an exotic fungus introduced on horticultural plant species such as the closely related Japanese Walnut or on foreign wood products, or that *Oc-j* is a minor native pathogen of a different North American species that has made a host jump.

The Butternut Canker affects trees of all ages, killing both the seedlings and mature trees, regardless of soil type (Nair *et al.* 1979; Ostry and Pijut 2000; Ostry and Woeste 2004). Hyphal pegs created by the fungus rupture the outer bark of infected trees, exposing asexual fruiting bodies which release masses of conidia (asexual spores) throughout the growing season during times of high relative humidity or rainfall (Tisserat and Kuntz 1983). Extruded spore masses are initially bound in mucus and eventually liberated by flowing water or rain drop impact (Nicholls 1979; Tisserat and Kuntz 1982; Cree 1995). Young cankers caused by the disease are typically inky-black, whitish-margined, and elongated-oval in shape (Nicholls *et al.* 1978). These typically originate at leaf scars, buds, lenticels, and naturally occurring or insect-caused openings in the bark (Nicholls *et al.* 1978). Branch cankers usually appear first in the upper or lower crown (Nicholls et al 1978; Tisserat and Kuntz 1984; Ostry and Pijut 2000). Large numbers of conidia are subsequently carried downward by water flow during rainfall events, allowing spores to lodge in bark openings along the tree trunk and on exposed roots (Tisserat and Kuntz 1983). The fungus initially affects the outer bark, rapidly causing the disintegration of bark cells and invading underlying wood where it eventually kills the vascular cambium (Kuntz *et al.* 1979; Ostry *et al.* 1994; Schultz 2003). Older branch, stem and root cankers are perennial, often covered by shredded bark and bordered by several callus layers (Kuntz *et al.* 1979; Ostry *et al.* 1994).

Although saplings are often quickly killed, mature trees may survive many years before succumbing to the disease due to severe crown die-back and gradual girdling from coalescing stem cankers (Kuntz *et al.* 1979; Ostry 1997a; Schultz 2003). Any sprouts developed from heavily infected trees are also infected and die within a few years (Ostry *et al.* 1994).

Spores of *Oc-j* are disseminated by wind, rain splash and as aerosols during rainfalls, remaining viable in air for at least 8 hours during weather conditions of cool temperatures and overcast skies (Tisserat and Kuntz 1983). In an airborne state, spores could be swept up above the tree canopy by air movement and dispersed over distances of 40 km or more (Tisserat and Kuntz 1983).

Although it is believed that insects act as vectors in long-distance dispersal of the pathogen, the extent of this role is not entirely understood (Halik and Bergdahl 2002; Stewart *et al.* 2004; Broders *et al.* 2015). Sampling in Vermont and Wisconsin identified 87 different insect species on Butternut, 57 of which were collected with some frequency and six of which (all beetles) were collected under the bark of diseased trees and carried the fungus (Katovich and Ostry 1998). In Vermont, Halik and Bergdahl (2002) found at least 17 species of beetles in eight families that carried *Oc-j* conidia. They also found that six to eleven percent of Butternut Curculio individuals carried the fungus. This may be especially significant because the Butternut Curculio creates feeding and oviposition wounds on Butternut shoots (Halik and Bergdahl 2002). Handfield (2011) lists 31 butterfly and moth species in Quebec that use Butternut as a host plant, all of which could also act as vectors. Insects may transport conidia via feeding, ovipositing, overwintering underneath the bark of dead or dying branches, or by movement between fallen infected branches and branches in the canopy (Halik and Bergdahl 2002; Stewart *et al.* 2004; Broders *et al.* 2015). Birds could also act as long-distance vectors between isolated subpopulations (Nicholls 1979), as could humans through harvesting and movement of lumber and firewood (Ostry and Woeste 2004).

The fungus occurs inside seeds, and seedlings emerging from infected seeds quickly develop cankers and die (Orchard 1984). The ability of the pathogen to persist for extended periods of time in infected nut-meats may partially explain very limited Butternut regeneration in some areas (Nair 1999) and could be a factor in long-distance dispersal of *Oc-j* (Schultz 2003).

Oc-j can survive saprophytically on dead trees and successfully sporulate for at least 20 months (Tisserat and Kuntz 1984). Dead and dying trees, particular heavily-cankered ones, may therefore act as major sources of conidia and significantly contribute to spreading the disease within a population.

Alternative host species may play an important role in the persistence and spread of the disease (Broders *et al.* 2015). Although Butternut seems to be the only species significantly affected by the pathogen, other species in the genus *Juglans* are susceptible to infection, including Black Walnut, English Walnut, Japanese Walnut, Heartnut (*J. ailantifolia* var. *cordiformis*) and hybrids between Heartnut and Butternut (*J.* x *bixbyi*) (Innes 1997; Orchard *et al.* 1982; Ostry 1997b; Ostry and Moore 2007; Broders and Boland 2011). Inoculations of greenhouse-grown saplings showed the fungus was able to colonize other hardwoods, most of which co-occur with Butternut in Canada (*): Pecan (*Carya illinoensis*), Shagbark Hickory* (*Carya ovata*), Bitternut Hickory*, American Hazel* (*Corylus americana*), Beaked Hazel* (*Corylus cornuta*), American Chestnut* (*Castanea dentata*), Black Cherry*, Northern Red Oak*, Bur Oak*, Black Oak* (*Q. velutina*) and White Oak* (Ostry 1998b; Ostry and Moore 2007). These results indicate that various other forest species may serve as reservoirs of the pathogen and raise the possibility that *Oc-j* originated as a pathogen of a genus other than *Juglans* (Michler *et al.* 2005). Throughout its range, Butternut is often found in stands containing one or several of the potential other hosts identified above.

No fully canker-resistant Butternuts have ever been confirmed. There is some evidence suggesting genetic tolerance may be present at very low frequency in natural populations (Ostry *et al.* 2003; Ostry and Woeste 2004; Michler *et al.* 2005; Ostry and Moore 2008; Forest Gene Conservation Association 2012; Woeste *et al.* 2009; Nadeau-Thibodeau 2015a). Work to identify tolerant or resistant Butternut for use in research and population recovery has been carried out in the United States and Canada (above authors, Beardmore pers. comm. 2015; Rioux pers. comm. 2015). Phenotypically tolerant or resistant trees growing in close proximity to heavily-cankered individuals have been known to remain disease-free for 10-20 years (Ostry and Woeste 2004; McKenna *et al.* 2011), but this putative resistance is rare and apparently overcome by artificial inoculation, suggesting that stem inoculations bypass an important resistance mechanism (McKenna *et al.* 2011). Nearly all individuals initially identified as potentially resistant eventually begin exhibiting signs of the disease after prolonged exposure to the pathogen (Rioux pers. comm. 2015). Moreover, genetic screening using DNA-based markers shows that individuals identified in situ as being potentially resistant commonly have some degree of hybridity with Japanese Walnut (Michler *et al.* 2005; Hoban *et al.* 2009; McCleary *et al.* 2009; Woeste *et al.* 2009; Zhao and Woeste 2010; McKenna *et al.* 2011). Hybrids do not necessarily have long-term tolerance, as Butternut Canker mortality has also been observed in confirmed wild hybrids in Ontario (Wilson pers. comm. 2016).

Following the initial 1967 report of the disease (Renlund 1971), *Oc-j* was documented and/or spread throughout the entire range of Butternut in North America (Ostry 1997a; Ostry and Woeste 2004). The rate of spread of this epidemic over the entire range of the host was faster than other lethal diseases of eastern North American hardwood forest species (Broders *et al.* 2015). *Oc-j* has devastated Butternut throughout its range, causing widespread declines of over 80%, widespread local extinctions, and threatening the survival of Butternut as a viable naturally occurring species (Fleguel 1996; Ostry 1998; Ostry *et al.* 2003; Schultz 2003; Bergdahl and Bergdahl 2011). Mortality will likely rise significantly, as nearly all remaining trees are affected by the disease (Bergdahl and Bergdahl 2011). Regeneration is also significantly hampered in infected populations, as seed production is greatly reduced in heavily infected trees and the seedlings that these trees produce often quickly succumb to the disease (Ostry and Pijut 2000; Ostry and Woeste 2004). For example, seedlings were observed in only three of 60 plots (with sites selected in 2008 based on having roughly 25 trees) from throughout Butternut range in Ontario during 2014-2015 (Wilson pers. comm. 2016) and large-scale demographic studies in the United States show very little recruitment into reproductive age classes has occurred since Butternut Canker became widespread (Parks *et al.* 2013; Boraks and Broders 2014). FGCA reports seedlings as being somewhat more frequent than suggested by Wilson (Boysen pers. comm. 2016), but the extent to which these are maturing into reproductive individuals is unclear.

Additional details on the pathogenesis of Butternut Canker and diagnosis of the disease can be found in Kuntz *et al.* (1979), Nair *et al.* (1979), Tisserat and Kuntz (1983), Tisserat and Kuntz (1984), Ostry *et al.* (1994), Woeste *et al.* (2009), Broders and Boland (2010, 2011) and Broders *et al.* (2015).

In Ontario, Butternut Canker was first identified in 1991 by the Forest Insect and Disease Survey (FIDS) unit of CFS, but 1992 FIDS surveys found cankers in the Cambridge area that were 20+ years old indicating that it had been present since 1972 or slightly earlier (Davis *et al.* 1992; data cited in COSEWIC 2003). In 1992, the FIDS unit found the canker at 22 of 30 sites sampled in southwestern Ontario. At that time, whole-tree mortality was most evident in the Ontario Ministry of Natural Resources' Cambridge District, where 27% of the trees surveyed had already been killed by the disease. Although there was no whole-tree mortality recorded in the eastern half of the province in 1992, greater than 90% of the trees examined in that region were found to be infected. Given the annualized mortality rates of Ontario Butternuts documented by Wilson (pers. comm. 2016), many or perhaps the majority of the Ontario trees found in 1992 are likely now dead (5.43% compounded annually from 1992 to 2016 would give 77% decline, though actual rates of decline are unclear over that period). At present, the disease is found throughout the entire native range of Butternut in Ontario. Butternut monitoring plots across southern Ontario found a 99.7% infection rate in 1,221 trees in 2014-2015 (Wilson pers. comm. 2016). However, Butternut Health Assessments (part of an Ontario provincial Species at Risk permitting process), indicate that a certain percentage of trees either do not have Butternut Canker or are showing some level of resistance to the disease. Between Aug 2013 and Jan 2017, within 127 registrations, qualified Butternut Health Assessors identified 384 category 2 trees (i.e. trees that do not have Butternut Canker or the disease is not advanced).

In Quebec, *Oc-j* was first detected in 1990, where it was observed in natural forest near Fort-Coulonge and at Waltham in the Ottawa River Valley (Innes and Rainville 1996). In 1994, the disease was detected in natural forest along the lower Ottawa Valley at Fassett, near Montréal at Deux-Montagnes and in the Eastern Townships at Frelighsburg, Glen-Sutton, Ascot Corner and Sainte-Cécile de Milton (Innes and Rainville 1996; Nadeau-Thibodeau 2015a). The following year, Innes and Rainville (1996) also report the presence of *Oc-j* on diseased Butternut and Black Walnut at nurseries far removed from any known occurrences, at Duchesnay (northwest of the city of Québec) and Berthierville (Lanaudière Region). In an effort to conserve healthy specimens and genetic diversity for use in recovery efforts, the Ministère des Forêts, de la Faune et des Parcs worked with the CFS in 1996 to establish four Butternut plantations inside and outside of the natural range of the species (Nadeau-Thibodeau 2015a). Within a few years, the pathogen was detected within these plantations and the project was abandoned (Bouchard *et al.* 2010). In 2001, screening from the Ministère de la Faune, des Forêts et des Parcs found that *Oc-j* had infected thousands of Black Walnut trees in a nursery at Berthier (Ministère des Resources Naturelles 2002). During a two-year survey and monitoring effort carried out in 2008 and 2009, canker mortality was found at all 17 sampling sites, located throughout the natural range of Butternut in Quebec (Innes and Nadeau-Thibodeau 2009; Bouchard *et al.* 2010; Nadeau-Thibodeau 2015a).

Detailed surveys recently carried out at nine sites in the Centre du Québec Region found that canker was prevalent at all sites and that average percentage of diseased trees across all sites exceeded 80% (Blais 2011). Similarly, inventories in the Lac Saint-François and Cap Tourmente National Wildlife Areas, near Cornwall and the city of Québec respectively, have shown that over 80% of trees are affected (Nadeau-Thibodeau 2015b) and Tanguay (2011) found 95% infection of 163 individuals in the Eastern Townships. At present, *Oc-j* is known to occur throughout the provincial range of Butternut and, although healthy trees still occur in very small numbers, completely unaffected stands are no longer found (Rioux pers. comm. 2015). Some regeneration (but not necessarily recruitment into reproductive age classes) is still occurring in Quebec’s Eastern Townships. Tanguay (2011) found seedlings in 13% of floodplain sites (n=15), 33% of highly calcium-rich mesic upland sites (n=24) and in 7% of moderately calcium-rich mesic upland sites (n=27), but she found saplings only in 7% of the floodplain sites and nowhere else. Rioux (pers. comm. 2015) reports that saplings in Quebec do not live long (with canker as the presumed cause of mortality), even in sites artificially opened to promote regeneration.

Butternut Canker was first detected in New Brunswick in 1997, when the disease was found at five sites in Carleton County, along the Saint John River at Peel, Stickney, Upper Brighton and Riverbank, and on the Meduxnekeag River at Jackson Falls (Harrison *et al.* 1998, 2005; Hopkin *et al.* 2001). Further survey efforts in 2004 by the CFS and the New Brunswick Department of Natural Resources resulted in the discovery of *Oc-j* at an additional four Carleton County and two Victoria County sites (Harrison *et al.* 2005). Sampling by CFS from 2013 to 2015 confirmed Butternut Canker throughout the provincial range of Butternut, with 70% (285 of 403) of trees being cankered, and the presence of *Oc-j* was detected at several sites on the lower Southwest Miramichi River in central New Brunswick (Beardmore pers. comm. 2015). The stands found along this river are isolated from other occurrences by roughly 45 km and were previously considered the last remaining unaffected native Butternut subpopulations in Canada and possibly range-wide. Where Butternut reaches its greatest frequency in Carleton and Victoria counties, the proportion of badly diseased trees appears to be over 50% and dead trees are common, sometimes roughly as common as live ones (Blaney and Mazerolle pers. obs. 1999-2015). Observed rates of mortality now probably underestimate cumulative canker effects because many of the first trees killed have lost their bark and fallen, and are becoming hard to spot and identify to species (Blaney and Mazerolle pers. obs. 1999-2015).

Habitat Conversion (IUCN Threats 1.1 Housing & urban areas, 1.2 Commercial & industrial areas, 2.1 Annual and perennial non-timber crops, 3.2 Mining & quarrying, 3.3 Renewable energy, 4.1 Roads & railroads, 4.2 Utility & service lines)

Most of Butternut's Canadian range is in the densely populated Great Lakes Plains National Ecological Area of southern Ontario and Quebec in which human landscape alteration is extensive and new development is frequent. As a result, remaining Butternut occur frequently adjacent to existing development or in the footprint of new developments or agricultural expansion. Collectively, development threats are very small relative to the extreme threat posed by Butternut Canker, and they are not expected to impact more than 10% of the Canadian population of Butternut in the next ten years (see Threat Calculator in Appendix 1). The threat to Butternut posed by development is also mitigated in Ontario and New Brunswick (see **Legal Protection and Status**; Sabine pers. comm. 2016), but not in Quebec (Pohu pers. comm. 2016), where no provincial protection is in place, by provincial policies that come into play when the species is identified via an Environmental Impact Assessment as present within a development footprint (see **Habitat Protection and Ownership**).

In Ontario, Butternut removal for development requires a permit under the Ontario *Endangered Species Act* and compensatory actions intended to provide a net benefit to the species (see **Legal Protection and Status**). The Ontario Environmental Registry (2016) lists 83 development projects since 2000 for which permits have been issued to remove or transplant Butternut or for which Butternut management plans have been enacted (allowing development with no Butternut removal). Projects include housing and commercial developments, quarries and aggregate pits, golf courses, solar power projects, and road construction and maintenance. Removal of up to 10 Category 2 (poor health but still alive) trees is allowed without a permit, but with compensatory planting, and such cases would not be tracked in the above system. Smaller developments, most significantly single residences being built in rural areas and conversion of uncropped areas to cropland, generally do not go through environmental assessments and thus would not be tracked in the Ontario Environmental Registry (2016). Thus additional loss of Butternut through habitat conversion is likely occurring at a low level on an ongoing basis. Based on similar provincial rates of economic growth (Conference Board of Canada 2016), development pressure in the densely populated St. Lawrence River corridor in Quebec would likely be similar to that in Ontario. Development pressure within Butternut range in New Brunswick is somewhat lower than in Ontario and Quebec because of lower population density, but all the above threats do occur (Blaney and Mazerolle pers. obs. 1999-2015), most notably along the

Saint John River in the vicinity of Fredericton, where Butternut occurrence is frequent and where rural residential estates with a river view are in demand (Beardmore pers. comm. 2016). Residential development within the floodplain is generally restricted by zoning and the *New Brunswick Clean Water Act*, but cutting trees for views that often accompanies residential development is not. As noted under **Legal Protection and Status**, New Brunswick occurrences are somewhat protected under in provincial policy in projects requiring Environmental Impact Assessment or Crown Land development review, though most small-scale development would not trigger either of these processes.

<u>Wood Harvesting (IUCN Threat 5.5)</u>

The threat described here includes only forest harvesting on sites that are subsequently left to regenerate and does not include removal via forest conversion to other uses. Forestry would not be a major threat to persistence in Canada in the absence of Butternut Canker because at many logged sites later regeneration might result in numbers remaining stable, or even increasing over time because of canopy opening. However, seedlings and saplings are increasingly rare in the Ontario and Quebec population (see **Threats** – **Butternut Canker**), and there are likely few trees entering mature age classes even in New Brunswick where seedlings and saplings remain fairly common (Mazerolle and Blaney pers. obs. 1999-2015; AC CDC 2016). Additionally, if any genetic tolerance or resistance is present, loss of remaining healthy trees through logging will eliminate that genetic potential.

Butternut is generally protected from harvesting (see **Legal Protection and Status**), but targeted harvesting of Butternut was listed as a significant threat in the Recovery Strategy for the Butternut in Canada (Environment Canada 2010), which noted that landowners in the United States and Ontario were pre-emptively removing Butternut before the trees died and lost their value. As canker mortality increases and healthy Butternut becomes rarer on the landscape, this motivation for Butternut removal may be decreasing. Additionally, in Ontario, all Butternut are protected until assessed by MNRF-designated Butternut Health Assessors. Those that are assessed and reported to MNRF as unhealthy can then be cut, harmed, or sold. Those assessed as healthier can only be removed or harmed if a replacement planting is done, or if a permit under the *Endangered Species Act* is issued with the requirement that planting or archiving activities are done representing a net benefit to the species (OMNRF 2015; planting of Butternut is done in excess of those removed). No equivalent policy relevant to tree cutting is in place in Quebec or New Brunswick outside of federal land. Deliberate, unauthorized cutting of Butternut in Ontario may sometimes occur in order for a development-oriented landowner to avoid dealing with Species at Risk regulations (Brunton pers. comm. 2016). Inadvertent cutting undoubtedly occurs to some extent in Ontario by landowners or inexperienced or under-trained contractors who are unaware of the species. Cutting of Butternut is unregulated in Quebec and New Brunswick, and is likely especially frequent in western New Brunswick, where about 95% of known occurrences are on private land (AC CDC 2016), use of hardwood firewood for heat is especially frequent (Statistics Canada 2010), a large pulp mill at Nackawic in the central part of Butternut's provincial range uses hardwood almost exclusively (Aditya Birla AV Group 2016) and cutting of hardwood stands supporting Butternut is common (Mazerolle and Blaney pers. obs. 1999-2015).

Introduced Genetic Material: Hybridization with Japanese Walnut (IUCN Threat 8.3)

In discussing hybridization with non-native walnuts as a threat it should be noted that because of the lack of disease resistance thus far found in genetically pure Butternut (Woeste *et al.* 2009; McKenna *et al.* 2011; Nadeau-Thibodeau 2015a), serious suggestion (e.g., Boraks and Broders 2014) has been made that propagation and dissemination of more resistant Japanese Walnut x Butternut hybrids may be the best available option for restoring the ecological role of Butternut into wild systems and preserving Butternut genes. Similar to the backcross breeding program which has been used to breed blight resistance into American Chestnut from Chinese Chestnut (*Castanea mollissima*) (Hebard 2005), hybrids and subsequent backcrosses could offer a means of developing resistant Butternut cultivars (Michler *et al.* 2005; Broders *et al.* 2015). Current practice in Canada (including COSEWIC assessments – COSEWIC [2010], Appendix E7), however, treats all confirmed hybrids as non-Butternuts with no specific protection.

Butternut cannot hybridize with native Black Walnut, but is known to hybridize with at least three walnut species of Asian and European origin, all of which are cultivated in Canada. Hybrids with English Walnut, resulting in *J.* x *quadrangulata*, can occur but are uncommon and not highly fertile (Woeste *et al.* 2009). Butternut also occasionally crosses with Manchurian Walnut (Rink 1990). The most prevalent hybrid, *J.* x *bixbyi*, results from the crossing of native Butternut with Japanese Walnut, a species first introduced in the U.S. in the mid-1800s and widely cultivated in North America over the last century (Woeste *et al.* 2009). Because most cultivated Japanese Walnut are the variety called Heartnut, hybrid offspring have commonly been referred to as Buarts or Buartnuts. Believed to be self-fertile (Zhao and Woeste 2010), Buartnut is able to cross with other hybrids and backcross with parent taxa, producing confusing combinations of traits (Ross-Davis and Woeste 2007; Zhao and Woeste 2010). Hybrid trees are highly vigorous, high yielding (Orchard *et al.* 1982) and have greater resistance to Butternut Canker (Nair 1999; Michler *et al.* 2005; Ostry and Moore 2007; Boraks and Broders 2014). For these reasons, hybrids of unknown provenance are believed to have been commonly selectively propagated as Butternuts over the last century (Woeste *et al.* 2009). Buartnuts can be very difficult to distinguish from pure Butternut based on morphology alone and are often impossible to identify with any certainty unless twigs and seeds can be examined (Michler *et al.* 2005; Ross-Davis *et al.* 2008b; Woeste *et al.* 2009). Though no single morphological trait is sufficient to distinguish between pure and hybrid Butternuts, Table 1 (modified from Woeste *et al.* 2009) summarizes morphological traits which, in combination, can allow for the identification of hybrids. Catling and Small (2001) provide a detailed key to all native and introduced walnut species and hybrids in Canada.

The degree to which introgression of Japanese Walnut genes is common within the natural range of Butternut has only recently been investigated, following the development of DNA-based markers which allow for effective screening (Ross-Davis *et al.* 2008b, McCleary *et al.* 2009; Zhao and Woeste 2010; Parks *et al.* 2014). Naturally occurring hybrids are now known to be common across the natural range, with highest incidences found in fragmented semi-rural landscapes (Michler *et al.* 2005; Hoban *et al.* 2009, 2012b,). Woeste *et al.* (2009) note that in some areas (not specified) in the U.S., virtually all "Butternut" are actually hybrids with some level of Japanese Walnut introgression. Zhao and Woeste (2010) found that most hybrids examined were not in fact true *J. x bixbyi*, but second generation hybrids (F_2), backcrosses or other complex hybrids. The common occurrence of Japanese Walnut and hybrids raises questions as to the purity of trees identified as being canker-resistant (Michler *et al.* 2005; Hoban *et al.* 2009, 2012b; McCleary *et al.* 2009; Zhao and Woeste 2010).

Hybridization with exotic *Juglans* species is considered a potential threat for Butternut in Canada (Environment Canada 2010). In areas where Japanese Walnut and/or Buartnut come into close proximity to natural Butternut, extensive hybridization and recurrent backcrossing could threaten the genetic integrity of affected populations. In Canada, hybridity has been detected throughout the range of Butternut. Hybrids are noted as common in Ontario (McLaughlin and Hayden 2012), with 10% of the healthiest single individuals selected from 60 Butternut monitoring sites by Wilson (pers. comm. 2016). In Eastern Ontario, however, hybrids are reported uncommon away from urban centres (Zurbrigg pers. comm. 2017). Hybrids are present but uncommon overall in both Quebec (Rioux pers. comm. 2015) and New Brunswick (Beardmore pers. comm. 2015). In Quebec, some candidate trees tested for potential resistance have turned out to be hybrids (Rioux pers. comm. 2015).

Problematic Native Species: White-tailed Deer (IUCN Threat 8.2)

White-tailed Deer are known to favour young Butternut trees for browsing and antler rubbing (Van Dersal 1938; Woeste *et al.* 2009; Boysen pers. comm. 2015), though this is not currently believed to be a significant threat (see Threats Calculator – Appendix 1). The observations of Ostry *et al.* (2003, excerpted below) in Wisconsin suggest that, under some circumstances, deer browse and antler rubbing could have a non-negligible impact on Butternut regeneration.

> "Deer have impacted the Butternut regeneration in two ways, by browsing and antler rubbing. While the frequency of browsed seedlings can be high, the majority of them are not seriously damaged. Deer browse may however be a net asset by controlling the competing trees and brush. Deer tend to use salient saplings to rub the velvet off their antlers as they harden. This behavior also has some role in mating and territorial dominance. Butternut tends to occupy open areas in stands where deer activity is high and this may account for the high incidence of damage observed, however, based on observations deer may preferentially select Butternut seedlings for unknown reasons. This damage may be as significant as that caused by browsing."

Deer significantly affect the composition of forest plant communities in the eastern United States and southeastern Canada (Russell *et al.* 2001). In northern hardwood forest, increases in deer density were found to cause declines in favoured browse species, producing altered plant communities dominated by species avoided by deer or resilient in response to deer browsing (Horsley *et al.* 2003). In the mixed conifer–hardwood forests in the Great Lakes region, widespread habitat modification and extirpation of native predators have acted to boost populations of White-tailed Deer to historically high densities (Rooney and Waller 2003). Projected climate change scenarios throughout the Canadian range of Butternut suggest that winter temperatures will become milder (Lemmen *et al.* 2008), which could lead to increases in White-tailed Deer populations and browsing pressure. Impacts from deer browsing and damage on young Butternut has been observed in Ontario (Boysen pers. comm. 2015), suggesting that in some situations, protection from deer may be necessary in order to foster regeneration.

Climate Change (IUCN Threat 11)

Current and future climate change effects on Butternut are difficult to adequately assess. Projected climate change scenarios for this century suggest milder winters, warmer mean summer temperatures and higher precipitation for much of Butternut's Canadian range (Lemmen *et al.* 2008). Southern Ontario, southern Quebec and New Brunswick are predicted to see an increase in mean temperature of 2 to 4°C by 2050, with maximum warming occurring in winter (Lemmen *et al.* 2008). These temperatures will be more similar to areas currently in the centre of Butternut's natural range so might improve growth and reproduction (if it were not suppressed by canker), unless changes in temperature and moisture regime favoured increased development of Butternut Canker.

Climate change can influence forest pathogen effects through: 1) direct effects on the development, survival and dispersal of pathogens, 2) changes in tree physiology that can influence resistance to pathogens and herbivore vectors and 3) indirect effects on the abundance of insect vectors of tree pathogens (reviewed in Ayres and Lombardero 2000). Milder winters, warmer growing seasons and changes in moisture availability can increase the prevalence and severity of tree pathogens by reducing winter mortality of insect vectors and increasing the development rate of insects and pathogens during the growing season (Weed *et al.* 2013). Scope and severity of diseases may be affected by climatic influences on sporulation and infection and/or changing tree susceptibility to infection (Sturrock *et al.* 2011; Weed *et al.* 2013). Warmer and longer growing seasons could promote the development of Butternut Canker in Canada because of the importance of humidity and rainfall in the production and dispersal of conidia (Tisserat and Kuntz 1983).

Limiting Factors

Low Genetic Diversity

In a study investigating genetic diversity in northeastern subpopulations of Butternut (nine subpopulations sampled in Quebec, New Brunswick and Vermont), Morin *et al.* (2000) concluded that parameters of genetic diversity (polymorphic loci, number of alleles per locus and average heterozygosity) in these subpopulations had very low values, much below those estimated for Black Walnut or other boreal tree species. Range-wide studies of genetic diversity (Hoban *et al.* 2010; Larrichia *et al.* 2015) in Butternut demonstrate a higher diversity in centrally-located United States populations and a marked reduction in diversity in Canadian subpopulations at the edge of the species' range in Ontario, Quebec and New Brunswick (although New Brunswick supports some unique genetic variation (Hoban *et al.*

2010; Romero-Severson 2012; Hoban pers. comm. 2015; Beardmore pers. comm. 2016)). If low genetic diversity corresponds to a low adaptive potential, Canadian subpopulations may be less capable of coping with environmental changes (Morin *et al.* 2000; Reed and Frankham 2003; Hoban *et al.* 2010) and less likely to develop resistance to the Butternut Canker (Schultz 2003).

Genetic diversity is likely to be further reduced by the widespread mortality caused by Butternut Canker to the point that small subpopulations may suffer a loss of fitness via inbreeding depression (Reed and Frankham 2003; Geburek and Konrad 2008). In a naturally regenerating stand of Butternut, Hoban *et al.* (2012a) detected a shift in allele frequencies and a loss of diversity due to a small number of contributing parents.

<u>High Levels of Seed Predation</u>

There is no evidence to suggest that excessive seed predation by native species is a threat to Butternut, but this was listed as a possible threat in the recovery strategy (Environment Canada 2010), where it was speculated that seed predator populations (Common Grackle, Grey Squirrel and White-tailed Deer) augmented by human land use changes could threaten seedling establishment already limited by canker. Insect granivory and vertebrate predation of nuts on the tree can lead to significantly lower viable seed yields (Ostry *et al.* 1994). The highly nutritious seeds of Butternut are consumed by small mammals, deer, birds, humans and various insects. Squirrels and other small seed-caching rodents actively seek out Butternut seeds (Ostry *et al.* 1994; Woeste *et al.* 2009), acting as important dispersal agents (Waldron 2003; Environment Canada 2010; see also references in **Dispersal and Migration**). Common Grackles, which often occur in higher densities in urban and agricultural landscapes (Graber and Graber 1963; Emlen 1974), are also reported to feed on immature fruit (Rink 1990).

Number of Locations

For the purposes of COSEWIC assessment, locations are defined by the scale of the most immediate threat. The primary threat to the species is clearly the fungal disease Butternut Canker, which is now present throughout the entire Canadian range. Although the canker arrived at different times across the Canadian range and there is some variation in current rates of infection and cumulative mortality, all Canadian occurrences will likely be subject to 90+% loss within one to three generations. The entire Canadian population should therefore be considered a single location.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

In Canada, Butternut was originally assessed as Endangered by COSEWIC in 2003. The species is currently listed as Endangered and included on *Schedule 1* of the federal *Species at Risk Act* (Government of Canada 2015).

In Ontario, it is currently granted provincial protection under *Schedule 3* of the *Endangered Species Act* (2007). In accordance with the act, the harming of the species or its habitat is generally prohibited, although the harvesting or removal of Butternut on private properties is allowed under certain circumstances. Trees are classified under three categories as follows: Category 1 – Non-retainable (heavily diseased trees), Category 2 – Retainable (healthy or slightly diseased trees) and Category 3 – Archivable (trees that show potential for disease tolerance). Following inspection and reporting (to MNRF) by a designated Butternut Health Assessor, any non-retainable trees can be cut, while a maximum of 10 retainable trees can be cut (OMNRF 2015), provided the proponent meets additional requirements such as the planting of Butternut seedlings that result in an “overall benefit” to the species. It is not yet known if the planting of small diameter trees that may rapidly succumb to Butternut Canker will truly replace the “retainable” larger trees.

In Quebec, Butternut is not protected through provincial legislation. It is, however, included in the *Liste des plantes vasculaires susceptibles d’être désignées menacées ou vulnérables* (MDDELCC 2015), an official list of sensitive plant species which is ratified by ministerial order. Species included on this list must be targeted by any surveys prompted by the provincial environmental impact assessment process. In some cases, measures to mitigate impacts on these species can be a requirement for project approval.

Butternut is listed under *New Brunswick`s Species at Risk Act* (2013), but with no prohibitions in place. During Environmental Impact Assessments and Crown land development reviews, New Brunswick Department of Energy and Resource Development (formerly Department of Natural Resources) requests proponents of potential development projects to survey for it in areas where it occurs, and may ask for mitigation measures when development projects might affect the species.

In the U.S., Butternut was formerly listed under Category 2 on the list of Endangered and Threatened Plants under the *Endangered Species Act*. This category was for species that showed evidence of vulnerability, but for which data were insufficient. The species was, however, delisted in 1995, owing to an amendment of the act in which Category 2 was entirely removed. It is, however, presently considered a Species of Special Concern, meaning that it requires species management considerations and could be considered for listing under the act, but that supporting information is insufficient at this time (Farlee *et al.* 2009). Natural heritage program websites list Butternut state-level status designations as follows: Kentucky (Threatened), Tennessee (Threatened), and Wisconsin (Special Concern).

Non-Legal Status and Ranks

Butternut is globally ranked as apparently secure (G4; NatureServe 2015) and nationally ranked as vulnerable to apparently secure in the United States (N3N4; NatureServe 2015) but the global rank has not been reassessed since 2006 and was assigned based on the now disproven assumption that canker resistant trees were widespread (NatureServe 2015). Butternut is also considered Imperilled to Vulnerable

(N2N3) in Canada, Imperilled (S2) in Quebec and Ontario (S2?) and Critically Imperilled (S1) in New Brunswick (AC CDC 2015; CDPNQ 2015; ONHIC 2015). The species is actively tracked by the ONHIC and the AC CDC. In Quebec, Butternut has not been actively tracked by the CDPNQ since 2013, but it is listed on the provincial list of *Espèces susceptibles d'être désignées menacées ou vulnérables au Québec* which does not confer any special protection.

In the United States, Butternut is generally considered a sensitive and rare species (Schultz 2003). Subnational status ranks in the U.S., as listed by NatureServe (2015) unless otherwise noted, are: Alabama (S1), Arkansas (S3), Connecticut (SNR – not ranked), Delaware (S3), District of Columbia (S1), Georgia (S2), Illinois (S2), Indiana (S3), Iowa (SU - unrankable), Kentucky (S2S3), Maine (SU), Maryland (S2S3), Massachusetts (S4?), Michigan (S3), Minnesota (S3), Mississippi (S2), Missouri (S2), New Hampshire (S3), New Jersey (S3), New York (S4), North Carolina (S2S3), Ohio (S4), Pennsylvania (S4), Rhode Island (SU), South Carolina (S3), Tennessee (S3), Vermont (S3), Virginia (S3?), Washington (SNA - exotic), West Virginia (S3), Wisconsin (S2S3; Wisconsin Natural Heritage Inventory 2016). The jurisdictions in which the species is ranked S4 have likely not updated their ranks to reflect declines and ongoing threats associated with Butternut Canker.

In addition to S-ranks and state legal status, Butternut is on a Watch List for Indiana and Massachusetts, is under review for future listing in Pennsylvania and is Exploitably Vulnerable (listed under state law but without prohibitions) in New York. Restrictions on harvest of Butternut on some public lands in the United States have been enacted and silvicultural guidelines for the management of Butternut have been developed (Ostry *et al.* 1994; Schultz 2003). Some federal and state agencies have established management policies aimed at retaining Butternut on public lands (Woeste *et al.* 2009). In 1992, the Minnesota Department of Natural Resources placed a moratorium on the harvest of healthy Butternut on some state lands (Schultz 2003).

Habitat Protection and Ownership

Available distribution and abundance data cannot determine the portion of the Canadian population on protected land, but it is clearly not large. The Mixedwood Plains Ecozone (Environment Canada 2013; essentially identical to the Great Lakes Plains National Ecological Area of COSEWIC 2014), representing most of the Ontario and Quebec range of Butternut, includes only 1.8% protected area (Environment Canada 2013) and relatively little Crown land. In New Brunswick, protected areas only cover 1.7% of the species' range, and roughly 87% of the New Brunswick range consists of privately owned land. Prior to Butternut Canker, Butternut was probably present in many smaller protected or managed lands in which it has now been extirpated. Nonetheless, the widespread distribution of Butternut means that it still occurs in a large number of provincial parks and provincial nature reserves, Conservation Areas (public lands in Ontario administered by government-affiliated non-profit agencies called conservation authorities), non-governmental nature reserves, municipal parks, provincial Crown land and other lands with some degree of conservation management. For example, all 60 plots of the OMNRF monitoring study (Wilson pers. comm. 2016) occur on public lands. Butternut is protected on federal land and it occurs on numerous Indian Reserves and other federal lands. Parks Canada's species database lists it as a native species of highest concern (status rank MA1, equivalent to an S1 provincial ranking but applicable to the managed area) in 13 areas including Point Pelee, Thousand Islands, and La Mauricie National Parks (Nantel pers. comm. 2016).

Butternut presents a challenge in the identification of Critical Habitat because it is a wide-ranging and locally common species and its main threat (Butternut Canker) is not habitat-related (Environment Canada 2010). As a result, Critical Habitat for the species has yet to be identified. The federal recovery strategy (Environment Canada 2010) includes a proposed schedule for research activities necessary for the identification of Critical Habitat, with a targeted completion date of 2019. In the interim, Butternut does not receive habitat protection under the federal *Species at Risk Act*.

The Province of Ontario has prepared a provincial recovery strategy (Poisson and Ursic 2013), which consists of the federal recovery strategy (Environment Canada 2010) with additional recommendations pertaining to habitat regulations. The document identifies general habitat as suitable areas within a 50 m radius around the trunk and proposes that habitat protection include a minimum radius of 25 m around the base of the stem irrespective of the tree's size. It advises that this protection should only be granted to "healthy" trees, and that areas covered by impervious surfaces (e.g., paved roads, sidewalks, buildings) as a result of existing and approved land uses be excluded from the regulated area. These recommendations have not yet been put into force.

Some Butternut habitat receives indirect protection from various provincial laws and policies pertaining to shoreline development, wetland and riparian buffers, and the protection of watercourses.

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BIOGRAPHICAL SUMMARY OF REPORT WRITERS

David Mazerolle holds an undergraduate degree in Biology and a Master's degree in Environmental Studies from the Université de Moncton, where he studied the biogeography of exotic vegetation in relation to habitat and disturbance regimes, producing an exotic invasive vegetation management strategy for Kouchibouguac National Park, on New Brunswick's eastern shore. After various research assistant positions, he worked from 2003 to 2005 as coordinator for plant survey and monitoring projects at the Bouctouche Dune Eco-centre, focusing on the rare coastal plants of New Brunswick's Northumberland Coast, including several Species at Risk. Since 2006, David has worked as a botanist for the Atlantic Canada Conservation Data Centre, a position that requires extensive knowledge on the region's flora, including both native and exotic species. An accomplished field botanist, he has over fifteen years experience working on various research, survey and monitoring projects and has authored and coauthored a large number of technical reports pertaining to rare plants in Atlantic Canada as well as numerous national and provincial Species at Risk status reports.

Sean Blaney is the Executive Director and Senior Scientist of the AC CDC, where he is responsible for maintaining status ranks and a rare plant occurrence database for plants in each of the three Maritime provinces. Since beginning with the AC CDC in 1999, he has discovered dozens of new provincial records for vascular plants and documented over 15,000 rare plant occurrences during extensive fieldwork across the Maritimes. Sean is a member of the COSEWIC Vascular Plant Species Specialist Committee and the Nova Scotia Atlantic Coastal Plain Flora Recovery Team, and has authored or co-authored numerous COSEWIC and provincial status reports. Prior to employment with AC CDC, Sean received a BSc in Biology (Botany Minor) from the University of Guelph and an MSc in Plant Ecology from the University of Toronto, and worked on a number of biological inventory projects in Ontario as well as spending eight summers as a naturalist in Algonquin Park, where he co-authored the second edition of the park's plant checklist.

COLLECTIONS EXAMINED

No collections were examined for the preparation of this status report.

Appendix 1: Threats Classification Table for Butternut (*Juglans cinerea*).

THREATS ASSESSMENT WORKSHEET

Species or Ecosystem Scientific Name	Butternut - *Juglans cinerea*
Element ID	
Elcode	
Date (Ctrl + ";" for today's date):	26/09/2016
Assessor(s):	Dwayne Lepitzki, Del Meidinger, Bruce Bennett, Sean Blaney, David Mazerolle, Karen Timm, Jacques Labrecque, Mary Sabine, Ruben Boles, Julie Nadeau, Dan Brunton, Sue Meades, Vivian Brownell, Barb Boysen, Tannis Beardmore, Rose Fleguel, Richard Wilson, Eric Snyder
References:	

Overall Threat Impact Calculation Help:

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

Assigned Overall Threat Impact:	**A = Very High**
Impact Adjustment Reasons:	
Overall Threat Comments	Generation time is 45 years; timing is 10 yrs or 3 gens, whichever is longer; 3 generations = 135 years. Based on current knowledge and EOs, ~41% in ON, ~44.8% in QC, and ~14.2% in NB

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1	Residential & commercial development	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	
1.1	Housing & urban areas	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	Overall, group agrees that scope is closer to the lower end of this range in Canada. There is some mitigation in place when trees are taken down but there is the possibility that hybrids are the replaced tree, which would be a further threat. Some low level small targeted harvesting of trees to remove potential restriction for development.
1.2	Commercial & industrial areas		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
1.3	Tourism & recreation areas		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
2	Agriculture & aquaculture	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2.1	Annual & perennial non-timber crops	D	Low	Small (1-10%)	Extreme (71-100%)	High (Continuing)	Conversion to agricultural land; in NB the issue is with potato crop. In SW and SE ON there is a lot of conversion to agricultural land but don't have the data. Also, some abandonment of agricultural land which may convert back to forest.
2.2	Wood & pulp plantations						
2.3	Livestock farming & ranching						
2.4	Marine & freshwater aquaculture						
3	Energy production & mining		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
3.1	Oil & gas drilling						
3.2	Mining & quarrying		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	Quarrying for aggregate does occur in the range of Butternut. Pressure in S ON for aggregate. The species does tend to concentrate in these types of habitat. In QC there is quarrying on limestone but scope was uncertain. In NB, is more sand/gravel than hard rock quarrying and impact would be very small overall. There are some sites where the impact may be higher (R. Fleguel)
3.3	Renewable energy		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	More impact from solar than wind farms in ON.
4	Transportation & service corridors		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
4.1	Roads & railroads		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
4.2	Utility & service lines		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use	D	Low	Small (1-10%)	Extreme - Serious (31-100%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals						
5.2	Gathering terrestrial plants		Negligible	Negligible (<1%)	Negligible (<1%)	High (Continuing)	Harvesting of nuts for consumption, and collection of juglone for medical purposes was discussed but was of neglible impact overall. Removal of nuts does decrease recruitment potential.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.3	Logging & wood harvesting	D	Low	Small (1-10%)	Extreme - Serious (31-100%)	High (Continuing)	Some low level small targeted harvesting in anticipation of mortality (counted above in urban and rural development), as well as general wood harvesting. Incidental harvesting could help recruitment. Informal cutting of trees for firewood was discussed. Incidental harvesting is ongoing. Some targeted logging with associated permits.
5.4	Fishing & harvesting aquatic resources						
6	Human intrusions & disturbance		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities						
6.2	War, civil unrest & military exercises		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Some Butternut on CFB Gagetown and there is possibility of incidental destruction. UXO at Ipperwash work ongoing. Overall of trivial impact as are on federal lands.
6.3	Work & other activities		Not a Threat	Negligible (<1%)	Neutral or Potential Benefit	High (Continuing)	Research ongoing on this or other species in same habitat which may be beneficial to population in long term. Collection of nuts for cryo-storage or propagation was discussed.
7	Natural system modifications		Unknown	Unknown	Unknown	High (Continuing)	
7.1	Fire & fire suppression						
7.2	Dams & water management/use						Mataquac Dam in NB (and likely others) will be reaching end of life and decisions (likely replacement) will be made in next 10 years. There may be impacts for this riparian species but they are uncertain at this time (may actually be positive).
7.3	Other ecosystem modifications		Unknown	Unknown	Unknown	High (Continuing)	Movement into a lower disturbance regime on a landscape scale may affect this species in the long term. May result in a lack of recruitment. However, blowdowns and informal disturbance (trails) may offer positive benefits. Invasive species, like Common Buckthorn, could limit habitat for regeneration.
8	Invasive & other problematic species & genes	A	Very High	Pervasive (71-100%)	Extreme (71-100%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.1	Invasive non-native/alien species	A	Very High	Pervasive (71-100%)	Extreme (71-100%)	High (Continuing)	Foremost threat is Butternut Canker, a lethal disease caused by the fungal pathogen *Ophiognomonia clavigignenti-juglandacearum*. Butternut Canker kills trees of all ages. Saplings are often quickly killed, while mature trees may survive many years before dying from severe crown loss and girdling by coalescing stem cankers. Field observations suggest >90% of population infected; resistant trees rare and often hybrids. Also suppresses regeneration. Mortality >80% observed in some areas. In Canada, Butternut Canker was first collected in Quebec in 1990 and then detected in Ontario in 1991 and in New Brunswick in 1997. Rates of infection and mortality are not presently well understood in Canada but given 3 generations, available data, personal observations and anecdotal information all suggest that rates will be comparable to those documented in the United States. High rates of mortality in US. NOTE infection estimates of 13 000 trees need to be considered carefully so that context is clear. Some disagreement as to what population estimate should be overall.
8.2	Problematic native species		Unknown	Restricted - Small (1-30%)	Unknown	High (Continuing)	Browsing by White-tailed Deer -- threat where deer in high population density. White-tailed Deer target Butternut but may be a local issue.
8.3	Introduced genetic material		Unknown	Large - Restricted (11-70%)	Unknown	High (Continuing)	*J. x bixbyi*, produced by hybridization with Japanese walnut, a species widely cultivated in North America over the last century. Hybrids believed to be self-fertile and able to cross with other hybrids and backcross with parent taxa. Hybrid trees are highly vigorous, high yielding and have greater resistance to Butternut Canker. Extensive hybridization and recurrent backcrossing could threaten the genetic integrity of affected population. Hybridization is indeed a threat to the pure species, but may be of benefit to the survival (due to resistance to canker by hybrids) of a future species (however hybridized) down the road.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
9	Pollution						
9.1	Household sewage & urban waste water						
9.2	Industrial & military effluents						
9.3	Agricultural & forestry effluents						
9.4	Garbage & solid waste						
9.5	Air-borne pollutants						
9.6	Excess energy						
10	Geological events						
10	Volcanoes						
10	Earthquakes/tsunamis						
10	Avalanches/landslides						
11	Climate change & severe weather		Unknown	Pervasive (71-100%)	Unknown	High - Low	Changes acting synergistically with other threats. No clear evidence of climate change effects on this species or its habitat at this time.
11	Habitat shifting & alteration						
11	Droughts						
11	Temperature extremes						
11	Storms & flooding						
Classification of Threats adopted from IUCN-CMP, Salafsky *et al*. (2008).							

COSEWIC
Assessment and Update Status Report

on the

Van Brunt's Jacob's-ladder
Polemonium vanbruntiae

in Canada

THREATENED
2002

COSEWIC
COMMITTEE ON THE STATUS OF ENDANGERED WILDLIFE IN CANADA

COSEPAC
COMITÉ SUR LA SITUATION DES ESPÈCES EN PÉRIL AU CANADA

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

COSEWIC 2002. COSEWIC assessment and update status report on the van Brunt's Jacob's-ladder *Polemonium vanbruntiae*. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vi + 22 pp.

Previous report:

Sabourin, A. and D. Paquette, 1994. COSEWIC status report on van Brunt's Jacob's ladder *Polemonium vanbruntiae* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 39 pp.

Production note: COSEWIC would like to acknowledge André Sabourin for writing the status report on Van Brunt's Jacob's ladder *Polemonium vanbruntiae*, prepared under contract with Environment Canada. Van Brunt's Jacob's ladder *Polemonium vanbruntiae* was formerly listed as van Brunt's Jacob's-ladder *Polemonium vanbruntiae*

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Également disponible en français sous le titre Évaluation et Rapport de situation du COSEPAC sur la situation de la polémoine de Van Brunt (*Polemonium vanbruntiae)* au Canada – Mise à jour.

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Van Brunt's Jacob's-ladder — Rejean Roy.

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COSEWIC
Assessment Summary

Assessment Summary – November 2002

Common name
Van Brunt's Jacob's-ladder

Scientific name
Polemonium vanbruntiae

Status
Threatened

Reason for designation
Few extant populations occupying very small habitats at risk from agricultural impacts, logging and other development pressures, and recreational activities.

Occurrence
Quebec

Status history
Designated Threatened in April 1994. Status re-examined and confirmed in November 2002. Last assessment based on an update status report.

COSEWIC
Executive Summary

Van Brunt's Jacob's-ladder
Polemonium vanbruntiae

Information on the species

Van Brunt's Jacob's-ladder (*Polemonium vanbruntiae*) is an herbaceous perennial of the Polemoniaceae. The stems are upright, 40 to 140 cm tall. The leaves are composed of 7 to 21 ovate to oblong leaflets. The panicled flowers, which are blue-violet in colour, are 15 to 25 mm in diameter and have 5 petals and 5 sepals; the stamens are yellow and strongly exserted. The fruit is an ovoid capsule containing brownish-black seeds.

Distribution

Van Brunt's Jacob's-ladder is endemic to the central Appalachians. It is found from West Virginia to the southernmost part of Quebec and eastern Maine. In Canada, this species is only known to occur in the Eastern Townships and Bois-Francs regions of Quebec, at the bottom of the Nicolet and Stoke River valleys. There is also a historic record for New Brunswick.

Habitat

This plant is found in moist habitats such as riparian alder thickets, wet clearings, riparian herbaceous meadows and old fields with sufficient moisture. These are open or semi-open habitats, subject to flooding in the spring, with rich soils, often located near the bottom of slopes or near streams. This montane species occurs in rather cool microclimates.

Biology

The species reproduces by seed or by rhizomes (vegetatively). The flowers are pollinated by a wide variety of insects, mainly honey bees and bumblebees. Seed germination occurs only after a period of cold, dry conditions.

Population sizes and trends

Currently, there are only 8 known Canadian populations, all found in Quebec, for a total of approximately 20,000 plants. Although two new populations were discovered in

Quebec in 2001, two other populations are considered to have disappeared, and the species is declining both in its extent of occurrence and its area of occupancy.

Limiting factors and threats

Encroachment by the farming and logging industries represents the main limiting factor and threat to Van Brunt's Jacob's-ladder. These industries have caused the decline or extirpation of some populations. Road construction and other projects altering drainage can also be detrimental, if they cause prolonged flooding or drying-up of the habitat.

Special significance of the species

Van Brunt's Jacob's-ladder is the only species of genus *Polemonium* that is native to Canada east of Alberta. It is rare and sporadic over its entire range. It has primitive characteristics and may be a relict species. Its great beauty gives the species a horticultural potential for wetland gardens.

Existing protection or other status designations

This plant is not found on any Canadian protected public land. However, an important site has just been purchased by a private conservation agency, and negotiations are either under way or planned for the purchase of other sites by the same agency. The species has been designated threatened in both Canada and Quebec, where it falls under the provincial *Threatened or Vulnerable Species Act*.

Summary of the status report

Although *Polemonium vanbruntiae* is threatened in Canada and is generally on the decline, new populations have been discovered recently, and potential sites still need to be explored. Moreover, conservation measures have recently begun to take shape, and they should, at the very least, stabilize the status of this species.

COSEWIC MANDATE

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

COSEWIC MEMBERSHIP

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

DEFINITIONS

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

* Formerly described as “Vulnerable” from 1990 to 1999, or “Rare” prior to 1990.
** Formerly described as “Not In Any Category”, or “No Designation Required.”
*** Formerly described as “Indeterminate” from 1994 to 1999 or “ISIBD” (insufficient scientific information on which to base a designation) prior to 1994.

The Committee on the Status of Endangered Wildlife in Canada (COSEWIC) was created in 1977 as a result of a recommendation at the Federal-Provincial Wildlife Conference held in 1976. It arose from the need for a single, official, scientifically sound, national listing of wildlife species at risk. In 1978, COSEWIC designated its first species and produced its first list of Canadian species at risk. Species designated at meetings of the full committee are added to the list.

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

Canada

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

Update
COSEWIC Status Report

on the

Van Brunt's Jacob's-ladder
Polemonium vanbruntiae

in Canada

2002

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SPECIES INFORMATION

Name and classification

Scientific name:	*Polemonium vanbruntiae* Britton
Relevant synonyms:	*Polemonium van-bruntiae* Britton *Polemonium caeruleum* L. subsp. *vanbruntiae* (Britt.) Davidson
Name of the order:	Solanales
Name of the family:	Polemoniaceae
French common names:	polémoine de Van Brunt, polémonium de Van Brunt
English common names:	Van Brunt's Jacob's-ladder, Appalachian Jacob's-ladder, Eastern Jacob's-ladder

Comment on the taxonomy: Until just recently, the specific epithet van-bruntiae was used in the scientific name. The epithet vanbruntiae, which complies with the International Code of Botanical Nomenclature, was officially used by the Ministère de l'Environnement du Québec for the first time in 1998 (Couillard, 1998; Gouvernement du Québec, 1998), but it had already been used by American authors (Johnson and Murray, 1988; Thompson, 1991).

Description

Herbaceous perennial emerging from a horizontal rhizome. Stems upright, 40-140 cm tall, glabrous, robust and single. Leaves alternate, compound, 2-50 cm long and 1.5-10 cm wide, glabrous; leaflets shortly petiolate, opposite or almost opposite, 1-3.5 cm apart, acuminate, entire; lower leaves with 15 to 21 ovate leaflets 15-60 mm long and 5-25 mm wide, upper leaves with 7 to 15 lance-oblong leaflets; inflorescence bracts glabrous or glandular-pubescent (Figure 1).

Inflorescence a rather narrow panicle, slightly glandular-pubescent. Flowers few, 2 to 8 per branch, scentless; pedicels densely glandular-pubescent, 2-15 mm long; calyx purple-green (at anthesis) to yellowish-green (at maturity), persistent; sepals 5, 8-17 mm long and 4-6 mm wide, pubescent with hairs up to 2 mm long, slightly glandular; corolla blue-violet and yellowish-green at the base, 15-25 mm in diameter, glabrous, tubular at the base; corolla lobes 5, 12-20 mm long and 7-10 mm wide; stamens 5, strongly exserted, 12-18 mm long, protruding 4-7 mm from corolla; anthers orange-yellow, 2-5 mm long; filaments white, villose at the base; style exserted, blue-violet, slightly longer than the stamens; stigma generally trilobate. Fruit an ovoid capsule, 5-7 mm long, 3-4 mm wide, generally 3-locular, sometimes 4- to 7-locular; seeds brownish-black, 1-10 per locule, slightly winged. 2n = 18, 36.

Figure 1. *Polemonium vanbruntiae* (drawing by Réjean Roy).

Polemonium vanbruntiae may be confused with *P. caeruleum* and *P. reptans*, two species introduced and cultivated in Canada, which occasionally escape near gardens and in disturbed habitats. The main differences between the three species are outlined below:

	P. caeruleum	***P. reptans***	***P. vanbruntiae***
1. Stamens and style	slightly exserted or level with the corolla.	inserted or level with the corolla.	strongly exserted.
2. Stems	20-90 cm tall, upright.	15-50 cm tall, spreading or prostrate.	40-140 cm tall, upright.
3. Lower leaf leaflets	19-29, lance-oblong, up to 10 mm wide.	11-17, lanceolate to ovate, up to 20 mm wide.	15-21, ovate, up to 25 mm wide.
4. Sepals	5-9 mm long.	5-8 mm long.	8-17 mm long.
5. Habitat	roadsides, waste ground.	rich woods.	moist open and semi-open habitats.

Readily available works providing the best descriptions include: Davidson (1950); Fernald (1950); Gleason and Cronquist (1991); Thompson (1991); Sabourin and Paquette (1992, 1994); Couillard (1998); Coursol (2001); Ministère de l'Environnement du Québec (2001); NatureServe (2001). Figure 1 illustration of *Polemonium vanbruntiae* was drawn by Réjean Roy.

DISTRIBUTION

Global range

Van Brunt's Jacob's-ladder is endemic to the central Appalachians, in eastern North America (Figure 2). Its range extends from West Virginia, in the south, to the southernmost portion of Quebec and eastern Maine, in the north. The species is sporadic over its entire range and is most frequent in New York State. Over the past ten years, there do not seem to have been discoveries indicating an extension of its range (Thompson, 1991; Sabourin and Paquette, 1992, 1994; NatureServe, 2001).

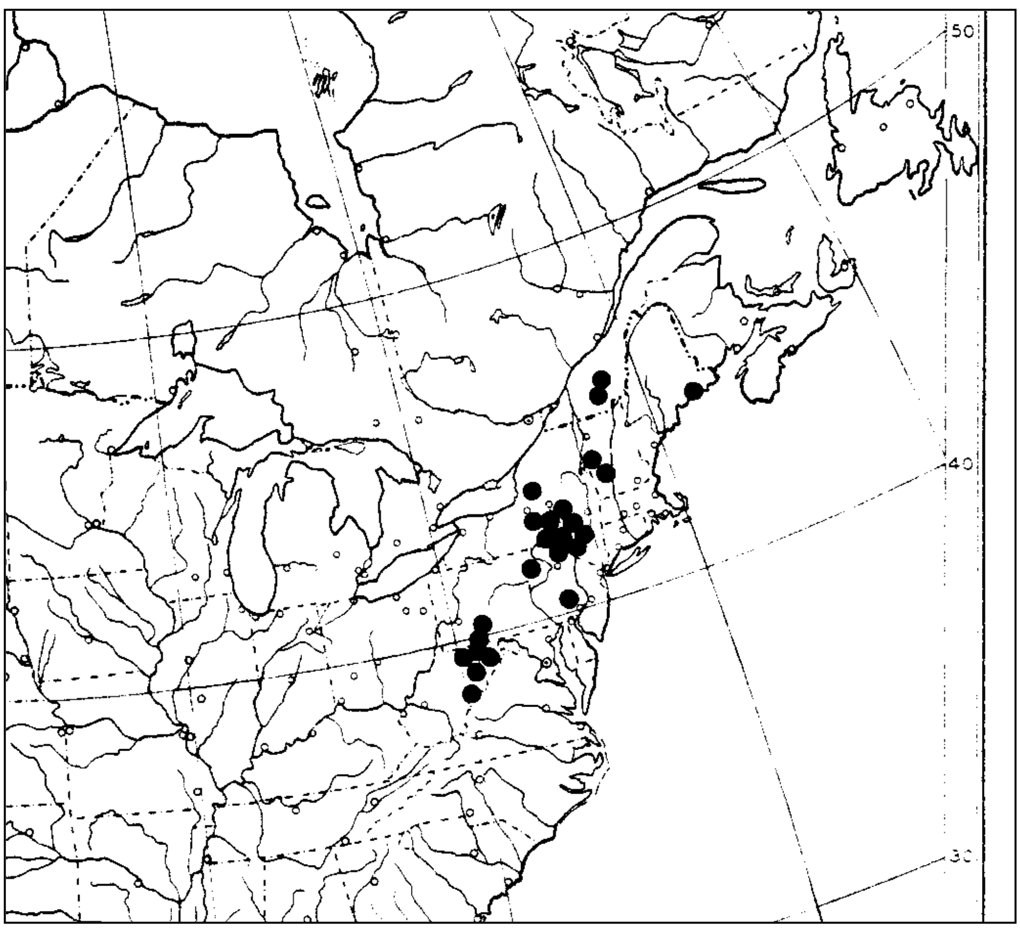

Figure 2. North American distribution of *Polemonium vanbruntiae* (one extirpated native historic population in New Brunswick is not mapped).

Canadian range

In Canada, *Polemonium vanbruntiae* is known to occur only in Quebec at the present time. A historic population (1885) was reported for southwestern New Brunswick at Trout Brook, Charlotte County (Sabourin and Paquette, 1992, 1994; Ministère de l'Environnement du Québec, 2001), but has not been seen since (Hinds, 1986; Blaney, pers. comm., 2001); another population reported for that same region, at Hoyt, Sunbury County, is considered by Hinds (1983) as possibly having been introduced.

In Quebec, the species has been observed in the Bois-Francs and Eastern Townships regions, at the southeastern tip of the province. The currently known populations are located in 3 regional county municipalities (RCM): Arthabaska, Asbestos and Le-Val-Saint-François.

Currently known locations

The Canadian locations of *Polemonium vanbruntiae* are listed below, with the exact number of populations within each of these locations. Eight extant locations are currently known, with a total of 12 populations. According to the Centre de données sur le patrimoine naturel du Québec, locations (occurrences) must be separated by a minimum distance of 1 kilometre.

RCM of Arthabaska

SAINTS-MARTYRS: 1 population; last seen on September 11, 2001, by Alain Meilleur.

DÉVELOPPEMENT-BOISVERT-EST: 3 populations; last seen on November 2, 2001, by Alain Gouge.

DÉVELOPPEMENT-BOISVERT-OUEST: 1 population; last seen on June 12, 2001, by André Sabourin and Alain Gouge.

Note: The two latter locations are separated by a distance of 1.5 km.

RCM of Asbestos

SAINT-ADRIEN: 1 population; last seen on July 12, 2001, by André Sabourin, Denis Paquette and Geoffrey Hall.

SAINT-CAMILLE: 2 populations; last seen on July 12, 2001, by André Sabourin and Denis Paquette.

HAM-SUD: 1 population; last seen on July 12, 2001, by André Sabourin, Denis Paquette and Geoffrey Hall.

RCM of Le-Val-Saint-François

STOKE RIVER: 2 populations; last seen on July 11, 2001, by André Sabourin and Denis Paquette.

MONT-CARRIER-SUD: 1 population; last seen on July 11, 2001, by André Sabourin and Denis Paquette.

In 2001, our fieldwork allowed us to discover two new locations in Quebec, those in Saint-Camille and in Ham-Sud. However, as these are located in the Nicolet-Centre River watershed, within the previously known range for the species, they do not represent true range extensions.

Extirpated locations

In Quebec, *Polemonium vanbruntiae* has not been seen since 1943 in the Arthabaska region, where it no longer appears to be present (Sabourin and Paquette, 1992, 1994). This region is located slightly northwest from the known extant range of the species.

Also, the species has not been seen since 1885 at Trout Lake, in southwestern New Brunswick (Hinds, 1986). However, the status of the species in this region is uncertain, due to a lack of significant research, and it is not clear whether the extant population in Hoyt (Hinds, 1983) is native or introduced. Further research would be needed in that part of the province, especially in the Magaguadovic, Oromocto, Digdeguash and St. Croix watersheds.

The extirpation of populations previously known from Arthabaska and Trout Lake represents a reduction of the global range of the species.

The fieldwork carried out in Quebec on July 4, 2000 (André Sabourin and Alain Gouge) and July 12, 2001 (André Sabourin and Denis Paquette) leads to believe that the Wotton location (Sabourin and Paquette, 1992, 1994) is now extirpated. However, as this population was located within the currently known range, its extirpation does not represent a true range reduction. Also, a small sub-population at Stoke River (ca. 100 plants) seems to be now extirpated. This site was bulldozed and drained in 2002, probably for a future agricultural field (Geoffrey Hall, pers. comm. 2002).

Extent of occurrence

The occurrence of *Polemonium vanbruntiae* in Canada extends over 644 square kilometres (46 x 14 km), essentially in Quebec. The long-term historic trend associated with this extent of occurrence seems to be one of decline, given the presumed extirpation of the populations in Arthabaska, Quebec, and Trout Lake, New Brunswick.

The actual area of occupancy is much smaller and covers approximately 5.1 ha, in Quebec. The area covered by each location is as follows:

Saints-Martyrs	**0.45 ha (150 x 30 m)**
Développement-Boisvert-Est	1.5 ha (200 x 30 m; 200 x 30 m; 100 x 30 m)
Développement-Boisvert-Ouest	0.9 ha (300 x 30 m)
Saint-Adrien	1 m^2 (1 x 1 m)
Saint-Camille	1.01 ha (100 x 100 m; 10 x 10 m)
Ham-Sud	0.15 ha (50 x 30 m)
Stoke River	1.1 ha (200 x 50; 50 x 30 m = extirpated in 2002)
Mont-Carrier-Sud	0.02 ha (20 x 10 m)

The current trend associated with the area of occupancy is on the decline. There has been a growth in the area of occupancy, mainly due to the locations discovered in 2001 at Saint-Camille and Ham-Sud (>1 ha), which more than compensate for the loss of the Wotton location, which was very small (<10 m^2) according to Sabourin and Paquette (1992, 1994), and the loss of a sub-population at Stoke River (0,15 ha) in 2002. Moreover, in 2001, new subpopulations were found at Développement-Boisvert-Ouest, which tripled the area of occupancy known in 1992 (0.3 ha, or 150 x 20 m); at Développement-Boisvert-Est, a third population was identified, the smallest, central one.

However, although there is a current increase in locations, these new sites presumably represent populations that already existed but were not known. With recent losses of sites or part of sites there has been a slight decline in the overall area of occupancy of the species in Quebec. Declines in occupancy likely are also primarily of historic occurrence following the arrival of the farming and logging industries in the area.

Moreover, no other recent discovery (in the last 10 years) was mentioned by the relevant resource persons, both in Quebec (Couillard, pers. comm., 2001) and in New Brunswick (Blaney, pers. comm., 2001).

HABITAT

Habitat requirements

In Quebec, our personal observations indicate that *Polemonium vanbruntiae* is found in moist habitats that are open to semi-open, rarely shady. This species occupies areas subject to seasonal flooding such as marshy alder or willow stands, riparian meadows associated with rivers or streams, wet clearings, and basins or depressions with herbaceous vegetation. The species occasionally escapes from these stable natural environments into successional environments such as waste grounds and old fields with sufficient moisture, or logging road ditches.

These moist habitats are often located near the foot of slopes, in seepage areas, or near rivers. The species tolerates spring or seasonal flooding, but does not tolerate flooding that is permanent or lasts during the whole growing season.

In Quebec, open or semi-open alder stands appear to be the species' original native habitat. This habitat is relatively specialized. In the United States, *Polemonium vanbruntiae* is considered a facultative wetland species (FACW), with a 67 to 99% likelihood of occupying moist habitats when it is found in a natural environment (Rhoads and Klein, 1993; Magee and Ahles, 1999). Our personal observations tend to indicate that this is also the case in Quebec, where the species comes very close to being an obligate wetland plant.

In Quebec, Van Brunt's Jacob's-ladder is found in environments where the terrain is flat or slightly sloping, even though the species is associated with the Appalachians, a mountainous region. This type of terrain promotes the accumulation of sediments and alluvial deposits that enrich the soils. The foot of slopes and other sites with some sort of seepage or water flow favour the formation of the rich, deep and humid soils that Van Brunt's Jacob's-ladder prefers. This substrate generally contains few or no stones.

The Quebec regions where Van Brunt's Jacob's-ladder occurs have a cool climate, and the species is found at moderately high elevations, between 205 and 355 metres. Further south, *Polemonium vanbruntiae* also prefers cool montane climates, and it is found at elevations above 1,200 metres in West Virginia (NatureServe, 2001).

Van Brunt's Jacob's-ladder rarely grows on unstable substrates. The only habitats where it grows that may correspond to such environments are forest road ditches; in fact, we saw the plant growing in ditches only at the two Développement-Boisvert locations.

Plant species most frequently associated with *Polemonium vanbruntiae* and occurring at almost all Quebec locations include: *Alnus incana* subsp. *rugosa*, *Calamagrostis canadensis*, *Clematis virginiana*, *Carex* spp., *Doellingeria umbellata*, *Eupatorium maculatum*, *Salix* spp., *Spiraea latifolia*, and *Thalictrum pubescens*.

The upper valleys of Nicolet River and its main branches and the Stoke River Valley are critical areas for the survival of *Polemonium vanbruntiae* in Quebec and in Canada. Although these valleys are already fragmented, the species still occurs in areas that are large enough to support it; however, the farming and logging industries will need to limit their expansion around Jacob's-ladder sites. It should be noted that these industries are stable or expanding in the Nicolet-Centre and Stoke River Valleys, whereas agriculture is declining in the upper Nicolet River Valley.

Trends

The former extent of the current locations is unknown. The extirpation of the Wotton population, between 1991 and 2000, may be due to the establishment of a Christmas tree plantation. Over the last 10 years, other populations have declined in terms of their number of plants, but not in terms of their area of occupancy. This is the case at Saints-Martyrs, where logging took place, and in the northern part of the Stoke River site, where a field was partially ploughed and mowed.

The Stoke River population is the most threatened of all, but both this location and the Mont-Carrier-Sud location are threatened by agriculture, which could expand and cause the extirpation of both populations.

Potential habitats seem to exist in the neighbouring valleys. The most favourable valleys are those of the Nicolet-Sud-Ouest and Watopéka Rivers, located within the extent of occurrence, and those of the Bécancour, Bulstrode and Saint-François Rivers, located outside the current extent of occurrence.

At the present time, no site is officially protected by a public authority in Quebec.

Protection/ownership

Currently, all Quebec locations of *Polemonium vanbruntiae* are located on private land.

The northern part of the Développement-Boisvert-Est location was purchased in September 2001 by the Société de conservation des milieux humides du Québec (SCMHQ), a private conservation agency. This purchase was specifically aimed at protecting *Polemonium vanbruntiae*. The Saints-Martyrs location also benefits from a conservation agreement (Alain Gouge, pers. comm., 2001); this is also the case for the southern and central parts of the Développement-Boisvert-Est location. The former is the most important location, both in terms of number of plants and of occupied surface area, and the Saint-Martyrs occurrence is average in this respect, so that a large proportion of the species’ habitat is already protected, or will likely be in the near future.

Moreover, negotiations are underway or planned for the protection of additional sites (Ms. Line Couillard, Ministère de l’Environnement du Quebec, pers. comm., 2001).

BIOLOGY

General

The two most important factors relating to the conservation status of this species are reproductive characteristics and climate conditions. Apparently, Van Brunt’s Jacob’s-ladder seeds can only germinate after a period of cold, dry conditions. However, the plant can also reproduce vegetatively.

Reproduction

Polemonium vanbruntiae can reproduce vegetatively or sexually. Asexual or vegetative reproduction takes place through the branched rhizomes of this perennial plant. In Vermont, E. Thompson (1991) observed that occasionally hundreds of stems can connect in the ground to form a clone covering tens of square feet. This would tend to reduce the number of genetically distinct plants in Quebec populations, where clones also seem to occur.

Sexual reproduction takes place by way of cross-pollination and mainly with the help of insects. Wherry (1935) and Thompson (1991) report that pollination is carried out by honey bees (*Apis mellifera*) and bumblebees (*Bombus* sp.). Our observations in 1991 and 1992 (Sabourin and Paquette, 1992, 1994) indicate that several other insects, such as butterflies, and even a bird, the ruby-throated hummingbird (*Archilochus colubris)* visit the flowers of *Polemonium vanbruntiae*. This suggests that the species can produce a large quantity of nectar. According to NatureServe (2001), the species is self-sterile.

A very important factor that must be considered is seed germination. In the course of various experiments, Brumback (1989) found that the seeds could not germinate under cold, wet conditions, but would readily germinate after being kept under cold, dry conditions (between September 1986 and April 1987). However, this author does not provide details on how long the seeds were kept before germination and under which temperature, humidity and light conditions they were maintained. Also, the experiences with this species at the Montréal Botanical garden demonstrated a low germination rate of 0 to 15% (A. Meilleur, pers. comm. 2002).

Survival

Little information is available on this subject. The field observations suggest some predation by white-tailed deer (*Odocoilus virginianus*), which may occasionally browse a few stems, but this does not appear to be an important factor in the plant's Canadian distribution.

Physiology

Polemonium vanbruntiae reaches its northern limit in Quebec, at about 46° latitude north, at Saints-Martyrs-Canadiens. As the elevation of this site is also the highest in Quebec for the species, almost 65 metres higher than the second highest site, it is possible that the species occurs even further north.

The species seems to have a good ability to adapt to changes in its environment, since it has been found in logging road ditches and agricultural old fields. However, there must be sufficient moisture throughout the growing season, without prolonged flooding or drought. Interestingly, in alder thickets, the species is often found on the mounds forming at the base of alders. According to NatureServe (2001), the plant seems to have a rather wide ecological tolerance, but it has a rather narrow pH range, and open areas with circumneutral springs would represent its ideal habitat. According to Wherry (1935), the pH ranges from circumneutral to slightly acidic.

Van Brunt’s Jacob’s-ladder is a perennial plant that prefers deep rich soils. In Quebec, it flowers for about 5 weeks, approximately from June 20 to July 25, with some year to year variation. The first fruit ripen around mid-August at the latest.

Movements/dispersal

Seed dispersal occurs most readily in winter, when the stems extend above the snow cover, and the seeds can be carried by the wind over the icy crust or the snowy surface; occasionally, the stems can break and roll away with the wind. The distance covered in this fashion may reach several hundred metres.

Nutrition and interspecific interactions

Polemonium vanbruntiae does not live as a symbiont or parasite with other species. However, companion plants provide, as they decompose, the organic matter needed to form the rich and deep soils preferred by Van Brunt’s Jacob’s-ladder. Of course, material deposited by rivers and streams or through seepage and run-off is also important in this respect.

Apart from the white-tailed deer, the plant may also be eaten by insects, but this type of negative interaction does not appear to be significant.

Behaviour/adaptability

Van Brunt’s Jacob’s-ladder can tolerate a certain level of habitat modification, but it does not tolerate major changes, such as permanent flooding or soil drying-up. For instance, the population at Saint-Adrien almost disappeared (1 plant observed in 2001) after a nearby road was widened, as this altered the drainage and resulted in prolonged flooding.

At Stoke River, one of the two sites (the one to the north) was mowed and partly ploughed during the late 1990s, and several Jacob’s-ladder plants disappeared. A similar change happened at Saints-Martyrs, because of logging and drainage work.

Transplantation has already been carried out successfully. There are at least 18 living specimens at the Montreal Botanical Garden. At the Garden, a team recently undertook cultivation and germination work on plants having a vulnerable or endangered status in Quebec, and *Polemonium vanbruntiae* is at the top of their list (A. Meilleur, pers. comm. 2002).

POPULATION SIZES AND TRENDS

The number of mature individuals of *Polemonium vanbruntiae* currently known in Canada is estimated at approximately 20,000, all in Quebec. In 2001, two new populations and two new subpopulations were discovered in Quebec, but this does not mean that the species is actually colonizing new sites, since these sites had never been explored. The density of populations varies from 1 to 20 individuals per square metre, based on our personal observations; the stricter density calculations made in 2001 can explain estimated population differences with the 1992 report, especially at Développement-Boisvert-Est. Accepting that the new populations recently discovered were always present but simply missed in previous surveys, there has been a slight decline in the overall population size due to recent losses of populations and declines at three.

Declines in the extent of occurrence and area of occupancy are primarily of historic occurrence. Recent discoveries are essentially of populations that were previously not documented. On the positive side, agriculture has been declining in certain regions, such as the upper Nicolet River Valley, and some wet fields have been abandoned only to be invaded by Van Brunt's Jacob's-ladder.

Certain locations may undergo cyclical changes in the number of plants, especially those that have a lot of plants growing on abandoned farm land. These locations will likely face progressive invasion by trees, unless farming activities are resumed. This is the case at the Développement-Boisvert-Est, Saint-Camille and Stoke River locations, where about three quarters of the plants are found.

The species has probably always been rare in Canada, given the scarcity of its specialized habitats within its narrow Canadian range. If such a conspicuous plant had occurred in other regions, it would not have gone unnoticed. Data for calculating the overall decline in populations are inadequate. However, the number of plants has definitely declined over the past ten years at the Saints-Martyrs and Stoke River locations. This decline can roughly be estimated as a loss of 500 to 1,000 plants, but these figures are very approximate and are not based on systematic field surveys. It is possible that this decline is continuing, but efforts to acquire sites or negotiate conservation agreements with owners could slow down or even halt the decline.

The total Canadian population of *Polemonium vanbruntiae* is made up of a few small populations and a few large ones, but these are located in 4 distinct watersheds, those of the Nicolet, Nicolet-Nord-Est, Nicolet-Centre, and Stoke Rivers.

The estimated size and quality rating of the currently known Canadian locations (all in Quebec) are given below. Quality rating criteria are given in Table 1.

Locations	Number of mature plants	Quality rating
Saints-Martyrs	900	C
Développement-Boisvert-Est	13,000	A
Développement-Boisvert-Ouest	330	C
Saint-Adrien	1	D
Saint-Camille	2,000	C
Ham-Sud	300	C
Stoke River	3,000	C
Mont-Carrier-Sud	70	D

Table 1. Criteria* used to rate the quality of the occurrences (locations) of *Polemonium vanbruntiae.*

Rating	
A	population of over 10,000 individuals in a habitat that is little or not disturbed by human activities and that is stable over the long term.
B	population of 1,000 to 10,000 individuals in a habitat that is little or not disturbed by human activities and that is stable over the long term.
C	population of 100 or more, and fewer than 1,000 individuals, in a habitat that may or may not be disturbed by human activities, or population of more than 1,000 individuals in a habitat highly disturbed by human activities (agriculture, logging) and not stable over the long term.
D	population of fewer than 100 individuals, in a habitat that may or may not be disturbed by human activities, or population of fewer than 1,000 individuals in a habitat highly disturbed by human activities (agriculture, logging) and not stable over the long term.

*Proposed by the author and adapted from the methodology used by the United States organization. The Nature Conservancy. The quality rating of each extant occurrence is based on the size and status of the populations (surface area occupied, density, number of fertile and vegetative individuals) and on the surrounding context (habitat integrity, and quality of the surrounding landscape from the standpoint of its impact on viability of the occurrence). Rating D presumably represents the viability threshold for the species.

LIMITING FACTORS AND THREATS

Personal observations indicate that the factors that most limit or threaten *Polemonium vanbruntiae* in Quebec are agriculture and logging.

Agricultural impact is due to mowing, ploughing, drainage and Christmas tree growing, especially in wet and/or riparian meadows. Impacts associated with agriculture have been noted in the Stoke River and Wotton locations, and the Saint-Camille and Mont-Carrier-Sud locations may also be at risk in the near future, because agriculture is already practised nearby.

Logging, through felling and drainage work, has already caused partial elimination of the Saints-Martyrs location. This may happen elsewhere, but actual and future conservation agreements and land purchases could halt this trend.

Road infrastructure work is another threat when the drainage is altered, as has happened at Saint-Adrien. However, only one other population is located near a road, the one in the southern part of the Stoke River location. No dam projects are planned within the extent of occurrence of Van Brunt's Jacob's-ladder.

Over the medium term, the construction of cottages or homes could threaten a portion of the Développement-Boisvert-Ouest location. Off-road vehicle trails can also damage Jacob's-ladder populations, as we have already seen in the northern part of the Développement-Boisvert-Est location.

SPECIAL SIGNIFICANCE OF THE SPECIES

- *Polemonium vanbruntiae* is endemic to the central Appalachians and is found in Canada and the United States.
- The species does not have an important ecological role, except perhaps for the survival of the flower-feeding insects in those locations where the plant exists.
- *Polemonium* is not a monotypic genus, but only one of its species, *P. vanbruntiae,* is native to Canada east of Alberta (Scoggan, 1979).
- The species is not at risk at the global scale, but it is rare (G3) and sporadic (Lavoie, 1992; Argus and Pryer, 1990; NatureServe, 2001).
- The species is protected in Canada, where it was designated as threatened in Canada, in 1994 (COSEWIC, 2000), and threatened in Quebec, in 1998 (Ministère de l'Environnement, 2001; Coursol, 2001). It has been on Canada's list of rare plants since 1990 (Argus and Pryer, 1990). There are no related forms that are threatened.
- The Canadian populations may contain genetic diversity important for the species' survival, since they represent the species' northernmost locations.
- Van Brunt's Jacob's-ladder is of scientific interest because of its primitive nature; according to Grant (1959), *Polemonium* is the most primitive genus within tribe Polemoniae.
- The plant is of public interest due to its great beauty as well as its horticultural potential in wetland gardens. According to Klimas and Cunningham (1981), North American Indians used to wash their hair with a leaf decoction from this plant. Cox (1985) mentions the astringent and sudorific medicinal properties of two related species, *P. caeruleum* and *P. reptans*, which are recommended for diarrhoea, stings, bites, and lung ailments.
- There is no negative public opinion against this species.
- *Polemonium vanbruntiae* may be confused with two cultivated plants, *P. caeruleum* and *P. reptans*, which occasionally escape cultivation but grow in slightly drier environments.

EXISTING PROTECTION OR OTHER STATUS

- *Polemonium vanbruntiae* is designated as threatened in Canada and will thus be protected under the federal *Species at Risk Act*. In Quebec, pursuant to the provincial *Threatened or Vulnerable Species Act* (R.S.Q., c. E-12.01), the species may not be harvested, destroyed or possessed outside of its natural environment, and stiff fines can be imposed (Couillard, 1998).
- At the international level, the species is not listed or designated in the IUCN Red Book, nor under the *Convention on International Trade in Endangered Species of Wild Fauna and Flora* (CITES), nor under the United States *Endangered Species Act*.
- No international agreements have been signed with respect to Van Brunt's Jacob's-ladder.

- The most recent status ranks for the species (Nature Serve, 2001) are as follows:
  Global status: G3
  National status:
    United States of America: N3
    Canada: N1
  Subnational status:
    United States of America: Maine (S1), Maryland (S2), New Jersey (SX), New York (S3), Pennsylvania (S1), Vermont (S2), West Virginia (S2); the species has been designated as threatened in Vermont (Thompson,1989) and endangered in Maine (Magee and Ahles, 1999)
    Canada: New Brunswick (SH), Quebec (S1)
- The species was designated as threatened in Canada, in 1994, by the Committee on the Status of Endangered Wildlife in Canada (COSEWIC, 2000), and as threatened in Quebec, in 1998, by the Government of Quebec (gouvernement du Québec, 1998).
- In Canada and in Quebec, there are no protected public areas where the species is found. The Société de conservation des milieux humides du Québec (SCMHQ), a private agency, recently purchased the northern part of the Développement-Boisvert-Est location, which is home to Quebec's largest *Polemonium vanbruntiae* population (Alain Gouge, *verbatim*, October 16, 2001).

SUMMARY OF THE STATUS REPORT

Declines in the extent of occurrence and the area of occupancy of *Polemonium vanbruntiae* are mainly of historic occurrence. Some localized recent declines at some sites have been documented. In total there are about 20,000 plants in Canada at eight locations in Quebec. Current and potential threats are mainly from logging and farming-related activities. These threats will probably continue to exist over the short, medium and long term, unless mitigative measures are taken.

Two new populations and two new subpopulations were discovered in 2001 in Quebec. It is clear that there is still a potential for future discoveries in Quebec, in watersheds where the species is known to occur and also adjacent watersheds, even though such searches often prove fruitless and must be carried out in difficult habitats. There is also a potential in southwestern New Brunswick.

Moreover, the planned and current purchases and conservation agreements with site owners, by the Société de conservation des milieux humides du Quebec and by the Ministère de l'Environnement du Quebec, suggest that the downward trends will be halted and that the species' status will stabilize.

Further research is needed for a better understanding of the actual current status of this species, both in Quebec and in New Brunswick. This research should be part of a Canadian *Polemonium vanbruntiae* recovery plan and involve a partnership agreement between the COSEWIC, the Ministère de l'Environnement du Quebec, the New Brunswick Department of Natural Resources and Energy, the SCMHQ, the Montreal Botanical Garden, as well as other public and private agencies of Canada and the two provinces.

TECHNICAL SUMMARY

Polemonium vanbruntiae
Van Brunt's Jacob's-ladder　　Polémoine de Van Brunt
Quebec

Information on the extent of occurrence and the area of occupancy	
• *extent of occurrence (EO) (km²)*	644 km²
• *specify the trend (on the decline, stable, growing, unknown)*	Decline
• *are there extreme fluctuations in the EO (order of magnitude > 1)?*	No
• *area of occupancy (AO) (km²)*	About 5 ha
• *specify the trend (on the decline, stable, growing, unknown)*	Slight decline
• *are there extreme fluctuations in the AO (order of magnitude > 1)?*	No
• *number of existing locations*	8 areas with 11 sub-populations
• *specify the trend (on the decline, stable, growing, unknown)*	Slight decline
• *are there extreme fluctuations in the number of locations (order of magnitude > 1)?*	No
• *habitat trend: specify the trend: on the decline, stable, growing, unknown of the area, extent or quality of the habitat*	Slight decline
Information on the population	
• *generation time (mean age of the parents in the population) (indicate the years, months, days, etc.)*	Primarily about 2 years to ample flowering for many species of this genus
• *number of mature specimens (able to reproduce) in the Canadian population (or specify a scale of plausible values)*	20,000 est.
• *total population trend: specify the trend: on the decline, stable, growing or unknown of mature specimens*	Slight decline
• *if the trend is on the decline, % of decline over the last/next 10 years or 3 generations, the one that is bigger (or specify that it involves a shorter period)*	About 4 to 7%
• *are there extreme fluctuations in the number of mature specimens (order of magnitude > 1)?*	No

• *is the total population seriously fragmented (most of the specimens are found in small populations, that are relatively isolated (geographically or otherwise) between which there are few exchanges, namely, ≤ 1 successful migration/year)?*	Yes
• *List each population and give the number of mature specimens in each population*	1- Saints-Martyrs: 900 2- Développement-Boisvert-Est:13,000 3- Développement-Boisvert-Ouest: 330 4- Saint-Adrien: 1 5- Saint-Camille: 2,000 6- Ham-Sud: 300 7- Stoke River: 3,000 8- Mont-Carrier-Sud: 70
• *Specify the trend in the number of populations (on the decline, stable, growing, unknown)*	Trend? New pops. found in sites previously not surveyed
• *Are there extreme fluctuations in the number of populations (order of magnitude > 1)?*	No
Threats (real or imminent for the populations or the habitats): Agriculture (mowing, drainage, ploughing, cultivation of Christmas trees); logging (felling, drainage); road infrastructures (prolonged flooding); residential development; off-road vehicle trails and use of such vehicles.	
Rescue effect (immigration from an outside source)	Unlikely due to disjunction from main range
• *Does the species exist elsewhere (in Canada or abroad)?*	In New Brunswick:? (potential) In the United States: yes
• *Status of the populations elsewhere?*	Maine: endangered (S1) New York: rare (S3) Vermont: threatened (S2)
• *Is immigration known or possible?*	Unlikely?
• *Would immigrants adapt to survive at this place?*	Yes
• *Does a sufficient habitat exist at this place for immigrants?*	Yes
Quantitative analysis	

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BIOGRAPHICAL SUMMARY OF THE CONTRACTOR

André Sabourin is a geographer by training, having obtained a Bachelor's Degree in Geography in 1972 from Université du Québec à Montréal. From 1973 to 1988, he practised botany as a hobby and became a self-taught biologist. In 1989, he obtained his first professional contract, from COSEWIC. In 1991, he published a *Guide des Crucifères sauvages de l'Est du Canada*. In 1991 and 1992, he did research on Van Brunt's Jacob's-ladder for COSEWIC, and he submitted his report in 1992. In 1997 and 2000, he returned to the field on behalf of the ministère de l'Environnement du Québec and the Société de conservation des milieux humides du Québec, to help with the conservation of this threatened species. He is the Canadian botanist with the most extensive knowledge on this plant and its habitat.

AUTHORITIES CONSULTED

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Blaney, S. October 2001. Botanist, Atlantic Canada Conservation Data Centre, P.O. Box 6416, Sackville, New Brunswick E4L 1C6.

COLLECTIONS CONSULTED

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