COSEWIC
Assessment and Status Report

on the

Common Five-lined Skink
Plestiodon fasciatus

Carolinian population
Great Lakes/St. Lawrence population

in Canada

Carolinian population - ENDANGERED
Great Lakes/St. Lawrence population - SPECIAL CONCERN
2021

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. 2021. COSEWIC assessment and status report on the Common Five-lined Skink *Plestiodon fasciatus,* Carolinian population and Great Lakes/St. Lawrence population in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. xvi + 61 pp. (https://www.canada.ca/en/environment-climate-change/services/species-risk-public-registry.html).

Previous report(s):

COSEWIC 2007. COSEWIC assessment and update status report on the Five-lined Skink *Eumeces fasciatus* (Carolinian population and Great Lakes/St. Lawrence population) in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. vii + 50 pp. (www.sararegistry.gc.ca/status/status_e.cfm).

COSEWIC 2001. COSEWIC assessment and status report on the Five-lined Skink *Eumeces fasciatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-41 pp.

Seburn, C.N.L. 1998. COSEWIC status report on the Five-lined Skink *Eumeces fasciatus* in Canada. Committee on the Status of Endangered Wildlife in Canada. Ottawa. 1-41 pp.

Production note:
COSEWIC would like to acknowledge Stephen Hecnar for writing the status report on Common Five-lined Skink (*Plestiodon fasciatus*), in Canada, prepared under contract with Environment and Climate Change Canada. This report was overseen and edited by Kristiina Ovaska, Co-chair of the COSEWIC Amphibians and Reptiles Specialist Subcommittee.

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Common Five-lined Skink — photo by Stephen Hecnar.

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COSEWIC Assessment Summary

Assessment Summary – April 2021

Common name
Common Five-lined Skink - Carolinian population

Scientific name
Plestiodon fasciatus

Status
Endangered

Reason for designation
This small and secretive lizard is restricted to isolated areas on the shores of lakes Erie, St. Clair, and Huron in Ontario. The population has experienced a long-term decline, and today exists only in nine small and widely separated subpopulations within a landscape heavily modified by urbanization and agriculture. Continuing threats include habitat loss from various sources, mortality and barriers to movement from an extensive network of roads, increased predation by raccoons and other species associated with disturbed habitats, and severe storms associated with climate change that are eroding shoreline habitats. The wildlife species' limited distribution across a low number of small isolated subpopulations and multiple continuing threats are the reasons for retaining Endangered status.

Occurrence
Ontario

Status history
The species was considered a single unit and designated Special Concern in April 1998. Split into two populations in April 2007. The Carolinian population was designated Endangered in April 2007. Status re-examined and confirmed in May 2021.

Assessment Summary – April 2021

Common name
Common Five-lined Skink - Great Lakes/St. Lawrence population

Scientific name
Plestiodon fasciatus

Status
Special Concern

Reason for designation
This small and secretive lizard occurs in the southern Canadian Shield in Ontario, from Georgian Bay to the St. Lawrence River. It is currently known from 87 subpopulations, three of which have been discovered since the previous status assessment. A declining trend is suspected but cannot be confirmed because of lack of systematic surveys at historically occupied sites. Threats include increased depredation by native and domestic animals, mortality on roads, incremental habitat loss from development, and habitat disturbance from recreation. The re-confirmed designation of Special Concern recognizes that this population may become Threatened if the threats are not effectively managed.

Occurrence
Ontario

Status history
The species was considered a single unit and designated Special Concern in April 1998. Split into two populations in April 2007. The Great Lakes/St. Lawrence population was designated Special Concern in April 2007. Status re-examined and confirmed in May 2021.

COSEWIC
Executive Summary

Common Five-lined Skink
Plestiodon fasciatus

Wildlife Species Description and Significance

Common Five-lined Skink is a secretive, diurnally active, semi-fossorial (burrowing), small lizard that reaches a maximum body size (snout-vent length) of approximately 86 mm. Juveniles have five light-coloured stripes on their black body and prominently display the species' most characteristic feature, a bright blue tail. Colouration fades with age in both sexes, although females retain more of the original colour pattern. In the breeding season, males develop reddish-orange colouration around the jaws and chin. The scales are unkeeled, giving the animal a smooth, shiny appearance. This species is eastern Canada's only lizard. It dominates both abundance and biomass in some herpetological communities. The charismatic skink can serve as a 'flagship species' inspiring the public to better understand and appreciate the importance of reptiles in Canada.

Distribution

The geographic range of Common Five-lined Skink roughly coincides with the deciduous hardwood forests of eastern North America, making it the most widely distributed lizard there. The species' distribution extends from the Atlantic seaboard west to Texas and Minnesota and from southern Ontario south to the Gulf of Mexico. In Canada, the species is restricted to two disjunct populations in Ontario: 1. the Great Lakes/St. Lawrence population on the southern Canadian Shield (from Georgian Bay east to the St. Lawrence River); and 2. the Carolinian population in southwestern Ontario (near the shores of lakes Erie, St. Clair, and Huron).

Habitat

Common Five-lined Skink primarily inhabits early successional habitat with low to moderate canopy cover. Individuals spend most of their time under cover that provides suitable microclimates and refuges from predators. The two populations in Ontario occur in distinct habitats. The Great Lakes/St. Lawrence population occurs on the Canadian Shield on rock outcrops or rock barrens embedded in a matrix of coniferous and deciduous forest, where individuals seek refuge under rocks overlaid on open bedrock or enter crevices and fissures. The Carolinian population occurs in stabilized dunes, open hardwood forest, grassland, and savannahs, generally with a sandy substrate. Individuals in both populations have a strong association with woody debris as refuge.

Biology

In Ontario, the active season of Common Five-lined Skink is usually from mid- April to early October. Individuals are sexually mature after they emerge from their second hibernation, at 21 months of age. Several weeks after mating, the female locates a suitable nest site, excavates a cavity, and lays a clutch of approximately nine eggs, which she will brood and defend. Females often nest communally. Generation time is estimated to be three years. Five-lined Skink is an active forager that consumes mainly invertebrates. Predators of the species include a range of birds, small mammals, and snakes. Skinks will often autotomize (voluntarily sever) their tail if seized by a predator, which helps them to escape.

Population Sizes and Trends

Currently, 87 Great Lakes/St. Lawrence subpopulations have been verified on the southern fringe of the Canadian Shield, while only nine Carolinian subpopulations have been confirmed to be extant in the past decade. The Carolinian population has declined historically, and declines have continued since the 1980s. Two of the largest subpopulations carry a high risk of extinction over the next 50 years, and all subpopulations have a low viability over the long term if threats are not managed. Skinks within the Great Lakes/St. Lawrence population remain widespread and abundant, but lack of systematic surveys at historically occupied sites hinders discerning trends. Population density varies greatly throughout the year, and cohort structure can vary among years depending on weather conditions and other factors.

Threats and Limiting Factors

Historically, habitat loss and alteration by agricultural expansion, urbanization, and forest encroachment have resulted in extirpations and isolation of subpopulations, particularly in the Carolinian population. This fragmentation has resulted in interpopulation distances exceeding dispersal capabilities of the skinks. The vast road network across southern Ontario further increases isolation and is a source of mortality. High water levels and more frequent and severe storms associated with climate change are eroding shoreline habitats of the Carolinian population. Historical extirpations of large-bodied predators have resulted in an overabundance of mid-sized predators such as Raccoons (*Procyon lotor*) and Striped Skunks (*Mephitis mephitis*) that prey on skinks. Other threats include illegal collecting, especially for the Carolinian population, predation by dogs and cats, road mortality, urban expansion, disturbance associated with increased human recreation, and potentially toxic effects of pollution. Destruction or removal of microhabitat features that provide refuges (e.g., cover rock or woody debris) can cause a decline in abundance.

Protection, Status and Ranks

Although listed as Secure in most southern United States jurisdictions, several northern jurisdictions consider the species Vulnerable. The status assessment by COSEWIC and designation under the federal *Species At Risk Act* is Endangered for the Carolinian population and Special Concern for the Great Lakes/St. Lawrence population (termed Southern Shield population provincially in Ontario). The Committee on the Status of Species at Risk in Ontario recognizes these two populations as Endangered and Special Concern, respectively, under Ontario's *Endangered Species Act*, concurring with COSEWIC's designations.

TECHNICAL SUMMARY – Carolinian population

Plestiodon fasciatus

Common Five-lined Skink - Carolinian population

Scinque pentaligne commun - Population carolinienne

Range of occurrence in Canada (province/territory/ocean): Ontario

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used)	3 years. Estimated, based on annual adult survival rate of 0.5–0.7
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Yes, observed, inferred, and projected decline
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Likely >30% based on observed decline of 32% in the largest monitored subpopulation and ongoing range-wide threats
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	Projected reduction of 10 – 70% based on threats calculator results (overall threat impact "High")
[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.	Suspected >30% based on observed decline of 32% in the largest monitored subpopulation and ongoing range-wide threats
Are the causes of the decline a. clearly reversible and b. understood and c. ceased?	a. Yes, but highly unlikely b. Yes c. No
Are there extreme fluctuations in number of mature individuals?	No. Not extreme in annual or multiyear change (i.e., order of magnitude) but disparate fluctuations and steep directional trends in some subpopulations.

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	8,389 km² (based on extant sites from 1998–2018) and adjusted to Canadian jurisdiction
Index of area of occupancy (IAO) (Always report 2x2 grid value).	336 km² (based on extant sites from 1998–2018)

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?	Yes. a. All 9 extant subpopulations (=Element Occurrences, EOs) have low long-term viability, including 2 of the largest subpopulations. b. Yes. Mean nearest neighbour distance of 31 km is beyond dispersal abilities of individuals, and habitat between subpopulations is inhospitable.
Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	4 – 9, maximum number corresponding to each extant subpopulation; 6 subpopulations are on shoreline and could be conceivably affected by a very large storm event; when combined, they reduce locations to a total of 4.
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Yes, observed decline (-66.8% long-term decline averaging -4.8% per decade).
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Yes, observed decline (-81.6% long-term decline with an average of -5.9% decline per decade, and -7.1% in the past decade).
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Yes, observed loss of 5 of 14 subpopulations based on lack of recent records. Timing of the disappearance is uncertain.
Is there an [observed, inferred, or projected] decline in number of "locations"*?	Yes. See above.
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes. Observed and projected decline from coastal erosion and human activities. Site visits to 41 historical localities indicated that 65.9% have lost habitat area or quality through urbanization or forest encroachment.
Are there extreme fluctuations in number of subpopulations?	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

* See Definitions and Abbreviations on COSEWIC web site and IUCN (Feb 2014) for more information on this term

Number of Mature Individuals (in each subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
Method 1, based on extrapolation from densities recorded at 3 sites to delineated area of EOs: 3,967 mature individuals (range 2,897–5,057). Method 2, based on multiplying average density recorded at 3 sites by number of EOs: 1,404 mature individuals (range 562–2,246).	<1000 /subpopulation
Total (rounded)	500 - 5000

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]?	Not done for the entire population; PVAs for two of the largest subpopulations indicate 12% and 38.9% probability of extinction in the next 20 years and a 30% and 97% probability of extinction in the next 50 years (see **Population Sizes and Trends**).

Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species? Yes, on 20 June 2019 (overall threat impact "high"; impact shown separately below for each category):

i. Transportation and service corridors (medium)
ii. Climate change and severe weather (medium to low)
iii. Invasive or other problematic species and genes (medium to low)
iv. Residential and commercial development (low)
v. Natural system modifications (low)
vi. Human intrusions or disturbance (low)
vii. Pollution (unknown)

What additional limiting factors are relevant?
Historical habitat fragmentation and habitat loss that highly isolate extant subpopulations; poor dispersal ability.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Vulnerable (S3) in MN, MI, NY, Not Ranked (NR) in OH, Apparently Secure (S4) in PA
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	Possibly
Is there sufficient habitat for immigrants in Canada?	No
Are conditions deteriorating in Canada?[+]	Yes
Are conditions for the source (i.e., outside) population deteriorating?[+]	Yes
Is the Canadian population considered to be a sink?[+]	No
Is rescue from outside populations likely?	No

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect)

Data Sensitive Species	
Is this a data sensitive species?	No

Status History:

COSEWIC: The species was considered a single unit and designated Special Concern in April 1998. Split into two populations in April 2007. The Carolinian population was designated Endangered in April 2007. Status re-examined and confirmed in May 2021.

Status and Reasons for Designation:

Status: Endangered	**Alpha-numeric codes:** B2ab(i,ii,iii,iv,v)
Reasons for designation: This small and secretive lizard is restricted to isolated areas on the shores of lakes Erie, St. Clair, and Huron in Ontario. The population has experienced a long-term decline, and today exists only in nine small and widely separated subpopulations within a landscape heavily modified by urbanization and agriculture. Continuing threats include habitat loss from various sources, mortality and barriers to movement from an extensive network of roads, increased predation by raccoons and other species associated with disturbed habitats, and severe storms associated with climate change that are eroding shoreline habitats. The wildlife species' limited distribution across a low number of small isolated subpopulations and multiple continuing threats are the reasons for retaining Endangered status.	

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Meets Threatened, A2b. Observed >30% decline in number of mature individuals over the past ten years, based on index of abundance at two of the largest subpopulations, and the causes of the decline have not ceased. Meets Threatened, A4b. Suspected >30% decline in number of mature individuals over ten years spanning past and future, based on index of abundance at two of largest subpopulations and threats calculator results
Criterion B (Small Distribution Range and Decline or Fluctuation): Meets Endangered, B2ab(i,ii,iii,iv,v). The IAO is 336 km², and the population is (a) severely fragmented and known to exist at minimum of 4 locations, and b) experiencing a continuing observed decline in EOO (i), IAO (ii), number of locations or subpopulations (iv), observed and projected decline in extent and quality of habitat (iii), and an observed, inferred and projected decline in number of mature individuals (v).
Criterion C (Small and Declining Number of Mature Individuals): Meets Threatened, C2a(i). Number of mature individuals (<5000) is below the threshold for Threatened and declining, with fewer than 1000 in any one subpopulation.
Criterion D (Very Small or Restricted Population): Not applicable. The population is not very small or restricted.
Criterion E (Quantitative Analysis): Not applicable. Analysis not conducted for entire population.

TECHNICAL SUMMARY – Great Lakes/St. Lawrence population

Plestiodon fasciatus

Common Five-lined Skink - Great Lakes/St. Lawrence population

Scinque pentaligne commun - Population des Grands Lacs et du Saint-Laurent

Range of occurrence in Canada (province/territory/ocean): Ontario

Demographic Information

Generation time (usually average age of parents in the population; indicate if another method of estimating generation time indicated in the IUCN guidelines (2011) is being used)	3 years. Estimated based on annual adult survival rate of 0.5–0.7
Is there an [observed, inferred, or projected] continuing decline in number of mature individuals?	Inferred and projected slow decline based on ongoing threats.
Estimated percent of continuing decline in total number of mature individuals within [5 years or 2 generations]	Unknown
[Observed, estimated, inferred, or suspected] percent [reduction or increase] in total number of mature individuals over the last [10 years, or 3 generations].	Unknown; 31 of 118 Element Occurrences (=subpopulations) (26%) are classified as historical or extirpated based on habitat loss or lack of observations; search effort has been insufficient to confirm extirpation at historical sites.
[Projected or suspected] percent [reduction or increase] in total number of mature individuals over the next [10 years, or 3 generations].	3–30% projected reduction based on threats calculator results (overall threat impact “Medium”)
[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 a. clearly reversible and b. understood and c. ceased?	a. Possibly b. Yes c. No
Are there extreme fluctuations in number of mature individuals?	Unknown

Extent and Occupancy Information

Estimated extent of occurrence (EOO)	38,042 - 39,043 km², based on records from 1998 - 2018 (min), and on all records (max).
Index of area of occupancy (IAO) (Always report 2x2 grid value).	2,784 - 5,328 km² based on records from 1998 - 2018 (min), and on all records (max).

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?	Unknown, but not likely. a. Not enough information is available to assess viability of subpopulations in most habitat patches. b. No. Mean nearest neighbour distance is 10 km between extant subpopulations, but relatively little habitat loss and fragmentation has occurred in the region, allowing for habitat continuity.
Number of "locations"* (use plausible range to reflect uncertainty if appropriate)	Likely >80, corresponding to subpopulations (=Element Occurrences), each of which faces a different combination of threats.
Is there an [observed, inferred, or projected] decline in extent of occurrence?	Unknown but possible decline; trend analysis complicated due to lack of targeted surveys of historical sites to confirm their status
Is there an [observed, inferred, or projected] decline in index of area of occupancy?	Unknown but possible decline; trend analysis complicated due to lack of targeted surveys of historical sites to confirm their status
Is there an [observed, inferred, or projected] decline in number of subpopulations?	Unknown; trend analysis complicated due to lack of targeted surveys of historical sites to confirm their status
Is there an [observed, inferred, or projected] decline in number of "locations"*?	Unknown; complicated by lack of targeted surveys of historical sites and newly discovered sites from increasing human visitation in some areas
Is there an [observed, inferred, or projected] decline in [area, extent and/or quality] of habitat?	Yes. Inferred and projected decline in area and quality of habitat considering growing threats in the region and long-term vegetation succession trends.
Are there extreme fluctuations in number of subpopulations?	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 subpopulation)

Subpopulations (give plausible ranges)	**N Mature Individuals**
Extrapolating average adult density for intensively studied localities (59.3/ha) to area of all extant EOs (11,483.5 ha) results in an estimate of 680,972 mature individuals. This is likely a gross overestimate, because some portions of delineated EOs are likely to be uninhabited by the species.	
Total (rounded)	>500,000

* See Definitions and Abbreviations on COSEWIC web site and IUCN (Feb 2014) for more information on this term

Quantitative Analysis

Is the probability of extinction in the wild at least [20% within 20 years or 5 generations, or 10% within 100 years]?	Not calculated

Threats (direct, from highest impact to least, as per IUCN Threats Calculator)

Was a threats calculator completed for this species? Yes, on 20 June 2019 (overall threat impact "medium"; threat impact is Low for each category):

i. Invasive or other problematic species and genes
ii. Residential and commercial development
iii. Human intrusions or disturbance
iv. Transportation and service corridors
v. Climate change and severe weather

What additional limiting factors are relevant? Poor dispersal ability.

Rescue Effect (immigration from outside Canada)

Status of outside population(s) most likely to provide immigrants to Canada.	Vulnerable (S3) in MN, MI, NY, Not Ranked (NR) in OH, Apparently Secure (S4) in PA
Is immigration known or possible?	No
Would immigrants be adapted to survive in Canada?	Possibly
Is there sufficient habitat for immigrants in Canada?	No
Are conditions deteriorating in Canada?[+]	Yes
Are conditions for the source (i.e., outside) population deteriorating?[+]	Yes
Is the Canadian population considered to be a sink?[+]	No
Is rescue from outside populations likely?	No

Data Sensitive Species

Is this a data sensitive species?	No

Status History:

COSEWIC:
The species was considered a single unit and designated Special Concern in April 1998. Split into two populations in April 2007. The Great Lakes/St. Lawrence population was designated Special Concern in April 2007. Status re-examined and confirmed in May 2021.

Status and Reasons for Designation:

Recommended Status: Special Concern	**Alpha-numeric codes:** not applicable

[+] See Table 3 (Guidelines for modifying status assessment based on rescue effect)

Reasons for designation:
This small and secretive lizard occurs in the southern Canadian Shield in Ontario, from Georgian Bay to the St. Lawrence River. It is currently known from 87 subpopulations, three of which have been discovered since the previous status assessment. A declining trend is suspected but cannot be confirmed because of lack of systematic surveys at historically occupied sites. Threats include increased depredation by native and domestic animals, mortality on roads, incremental habitat loss from development, and habitat disturbance from recreation. The re-confirmed designation of Special Concern recognizes that this population may become Threatened if the threats are not effectively managed.

Applicability of Criteria

Criterion A (Decline in Total Number of Mature Individuals): Not applicable. Insufficient data to reliably infer, project, or suspect population trends above thresholds.
Criterion B (Small Distribution Range and Decline or Fluctuation): Not applicable. EOO of 38,042 - 39,043 km^2 and IAO of 2,784 - 5,328 km^2 exceed thresholds.
Criterion C (Small and Declining Number of Mature Individuals): Not applicable. Number of mature individuals is estimated to be >500,000, exceeding thresholds.
Criterion D (Very Small or Restricted Population): Not applicable. The population is not very small or restricted.
Criterion E (Quantitative Analysis): Not applicable. Analysis not conducted for entire population.

PREFACE

This status report is a living document incorporating much of the information provided in the previous report (COSEWIC 2007). Since the previous report, both the scientific and common names of this species were changed from *Eumeces fasciatus*, Five-lined Skink, to *Plestiodon fasciatus*, Common Five-lined Skink, following Crother *et al*. (2017). Many more observation records have become available, and considerably more research has been conducted on the species since the previous report. A federal recovery strategy for the Carolinian population (Environment Canada 2014) and a management plan for the Great Lakes/St Lawrence population (Environment Canada 2013) have been prepared. This report adds and interprets updated information on distribution, habitat, movements, reproduction, diet, predation, conservation, and population trends.

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
(2021)

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

Common Five-lined Skink
Plestiodon fasciatus

in Canada

2021

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WILDLIFE SPECIES DESCRIPTION AND SIGNIFICANCE

Name and Classification

Common Five-lined Skink (*Plestiodon fasciatus*), le scinque pentaligne commun in French, belongs to the family Scincidae. Formerly the species was included in the genus *Eumeces*, which included species from across North and Central America, North and Southeast Asia, and North Africa (Fitch 1954). The first comprehensive examination of *Eumeces* revealed at least 50 recognized species that shared a relatively conserved morphology (Taylor 1936). Genetic work suggested that *Eumeces* was not monophyletic and should be split into multiple genera. Taxonomists recommended that the genus name *Plestiodon* be applied to all *Eumeces* species in North America (Schmitz *et al*. 2004; Brandley *et al*. 2005, 2012). Three species of *Plestiodon* occur in Canada: *P. fasciatus* (Five-lined Skink), *P. septentrionalis* (Prairie Skink), and *P. skiltonianus* (Western Skink). The classification of the Common Five-lined Skink is as follows:

Class: Reptilia

Order: Squamata

Family: Scincidae

Genus: *Plestiodon* Duméril and Bibron, 1839

Species: *P. fasciatus* (Linnaeus 1758)

Despite the extensive global geographic range of *P. fasciatus* and the variety of habitat and environmental conditions it occupies, there are no recognized subspecies. However, genetic analyses suggest that substantial phylogenetic structure exists within the species (Howes *et al*. 2006; Richmond 2006), and that cryptic species may exist, particularly in the eastern United States of America (USA) portion of the range (Crother *et al*. 2017).

Morphological Description

Most adults range from 12.5–22.2 cm total length (including tail; TL) with a maximum body length of approximately 86 mm snout-vent length (SVL) (Powell *et al*. 2016). Adults have a wedge-shaped head and a slender, elongated body ending with a tail that can be autotomized (detached if seized by a predator) and regenerated. Their laterally flattened bodies and moderately developed limbs make them adept burrowers, enabling them to find refuge under a variety of cover objects. Their well-developed toes and strong claws provide them with agility over a variety of substrates and the ability to climb rough surfaces and trees (Fitch 1954).

Hatchling *P. fasciatus* are approximately 25 mm in SVL and 58 mm in TL. They have five thin white, yellow, or cream-coloured longitudinal stripes on their black body (Powell *et al*. 2016). Body colouration and pattern fade with age to become brown, grey, to solid bronze in both sexes. Females generally retain more of the juvenile colouration and pattern than males. The species' characteristic bright blue tail is most obvious in hatchlings and juveniles but fades to grey in adults. During breeding season, adult males develop bright orange-red colouration around the jaws and chin, and some very large females may show some pink around the chin. Unkeeled scales give individuals a smooth, shiny appearance and perhaps explain why the species is often misidentified as a salamander by the general public (Fitch 1954).

Population Spatial Structure and Variability

Spatial Structure:

The Canadian populations of *P. fasciatus* became isolated about 4000 YBP (years before present) when isostatic rebound changed post-glacial spillways leading to the current configuration of the Lower Great Lakes and its drainages (Strahler 1971). The water barrier that persists to present times eliminated connection with populations in the United States, isolating the Canadian populations at the northern periphery of the species' range. This isolation has resulted in considerable genetic differentiation (see **Genetic Description**).

Extant Carolinian subpopulations are highly isolated from each other (13–55 km, *n* = 9) with a mean nearest neighbour distance of 30.7 ± 5.32 km (Hecnar and Brazeau 2016). Natural colonization from a neighbouring subpopulation following a local extinction event is virtually impossible considering poor dispersal capabilities of the skinks (less than 1 km) and nature of the landscapes separating subpopulations. Extant Great Lakes/St. Lawrence subpopulations are less isolated from each other (2–30 km, *n* = 87) with a mean nearest neighbour distance of 9.8 ± 0.51 km (Hecnar unpubl. data). This mean nearest neighbour distance is likely an overestimate, owing to the limited search effort and high likelihood of undocumented occurrences in this region.

Genetic Description, Range-wide:

A phylogeographic study spanning the global range of *P. fasciatus* revealed six major mitochondrial lineages (Figure 1). Similar to other eastern North American herpetofauna, *P. fasciatus* populations are structured in a manner that reflects divergence from east to west (longitudinal phylogeographic structure). Phylogeographic patterns are consistent with fragmentation due to refugial and post-glacial dynamics, but deep divergences among some lineages imply historical fragmentation that predates the Pleistocene (Howes *et al*. 2006). The species has three broadly distributed (East, Central, and West) and three geographically restricted lineages (Carolinas, Oklahoma, and Wisconsin). The most broadly distributed is the East lineage. It spans from the Mississippi River east to the Atlantic Ocean and includes all Ontario populations.

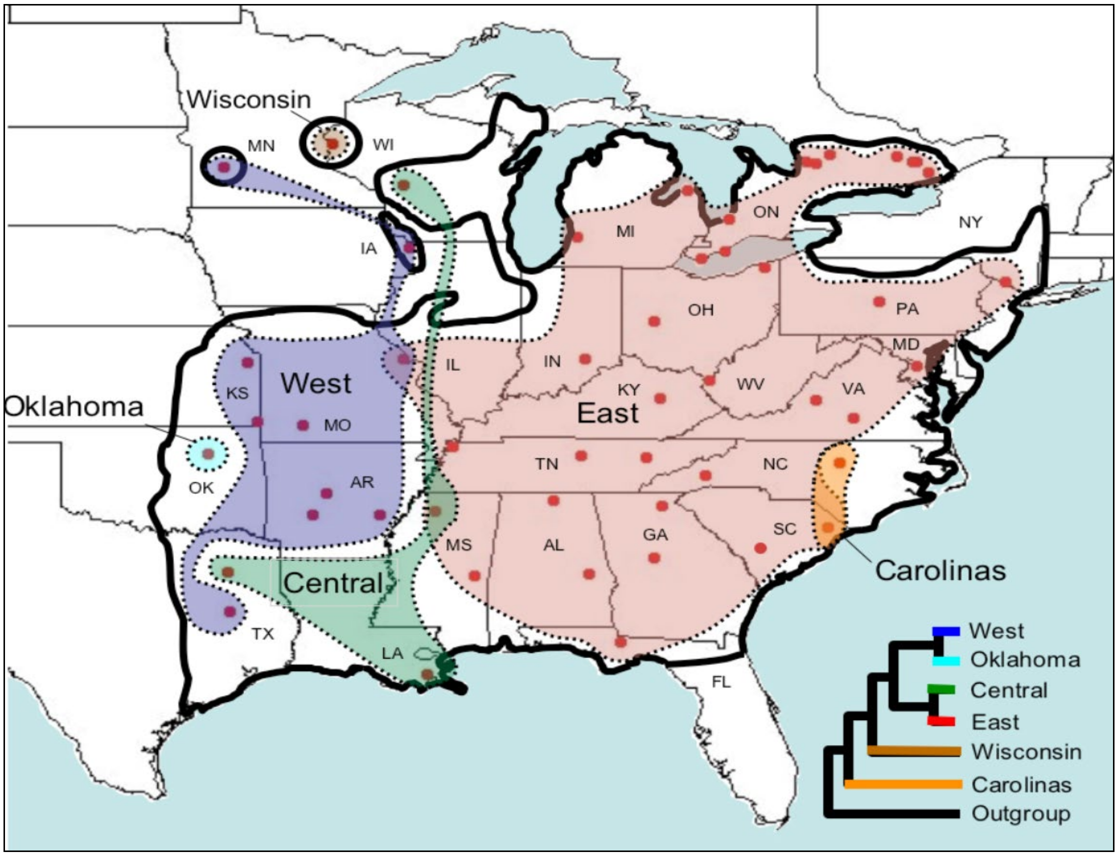

Figure 1. Distribution and mitochondrial lineage groupings of *Plestiodon fasciatus* (range distribution based on Conant and Collins 1998). States and provinces are indicated by abbreviations and sampling sites are marked with circles. Species' range borders are marked with thick lines and include three disjunct series of populations (MN, WI, and IA). Based on analysis of 769 bp (base pairs) of the mitochondrial DNA and including three main lineages (East, Central, West) and three geographically isolated lineages (Carolinas, Oklahoma, Wisconsin). A simplified phylogeny in the lower right of this figure shows the relationships among these different lineages. Adapted from Howes *et al*. (2006).

<u>Genetic Description, Ontario populations:</u>

Although Ontario's Carolinian and Great Lakes/St. Lawrence populations belong to the same mitochondrial lineage, they show considerable genetic divergence based on rapidly evolving microsatellite markers (Howes *et al*. 2006; Howes and Lougheed 2008). Pair-wise genetic differences in allele frequencies among thirty subpopulations from across the species' range were estimated using Nei's standard genetic distance (Nei 1978). An unrooted neighbour-joining tree was constructed based on these pair-wise genetic distances among populations; support for each cluster of the tree was based on bootstrapping genotypes among populations and is indicated as a percent (Figure 2). Great Lakes/St. Lawrence subpopulations (n = 7) form an exclusive cluster, whereas Carolinian subpopulations (n = 2) form another cluster together with a subpopulation from eastern Michigan (Howes *et al*. 2006). Genetic differentiation (based on F_{ST}) between all pairs of Ontario populations was calculated to determine if average genetic differentiation between

Great Lakes/St. Lawrence and Carolinian populations exceeded that within each series of subpopulations. F_{ST} (Wright 1969) is a standard measure of genetic differentiation between two populations and values can range from 0 (no genetic differentiation) to 1 (complete genetic differentiation). Mean genetic differentiation within Great Lakes/St. Lawrence populations was 0.10 (n = 21), and the genetic differentiation between the only pair of Carolinian subpopulations examined was also 0.10 (Howes and Lougheed unpubl. data cited in COSEWIC 2007). In contrast, the mean genetic differentiation between Great Lakes/St. Lawrence and Carolinian populations was higher at 0.15 (n = 14). All pair-wise comparisons were highly significant (Howes and Lougheed unpubl. data cited in COSEWIC 2007), suggesting that Great Lakes/St. Lawrence and Carolinian populations in Ontario show highly significant genetic isolation from each other.

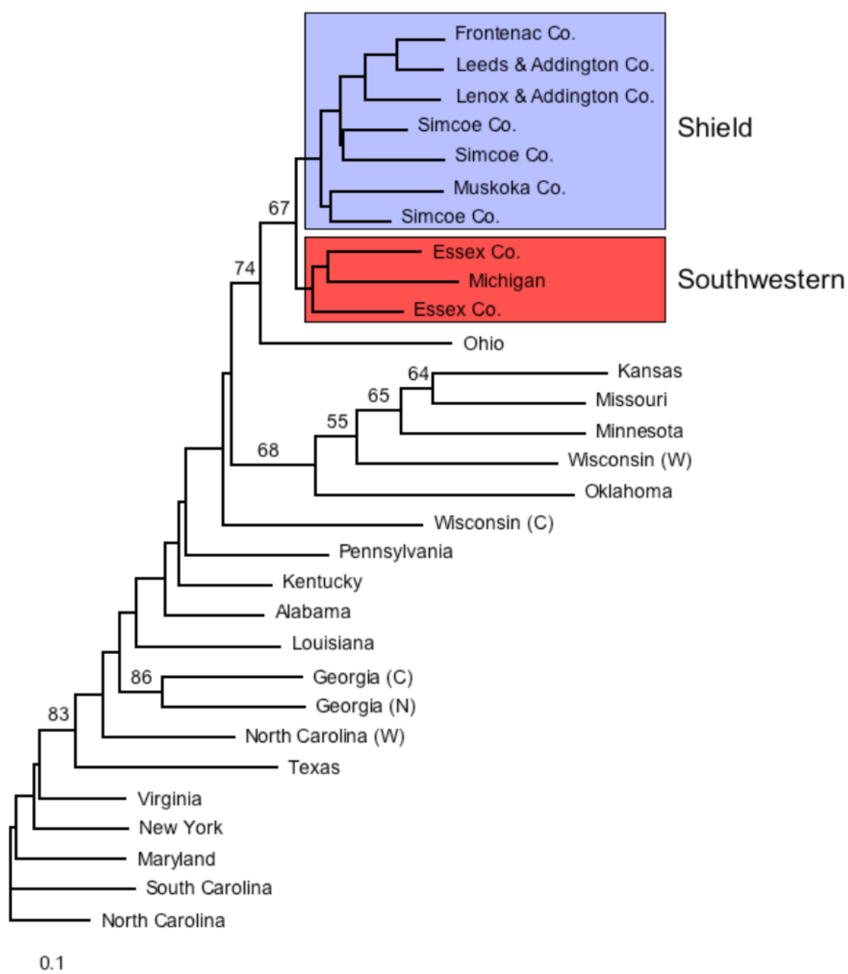

Figure 2. Neighbour-joining dendrogram based on Nei's (1978) genetic distance among subpopulations of *Plestiodon fasciatus* as determined by six microsatellite loci. Bootstrap values (>50%) from 1,000 replicates are shown. The state (U.S.) or county (Ontario) where each subpopulation was sampled is indicated. The Shield and Southwestern groups include Great Lakes/St. Lawrence and Carolinian DUs, respectively. From COSEWIC (2007), courtesy of Briar Howes.

Extant Carolinian subpopulations are geographically isolated from each other. Significant genetic differentiation exists between the Rondeau Provincial Park (RPP) and Point Pelee National Park (PPNP) subpopulations (COSEWIC 2007), which is not surprising given that they are separated by 70 km. Subpopulations in the Great Lakes/St. Lawrence population separated by as little as 3–5 km showed significant genetic distinction based on microsatellite analyses (Wick 2004). Wick (2004) also showed that water is an effective barrier to gene flow in the species, and that an island subpopulation in their study site had reduced genetic diversity relative to neighbouring subpopulations that were within approximately 2 km or less.

Designatable Units

Reassessment by COSEWIC (2007) and subsequent designation under the federal *Species at Risk Act* recognized two designatable units (DUs) based on genetic evidence, range disjunction, and biogeographic distinction. Re-examination of the original reasons for designating the Carolinian and the Great Lakes/St. Lawrence (GLSL) populations as separate DUs in this report supports retaining the two separate DUs based on discreteness and evolutionary significance.

Discreteness:

The two populations may have dispersed into Canada along different post-glacial dispersal routes: Carolinian population from the south along the Central Great Lakes route around the western end of Lake Erie, and the Great Lakes/St. Lawrence population along the Appalachian/Eastern Boreal route, first north between the eastern end of Lake Ontario and Appalachian Mountains and then west and south (see O'Connor and Green 2016 for potential post-glacial dispersal routes for Canadian amphibians and reptiles). Natural fragmentation of former tallgrass prairie and oak savannah habitats from changing climate over the past 4,000 years has fragmented habitats and further isolated the two populations; the fragmentation has been compounded and accelerated by anthropogenic habitat loss and alteration over the past century (see **Habitat Trends**). With the loss of the closest Carolinian subpopulation to the GLSL subpopulations on the Niagara Peninsula, extant populations in the two populations are now separated by about 225 km.

Evolutionary significance:

These two populations occur in two different COSEWIC terrestrial Amphibians and Reptiles Faunal Provinces with different climates and physiography, which has likely resulted in local adaptations. Skinks in the Carolinian population occur in areas with deep, often sandy soils, overlying calcareous bedrock, where woody debris provides critical cover. Skinks in the GLSL population occur within the Canadian Shield and Hurontario faunal provinces on rock outcrops or rock barrens with little soil where broken or loose rock and crevices or fissures provide critical cover. Research subsequent to the 2007 assessment strengthens the evidence that different habitats and microsites are used by skinks in the two areas, suggesting local adaptations (Hecnar 1991; Howes and Lougheed 2004; Brazeau 2016; Feltham 2020).

Special Significance

Plestiodon fasciatus is one of only six native lizard species in Canada and the only lizard species in eastern Canada. Skink abundance and biomass currently dominate or co-dominate other species in herpetofaunal community structure in coastal areas of the Carolinian DU, suggesting that they have played an important role in ecosystem functioning historically and continue to do so where they still persist (Hecnar *et al*. 2018). Skink presence in several protected areas in southern Ontario also serves as an important 'umbrella species' for herpetofaunal conservation and education of the public in one of the most human-altered regions of Canada. Presence of *P. fasciatus* in Canada may also have special significance in terms of human health because they serve as a dilution host (directing ticks away from more effective intermediate hosts), so reducing prevalence of the bacterium that causes lyme disease by 11–52% in tick vectors, potentially lowering risk of infection in humans (Giery and Ostfield 2007; McAllister *et al*. 2013). Pictographs of a "snake with legs" in Lake Superior and Petroglyphs Provincial Parks can be interpreted as a skink (Seburn and Seburn 1998; S. Hecnar pers. obs.), suggesting that the species may have been significant historically to First Nations.

DISTRIBUTION

Global Range

The geographic range of *P. fasciatus* roughly coincides with the Temperate Deciduous Forest biome (hardwood forest) of eastern North America (Fitch 1954; Lomolino *et al*. 2017), making it the most widely distributed species in its genus (Taylor 1936; Powell *et al*. 2016) and the most widely distributed lizard in eastern North America (Powell *et al*. 2016). The species' range extends from the Atlantic seaboard west to Texas and Minnesota and from southern Ontario south to the Gulf of Mexico (Figure 1). The range spans roughly 1,800 km from north to south and 1,900 km from east to west (Fitch 1954; Powell *et al*. 2016).

Canadian Range

Approximately 2% of the *P. fasciatus* global geographic range occurs in Canada, where the species occurs in two disjunct regions in southwestern and south-central Ontario. The Carolinian DU is distributed primarily near the shores of lakes Erie, St. Clair, and Huron (Figure 3). The GLSL DU is distributed along the southern margin of the Canadian Shield from Georgian Bay eastward to Leeds and Grenville counties (Figure 3).

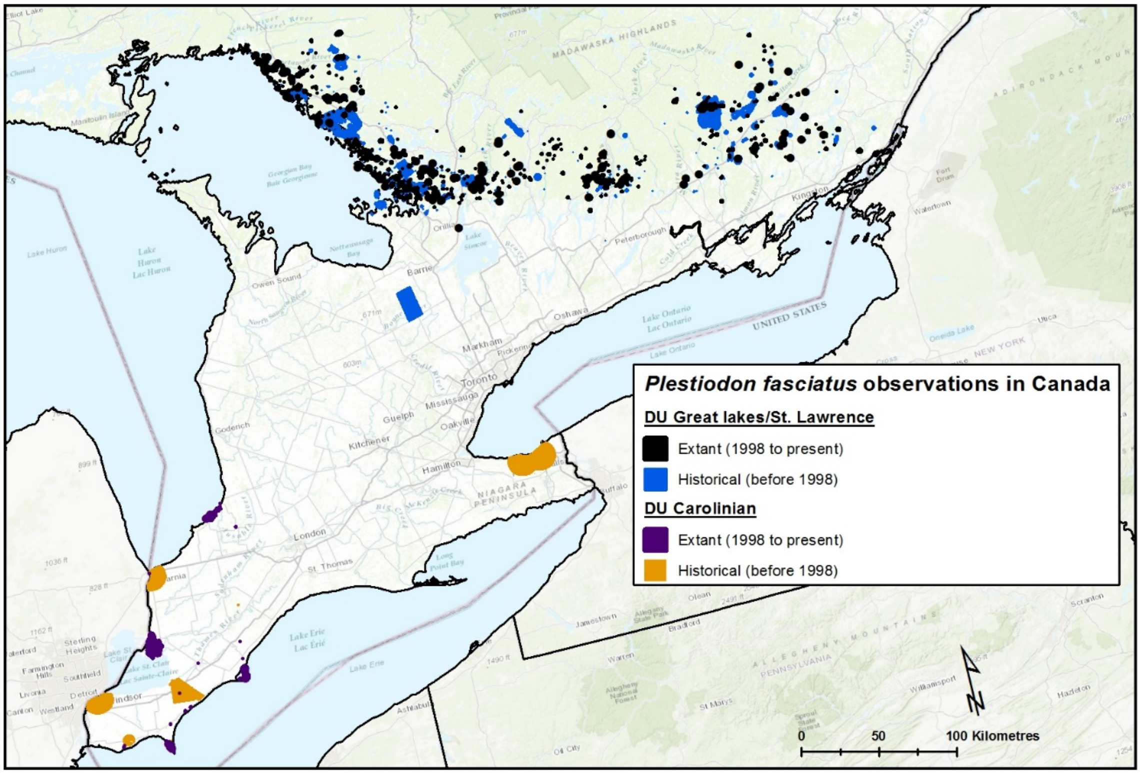

Figure 3. Range of *Plestiodon fasciatus* in Canada based on records available as of 2018 (Source: NHIC, ORAA). Map prepared by Rosana Nobre Soares, COSEWIC Secretariat. Note: The blue rectangle west of Barrie is based on a single record from 1939 with uncertain coordinates in the former Tosorontio Township, now merged with Adjala Township.

Distribution of records of the skink in southern Ontario closely matches distribution of relict prairie and savannah patches associated with the post-glacial expansion of the prairie peninsula from the Midwest USA into southern Ontario (Smith 1957; Sowers 2018). *Plestiodon fasciatus* is considered a cold-adapted primary invader that followed retreating glaciers from southern refugia (Holman 1992, 1995). Existence of a land bridge in the past between what is now Michigan and southwestern Ontario (Hecnar *et al*. 2002), together with genetic evidence (Howes *et al*. 2006; Howes and Lougheed, 2008), suggests that skinks entered southern Ontario when the region was mostly open habitat, allowing them to advance to the southern fringe of the Canadian Shield (Sowers 2018), where temperature likely set the northern distributional limit (Feltham 2020).

The current pattern of isolated subpopulations, especially in the Carolinian DU, near prairie remnants, savannahs, and open shorelines (Sowers 2018), suggests that habitat loss has been ongoing for several thousands of years. However, the rate of loss was rapidly accelerated with anthropogenic landscape conversion to agriculture and urban expansion in what is now one of the most human-altered regions of North America (Bakowsky and Riley 1994). Existence of a historical pictograph that resembles a skink in Lake Superior Provincial Park and the archipelago named the Lizard Islands just offshore suggests that the species may have ranged farther north in the warmer and drier

Hypsithermal Period 9,000–5,000 YBP (Hecnar unpubl. data).

Extent of Occurrence and Area of Occupancy

Extent of occurrence (EOO) and index of area of occupancy (IAO) were calculated using standard COSEWIC methods: minimum convex polygon for EOO; 2 x 2 km grids for IAO based on distribution records (Table 1). Verified observation records from the Ontario Ministry of Natural Resources and Forestry (MNRF) Natural History Information Centre's (NHIC) and Ontario Nature's Ontario Reptile and Amphibian Atlas (ORAA) databases were combined for analyses.

Table 1. Extent of occurrence (EOO) and index of area of occupancy (IAO; 2 x 2 km grids) based on observational records (NHIC, ORAA) for all records combined (extirpated, historical, extant)[1], currently extant (since 1998), and extant records for each of the last two decades. CL – Carolinian, GLSL – Great Lakes/St. Lawrence.

DU	Data	EOO (km^2)	IAO (km^2)	No. of 2x2 km grid cells
CL (all records)	1881–2018	25,670 adjusted to 24,692[2]	1,824	456
CL (extant)	1998–2018	8,527, adjusted to 8,389[2]	336	84
CL (extant)	1999–2008[3]	6,383	124	31
CL (extant)	2009 - 2018	8,527, adjusted to 8,389[2]	312	78
GLSL (all records)	1904–2018	48,046	5,604	1,401
GLSL (known extant)	1998–2018	38,042	2,784	696
GLSL (known extant + historical)	1998–2018	39,043	5,328	1,332
GLSL (known extant)	1999–2008	33,083	1,492	373
GLSL (known extant)	2009–2018	32,938	1,456	364

[1] Extirpated=species no longer present, historical=presence not verified in past 20 years, extant=presence verified in past 20 years.

[2] Minimum convex polygon clipped to Canadian jurisdiction

[3]Values as known at the time of previous assessment

Status of observation records are classified following NHIC practice (based on Nature Serve definitions) as historical, extirpated, or extant. A historical site is a locality where the species was formerly present, but its presence has not been verified in the past 20 years. An extirpated site is one where the species occurred previously but no longer occurs. A site is considered extant when species' presence has been verified within the past 20 years (since 1998). Element Occurrences (EOs) for this species consist of an aggregation of observation localities separated by at least a 5 km buffer or by a physical barrier from other localities, as remotely determined by GIS. An EO thus represents a potentially distinct subpopulation. EOs are classified as extant, historical, or extinct, as described above for observation records.

In the Carolinian DU, of a total of 14 EOs, nine are considered extant, one of which was discovered since the previous status assessment (in 2015, near Coatsworth, east of Wheatley by Lake Erie shoreline; Hecnar and Brazeau 2016, 2017). Based on extant records and adjusted to Canadian jurisdiction, the EOO for this DU is 8,389 km^2 and IAO is 336 km^2 (Table 1; Figure 4). Considerable search effort has been expended within the range of this DU, including revisits to historical sites; therefore, using only the confirmed extant sites since 1998 for the calculations is justifiable. Comparison of EOO and IAO for current extant records (1998–2018) to all available records (1881–2018) suggests a long-term declining trend (-66.8% EOO, -81.6% IAO) (calculations from unadjusted values in Table 1). Extrapolation suggests an average decline of -4.8% (EOO) and -5.9% (IAO) per decade. Comparison of 2009–2018 to 1999–2018 (which assumes that all sites detected during this period were extant in 1999) shows that IAO decreased by 7.1% (336 to 312 km^2) over the past decade even though 95.6% of records are from 2009–2018.

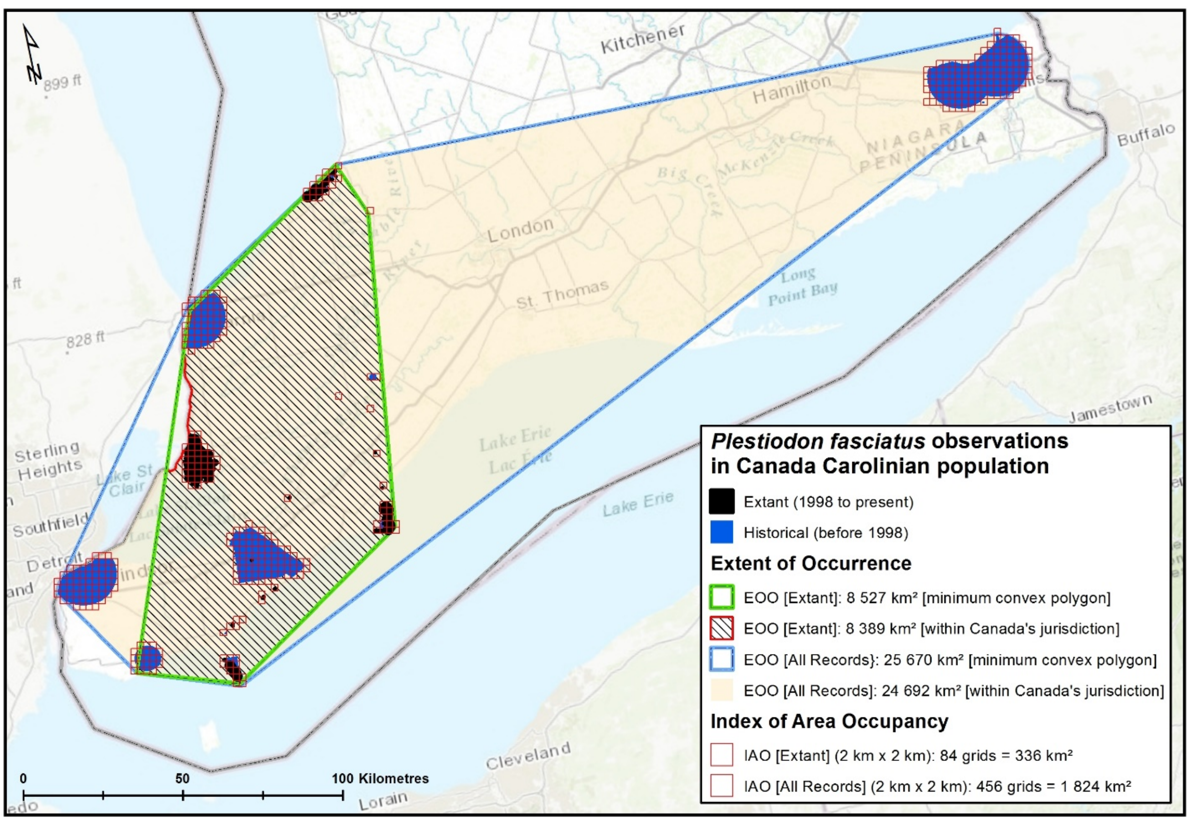

Figure 4. Extent of occurrence (EOO) and index of area of occupancy (IAO) based on observation records (Source: NHIC, ORAA) for the Carolinian population. Map prepared by Rosana Nobre Soares and Sydney Allen, COSEWIC Secretariat.

In the GLSL DU, 87 of total of 118 EOs are considered extant, three of which were discovered since the previous status assessment (Table 2). For this DU, the EOO is 38,042 km^2 and IAO 2,784 km^2, based on records designated as extant from 1998–2018; if both extant and historical records are included, the values are 39,043 km^2 and 5,328 km^2, respectively (Table 1, Figure 5). The latter values may be more appropriate, because it is likely that the historical designation at the majority of sites is a result of observer bias (i.e., these sites may not have been surveyed in the past 20 years) rather than a representation of a true decline or extirpation. There is no obvious broad-scale pattern to the distribution of historical occurrences, such as an association with a particular region or landscape change. This suggests that the exact historical sites may simply not have been visited in recent years, making it problematic to compare EOO and IAO values for current and all available records. However, if the status designation of occurrences is taken at face value, a declining trend emerges. Comparison of current extant records (1998–2018) to all available records (1904–2018) shows a long-term declining trend (-20.8% EOO; -50.3% IAO) with an average long-term decline of -1.8% (EOO) and -4.4% (IAO) per decade (Table 1). Comparison of the past two decades (1999–2008 vs. 2009–2018) suggests a smaller short-term decrease (-0.4% EOO, -2.4% IAO). The above trends are confounded by search effort biases.

Table 2. Current status (as of 2019) of Natural Heritage Information Centre Element Occurrences (EOs) revised from last NHIC assessments (2016 Carolinian, 2011 Great Lakes/St. Lawrence). Total number of EOs (area ha). Designatable Units (DU): CL – Carolinian, GLSL – Great Lakes/St. Lawrence.

DU	Total EOs	Extant	Historical[2]	Extirpated[3]
CL	14 (1371)	9[1] (918)	4 (450)	1 (3)
GLSL	118 (32,820)	87 (11,483)	29 (2,681)	2 (18,655)[4]
Combined	131 (34,191)	96 (12,401)	32 (3,147)	3 (18,658)

[1]Possibly 9 extant EOs as one recent unprocessed record exists for a historical EO in Tilbury Township (see Fluctuations and Trends).

[2]No verified records in a formerly extant EO over the past 20 years.

[3]Not located despite intensive searches of a formerly historical EO.

[4]Area estimate is based on assessment of known records. Actual area is unknown because of uncertainty in location description of record.

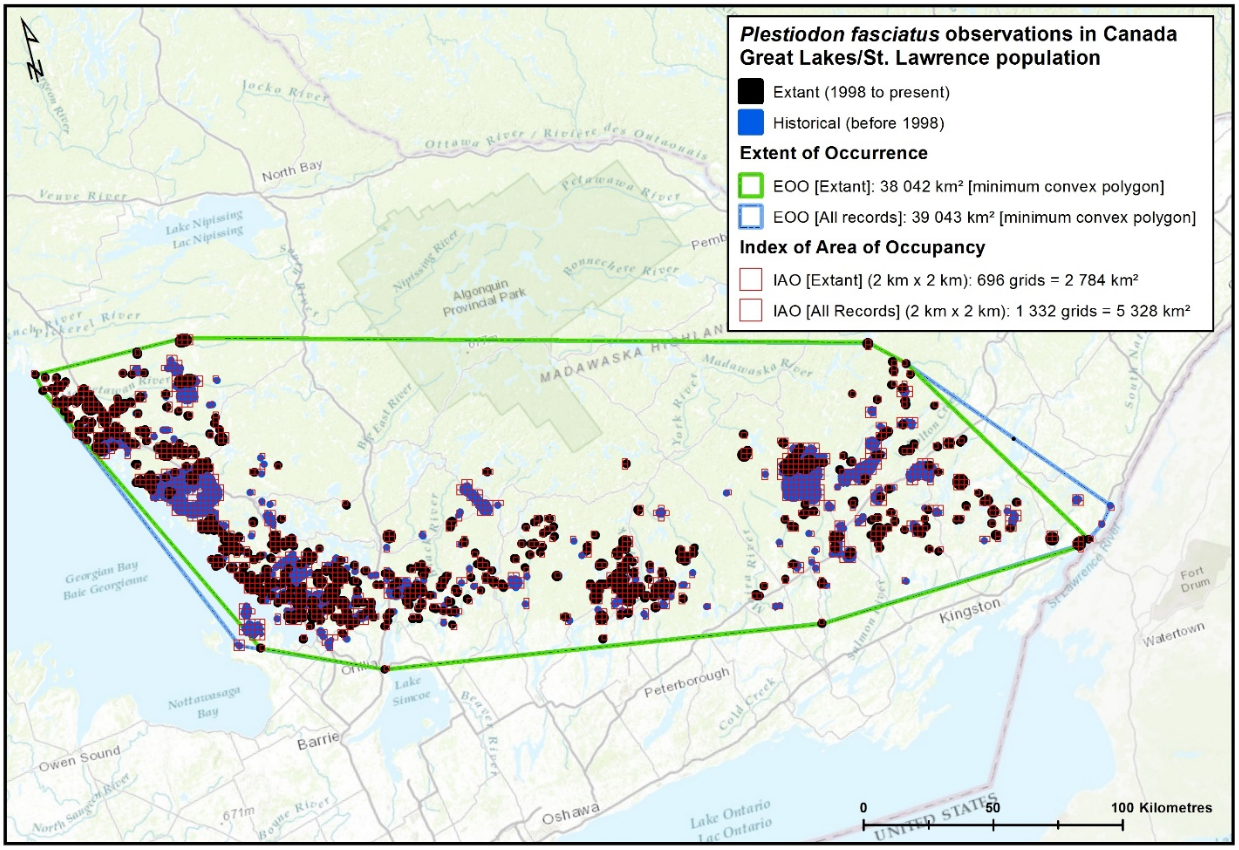

Figure 5. Extent of occurrence (EOO) and index of area of occupancy (IAO) based on observation records (Source: NHIC, ORAA) for the Great Lakes/St. Lawrence population. Calculations based on combining extant and historical records but excluding two sites considered to be extirpated. Map prepared by Rosana Nobre Soares and Sydney Allen, COSEWIC Secretariat.

For a rough comparison with the areas calculated by the standard method, areas determined by NHIC for EOs were also examined (NHIC 2019). EOs more closely approximate biological area of occupancy than IAO, but include uncertainty resulting from incomplete survey effort. EOs were last calculated for skinks by NHIC in 2016 for the Carolinian DU and in 2011 for the GLSL DU. The area of an EO should not be interpreted as the area actually occupied by the species or its habitat extent as it simply reflects the best-known distribution information that can be discerned from reported observation records (T. Taylor pers. comm. 2019). Total EO area is also based on GIS interpretation without ground-truthing and would still likely overestimate actual habitat area used. The total area of occupancy based on EOs was 918 ha (9.2 km^2) for the Carolinian population (*n* = 9 extant EOs) and 11,483 ha (115 km^2) for the Great Lakes/St. Lawrence population (*n* = 87 extant localities) (Table 2).

Search Effort

A combined total of 5,821 observation records spanning from 1881–2018 were compiled from databases (OMNRF NHIC, ORAA) and museum specimen records (Canadian Museum of Nature, ROM Ontario Museum, Carnegie Museum of Natural History, Cornell University, University of Michigan). This provides a fourfold increase from the 1,406 Ontario Herpetofaunal Summary records that were available at the time of the last status assessment (COSEWIC 2007). Two new localities were documented in the Carolinian DU: Point Edward (Choquette *et al*. 2010; Hecnar and Brazeau 2016), linked to an existing EO (Exmouth) by NHIC; 0.4 ha residential site near the hamlet of Coatsworth, on the shore of Lake Erie (Hecnar and Brazeau 2016, 2017), which represents a separate EO (under assessment by NHIC at the time of the preparation of this report). The increased number of records resulted from growing public interest in herpetofauna, ease of reporting records with technological developments, and additional surveys and research projects rather than indicating expanding distribution.

In addition to data from targeted research and monitoring efforts, Ontario Nature's Ontario Reptile and Amphibian Atlas (ORAA) and other citizen science initiatives have increased search effort greatly over the past decade. These records come largely from incidental observations submitted by the general public. The ORAA incorporated and expanded upon the Ontario Herpetofaunal Summary (OHS) database (Oldham and Weller 2000).

Projects in the Carolinian DU since the last report include research on several aspects of *P. fasciatus* ecology, habitat restoration, and continued annual monitoring at Point Pelee National Park (Baptista 2007; Hecnar and Hecnar 2011, 2013, 2019; Hecnar *et al*. 2012; Brazeau *et al.* 2015; Myschowoda 2015), Rondeau Provincial Park (Brazeau *et al.* 2015; Brazeau 2016; Hecnar and Brazeau 2015, 2016, 2017), and Oxley Poison Sumac Swamp (OPSS) (McCarter pers. comm. 2016, 2017; Crosthwaite pers. comm. 2018). Surveys and research were also conducted at Pinery Provincial Park (Prisciak 2015, 2016; Prisciak *et al.* 2017; Hecnar *et al.* 2018). Surveys were also carried out to evaluate habitat quality at 41 historical skink localities in southwestern Ontario in 2015, and two undocumented extant localities were found (Choquette *et al.* 2010; Hecnar and Brazeau 2016, 2017).

In the GLSL DU research evaluating habitat use and population size was conducted at eight localities in Kawartha Highlands and Queen Elizabeth II Wildlands Provincial Parks (Feltham 2020). Searches for skinks were also conducted annually at three localities in Georgian Bay Islands National Park with persistence confirmed each year at two localities but no observations at the third locality over the past 10 years (Promaine pers. comm. 2018). Since 1998, 62.1% of records were from the past decade (2009–2018), indicating that search effort has increased, but it has not specifically targeted historical sites.

HABITAT

Habitat Requirements

Habitats used by *P. fasciatus* vary across the species' North American range. In the southern parts of its range, the species occurs in more heavily wooded habitats (Watson 2008; Watson and Gough 2012), whereas in central and northern parts of its range, including Ontario, the species is found in increasingly open habitats with suitable cover objects for shelter (Fitch 1954; Brazeau 2016). Open macrohabitat provides increased sunlight and warmth in regions with cool climate. Within forested regions in Ontario and Minnesota, the species is most abundant in or near open well-drained habitats such as rock outcrops, prairie remnants, stabilized dunes, or other open areas, often with sandy soils (Patch 1934; Seburn 1990; Howes and Lougheed 2004; Moriarty and Hall 2014). Site occupancy for skinks declines abruptly when forest canopy cover reaches approximately 50% in the Carolinian population (Brazeau 2016) or 60% in the GLSL population (Feltham 2020). Visual surveys and telemetry indicate that skinks select open habitats over forest (Hecnar and Brazeau 2015; Brazeau 2016; Brazeau and Hecnar 2018), but forest or forest edge habitats are used to some extent.

Suitable microhabitats are of vital importance to *P. fasciatus*, as individuals spend most of their time in refuges under cover from which they make short forays to forage or bask (Fitch and von Achen 1977). Individuals are susceptible to desiccation stress (Noble and Mason 1932; Fitch 1954) and extreme temperatures, thereby making availability of shelter essential (Hecnar and M'Closkey 1998). Shelter with suitable thermal properties allows individuals to maintain a body temperature close to their preferred optimal temperature, while providing a refuge or concealment from predators (Hecnar 1994; Quirt *et al*. 2006; Brazeau 2016). The shelter type used depends on habitat and available cover (Brazeau and Hecnar 2018; Feltham 2020). Occasionally some individuals seek shelter in buildings (Hecnar unpubl. data).

Little is known about selection of hibernacula. *Plestiodon fasciatus* cannot survive extended periods below freezing (Neill 1948; Fitch 1954) and must find shelter below the frost line but above the water table. Depending upon the insulating effect of snow depth, the frost line can vary from 0.1 to 3 m deep (Tihen 1937; Fitch 1954; Lang 1982; Hecnar *et al*. 2012; Hecnar *et al*. unpubl. data). Skinks hibernate alone, in groups, or communally with other reptile species. Evidence in the Carolinian population suggests that individuals burrow underground under or near cover objects they use near the end of the activity season (Hecnar *et al*. 2012). Other overwintering sites include rotting logs and stumps, ground litter, mammal burrows, crevices or fissures in rock formations, inside buildings or their foundations, and piles of sawdust or vegetation (Fitch 1954; Harding 1997; MacCulloch 2002; Hecnar *et al*. 2012).

Beyond these general characteristics there are differences in the type of habitat and cover used between the Carolinian (Seburn 1993; Hecnar 1994; Brazeau 2016) and GLSL DUs (Howes and Lougheed 2004; Quirt *et al*. 2006; Feltham 2020).

Carolinian DU

Most Carolinian subpopulations occur along or near the shores of lakes Erie, St. Clair, and Huron, and major tributaries in areas of hardwood forest. Remaining potential habitat is extremely patchy due to anthropogenic fragmentation (agricultural lands and urban areas) (Hecnar and Brazeau 2016; Sowers 2018). Individuals are generally found under woody debris in clearings within stabilized sand dunes, savannahs, relict prairie patches, open forested areas and wetland areas (Seburn 1993; Hecnar 1994; Brazeau 2016). Stabilized dune and savannah are strongly preferred over anthropogenic and forest habitats (Brazeau 2016). Point Pelee National Park (PPNP) contains the longest-studied subpopulation of skinks in Canada. Research conducted in PPNP over the past 30 years has shown that individuals have a strong association with woody debris as a cover element (Seburn 1990, 1993; Hecnar 1991, 1994; Hecnar and M'Closkey 1998). Open habitats and associated woody debris are also important for skinks in Rondeau Provincial Park (RPP) (Hecnar and Brazeau 2015; Brazeau 2016), Pinery Provincial Park (PPP) (Prisciak 2015, 2016), and other localities in the region (Hecnar and Brazeau 2016). Numbers of skinks observed at Carolinian sites have increased as woody debris is added by windstorms, tornadoes, driftwood deposition, and felling trees along hydro lines (S. Hecnar pers. obs). Other cover materials used include hollows in standing snags or live trees and artificial materials such as piles of building materials, utility poles (Seburn 1990), wooden boardwalks (Hecnar and M'Closkey 1998), and hollows in brick or stone walls (Brazeau 2016; Brazeau and Hecnar 2018). Skinks in PPNP prefer larger (logs >17 cm diameter, boards > 1,700 cm^2 in area) and moderately decayed woody debris over small and un-decayed woody debris. Larger debris provides more suitable substrate moisture levels and temperatures (Hecnar 1991; Seburn 1993; Brazeau 2016). Microsites selected by nesting females in PPNP were a subset of microsites selected by all individuals throughout the season (Seburn 1993). Nest microsites tended to be under logs rather than artificial boards, and soil moisture was higher than in other selected microsites (16.6–67.3% and 2.2–24.6% respectively) or than in the ambient environment (Hecnar 1994).

Great Lakes/St. Lawrence DU

This population is distributed along the southern edge of the Canadian Shield on rock outcrops embedded within a matrix of mixed forest, lakes, and wetlands. Potential rock outcrop habitat is patchy due to natural fragmentation and processes (e.g., succession, fires) within the region (Sowers 2018). Nearly all observations on the Shield indicate an association with rocky microhabitat (Oldham and Weller 2000; Howes and Lougheed 2004). Skinks use loose rock on open rock faces or crevices and fissures in the exposed bedrock as cover elements and are rarely observed away from cover (Howes and Lougheed 2004; Crowley pers. comm. 2019).

Nearly all individuals are observed under surface rocks (Howes and Loughheed 2004; Quirt *et al*. 2006), but some use moss, lichen, leaf litter, soil, vegetation, and woody debris. Increased underground activity appears to occur in the warmer months of July and August (Howes and Loughheed 2004; Quirt *et al*. 2006; Feltham 2020). Individuals that are basking often seek refuge in crevices and fissures in the surface of the exposed bedrock. The importance of these larger rock features as retreat sites is likely underrepresented because surveys are usually limited to rocks that are small enough to lift or flip (Crowley pers. comm. 2019).

Habitat Trends

A long-term habitat loss has occurred in the Canadian portion of the species' range, as reflected in declining distribution trends of *P. fasciatus*, particularly in southwestern Ontario. Habitat loss is likely a result of a combination of both natural and anthropogenic factors. Historically, much of southern Ontario was covered by tallgrass prairie and oak savannah that developed during the warmer and drier conditions of the Holocene Climatic Optimum (aka Hypsithermal; 9,000–5,000 yBP) (Bakowsky and Riley 1994; MNRF 2009). During that time *P. fasciatus* would have been able to disperse from Michigan into southwestern Ontario, as the present configuration of the Great Lakes and their interconnecting channels had not yet developed. The climate then became cooler and wetter promoting forest development that fragmented the open prairie and savannah habitat. This natural fragmentation proceeded slowly producing 'islands' of open habitat. Loss and isolation of open habitats such as prairie remnants, savannahs, dunes along lakeshores, alvars, and rock outcrops, has likely been ongoing for the past 4,000 years. This process was rapidly accelerated by conversion of natural landscapes to agriculture, urban expansion, and fire suppression, producing one of the most highly human-altered regions of North America (Bakowsky and Riley 1994; Hecnar and Brazeau 2016; Sowers 2018). Fragmentation continues with the expansion of the road network and increasing traffic flow (Ontario Biodiversity Council 2018), further reducing natural habitat and increasing the degree of isolation of remaining patches.

<u>Carolinian DU</u>

The rate of habitat change has been historically severe; this primarily anthropogenic habitat change has undoubtedly contributed to the decline in both number and size of subpopulations within this region over the last three to five decades (Tables 1– 3). The Carolinian forest in southwestern Ontario is Canada's most biologically diverse region, but agriculture and urban development have drastically altered the region and continue to threaten remaining habitat. The Carolinian Ecozone covers only about 1% of Canada's area, but provides habitat for 24% of Canada's species at risk; it is the most human-affected area of the country with only about 10% of natural lands remaining (Carolinian Canada Coalition 2018).

Excluding urban centres, nearly all the remaining land area in the Carolinian zone has been converted to intensive agriculture. Currently 78% of the land cover in the Lake Erie – Lake Ontario Ecoregion is classified as cropland and 12% as forested (MNRF 2009). Although farm fields provide much open habitat, debris for cover is largely limited to forest edges. The general trend in agricultural landscapes over the past five decades has been to reduce hedgerows and "back 40" woodlots to increase cultivated area.

In some areas, fire suppression and other management activities may limit the amount of open habitat available for use by *P. fasciatus,* similar to habitat losses in Kansas explained by forest encroachment (Fitch 2006a,b). Recent visits to localities classified as historical or extirpated in the Carolinian indicated that 27 of 41 (65.9%) sites had lost habitat to agriculture, urbanization, or forest encroachment (Hecnar and Brazeau 2016). Classification of five of the 14 EOs in the region as historical or extirpated based on habitat loss and lack of observations suggests a habitat loss rate of 36% over the past 50 years (Table 2). Restoration efforts to increase the quantity and quality of habitat through prescribed burns and/or clearing vegetation have been conducted at four localities (Point Pelee National Park, Rondeau and Pinery Provincial Parks, Oxley Poison Sumac Swamp). Augmentation of woody debris for cover has been ongoing since 1998 at PPNP, and skink abundance has increased as a result of restoration efforts at all four localities (Hecnar and M'Closkey 1998; Hecnar and Hecnar 2013; Hecnar and Brazeau 2016; Nature Conservancy Canada 2016; Hecnar *et al*. 2018). However, stabilized dune, savannah, and forest edge habitats in some localities are being lost at increasing rates because of high water and increasing storm erosion events associated with climate change along the coasts of Lake Erie (Hecnar and Hecnar 2013; Hecnar *et al*. 2018). Water levels continue to rise, reaching record highs in 2019 (see *Climate change and severe weather* under **Threats**).

Great Lakes/St. Lawrence DU

The GLSL DU exists in an area that has less human disturbance relative to other parts of southern Ontario, but increased cottage development, road expansion, and outdoor recreation threaten skink habitat in the Canadian Shield region. Most of the land lies in the Georgian Bay Ecoregion where only 3% is classified as agricultural (pasture), 78% is forest, and 11% is water (MNRF 2009). Agricultural land coverage increases to 57% at the southern boundary of the population in the Lake Simcoe – Rideau Ecoregion (MNRF 2009). Loss of open rock outcrop habitat due to successional processes is relatively slow compared to natural succession in Carolinian subpopulations (Seburn and Seburn 1998); therefore, the natural rate of change in Canadian Shield habitat is a relatively low threat. However, it should be noted that rock outcrops and barrens are post-glacial relict areas that are affected by the natural balance of succession and wildfire. In general, fire suppression is an active management strategy for human safety in the region. Some habitat management activities have occurred in the region, particularly in protected areas. For example, augmentation of cover rock occurred at seven areas in the Fitzwilliam Mountain property of the Thousand Islands National Park (Lynch and Lewis 2013).

BIOLOGY

Life Cycle and Reproduction

Plestiodon fasciatus has four main life stages: egg, hatchling, juvenile, and adult. Eggs are laid in mid-summer, and hatchlings are active in late summer until hibernation begins in early autumn. Individuals emerge from their first hibernation and develop as juveniles until their second hibernation. Sexual maturation occurs after emergence from the second hibernation. Maximum lifespan is nine or ten years, but generally few survive beyond five or six years of age (Fitch 1954, 1956). Generation time is estimated to be about three years, based on average age of adults and annual adult survival rate of 0.5–0.7 (Fitch 1954; Hecnar unpubl. data).

Age of sexual maturity is 21 months based on studies in Kansas (Fitch 1954) and South Carolina (Vitt and Cooper 1986a), although size at maturity differed between the two sites (60 mm and 52 mm, respectively). Some juveniles in a Carolinian population achieved minimum breeding size in their first summer, although it is unlikely that these individuals successfully reproduced until their second summer (Seburn and Seburn 1998). Mean SVL of nesting females at Point Pelee National Park was 6.8 ± 0.03 cm (range 5.8–7.9 cm, n = 198) (Hecnar and Hecnar 2019). The minimum body size of nesting females and phenology in Ontario suggest that the average age at sexual maturity is similar throughout the species' North American range.

Across the species' range females tend to be highly aggregated throughout summer and especially during the nesting season (Cagle 1940; Fitch 1954; Seburn 1993; Hecnar 1994). Communal nesting is common and appears not to be the result of limited nesting sites in a Carolinian population (Hecnar 1994). Communal nesting allows for more continuous egg guarding by females (Fitch 1954), as females will brood their own eggs as well as eggs from other females (Noble and Mason 1933; Fitch 1954; Vitt and Cooper 1989; Seburn 1993; Hecnar 1994).

Females lay one clutch annually several weeks after mating (Fitch 1954; Seburn 1990; Hecnar 1994), typically from late June to early July in the Carolinian region and early to mid-July on the Shield. Clutch size averages about 9–10 eggs and does not show any trends across the species' range (Hecnar and Hecnar 2019). Mean clutch size at Point Pelee was 9.2 ± 0.08 SE eggs (range 1–19, n = 1,105 nests) and was not correlated with temperature, precipitation, or skink density over 28 years (Hecnar and Hecnar 2019). Eggs have thin parchment shells that are easily punctured (Fitch 1954) and are likely the most vulnerable life stage (Fitch and Fitch 1967). Important physical variables affecting egg development in reptiles, *P. fasciatus* included, are temperature, soil moisture, and gas exchange (Packard and Packard 1988). Females brood their eggs for 4 to 6 weeks and hatching typically occurs in Ontario from late July to mid-August.

A high level of maternal care behaviour exists in *P. fasciatus* (Fitch 1954; Vitt and Cooper 1989; Hecnar 1994). Females rarely leave their eggs unattended (Fitch 1954) and aid in the successful development in a variety of ways (Groves 1982), including rotating eggs for exposure to air (Fitch 1954) and defending the nest from predators (Noble and Mason 1933; Fitch 1954; Vitt and Cooper 1989). Females may also relocate nests with eggs following a disturbance or a change in environmental conditions (Fitch 1954; Vitt and Cooper 1989).

Physiology and Adaptability

Skinks thermoregulate by adjusting their microhabitat use. Fitch (1954) determined that the preferred temperature range of *P. fasciatus* was 28–36°C, although individuals can tolerate temperatures as high as 42°C. Individuals can survive temperatures as low as -1°C for short periods (< 30 min) and are mobile at 1.8–13.5°C, temperatures below those at which most other North American reptiles can move (Fitch 1954). In Ontario, skinks are inactive in hibernacula from about early October to mid-April. Temperatures in the GLSL DU's range are generally far from optimum for reptiles even during the active season (Row and Blouin-Demers 2006), making microhabitat selection especially important. During late May and early June, individual *P. fasciatus* selected rocks as cover elements that provided them with thermal conditions that most closely matched their preferred body temperature range (Quirt *et al*. 2006). Presumably, this allows them to maximize time at temperatures that optimize physiological processes (Quirt *et al*. 2006).

Skinks show significant aggregation behaviour throughout the year (Hecnar 1991; Seburn 1993; Hecnar 1994), but especially during hibernation (Fitch 1954; Cooper and Garstka 1987). Small groups of hibernating individuals have been observed across the range (Hamilton 1948; Neill 1948; Fitch 1954). In 1986 and 1987, spring aggregations of 25 individuals and 27 individuals, respectively, were found in a Carolinian subpopulation (Weller and Oldham 1988). Experimental research on the congeneric Broad-headed Skink, *E. laticeps*, showed that individuals tended to aggregate despite the presence of multiple hibernation sites (Cooper and Garstka 1987). Aggregation was more likely to occur during periods of low temperatures, implying that there may be a thermal benefit to aggregation behaviour during hibernation.

Dispersal and Migration

Plestiodon fasciatus is not territorial, but individuals do tend to limit their activities to small, familiar areas with loosely defined boundaries, at least over short periods. Size of a home range depends on sex and age of an individual as well as type of habitat and may vary across sites. In the Carolinian population, home ranges averaged 233 ± 56.6 m^2 (range 53–704 m^2) during late summer (August-September) (Hecnar and Brazeau 2016; Brazeau and Hecnar 2018); in the GLSL population, home ranges averaged 355 ± 100.6 m^2 (range 34–1422 m^2) during mating season (May-June) (Feltham 2020). Site fidelity does not appear to be strong; however, some individuals return to the same cover objects within and between seasons (Hecnar and Brazeau 2016; Brazeau and Hecnar 2018). Low recapture rates from year to year reported from Kansas (Fitch 1954) and Ontario (Seburn 1993) may result from individuals shifting their home ranges.

Mark-recapture has revealed that although individuals have been found up to 208 m from the original point of capture, they are generally recaptured within a short distance of the previous capture (Fitch 1954). In the Carolinian population, maximum recorded movements within one season were 107 m for hatchlings and 25 m for yearlings (Seburn 1993). Telemetry revealed average daily movements in summer of 6.9 ± 7.19 m for adult males and 4.4 ± 5.44 m for adult females (Hecnar and Brazeau 2016). The average total distance moved over 16 days was 37.1 ± 8.6 m (range 0–176 m, n = 31) (Hecnar and Brazeau 2016; Brazeau and Hecnar 2018). The results of this first telemetry study suggest that traditional mark-recapture studies may have underestimated movements of this species, and that some individuals may occasionally make longer distance movements (up to 176 m recorded), as Fitch (1954) suggested. However, these movements are well below distances among subpopulations (see **Spatial Structure and Variability**). Genetic research performed in one GLSL subpopulation revealed that no age or sex class tended to disperse more than another, but because females may leave their home range to nest, hatchlings are born outside the maternal home range and could therefore be considered "dispersers" (Wick 2004).

Interspecific Interactions

Food habits

Plestiodon fasciatus is a generalist arthropod predator that consumes a wide variety of prey but shows preference for arachnids (spiders and harvestmen), orthopterans (grasshoppers), and blattids (cockroaches) (Fitch 1954; Hecnar *et al*. 2002). Ants are rarely consumed (Fitch 1954; Hecnar *et al*. 2002; Brazeau *et al*. 2015). Other diet items include: ant lions, aphids, beetles, caterpillars, crickets, damselflies, earwigs, leafhoppers, snails, sow bugs, termites, ticks, weevils, earthworms (Fitch 1954; Judd 1962; Hecnar *et al*. 2002; Brazeau *et al*. 2015), and occasionally bees and wasps (McIlhenny 1937), scorpions (Watson and Formanowitz 2007), small crustaceans, and vertebrates (Taylor 1936; Fitch 1954).

Predation

Identified predators of *P. fasciatus* across the species' distribution include Raccoons (*Procyon lotor*), crows, hawks, foxes, minks, weasels, skunks, opossums, armadillos, snakes, moles, shrews, fish, spiders, and alligators. Domestic cats and dogs are also predators of skinks (Fitch 1954; Oldham and Weller 2000).

Most often, individuals rely on concealment and respond to a potential predator by "freezing" (Fitch 1954). Skinks can autotomize their tail as a defence mechanism. Once severed, the tail will thrash for up to several minutes, distracting the predator, allowing the lizard to escape (Fitch 1954). Although tail autotomy may be an effective predator avoidance mechanism, it may also be costly, as it could impair locomotion, result in loss of social status, and reduce growth or reproduction (Goodman 2006). The tail also provides lipid storage used for energy during hibernation, and loss late in the season may limit overwintering success (Vitt and Cooper 1986b).

POPULATION SIZES AND TRENDS

Sampling Effort and Methods

Population sizes and trends are poorly known because of the secretive nature and semi-fossorial habits of *P. fasciatus.* Challenges include distinct seasonality, shifting home ranges, and lack of detection of individuals in underground burrows and other inaccessible retreats. Not surprisingly, mark-recapture studies have had low recapture rates, resulting in wide confidence intervals (Fitch 1954; Seburn 1990). Visual encounter surveys provide an index of abundance (Hecnar and M'Closkey 1998) that can be useful for detecting trends; however, they will underestimate true abundance.

Population size or density estimates are available for three localities within the Carolinian DU (Point Pelee National Park, Rondeau and Pinery provincial parks) and for eight localities within the GLSL DU (four in Kawartha Highlands, and four in Queen Elizabeth II Wildlands Provincial Parks) (Table 3). Detailed knowledge of trends is limited to only two Carolinian localities (29 years at Point Pelee, six years at Rondeau). Methods used in these studies include mark-recapture by toe-clipping (Seburn 1990, 1993) and PIT (passive integrated transponder) tagging (Feltham 2020), and visual encounter surveys during the peak of skink activity during summer (Hecnar 1991; Hecnar and Hecnar 2013; Brazeau 2016; Hecnar *et al*. unpubl. data). Estimates of population size can be made using abundance data from visual surveys during peak activity (nesting period). Accuracy of these visual surveys can be improved by applying a correction factor to account for unseen individuals (Brazeau and Hecnar 2018; Hecnar *et al*. 2018). The correction includes adjusting the sex ratio to 1:1 and multiplying total number of individuals observed by 30% to account for individuals not seen because they were inaccessible (Brazeau and Hecnar 2018; Hecnar *et al.* 2018).

Table 3. Population size, total habitat area, and average density estimates for individual subpopulations within the Carolinian (CL) DU and smaller localities within the Great Lakes/St. Lawrence (GLSL) DU that have been surveyed intensively (data sources: Hecnar unpubl. data for CL; Feltham 2020 for GLSL). Habitat areas for Point Pelee National Park (PPNP), Rondeau Provincial Park (RPP), and Oxley Poison Sumac Swamp (OPSS) are total available habitat determined by GIS and ground-truthing. Total subpopulation size for Pinery Provincial Park (PPP) could not be estimated as total habitat area used by skinks is unknown. Habitat areas for GLSL subpopulations are for areas surveyed. Density for PPP is based on detailed surveys for a small area (Hecnar *et al.* 2018). Subpopulation acronyms for GLSL are defined in Feltham (2020).

DU	Subpopulation or locality	[1]Population size: all individuals (no. of adults)	Habitat area (ha)	Density: total no. /ha (no. of adults/ha)	Year
CL	PPNP	514 (333)	50.78	10 (7)	2018
CL	RPP	164 (120)	99.00	2 (1)	2018
CL	PPP	unknown	6.38	7 (5)[2]	2015

DU	Subpopulation or locality	[1]Population size: all individuals (no. of adults)	Habitat area (ha)	Density: total no. /ha (no. of adults/ha)	Year
CL	OPSS	21 (15)	1.00	21 (15)	2017
Total or mean		**699 (468)**	**157.16**	**10 (6.8)**	
GLSL	BRLR	154 ± 4.8 (99)	1.62	95 (61)	2012
GLSL	LNGL	455 ± 41.0 (291)	1.73	263 (168)	2012
GLSL	LPRD	234 ± 8.7 (150)	3.65	64 (41)	2012
GLSL	MRVR	55 ± 3.7 (35)	2.21	25 (16)	2012
GLSL	BRRD	27 ± 2.1 (17)	1.08	25 (16)	2012
GLSL	BRVB	68 ± 4.0 (44)	0.76	90 (58)	2012
GLSL	FCTR	145 ± 7.3 (93)	1.73	84 (54)	2012
GLSL	MKRD	155 ± 8.1 (99)	1.65	94 (60)	2012
Total or mean		**1293 (834)**	**14.43**	**93 (59)**	

[1] Numbers of individuals in CL subpopulations are from corrected actual count data (Hecnar unpubl. data). Numbers of total individuals in GLSL subpopulations from mark recapture estimates (Feltham 2019). Number of adults in GLSL subpopulations estimated from proportion of adults in total captures in 2012 [0.639] (Chap. 2, Table 4 in Feltham 2020).

[2] Density is calculated using number of individuals observed in the smaller area that was actually surveyed (6.38 ha).

Population size for each DU was estimated by extrapolation. In Method 1, the average density of known subpopulations was multiplied by total area of extant EOs in each DU. In Method 2, the average size of known subpopulations was multiplied by the number of known extant subpopulations. Using average subpopulation size provided an alternate method for comparison but could only be used for the Carolinian DU because there are no estimates of size available for any Great Lakes/St. Lawrence subpopulations. Similarly, an estimate of temporal trends in total population was inferred by comparing numbers of historical versus extant EOs.

General population trends for two Carolinian subpopulations were determined from annual peaks of abundance by time series analysis using the Mann-Kendall Test (Hecnar and Hecnar 2011). Risk of extinction was determined by unstructured population viability analyses (for details see Hecnar and Hecnar 2013; Hecnar and Brazeau 2017).

Abundance

Carolinian DU:

Average adult density for four intensively studied subpopulations with density estimates (calculated from Table 3) is 6.8/ha, and the total area of all extant EOs is 918.2 ha (Table 4). Using Method 1, population size is roughly estimated as 6,244 adults (6.8 x 918.2). A more accurate density-based estimate is made by using specific densities for known individual sites multiplied by ground-truthed habitat area estimates (PPNP, RPP, PPP, OPSS; Table 3) and then adding average density multiplied by the estimated area for the other subpopulations (1,467 + 2,500 [6.8 x 367.6 ha]). This more accurate estimate results in 3,967 adults (range 2,897–5,057). Using Method 2, the average adult abundance for three intensively studied subpopulations with a population estimate was calculated from Table 3 as 156 ± 93.5 SE. By multiplying with the number of extant subpopulations, an estimate of 1,404 adults is derived (156 x 9; range 562–2,246). The true population size for the Carolinian DU likely lies between the estimates calculated by these two methods and is likely to be <5000 mature individuals. The nine extant subpopulations are relatively small, with none exceeding 1000 mature individuals.

Table 4. Estimated area of habitat for extant Carolinian subpopulations by Element Occurrence (source: NHIC). Coatsworth is a new locality (Hecnar and Brazeau 2016) and Tilbury Township is currently recognized as 'historic' but has a single recent unprocessed observation. Area listed is from NHIC EO shape area for all localities and tends to overestimate actual amount of habitat (see Abundance section). Areas for Point Edward and Coatsworth are based on site visits (S. Hecnar unpubl. data). Few data were available for Walpole Island, and the area is most likely overrepresented in the calculations.

Locality	Last Observed	Area (ha)[1]	Viability rating[2]
Point Pelee National Park	2019	171.4	AB – Excellent or Good
Rondeau Provincial Park	2019	122.3	B – Good
Pinery Provincial Park	2019	199.6	C – Fair
Walpole Island First Nation	2019	326.6[3]	Not Assessed
Oxley Poison Sumac Swamp	2019	56.7	Not Assessed
Kopegaron/Wheatley	2015	29.0	Not Assessed
Point Edward/Exmouth	2015	0.1	Not Assessed
Coatsworth	2015	0.4	Not Assessed
Tilbury Township	2014	12.1	Not Assessed
Total		918.2	

[1] GIS calculated shape area (Source: NHIC).

[2] Viability is estimated likelihood of persistence over 20–100 years based on numbers and quality of records assessed by the NHIC. Last assessment was in 2015, not including recent observed declines in monitored subpopulations (Point Pelee, Rondeau).

[3] Much uncertainty about the area actually occupied by the skinks, which is probably much smaller.

Great Lakes St. Lawrence DU:

Average adult density for intensively studied localities (calculated from Table 3) is 59.3/ha, and the total area of all extant EOs is 11,483.5 ha (Supplementary Information 1). The density is much greater than in the Carolinian DU, most likely due to higher quality habitat. Based on this density, the total abundance is estimated as 680,972 adults (59.3 x 11,483.5). If the 28 historical EOs are assumed to be 'extant', total adult abundance estimate would be 840,014 (59.3 x 14,165.5), based on average density. This extrapolation most likely overestimates the true population size, but it may well exceed 500,000. The size of most subpopulations is unknown.

Potential biases:

Total EO area is based on GIS interpretation without ground-truthing and likely overestimates the actual occupied habitat area. For example, the EO area estimates for PPNP, RPP, and OPSS are 171,122, and 57 ha, respectively (Table 4); however, estimates from detailed surveys at these localities are 51, 99, and 1 ha, respectively (Hecnar and Brazeau unpubl. data). Within the Carolinian DU, the estimates for Walpole Island subpopulation, in particular, may be overestimates because there is much uncertainty about the size of the occupied area due to paucity of available data. Also, density estimates are derived from only a small number of localities in each DU. Those in the GLSL DU are from localities subjectively selected for a research project that likely have higher than average habitat quality, potentially resulting in overestimates. Conversely, undocumented subpopulations may exist due to gaps in the search effort. Thus, estimates for both DUs, but particularly for the GLSL DU, should be interpreted with caution.

Fluctuations and Trends

Carolinian DU:

Five of 14 EOs from the Carolinian region are classified as historical (4) or extirpated (1) based on lack of recent observations and loss of habitat, which suggests an overall, long-term (over past several decades) decline of 35.7% (Table 2). The exact timing of the disappearances is difficult to determined due to lack of systematic visits to all sites in the past. These values have been updated from previous 13 EOs (8 extant, 5 historical, 1 extirpated) based on new information, described below. Given recent search effort and/or large-scale habitat loss (Hecnar and Brazeau 2016, 2017; Hecnar unpubl. data), it is likely that four of the five EOs previously considered historical are extirpated, and that these absences reflect true declines. A recent verified observation of a single juvenile from an agricultural locality in the remaining historical EO (in Tilbury Township) suggests that this EO is extant, but little suitable habitat remains. Based on this observation, the locality is considered extant, and the discovery of a new locality (Hecnar and Brazeau 2016) revises the previous classification to a total of 14 EOs, nine of which are considered extant (Table 2). The timing of the disappearance of the now extirpated EOs is uncertain.

Information on long-term population fluctuations and trends of *P. fasciatus* is limited to studies from the two largest subpopulations (Point Pelee NP, Rondeau PP) (Figure 6). Population estimates based on summer annual peak activity surveys over the past 29 years (1990–2018) at Point Pelee ranged from 61–522 (Hecnar unpubl. data) with a modest but highly significant increasing trend. Population estimates for the Rondeau subpopulation exist for the past 6 years (2013–2018) and ranged from 164–501 (Hecnar *et al.* unpubl. data), but showed a marginally significant declining trend; over this period, abundance declined by 63.6% (450–164 in 2018). Interestingly, the Point Pelee subpopulation also showed a decline similar to Rondeau when a trend analysis was confined to the same six-year period (Figure 6). Both subpopulations declined by about 65% over this timeframe. If the past 10 years of data (~3 generations) are considered for

PPNP, the decline was 7% based on the linear trend or 32% based on actual estimated annual total abundance (253–172 in 2018). The increasing trend at Point Pelee over the longer-term (29 years) is likely the result of active management (augmenting woody debris, prescribed burns, and clearing) that appears to have reversed the decline that occurred from 1990 to 1996 by increasing the quantity and quality of habitat (Hecnar and Hecnar 2013). The decline over the past six years coincides with increased storm surges, flooding, and habitat loss by storm erosion events. Disparate short-term trends were noted in comparing the three largest subpopulations from 2013 to 2015, where abundance at Pinery Provincial Park increased while it simultaneously decreased at Point Pelee and Rondeau (Hecnar *et al*. 2018). The recent declines of abundance in the two largest Carolinian subpopulations in protected areas suggest that similar trends may be occurring in unprotected, unmonitored subpopulations.

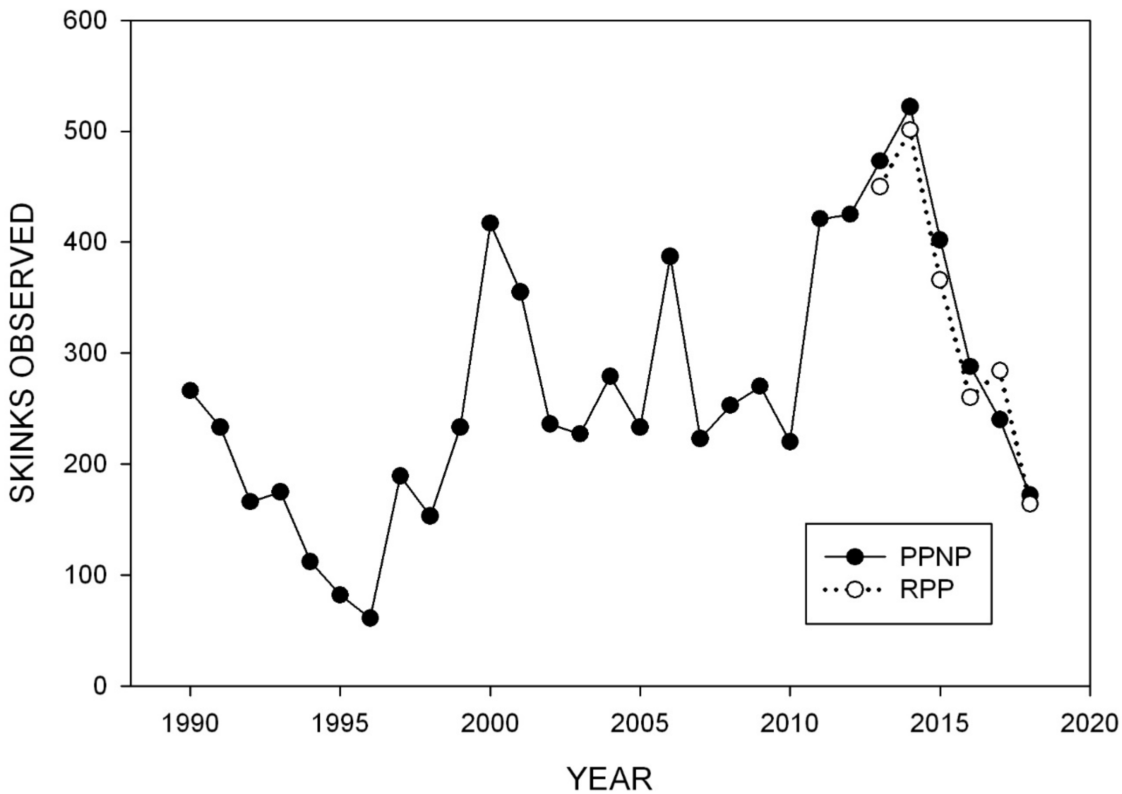

Figure 6. Long-term *Plestiodon fasciatus* population trend at Point Pelee National Park (PPNP, 29 y) and Rondeau Provincial Park (6 y). Based on unpubl. data by S. Hecnar.

Population Viability Analyses (PVA) indicated that despite a long-term trend of increasing abundance at Point Pelee NP, the subpopulation carried a considerable risk of extinction over the next 50 years. The risk of extinction at Point Pelee was particularly high (20.3–41.3 %) when calculated from variance in population growth rates from 1998 to 2012 (for details see Hecnar and Hecnar 2011, 2013). Repeating this analysis based on long-term data from 1990 to 2018 indicates that the Point Pelee subpopulation currently has a 30% chance of extinction in the next 50 years or about 12.0% over the next 20 years (Hecnar unpubl. data). The model included a geometric growth rate of $\lambda = 1.05$, SD = 0.572, an annual survivorship of 0.7, and was based on 1000 iterations using Ramas ® EcoLab 2.0 software (Akçakaya *et al*. 1999). The PVA simulation for the Rondeau subpopulation based on data from 2013 to 2018 resulted in a 97.3% chance of extinction over the next 50 years or about 38.9% over the next 20 years. The model included a geometric growth rate of $\lambda = 0.82$, SD = 0.243, an annual survivorship of 0.7, and was based on 1000 iterations using Ramas ® EcoLab 2.0 software (Akçakaya *et al*. 1999).

A rough estimate of the Carolinian population trend for the next decade can be made using the threats calculator results (see **Threats**). An overall threat impact of "High" indicates a projected 10 to 70% population decline from threats operating over the next 10 years.

Great Lakes/St. Lawrence DU:

Series of abundance data for multiple years are not available to determine if any temporal trends are occurring for any subpopulations in this DU. However, annual observations at three sites in the Georgian Bay Islands NP appear to be decreasing relative to effort (Promaine pers. comm. 2018). No individuals have been found at one of these sites despite searches for over 10 years (Promaine pers. comm. 2018).

Thirty-one of 118 EOs (26%) are classified as historical (n=29) or extirpated (n=2) based on habitat loss or lack of recent observations; however, the "historical" classification of most of these sites probably reflects lack of search effort over the past 20 years rather than true declines in occurrence (see **Extent of Occurrence and Area of Occupancy**). An overall threat impact of "Medium" indicates a projected 3 to 30% population decline from threats operating over the next 10 years.

Population Fragmentation

For a population to be considered severely fragmented, as per COSEWIC and IUCN definition, more than 50% of the population must exist in habitat patches smaller than required for long-term viability. The habitat of both DUs of *P. fasciatus* is naturally highly fragmented; this is accentuated by human land uses, which are particularly pronounced within the range of the Carolinian DU. EOs delineated by NHIC are considered to represent subpopulations among which there is little or no exchange of individuals. Dispersal abilities of skinks are poor, and distances among EOs are greater than what individual skinks are expected to travel (see **Population Spatial Structure and Variability**); genetic differentiation among subpopulations corroborates their isolation (see **Genetic Description**). In the absence of habitat mapping at an appropriate fine scale, areas occupied by EOs are considered as proxies for habitat patches, justifiable in light of the specific habitat requirements of the species. Population viability typically decreases and risk of extinction increases with habitat loss, habitat degradation, and isolation resulting from fragmentation (Akçakaya *et al*. 1999; Lomolino *et al*. 2017).

For Carolinian subpopulations, three of nine extant EOs (PPNP, RPP, PPP) have been assessed by NHIC as reasonably secure over the short term, representing 38.1% of the total area of occupancy (IAO) (Table 4). However, the most recent assessment was in 2015 and did not include observed declines over the past six years (Point Pelee, Rondeau). All EOs have been visited in recent years. Isolation of EOs vastly exceeds dispersal capabilities of the species (see **Dispersal and Migration**), virtually eliminating any chance of recolonization. PVA calculated for the two largest of these viable subpopulations (PPNP, RPP) showed an extinction risk of 30% and 97%, respectively, over the next 50 years (see **Fluctuations and Trends**). Therefore, even these two largest subpopulations are not considered viable over the long term. The other extant subpopulations are smaller, some with only a few individuals detected in recent years, and would therefore carry a high risk of extirpation. Inferences from this analysis and from the degree of habitat fragmentation in the Carolinian zone suggest that no subpopulation is viable over the long term unless threats are managed. This lack of viability, declining abundance trends, high risk of extinction, small habitat patch size (6 of 9 subpopulations), and extreme isolation characterize these subpopulations. Therefore, the Carolinian population is considered severely fragmented.

For GLSL subpopulations, two EOs have been assessed by NHIC of fair viability (i.e., high likelihood of persistence if current conditions prevail). However, not all EOs, extant or historical, have been assessed for viability. New occurrences continue to be found, reflecting increased search effort. In light of the above uncertainties, severe fragmentation cannot be evaluated at present for this DU.

Rescue Effect

Both Canadian DUs are geographically isolated from neighbouring populations in the USA by a barrier imposed by the Great Lakes and the St. Lawrence River. The adjacent landscapes along these waterways between USA and Canada are also among the most highly urbanized, industrialized, and intensively farmed areas in North America. Two Carolinian subpopulations have genetic affinity with eastern Michigan but are separated by physical barriers (Howes *et al*. 2006). There is also considerable genetic differentiation between the Canadian and the other US populations (Howes *et al*. 2006). Three of four neighbouring populations in the USA are designated as vulnerable. Rescue from neighbouring or healthy populations there is not possible because of physical barriers preventing movement and distances exceeding dispersal capability.

THREATS AND LIMITING FACTORS

Limiting Factors

The most important limiting factor affecting *P. fasciatus* in Canada historically and currently is habitat fragmentation, resulting from the presence of physical barriers and habitat loss from long-term climate change and vegetation succession. These natural limiting factors are now also influenced and accelerated by human actions. Poor dispersal ability further accentuates isolation and limits recovery of subpopulations after perturbations. Abiotic factors, such as ambient temperature, similarly limit the species' distribution at the northern extremity of its range in Canada.

Genetic evidence indicates that the Mississippi River acted as a major barrier during post-glacial recolonization (Howes *et al.* 2006). Skinks are present on only about 7% of islands adjacent to shoreline subpopulations in the Great Lakes (Hecnar *et al*. 2002) with genetic differentiation on islands detected over isolation distances as short as 3.5 km (Wick 2004). Skinks have not been able to recolonize suitable habitat in the historical locality of Erieau, Ontario, just 180 m across the bay from the relatively large skink population on the Rondeau peninsula (Hecnar and Brazeau 2016). Ussher and Cook (1979) suggested that poorly drained lowlands set the eastern range limit for skinks in Ontario.

Threats

The IUCN Threats Calculator was applied to *P. fasciatus* in June 2019 by a panel of experts (Appendices 1 and 2). The process consists of assessing impacts for each of 11 main categories of threats and their subcategories, based on the scope (proportion of the population exposed to the threat over the next 10-year period), severity (proportion of the segment of the population exposed to the threat predicted to decrease within the next 10 years or 3 generations, whichever is longer), and timing of each threat. The applicable threats are discussed below in their approximate, perceived order of importance for each of the DUs.

<u>Carolinian DU:</u>

The assigned overall threat impact was "High" based on 1 - 3 medium and 3 - 5 low impact threats (Appendix 1). Specific threats are discussed below.

Transportation and service corridors (threat impact = medium)

High density of roads and increasing traffic levels result in road mortality and can act as barriers to movement. Southern Ontario has the highest road density in Canada with increasing traffic flows. The length of paved roads has increased 5-fold in recent decades (Ontario Biodiversity Council 2018). Use of roadside habitats, crossing or basking on roads, and the risk of road mortality for *P. fasciatus* has been noted in Ontario (Farmer and Brooks 2012; Baxter-Gilbert *et al*. 2013) and elsewhere (Florida – Aresco 2005; Illinois – B. Howes pers. obs. cited in COSEWIC 2007; North Carolina – Homyack *et al*. 2016). Research at

PPNP and RPP revealed that road mortality of skinks averaged (mean: 0.22; standard deviation: 0.72) roadkills /10 km of road/day from spring to fall and peaked at 6.25 roadkills/10 km/day in June when adults actively search for mates and nest sites (Farmer and Brooks 2012). Mortality rate also accelerates when speed limits exceed 50 km (Farmer and Brooks 2012). Surveys and telemetry at RPP in the Carolinian DU suggested that the main park road reduces skink movements or acts as a barrier (Brazeau 2016; Brazeau and Hecnar 2018).

Climate change and severe weather (threat impact = medium – low)

Increased temperatures and longer active season associated with climate change seem favourable for an ectotherm that hibernates. More atmospheric energy would likely also mean greater frequency and severity of storm events. Increased tornadoes in the Carolinian zone may help open up habitats by reducing canopy cover and adding more woody debris. However, greater energy likely also means increased loss of shoreline dune habitat that *P. fasciatus* prefers. Longer activity seasons may also increase risk from other factors such as road mortality or predation. The wide range of estimated severity reflects some uncertainty because of the combination of some positive effects with overall negative impact of climate change on skinks.

Increasing frequency of drought, higher temperatures, and storm erosion and flooding events associated with record high lake water levels are of concern. The three largest extant subpopulations (PPNP, RPP, PPP) are at greatest risk because they are on shorelines of the Great Lakes. Habitat loss and mortality of hibernating skinks associated with winter storms and flooding contributed to the severity rating. For southern Ontario, virtually all models predict a temperature increase by several degrees, especially in winter, in upcoming decades. Precipitation predictions are more variable among areas of southern Ontario ranging from about 10% drier to 10% wetter (MNRF 2019). Great Lakes water levels have been rising since 2014 and reached record highs in 2019, but model predictions are quite variable (NOAA 2019). Ultimately, increased temperature and evapotranspiration should result in long-term lowering of lake water levels.

Most of the extant sites in the Carolinian population are in stabilized dune habitat on or near lake shorelines, and there is concern over currently rising lake water levels and increased frequency and severity of storm erosion and flooding events. The relationship between skink abundance and shoreline change rate at Point Pelee was highly significant ($F_{1,15} = 77.0$, $R^2 = 0.84$, $P < 0.001$) with fewer skinks in quadrats with high erosion rates (Hecnar and Hecnar 2013). Rising water levels and increased storm erosion in recent years have resulted in nearly complete loss of over 8 km of skink shoreline habitat at Point Pelee (S. Hecnar pers. obs.). Higher skink density was noted on the east side relative to the west side of the Point Pelee peninsula before a major storm occurred in 1972 causing extensive habitat loss and flooding (Rivard and Smith 1973a,b). Annual skink surveys since 1990 documented gradual recolonization of the east beach until 2014 (Hecnar and Hecnar unpubl. data). During the past two decades, both storm frequency and severity have increased, as expected with climate change.

Invasive and other problematic species (threat impact = medium – low)

This threat accrues from increased predation from mesopredators and pets. Human actions have altered predator-prey dynamics in southern Ontario. Observations in one Carolinian subpopulation (PPNP) suggest considerable predation of skinks by Raccoons (Hecnar and Hecnar 2005, 2013). Research indicates that Raccoon density in PPNP is four-fold higher than the average density in rural Ontario (Phillips and Murray 2005) and seven-fold higher on some islands in Thousand Islands National Park (formerly St. Lawrence Islands National Park) (Gonzales 2008). The frequency of tail loss rates in skinks, which likely reflects predation risk, is also positively correlated with Striped Skunk abundance in PPNP (Myschowoda 2015).

Residential and commercial development (threat impact = low)

Housing and commercial sites bordering some subpopulations are expanding; the skinks are unable to co-exist with heavily urbanized areas. Many of the historical and extirpated localities in the Carolinian DU are in areas that have become converted to cities and towns (Hecnar and Brazeau 2016). Urban sprawl and migration of people from rural to urban areas continue. Currently 7% of the land cover in the Lake Erie – Lake Ontario Ecoregion is classified as urban (MNRF 2009). However, observations (NHIC, ORAA) suggests that *P. fasciatus* will use some residential structures in sites that are not heavily urbanized.

Natural system modifications (threat impact = low)

This threat accrues from gradual forest encroachment reducing the open characteristic of habitat suitable for skinks. Long-term forest encroachment replacing prairie habitat has resulted in collapse of skink populations in Kansas (Fitch 2006a,b).

Studies indicate that *P. fasciatus* tolerates fires well (Perry *et al*. 2012; Hromada *et al*. 2018) and that skink abundance responds positively to fires, which improve habitat quality by preventing forest canopy closure (Matthews *et al*. 2010; Greenberg *et al*. 2018). Periodic fires function as a natural agent of disturbance in prairie and savannah habitats in the Carolinian region. First Nations people also used fires to maintain prairie and savannah habitat before European colonization began (Bakowsky and Riley 1994). In southern Ontario, skinks occur only at sites with less than 50–60 % forest canopy cover (Brazeau 2016; Feltham 2020). Evaluation of 41 historical skink sites in 2015 indicated that forest encroachment, conversion to intensive agriculture, and urbanization have negatively affected habitat quality and quantity in the Carolinian population (Hecnar and Brazeau 2016). The severity of the threat impact will increase over the long term.

Human intrusions and disturbance (threat impact = low)

Hundreds of thousands of people visit national and provincial parks in the Canadian range of *P. fasciatus* each year. Visitations tended to level off and decline in the digital age but have begun increasing again over the past decade (Parks Canada 2018). Visitors to parks and crown lands can have negative effects on skinks by their traffic flow as pedestrians and use of off-road vehicles, degrading habitats and disturbing animals. Negative effects include trampling of skinks, disturbing basking individuals, and moving or removing cover objects that provide essential refuges for skinks. Seasonal residents with cottages can also have negative effects within parks, such as encroachment into surrounding natural areas, introduction of invasive species (including subsidized predators), and disturbance of basking individuals.

Hecnar and M'Closkey (1998) showed that loss of microhabitat elements in a Carolinian subpopulation (PPNP) resulted in a three- to five-fold decline in skink abundance in 1990–1995. Loss of microhabitat is clearly the most severe form of habitat degradation, but repeated disturbance can also negatively impact abundance. Significantly fewer skinks were found in areas that had high levels of human disturbance relative to areas of low human disturbance (Hecnar and M'Closkey 1998). A single alteration to a microhabitat element could result in a decline of its quality. For instance, a cover rock or log that is flipped and not replaced exactly in its original position may alter microclimatic conditions with negative effects on skinks and nests. Skinks are also occasionally found crushed under wood or rock cover objects that were stepped on by visitors or hikers (S. Hecnar pers. obs.).

Even subpopulations within protected areas are at risk of microhabitat alteration, as woody debris is cleared from beaches for aesthetic reasons, or removed for firewood or use in gardens (Hecnar and M'Closkey 1998). In fact, human intrusion and disturbance can often be higher in provincial parks than in surrounding areas, as trails and roads provide access and attract many people to these sites.

The trend of increasing skink abundance in some Carolinian sites is largely a result of debris augmentation and habitat restoration. indicating that active management can reduce the threat to the species. A positive effect of human intrusion was noticed at PPNP where annual risk of avian predation decreased as visitor numbers increased (Myschowoda 2015). Human presence in skink habitat appeared to have reduced avian predator activity. However, a negative effect of human intrusion is increased mammalian predator activity (see *Invasive and other problematic native species)*.

Potential threats (unknown impact)

No specific information exists on the effects of contaminants on *P. fasciatus*. However, ecotoxicological effects of contaminants are well documented for herpetofauna including various lizards and other skink species (Sparling *et al*. 2010). Numerous pesticides, herbicides, and fertilizers with toxicological effects are regularly used across the intensive agricultural landscapes of southern Ontario. Monitoring data from across the Canadian range of the species indicate that levels of agricultural pollutants regularly exceed provincial health and environmental guidelines, especially in the Carolinian region (MECP 2019a). Fine particulate matter also indicates substantial air pollution from industrial and urban sources with moderate to high levels in the Carolinian population range and moderate levels in the Great Lakes St. Lawrence population range (Statistics Canada 2019).

Contaminant exposure of skinks would be mostly through diet and maternal transfer to eggs (Russell pers. comm. 2019). Persistent bio-accumulative and toxic chemicals of immediate environmental concern or of potential impact are monitored across the Ontario range of the species (MECP 2019b).

High levels of persistent organochlorine contaminants occur even in protected areas and will persist for the long-term (Russell and Hecnar 1996; Russell and Haffner 1997; Russell *et al*. 1999; Russell pers. comm. 2019). Chemicals such as DDT, DDE, PCB, and PAHs can persist for decades to centuries in many areas of southern Ontario because of heavy use in the past before ecotoxicological effects were known. Despite subsequent bans on use of these chemicals, their environmental persistence, in addition to toxic effects of many new generation pesticides and herbicides now being widely used across southern Ontario, can contaminate prey that skinks consume. The magnitude of the pollution threat to skinks will likely continue to increase as human populations grow in southern Ontario.

<u>Great Lakes/St. Lawrence DU:</u>

The assigned overall threat impact for the GLSL DU was Medium, based on five low impact threats (Appendix 2). Specific threats are discussed below.

Invasive and other problematic species (threat impact = low)

Human actions have altered predator-prey dynamics throughout southern Ontario. However, the severity of impact from mid-sized carnivore predation is lower than for the Carolinian population because more natural habitat remains, there is less fragmentation, and more native species persist in the GLSL population. Raccoon density is seven-fold higher than the average expected on some islands in St. Lawrence Islands National Park (Gonzales 2008).

Residential and commercial development (threat impact = low)

Urban expansion is largely limited to cottages and small towns, rather than widespread high-density urban developments. Although the human density is relatively low and the land cover is much less impacted in the GLSL DU than in the Carolinian DU, urbanization is slowly increasing with cottage and recreational development. The increase is associated with attempts to accommodate increased tourism from some of Ontario’s largest cities in or near this DU.

Human intrusions and disturbance (threat impact = low)

Recreational activities occur throughout much of the range of this DU and have increased over the past decade. Removal and movement of rock to construct fire pits and rock structures occur frequently in protected areas (NHIC records 2018; Crowley pers. comm. 2019; Feltham 2020). Some disturbance is also caused by off-road vehicle use (Feltham pers. comm. 2018).

Transportation and service corridors (threat impact = low)

Skinks in this DU are exposed to moderately high road density and traffic flow. The road network in the region is slowly expanding with improvements to highways to accommodate increasing human travel for recreation. Researchers have documented road mortality of skinks and suggested that artificial debris and high densities of insects maimed by vehicle collisions along highways may attract *P. fasciatus* (Baxter-Gilbert *et al*. 2013). Vehicles driven or parked on rock barrens have also been identified as a potential threat to skinks (Feltham 2020). In addition to causing mortality, large roads, particularly Ontario's 400-series highways, can also act as a barrier to skink movements, further fragmenting and isolating subpopulations.

Climate change and severe weather (threat impact = low)

The threat to skinks is from increasing frequency of droughts and higher summer temperatures, which are likely to reduce nesting success by skinks. Nests and eggs are prone to desiccation. Increasing water levels in lakes and rivers in recent years are not considered to be a current concern because skink habitat tends to occur on higher rock outcrops in this region.

Number of Threat-based Locations

<u>Carolinian DU:</u>

Transportation and service corridors and Climate change and severe weather were identified as the two most significant threat categories affecting the Carolinian DU. Expanding road networks and improvements of major thoroughfares to accommodate increased vehicle traffic have the potential to affect all subpopulations. Similarly, storm flooding and erosion events also impact all subpopulations because of the low elevation of the region. Only three of the nine subpopulations would have relatively less risk than coastal subpopulations because they are somewhat inland from the shores of Lake Erie (Oxley Poison Sumac Swamp, Kopegaron/Wheatley, Tilbury Township). Specific threatening events (e.g., creation or improvement of a road or a severe storm flooding or erosion event) can be large in scope and affect the entirety of each subpopulation.

Given the extreme isolation of the subpopulations (see **Population Fragmentation** section above), the impact of most threatening events will be localized to individual subpopulations. Thus, each subpopulation should normally be considered a single location, for a total of nine Carolinian locations. A large-scale century storm event could potentially impact multiple subpopulations simultaneously, especially all six coastal subpopulations; risk of such an event occurring within the next 10 years is low but increasing under predicted climate change scenarios. Combining these subpopulations, would result in a total of four threat-based locations.

Great Lakes/St. Lawrence DU:

Far less information on the status of subpopulations and the scope of threats facing them is available for this DU than for the Carolinian DU. Therefore, the number of threat-based locations is uncertain but it may as large as 87, corresponding to each subpopulation.

PROTECTION, STATUS AND RANKS

Legal Protection and Status

The Carolinian population is listed as Endangered and the GLSL population as Special Concern under the federal *Species at Risk Act* (SARA), based on the assessment by COSEWIC in 2007 (listed on Schedule 1 in 2009). In 2009 the Committee on the Status of Species at Risk in Ontario (COSSARO) placed the species on the Species at Risk in Ontario List under the *Endangered Species Act* (2007) matching the federal status designations. Individuals and residences on lands managed by Parks Canada are protected by the *Canada National Parks Act* as well as by provisions in SARA. Both Canada and the USA are signatories on the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), but *P. fasciatus* is currently not on its species' watch list.

A recovery strategy for the Common Five-lined Skink (Carolinian and Southern Shield populations) was developed under Ontario's *Endangered Species Act* in 2010. The provincial recovery strategy provides science-based advice to government on the actions that are necessary to recover a species. The provincial recovery strategy was followed by the Government Response Statement in 2011, which identifies the actions that the government of Ontario intends to take or support to help recover the species.

A management plan under SARA covering 44 of 178 (33%) EOs for *P. fasciatus* in the GLSL population was developed in 2013 (Environment Canada 2013). The plan highlighted the need for surveys to determine distribution and viability of EOs, development and implementation of management strategies, and increased communication. A draft recovery strategy under SARA was developed in 2010 for the Carolinian population, followed by a proposed recovery strategy in 2014 (Environment Canada 2014), and final recovery strategy in 2019 (Environment and Climate Change Canada 2019). Recovery strategies and management plans provide conservation advice but do not protect the species.

Non-Legal Status and Ranks

Globally, *P. fasciatus* is assessed as Least Concern (LC: IUCN 2018) and Secure (G5: NatureServe Explorer 2018). Nationally, its status is Vulnerable (N3) in Canada but Secure (N5) in the USA; sub-nationally, its status is Secure in 17 of 35 (49%) jurisdictions across its global range (NatureServe Explorer 2018). In the eleven more northerly US jurisdictions, it is Extirpated (1), Imperilled (1), Vulnerable (5), or Apparently Secure (4). In the five states adjacent to the Canadian portion of the species' range it is Vulnerable (S3) in three (Michigan, Minnesota, New York), Apparently Secure (S4) in one (Pennsylvania), and Status Not Ranked (SNR) in one (Ohio).

Habitat Protection and Ownership

Distribution records available as of December 2018 (NHIC + ORAA) indicate that 49.9% of the total Canadian IAO for the species is within governmental protected areas. The importance of habitat protection continues to increase as habitat becomes more fragmented and reduced by human development in both DUs. Slightly different levels of protection exist when the two DUs are considered separately.

<u>Carolinian DU:</u>

Five of nine (56%) extant EOs have some habitat protection (national, provincial, or municipal parks or reserves) over a portion of their area. Of all records 97.1% are from 10 protected areas that represent 38.1% (128 of 336 km^2) of the IAO (Supplementary Information 2). The remaining 61.9% of the area is under private ownership. The three largest subpopulations (PPNP, RPP, PPP) account for 91% of the IAO that is located within protected areas.

<u>Great Lakes/St. Lawrence DU:</u>

Of the 87 extant EOs 23 (26%) have habitat protection over a portion of their area, with the remainder being entirely on private or crown lands. Of all records 22.4% are from 36 protected areas that represent 51.2% of the IAO (Supplementary Information 2). A greater amount of protected area occurs in this DU (1,428 of 2,784 km^2) than in the Carolinian DU. A considerable amount of the remaining IAO area (48.8%) is on crown land. Much of the private land retains natural habitat.

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BIOGRAPHICAL SUMMARY OF REPORT WRITER

Steve Hecnar is a Professor of Biology at Lakehead University. His interests include ecology, biogeography, ecotoxicology, and conservation. He is especially interested in long-term–large scale dynamics of populations and communities, particularly of reptiles and amphibians. Steve completed his B.Sc. in Biology at Lakehead University in 1979 then worked for a decade in the fields of forestry and engineering. He returned to pursue graduate studies completing his M.Sc. in 1991 and Ph.D. in 1996 in Biology at the University of Windsor. Hecnar and his students have studied various aspects of the Common Five-lined Skink's biology over the past three decades.

COLLECTIONS EXAMINED

Occurrence data were obtained from the Ontario Ministry of Natural Resources and Forestry Natural Heritage Information Centre (NHIC), and Ontario Nature's Ontario Reptile and Amphibian Atlas (ORAA). These sources also incorporate older data from the previous Ontario Herpetofaunal Summary atlas project. Information on specimens held in the Canadian Museum of Nature (CMN), and the Royal Ontario Museum (ROM) collections was also obtained and reviewed.

Appendix 1. Threats calculator spreadsheet for the Carolinian population of Common Five-lined Skink.

Species or Ecosystem Scientific Name	Common Five- lined Skink *Plestiodon fasciatus* - Carolinian population			
Element ID			**Elcode**	
Date :	6/20/2019			
Assessor(s):	Steve Hecnar (Status Report Writer), Kristiina Ovaska (Co-chair), Tom Herman (Co-chair), Rosana Soares (secretariat), Christina Davy (Ont rep), Constance Browne (SSC member), Joe Crowley (SSC member), Lea Randall (SSC member), Pamela Rutherford (SSC member), Njal Rollinson (SSC member), Dave Cairns, Josh Feltham, Briar Howes, Laura Gardiner (Parks Canada), Karolyne Pickett			
References:	Draft COSEWIC status report			
		Overall Threat Impact Calculation Help:	**Level 1 Threat Impact Counts**	
	Threat Impact		**high range**	**low range**
	A	Very High	0	0
	B	High	0	0
	C	Medium	3	1
	D	Low	3	5
		Calculated Overall Threat Impact:	High	High
		Assigned Overall Threat Impact:	**B = High**	
		Impact Adjustment Reasons:		
		Overall Threat Comments	***generation time 3 years; IAO 336 km²; consider all occurrences from where they are records and no evidence of extirpation; proportion of population outside protected areas (<5%)***	

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)	Habitat loss, degradation & isolation of subpopulations due to urbanization has been historically severe. Most known sites are in protected areas; there may be a few very small undiscovered occurrences. Urban expansion is continuing with some increasing residential development on or near boundaries of EOs including the large subpopulations Point Pelee (PPNP), Pinery (PPP), and Rondeau (RPP). These three subpopulations represent over half the total DU. The expansion would affect the peripheral individuals outside the boundaries of the sites and further hinder movements. Scope is near lower end of "Small".

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
1.2	Commercial & industrial areas		Negligible	Negligible (<1%)	Extreme (71-100%)	Moderate (Possibly in the short term, < 10 yrs)	Heavy industrialization in the area, but it is localized near urban areas. Some expansion of commercial areas has occurred outside of the three big subpopulations (PPNP, PPP, RPP).
1.3	Tourism & recreation areas	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	Little expansion in recent decades, but some park infrastructure development (trails, picnic areas) has occurred and is predicted. Recent small infrastructure developments in the range of the three big subpopulations include a picnic area with paved over parking lot and change/washrooms, which were constructed over skink habitat and restrict connectivity along beach/dune.
2	Agriculture & aquaculture		Negligible	Negligible (<1%)	Serious (31-70%)	High (Continuing)	
2.1	Annual & perennial non-timber crops		Negligible	Negligible (<1%)	Serious (31-70%)	High (Continuing)	Intensive agriculture covers 78% of area resulting in historical habitat loss and isolation. Currently, these areas are not expanding. Habitat on private lands is more likely to be converted to housing than to agriculture. Severity is serious because skinks are unlikely to survive on cultivated land.
2.2	Wood & pulp plantations						Few plantations in the area; some selective harvesting in woodlots.
2.3	Livestock farming & ranching		Negligible	Negligible (<1%)	Serious (31-70%)	Moderate (Possibly in the short term, < 10 yrs)	Some livestock farming, mostly dairy; increasing development of factory farms. Most is peripheral to skink sites and is not reducing habitat, hence the scope is negligible.
2.4	Marine & freshwater aquaculture						
3	Energy production & mining		Negligible	Negligible (<1%)	Unknown	Moderate (Possibly in the short term, < 10 yrs)	
3.1	Oil & gas drilling		Negligible	Negligible (<1%)	Negligible (<1%)	Moderate (Possibly in the short term, < 10 yrs)	No increase in number of oil wells or production is expected, but much of Canada's natural gas reserve is stored in underground shale deposits, common in the region. Unlikely but possible reactivation of wells. There are ~2,500 wells in area, but most are not in operation, and none are in the immediate vicinity of skink sites; the closest ones are near the Pinery subpopulation.
3.2	Mining & quarrying						Few mines, some small quarries; three big salt mines with extensive tunnel networks are in the area but not in the immediate vicinity of skink sites.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
3.3	Renewable energy		Negligible	Negligible (<1%)	Unknown	High (Continuing)	>2000 wind turbines are operating in the area with concerns about negative effects of sonic and seismic activities on animal health. None are in the immediate vicinity of skink sites. Expanding literature on negative health effects on humans and animals in general, but there is currently no specific literature on skinks. Use of solar energy is increasing. Effects on skinks would be from shading by large solar panels and from land clearing - this is an emerging threat with unknown severity.
4	Transportation & service corridors	C	Medium	Restricted (11-30%)	Serious (31-70%)	High (Continuing)	
4.1	Roads & railroads	C	Medium	Restricted (11-30%)	Serious (31-70%)	High (Continuing)	The area has the highest road density in Canada with some expansion, and traffic volume has increased five-fold in recent decades. Effects on skinks are mainly from roadkill, but roads also function as barriers to movements (S. Hecnar unpubl. telemetry data), potentially leading to isolation and fragmentation of subpopulations. There is evidence of substantial roadkill on some park roads: average of 0.22 individuals/10 km/day recorded on busy park roads at Point Pelee and Rondeau. However, at Point Pelee, the majority of the subpopulation is near beaches with no roads nearby; at Pinery, roads do not overlap much with skink habitat; roadkill is an issue in Rondeau: (9, 35, 6 roadkill skinks found in 2014, 2015, and 2015, respectively, during bi-weekly bicycle surveys; C. Davy pers. comm. 2019). The scope was determined for the portion of the population that is expected to be near roads and reflects short movement distances typical to the species. There is much uncertainty about severity, but because of the small size of subpopulations, losses to roadkill are of concern.
4.2	Utility & service lines		Not a Threat	Negligible (<1%)	Neutral or Potential Benefit	High (Continuing)	Numerous corridors exist, but they have likely a positive effect on habitat because their development and maintenance create open habitat and corridors.
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	
5.1	Hunting & collecting terrestrial animals		Negligible	Negligible (<1%)	Slight (1-10%)	High (Continuing)	Several cases of illegal collection and export of reptiles have occurred, and this activity is still ongoing. Less demand for skinks on pet market than for other reptiles.
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting		Not a Threat	Negligible (<1%)	Neutral or Potential Benefit	High (Continuing)	Some selective cutting of hardwoods has occurred in remaining woodlots and conservation areas in recent decades.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.4	Fishing & harvesting aquatic resources						
6	Human intrusions & disturbance	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	Some of Canada's busiest parks are in the region, and visitor numbers have increased over the past decade after some declining use with the start of digital age. Since 2020, Covid-19-related travel restrictions have led to further increases in use of provincial and national parks by residents. Negative effects include removal or alteration of woody debris by park visitors and damage from ATV use. However, there may be reduced predation on skinks due to visitor presence in open habitats.
6.2	War, civil unrest & military exercises						
6.3	Work & other activities						
7	Natural system modifications	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
7.1	Fire & fire suppression	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Skinks tolerate fire well. Fire suppression is an issue, but suitable open habitat can be created/restored by other means. Long-standing fire suppression through forest succession has reduced open prairie and savannah habitat that historically covered the region. Research at Rondeau indicates a threshold effect for skinks when canopy reaches 50% coverage. Skink habitat is being lost through succession in some areas of parks, and recent visits to 41 historical skink sites in region indicated that forest encroachment had occurred at most sites (S. Hecnar unpubl. data). However, the process is operating at slow speed; hence the severity was deemed Slight over the next 10-year period. Habitat restoration is in progress at Point Pelee (prescribed burning, clearing shrubs, removal of invasive species). Research on prescribed burning shows that burning per se doesn't improve habitat, while opening of the canopy does.
7.2	Dams & water management/use						
7.3	Other ecosystem modifications						
8	Invasive & other problematic species & genes	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	
8.1	Invasive non-native/alien species	D	Low	Large (31-70%)	Slight (1-10%)	High (Continuing)	Some evidence of dogs and cats taking skinks has been documented. Cat predation from surrounding areas is also an issue; Ontario Herp Atlas reports some cases.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.2	Problematic native species	CD	Medium - Low	Pervasive (71-100%)	Moderate - Slight (1-30%)	High (Continuing)	Mesopredator release resulting from loss or large mammalian predators continues to elevate predation risk on small bodied prey. There is some evidence of high densities of raccoons, skunks, and other medium sized predators affecting skinks. Predation from elevated densities of mesopredators is an important threat across the entire Canadian range of species, but that there is uncertainty about the magnitude of the impact on populations.
8.3	Introduced genetic material						
9	Pollution		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	
9.1	Household sewage & urban waste water						Some bio-concentration of toxins may be occurring, but there are no data.
9.2	Industrial & military effluents						Some pollution exists from industries and past inputs of toxins with long half-lives. Some industrial contamination continues, but the inputs are reduced in the current economic environment. No data on effects on skinks are available.
9.3	Agricultural & forestry effluents		Unknown	Pervasive (71-100%)	Unknown	High (Continuing)	Heavy inputs from agricultural fertilizers, herbicides, and pesticides have occurred historically and continue. Toxicological effects on skinks are inferred based on evidence from other herpetofauna. Heavy past use of DDT and other organochlorines will likely affect fauna in the region for decades to centuries based on known levels and half-lives. High concentrations of toxins have been found in reptiles at Point Pelee, but skinks have not been tested. The group agreed that this threat is pervasive and that severity remains unknown due to lack of data.
9.4	Garbage & solid waste						Likely some risk near landfills and dumps.
9.5	Air-borne pollutants						Considerable air pollution exists across region and likely has some health effects. No data on effects on skinks are available.
9.6	Excess energy						
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						Minor earthquakes occasionally occur in the region. Possibly increased risk of future activity because of extensive salt mining and natural gas storage in region.
10.3	Avalanches/landslides						Very low risk as most of the region has low elevation.
11	Climate change & severe weather	CD	Medium - Low	Restricted (11-30%)	Serious - Moderate (11-70%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.1	Habitat shifting & alteration						
11.2	Droughts	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Increasing frequency of droughts has been recorded in recent decades in SW Ontario, and the trend is likely to continue under climate change. Skinks would be affected mostly during the nesting period, as eggs in nests under moss would be subject to drying out.
11.3	Temperature extremes						Increasing temperatures may occasionally exceed thermal maxima.
11.4	Storms & flooding	CD	Medium - Low	Restricted (11-30%)	Serious - Moderate (11-70%)	High (Continuing)	Increasing lake levels and associated storm flooding affect coastal skink habitats through erosion and increasing groundwater levels, which in turn elevate mortality risk of hibernating skinks. The scope reflects the extent of coastal localities and shoreline change rates, extrapolated from past 10 years, especially in Point Peele but also at some other sites. Overall lowering of lake levels is projected by some models, but these initial predictions are currently being revised (T. Dobbie pers. comm. to S. Hecnar after the threats call). Currently, water levels are record high, and initial observations suggest lower skink numbers again this year (2019) at Point Pelee associated with further habitat loss and degradation of shoreline and some interior habitats (S. Hecnar unpubl. data). This is a major threat to subpopulations in the DU. Fluctuations of water levels due to storm surges may also be a problem.

Appendix 2. Threats calculator spreadsheet for the Common Five-lined Skink Great Lakes/St. Lawrence population.

Species or Ecosystem Scientific Name	Common Five-lined Skink *Plestiodon fasciatus* - Great Lakes/St Lawrence population			
Element ID				**Elcode**
Date:	6/20/2019			
Assessor(s):	Steve Hecnar (Status Report Writer), Kristiina Ovaska (Co-chair), Tom Herman (Co-chair), Rosana Soares (secretariat), Christina Davy (Ont rep), Constance Browne (SSC member), Joe Crowley (SSC member), Lea Randall (SSC member), Pamela Rutherford (SSC member), Njal Rollinson (SSC member), Dave Cairns, Josh Feltham, Briar Howes, Laura Gardiner (Parks Canada), Karolyne Pickett			
References:	Draft COSEWIC status report			
	Overall Threat Impact Calculation Help:		**Level 1 Threat Impact Counts**	
	Threat Impact		**high range**	**low range**
	A	Very High	0	0
	B	High	0	0
	C	Medium	0	0
	D	Low	5	5
	Calculated Overall Threat Impact:		Medium	Medium
	Assigned Overall Threat Impact:		**C = Medium**	
	Impact Adjustment Reasons:			
	Overall Threat Comments		***generation time 3 years; 87 extant EOs (draft status report, spring 2019); undocumented localities may well exist, and this is taken into account in the assignment of scope for threats. Revisions were made based on post-call comments.***	

Threat		**Impact (calculated)**		**Scope (next 10 Yrs)**	**Severity (10 Yrs or 3 Gen.)**	**Timing**	**Comments**
1	Residential & commercial development	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	
1.1	Housing & urban areas		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	The region has relatively low human population density, but some habitat loss and degradation is occurring because of increasing urban development.
1.2	Commercial & industrial areas		Negligible	Negligible (<1%)	Extreme (71-100%)	High (Continuing)	Some increase has occurred in recent decades, affecting very little skink habitat.
1.3	Tourism & recreation areas	D	Low	Small (1-10%)	Moderate (11-30%)	High (Continuing)	Increasing development of recreational sites and infrastructure is likely because the region is a popular tourist destination for several of Canada's largest cities. Cottage development is a major contributor to this category and the reason why the scope is above 1%.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
2	Agriculture & aquaculture		Negligible	Negligible (<1%)	Serious (31-70%)	Moderate (Possibly in the short term, < 10 yrs)	
2.1	Annual & perennial non-timber crops		Negligible	Negligible (<1%)	Serious (31-70%)	Moderate (Possibly in the short term, < 10 yrs)	Agriculture covers only about 3% of total area but increases to about 57% in Simcoe-Rideau area of the region. There is little new land conversion, although a few more farms may be started in future.
2.2	Wood & pulp plantations						Some plantations and forest harvesting occur in region.
2.3	Livestock farming & ranching		Negligible	Negligible (<1%)	Serious (31-70%)	Moderate (Possibly in the short term, < 10 yrs)	Very little livestock farming occurs.
2.4	Marine & freshwater aquaculture						
3	Energy production & mining		Negligible	Negligible (<1%)	Moderate (11-30%)	High (Continuing)	
3.1	Oil & gas drilling						
3.2	Mining & quarrying						Few mines and some small quarries are present, and no major new developments are known.
3.3	Renewable energy		Negligible	Negligible (<1%)	Moderate (11-30%)	High (Continuing)	Concern was expressed over expansion of solar panel sites on rock outcrops/alvars that are important skink habitat. Solar panels can cover large areas, shading skink habitat. An emerging issue for this DU.
4	Transportation & service corridors	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	
4.1	Roads & railroads	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Moderately high road density is present with some recent expansion; traffic volume has increased five-fold in recent decades. Skinks are vulnerable to road mortality (see Carolinian DU), but road densities are lower in the range of this DU. Roads also pose barriers to movements (S. Hecnar unpubl. data) and potentially isolate and fragment subpopulations.
4.2	Utility & service lines						Numerous corridors exist but they likely have a positive effect on habitat because development and maintenance create open habitat.
4.3	Shipping lanes						
4.4	Flight paths						
5	Biological resource use		Not a Threat	Small (1-10%)	Neutral or Potential Benefit	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
5.1	Hunting & collecting terrestrial animals						Some illegal collecting may be occurring, but the level of risk is low.
5.2	Gathering terrestrial plants						
5.3	Logging & wood harvesting		Not a Threat	Small (1-10%)	Neutral or Potential Benefit	High (Continuing)	Some forest harvesting occurs in region (mostly as part of small-scale operations), but it likely improves habitat quality over the long term. While harvesting is limited in scope, there may be some negative effects of skidders initially, but if well managed, it will improve habitat ultimately.
5.4	Fishing & harvesting aquatic resources						
6	Human intrusions & disturbance	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	
6.1	Recreational activities	D	Low	Restricted (11-30%)	Slight (1-10%)	High (Continuing)	Much recreation occurs in the region, which includes busy parks. Visitor numbers have begun to increase over the past decade after some declining use with the start of digital age. Since 2020, Covid-19-related travel restrictions have led to further increases in use of provincial and national parks by residents. Negative effects on skinks include removal and rearranging rocks by visitors, such as building of rock structures/piles. There is some evidence of off-road vehicles causing habitat degradation. Scope reduced from "large" to "restricted" in response to review comments.
6.2	War, civil unrest & military exercises						
6.3	Work & other activities						
7	Natural system modifications		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	
7.1	Fire & fire suppression		Negligible	Pervasive (71-100%)	Negligible (<1%)	High (Continuing)	Skinks tolerate fire well, and literature indicates that skinks are adapted to habitats with frequent fire regimes. Fire suppression may be an issue, and it is what is scored here. Fire suppression allows succession to advance. While pervasive in scope, it is occurring extremely slowly. Skink habitats are less affected on the shield than in the Carolinian zone. Severity of impacts over the next 10 years hovers around 1% and may even be negligible because how succession affects rock outcrops.
7.2	Dams & water management/use						
7.3	Other ecosystem modifications						
8	Invasive & other problematic species & genes	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
8.1	Invasive non-native/alien species	D	Low	Small (1-10%)	Slight (1-10%)	High (Continuing)	Incidents of pets taking skinks have been documented. Cat predation is possible, especially around residences and agricultural areas
8.2	Problematic native species	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Mesopredator release resulting from loss or large mammalian predators continues to elevate predation risk on small bodied prey. There is some evidence of high densities of raccoons, skunks, and other medium sized predators affecting skinks. While an important threat across the entire Canadian range of species, there is uncertainty about the magnitude of the impact on populations. Severity was scored lower than for the Carolinian DU because there is less anthropogenic habitat disturbance and probably fewer mesopredators.
8.3	Introduced genetic material						
9	Pollution						
9.1	Household sewage & urban waste water						Some localized water pollution is present, but likely of overall low extent.
9.2	Industrial & military effluents						Little industrial contamination in the region.
9.3	Agricultural & forestry effluents						Likely some inputs of contaminants from forest management, but a very restricted area is involved. No data on effects on skinks are available.
9.4	Garbage & solid waste						Likely some risk near landfills and dumps.
9.5	Air-borne pollutants						Low levels of occasional air pollution are likely, but it not considered an issue for the skinks.
9.6	Excess energy						
10	Geological events						
10.1	Volcanoes						
10.2	Earthquakes/tsunamis						
10.3	Avalanches/landslides						
11	Climate change & severe weather	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	
11.1	Habitat shifting & alteration						
11.2	Droughts	D	Low	Pervasive (71-100%)	Slight (1-10%)	High (Continuing)	Increased droughts are considered the most important threat of climate change for this DU. Impacts on skinks are from desiccation of nests and eggs - nests are under moss & lichen mats that are prone to drying out. Nest sites need to have some moisture for successful incubation of eggs.
11.3	Temperature extremes						Increasing high temperatures occasionally exceeding thermal maxima.

Threat		Impact (calculated)		Scope (next 10 Yrs)	Severity (10 Yrs or 3 Gen.)	Timing	Comments
11.4	Storms & flooding						Increased storm activity and localized flooding have occurred in recent decades and could affect hibernation sites. This is less of an issue for this DU than for the Carolinian DU that occupies lakeshore habitats. For this DU, skink habitat is generally at higher elevation on rock outcrops that are not subject to flooding.