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COVER: Studies on Canadian Amphibians and Reptiles in Honour of Dr. Francis Cook. Centre: Dr. Francis Cook (photo: Brian Coad). See Editorial on pages 1–3. The inset photos (clockwise from top right) are: Northern Pacific Rattlesnake (*Crotaus o. oreganus*; photo: Karl Larsen; see article on pages 30–35), Spotted Turtle (*Clemmys guttata*; photo: David Seburn; see article on page pages 18–19), Fowler's Toad (*Anaxyrus fowleri*; photo: Katherine Yagi; see article on pages 46–52), Common Gartersnake (*Thamnophis sirtalis*; photo: William Halliday; see article on pages 25–29), and Painted Turtle (*Chrysemys picta*; photo: Patrick Moldowan; see article on pages 20–24).

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THE OTTAWA FIELD-NATURALISTS' CLUB

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Introduction to the Special Issue on herpetology in Canada

It is our great pleasure to introduce this special issue of *The Canadian Field-Naturalist* (CFN), which focusses on herpetology (the study of amphibians and reptiles) in Canada. This special issue has a wide range of articles and notes covering a large diversity of amphibians and reptiles in Canada. The last special issue of CFN was in 1999 (see Cook [1996] for a history of special issues and The Canadian Field-Naturalist [1998] for a list of the special issues 1995–1999).

This special issue is dedicated to Dr. Francis Cook. Francis has made a large mark on herpetology in Canada, so it is extremely fitting that we dedicate this special issue to him. This issue is also extremely timely: Francis was added to the Order of Canada in 2018 (Governor General of Canada 2018), and many of the reasons behind that nomination were related to his career as a herpetologist. Francis turned a life-long interest in amphibians and reptiles (Figure 1) into a remarkable career in herpetology. Francis authored 16 books, book chapters, and monographs on herpetology, and authored 47 journal articles on herpetology in a variety of different journals, including many in CFN. Included among his publications is his classic book *An Introduction to Canadian Amphibians and Reptiles* (Cook 1984). His published herpetological contributions focussed on the diversity of amphibians and reptiles across Canada. He has published on every major group of amphibians and reptiles that live in Canada, including frogs, toads, salamanders, turtles, snakes, and lizards, and has published on a variety of topics, including taxonomy and biogeography. Francis has also demonstrated his broad knowledge of herpetology by reviewing nearly 100 different books on herpetology. Part II of this special issue will contain a bibliography of his publications.

Francis has been very involved in the conservation of amphibians and reptiles through his involvement with the Committee on the Status of Endangered Wildlife in Canada (COSEWIC). Francis was the chairperson of the COSEWIC subcommittee for amphibians and reptiles between 1981 and 1994, during which time he edited 13 COSEWIC reports on amphibians and reptiles. He has also been a reviewer for COSEWIC since 1994.

FIGURE 1. Francis Cook with an Eastern Foxsnake (*Pantherophis gloydi*) collected from Long Point, Ontario, by Francis and Sherman Bleakney (then Curator of Herpetology), 28 August 1956. Photo: S. Bleakney.

Finally, Francis's tenure as Curator of the Herpetology Section for the Canadian Museum of Nature from 1960 to 1991, and Curator Emeritus and Research Associate since 1994, has led to an enormous contribution to the field of herpetology. Francis helped build the herpetology collection from 14 000 to 133 000 specimens, which is the largest collection of Canadian herpetological specimens in the world. Francis's knowledge of these herpetological museum specimens has helped countless graduate students and researchers. More than just a curator of specimens, Francis has been a curator of knowledge (Figure 2). Before the age of scholarly search engines, Francis was an amazing resource for knowing the herpetological literature, including not only journal articles, but also student theses. Francis was, and still is, the person to talk to when reviewing the herpetological literature.

In addition to honouring Francis Cook's many contributions to herpetology, we especially want to recognize his long dedication to CFN. Francis was the Editor-in-Chief of CFN for an impressive 34 years, making him the longest serving editor in the journal's 100+ year history. Francis first took on the editorial reins from 1962 to 1966, a time long before email and web submission of manuscripts. He stepped forward again in 1981 to edit the journal, remaining as the Editor-in-Chief until 2010. In total, Francis edited 35 volumes of CFN. After stepping down as the Editor-in-Chief, Francis continued on as the Associate Editor for herpetology and tributes from 2011 to 2016 (see Catling *et al.* 2016).

After conceiving the idea of this special issue, we put out a call for papers to Canadian herpetologists, including to members of the Canadian Herpetological Society, and they did not disappoint. Twenty-two articles and notes on all aspects of herpetology in Canada are part of this special issue. In fact, we received so many submissions that we had to split the special issue into two issues of CFN: 132(1) and 132(2). Eight articles and notes focus on turtles, six on snakes, four on frogs and toads, three on salamanders, and one is a checklist of amphibians and reptiles; we did not receive any submissions on lizards. These articles also represent the geographic breadth of Canada, with articles from the Mari-

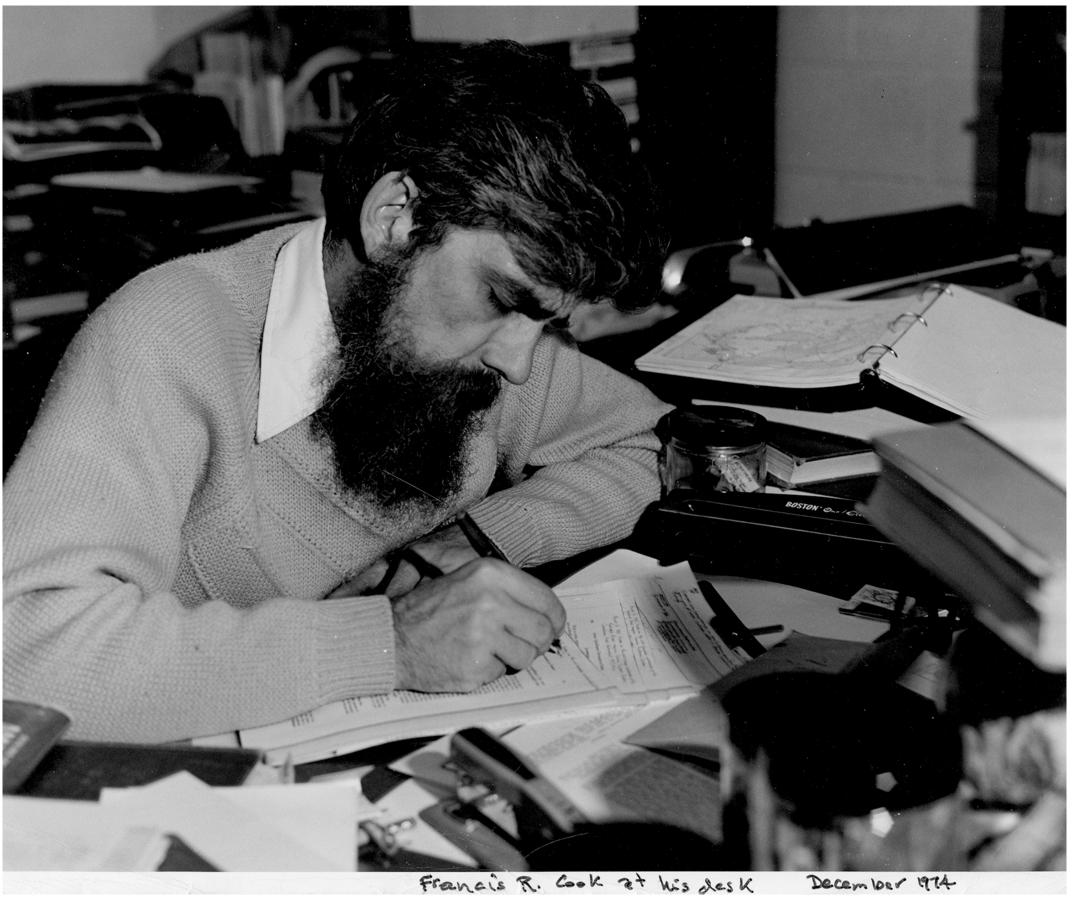

FIGURE 2. Francis Cook at work at the Canadian Museum of Nature, 1974. Photo: Canadian Museum of Nature.

times, eastern Canada, the Prairies, the West Coast, and even northern Canada.

In Part I of the special issue we have three articles and nine notes describing patterns of colouration (McAlpine and Gilhen), updates to species distribution (Gilhen and Power; Power and Gilhen), various aspects of fitness (Eye *et al.*; Gregory and Farr; Halliday and Blouin-Demers; Seburn), habitat use (Green and Yagi; Slough and deBruyn), behaviour (LeGros), sex-bias in capture rates (Moldowan *et al.*), and by-catch (Lennox *et al.*). Species described in this issue include three turtle species—Snapping Turtle (*Chelydra serpentina*), Painted Turtle (*Chrysemys picta*), and Spotted Turtle (*Clemmys guttata*); five snake species—Common Gartersnake (*Thamnophis sirtalis*), Western Terrestrial Gartersnake (*Thamnophis elegans*), Great Basin Gophersnake (*Pituophis catenifer deserticola*), Northern Pacific Rattlesnake (*Crotalus o. oreganus*), and Western Yellow-bellied Racer (*Coluber constrictor mormon*); three species of frogs and toads—Spring Peeper (*Pseudacris crucifer*), Fowler's Toad (*Anaxyrus fowleri*), and Western Toad (*Anaxyrus boreas*); and two salamander species—Eastern Red-backed Salamander (*Plethodon cinereus*) and Mudpuppy (*Necturus maculosus*).

Part II of the special issue will contain seven articles and three notes. Topics include habitat use (Atkinson-Adams *et al.*; Cairns *et al.*; Edkins *et al.*; Marchand *et al.*; Powell *et al.*), predation (Karson *et al.*), range expansions and species checklists (Choquette and Jolin; Rashleigh and Crowell), toxicology (de Solla and Gugelyk), and a variety of natural history observations (Cairns *et al.*; Davy *et al.*; Powell *et al.*). Species described in that issue will include three turtle species—Snapping Turtle, Western Painted Turtle (*Chrysemys picta bellii*), and Spiny Softshell Turtle (*Apalone spinifera*); two snake species—Bullsnake (*Pituophis catenifer sayi*) and Red-bellied Snake (*Storeria occipitomaculata*); one frog species—Spring Peeper; and one salamander species—Long-toed Salamander (*Ambystoma macrodactylum*).

Herpetology is alive and well in Canada, with herpetologists studying interesting and important aspects of the natural history and ecology of amphibians and reptiles across the country. This special issue highlights the research being conducted by a subset of these herpetologists and, just like with Francis Cook's research, there is a great diversity of what herpetologists are studying in this country.

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Snapping Turtle—Tortue serpentine—turtle mi' kjikj (snapping; *Chelydra serpentina*), added to the herpetofauna of Cape Breton Island, Nova Scotia, Canada

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Gilhen, J., and T. Power. 2018. Snapping Turtle—Tortue serpentine—turtle mi' kjikj (snapping; *Chelydra serpentina*), added to the herpetofauna of Cape Breton Island, Nova Scotia, Canada. Canadian Field-Naturalist 132(1): 4–7. https://doi.org/10.22621/cfn.v132i1.2020

Abstract
Snapping Turtle (*Chelydra serpentina*) is native to mainland Nova Scotia, but its status on Cape Breton Island has been uncertain. Although it was recorded from Cape Breton Island as early as 1953, until 1984, it was known from only three widely scattered locations. Since that time, additional reports received from the public by Nova Scotia Department of Natural Resources and the Nova Scotia Museum of Natural History suggest that the species is native to Cape Breton Island. Thus, we are adding Snapping Turtle to the native herpetofauna of Cape Breton Island, Nova Scotia.

Key words: Snapping Turtle; *Chelydra serpentina*; herpetofauna; Mira River watershed; Cape Breton Island; Nova Scotia; Canada

Snapping Turtle (*Chelydra serpentina*; Figure 1), is native to mainland Nova Scotia. It was first recorded on Cape Breton Island in 1953 when a large adult was reported from the beach at Port Hood, Inverness County (Bleakney 1958; Gilhen 1984). In 1977, two additional specimens were collected from Richmond and Cape Breton counties (Gilhen 1984). Thus, until 1984, the species was known only from these three widely scattered locations, and the individuals were presumed to be released or escaped captive turtles originating from the mainland (Gilhen 1984).

Since 1984, reports received from the public by the Nova Scotia Department of Natural Resources and the Nova Scotia Museum of Natural History show that the species is much more widely distributed than believed earlier. Detailed investigation of all reports of Snapping Turtle between 1953 and 2017 (n = 75) has provided a much clearer picture of the distribution of this species on Cape Breton Island, particularly in the Mira River watershed (Figure 2; Power and Gilhen 2018). These reports include adult turtles, especially nesting females, as well as juveniles (Figure 3). On 12 July 2006, we excavated the first documented nest of Snapping Turtle on Cape Breton Island at Intervale Road, Huntington (Mira River watershed), Cape Breton County (Figure 4).

FIGURE 1. Adult Snapping Turtle (*Chelydra serpentina*) searching for a nest site at Intervale Road, Huntington, Cape Breton County, Nova Scotia, on 25 June 2014. Photo: Terry Power.

Bleakney (1958) and Gilhen (1984) discussed the zoogeography of the herptiles of Nova Scotia in the context of land connections to the islands of the Gulf of St. Lawrence during the postglacial period. Evidence for a land connection from Cape Breton Island to mainland Nova Scotia during that period (~13 000–8000 years ago) is well documented (Shaw *et al.* 2002). Another freshwater turtle, Wood Turtle (*Glyptemys insculpta*), has long been recognized as a native species on Cape Breton Island (Gilhen 1984). Based on current understanding of the distribution and ecology of Snapping Turtle in both eastern Canada and elsewhere, we conclude that it (along with Wood Turtle), arrived in Cape Breton via a land bridge during the postglacial period and is native to Cape Breton Island (Power and Gilhen 2018). Therefore, we are adding Snapping Turtle to the herpetofauna of Cape Breton Island, Nova Scotia. We present an updated taxonomic list (after Crother 2008) of amphibians and reptiles of Cape Breton Island, Nova Scotia, Canada (Table 1).

FIGURE 2. Centre of the known distribution of Snapping Turtle (*Chelydra serpentina*) in the Mira River watershed on Cape Breton Island, Nova Scotia, Canada. Map of Nova Scotia by Nick Deagle, Nova Scotia Department of Natural Resources. Contains information licensed under the Open Government Licence – Nova Scotia.

FIGURE 3. Juvenile (13-year-old) Snapping Turtle (*Chelydra serpentina*) observed at Petersfield Provincial Park, Cape Breton County, Nova Scotia on 24 July 2013. Photo: Terry Power.

FIGURE 4. a. The first documented nest of Snapping Turtle (*Chelydra serpentina*) on Cape Breton Island, excavated on 12 July 2006 at Intervale Road, Huntington (Mira River watershed), Cape Breton County with MacKinnon Lake (a tributary of Salmon River) in the background; b. The same nest. Photos: Terry Power.

TABLE 1. Updated taxonomic list of amphibians and reptiles of Cape Breton Island, Nova Scotia, Canada (styled as in Crother 2008).

CAUDATA — SALAMANDERS
Notophthalmus Rafinesque, 1820 — EASTERN NEWTS
Notophthalmus viridescens viridescens (Rafinesque, 1820) — Red-spotted Newt
Ambystoma Tschudi, 1838 — MOLE SALAMANDERS
Ambystoma laterale Hallowell, 1856 — Blue-spotted Salamander
Ambystoma maculatum (Shaw, 1802) — Spotted Salamander
Hemidactylium Tschudi, 1838 — FOUR-TOED SALAMANDERS
Hemidactylium scutatum (Temminck and Schlegel in Von Siebold, 1838) — Four-toed Salamander
Plethodon Tschudi, 1838 — WOODLAND SALAMANDERS
Plethodon cinereus (Green, 1818) — Eastern Red-backed Salamander
ANURA — FROGS
Anaxyrus Tschudi, 1845 — NORTH AMERICAN TOADS
Anaxyrus americanus americanus (Holbrook, 1836) — Eastern American Toad
Pseudacris Fitzinger, 1843 — CHORUS FROGS
Pseudacris crucifer (Weid-Neuwied, 1838) — Spring Peeper
Lithobates Fitzinger, 1843 — AMERICAN WATER FROGS
Lithobates clamitans (Latreille, 1801) — Green Frog
Lithobates clamitans melanota (Rafinesque, 1820) — Northern Green Frog
Lithobates palustris (LeConte, 1825) — Pickerel Frog
Lithobates pipiens (Schreber, 1782) — Northern Leopard Frog
Lithobates septentrionalis (Baird, 1854) — Mink Frog
Lithobates sylvaticus (LeConte, 1825) — Wood Frog
SQUAMATA — SNAKES
Storeria Baird and Girard, 1853 — NORTH AMERICAN BROWNSNAKES
Storeria occipitomaculata (Storer, 1839) — Red-bellied Snake
Storeria occipitomaculata occipitomaculata (Storer, 1839) — Northern Red-bellied Snake
Thamnophis Fitzinger, 1843 — NORTH AMERICAN GARTERSNAKES
Thamnophis sirtalis (Linnaeus, 1758) — Common Gartersnake
Thamnophis sirtalis pallidulus Allen, 1899 — Maritime Garter Snake
Diadophis Baird and Girard, 1853 — RING-NECKED SNAKES
Diadophis punctatus (Linnaeus, 1766) — Ring-necked Snake
Diadophis punctatus edwardsii (Merrem, 1820) — Northern Ring-necked Snake
Opheodrys Fitzinger, 1843 — GREEN SNAKES
Opheodrys vernalis (Harlan, 1827) — Smooth Greensnake
TESTUDINES — TURTLES
Chelydra Schweigger, 1812 — SNAPPING TURTLES
Chelydra serpentina (Linnaeus, 1758) — Snapping Turtle
Glyptemys Agassiz,1857 — SCULPTURED TURTLES
Glyptemys insculpta (LeConte 1830) — Wood Turtle
Dermochelys Blainville, 1816 — LEATHERBACK SEA TURTLES
Dermochelys coriacea (Vandelli, 1761) — Leatherback Sea Turtle*

*Annual visitor to the coast of Cape Breton Island and Nova Scotia.

Acknowledgements

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Status, distribution, and nesting ecology of Snapping Turtle (*Chelydra serpentina*) on Cape Breton Island, Nova Scotia, Canada

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Abstract
Based on current knowledge of the ecology and distribution of Snapping Turtle (*Chelydra serpentina*), both in eastern Canada and elsewhere, we conclude this species is native to Cape Breton Island. Seventy-two reports of Snapping Turtle from Cape Breton (1999–2017) indicate a range centred in the area south of Bras d'Or Lake. Date of oviposition ranged from 19 June to 10 July (median = 26 June) among 26 nests observed during 2012–2014. Clutch size for these nests was 23–65 eggs (mean = 46) and among 25 protected nests average rate of hatchling emergence was 21.5%. Time from oviposition to emergence of hatchlings (n = 256) was 75–120 days (mean = 87.2; SD = 9.0) among 20 nests. First emergence ranged from 9 September to 20 October (75–114 nest days; mean = 90) and last emergence ranged from 13 September to 28 October (86–120 nest days; mean = 100). Duration of emergence ranged from one day (i.e., synchronous emergence; five nests) to 37 days (mean = 11 days). The number of days on which hatchlings emerged at a nest ranged from one to nine days (mean = 4 days). Maximum carapace length was 25.0–31.8 mm (mean = 29.0 mm) and maximum carapace width was 23.5–30.0 mm (mean = 27.0 mm) for 256 hatchlings that emerged from 20 protected nests. Mass of hatchlings was 4.9–9.9 g (mean = 7.8 g).

Key words: Snapping Turtle; *Chelydra serpentina*; status; distribution; nesting ecology; clutch size; hatching success; Cape Breton Island; Nova Scotia; Canada

Introduction
Snapping Turtle (*Chelydra serpentina*) is native to mainland Nova Scotia and was first recorded present on Cape Breton Island in 1953 when a large adult was reported from the ocean beach at Port Hood, Inverness County (Bleakney 1958; Gilhen 1984). However, until 1984, Snapping Turtle was known to be present in Cape Breton from only three widely scattered locations that were believed to be the result of released/escaped captive turtles (Gilhen 1984) and this view of the species' status has remained up until the present (COSEWIC 2008; Environment and Climate Change Canada 2016). Our observations, together with reports received from the public by both Nova Scotia Department of Natural Resources (NSDNR) and the Nova Scotia Museum (NSM) within the past two decades, indicate Snapping Turtle is much more widely distributed than earlier believed. Beginning in 1999, detailed investigation of all reports of Snapping Turtle was undertaken to better understand the status and distribution of this species in Cape Breton. On 12 July 2006, we excavated the first documented nest of Snapping Turtle in Cape Breton at Intervale Road, Huntington, Cape Breton County (Gilhen and Power 2018). From 2012 to 2014, we investigated the nesting ecology of this species at this site.

Snapping Turtle was assessed Special Concern by the Committee on the Status of Endangered Wildlife in Canada in 2008 (COSEWIC 2008) and is listed as Special Concern under the Canadian *Species at Risk Act* in 2011 (SARA Registry 2018) with a proposed Management Plan drafted in 2016 (Environment and Climate Change Canada 2016). Snapping Turtle was listed Vulnerable under the Nova Scotia *Endangered Species Act* in 2013, but to date, the presence of a naturally occurring population has not been recognized on Cape Breton Island (COSEWIC 2008; Environment and Climate Change Canada 2016). This paper discusses the status of Snapping Turtle on Cape Breton Island, summarizes known distribution based on personal observations as well as records from NSDNR and NSM (n = 75; 1953–2017), and presents data on time of nesting, location of nests, clutch size, time of emergence of hatchlings, survivorship to emergence, and size of hatchlings for nesting areas located at Huntington, Cape Breton County, Nova Scotia.

Study Area
Cape Breton Island is located off northeastern mainland Nova Scotia, Canada, (approximately. 45.5–47.0°N, 59.5–61.5°W) separated from the mainland by the Strait of Canso, an approximately 2 km wide stretch of ocean connecting the Gulf of St. Lawrence to the north with the Atlantic Ocean to the south (Figure 1). A permanent land connection between Cape Breton Island and main-

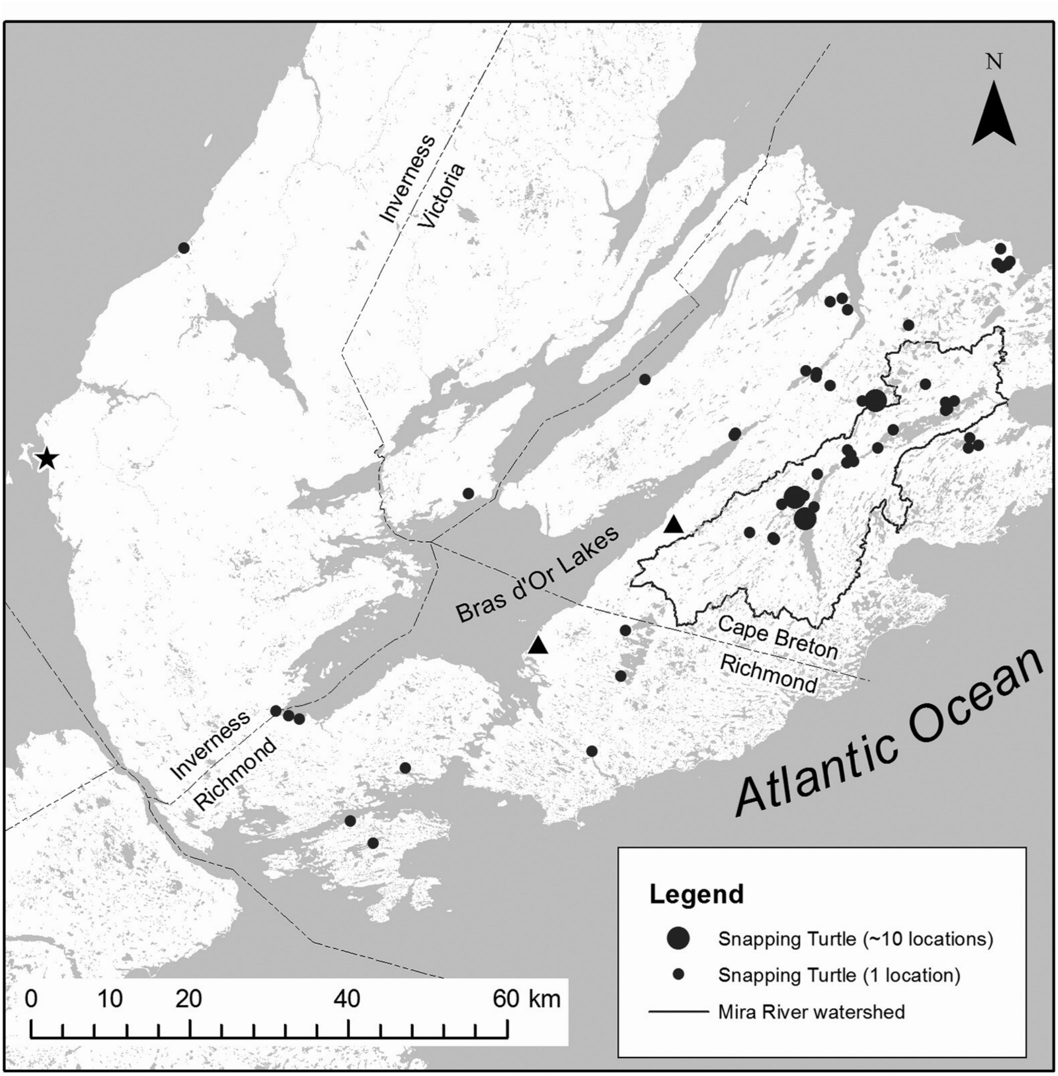

FIGURE 1. Distribution of records for Snapping Turtle (*Chelydra serpentina*) on Cape Breton Island, Nova Scotia, Canada 1953–2017 (n = 75) including a single record for 1953 (black star; Bleakney 1958; Gilhen 1984), two records for 1977 (black triangles; Gilhen 1984), and 72 records from 1999–2017 (black dots; this study). Contains information licensed under the Open Government License, Nova Scotia.

land Nova Scotia was completed in 1955 with the construction of the Canso Causeway. This narrow connection is a busy thoroughfare and a hostile environment with approaches through industrial lands, affording almost no opportunities for migration of freshwater turtles to or from Cape Breton Island.

Methods

All reports of Snapping Turtles for Cape Breton Island received from the public by NSDNR and NSM, as well as observations by NSDNR staff, between 1999 and 2017 were investigated and recorded. Interviews, correspondence, photographs, and site visits were used to verify reports and collect accurate location data. Historical records by Bleakney (1958; one record) and Gilhen (1984; three records) were also reviewed. All locations were collated into NSDNR's Biodiversity Investigation Report system and exported to ArcMap GIS (Esri, California, USA) for mapping.

Surveys of known nesting areas at Huntington, Cape Breton County were conducted in June and July 2012–2014 to determine onset and duration of nesting and to locate nests. Three localized nesting areas were surveyed including two roadside nesting areas and one natural riverine nesting area located on a gravel bar (island) in Salmon River near Intervale Road. Surveys were conducted on almost all days in the early part of the nesting season and more opportunistically thereafter. All visible nest attempts were global positioning system mapped and examined to determine if a nest was present. All nests discovered were immediately excavated, eggs were removed and carefully placed in the upright position, counted and returned to the nest in the same upright position, and the nest was re-buried. All nests were covered with 1 cm mesh galvanized hardware cloth screen fastened to 60 cm × 60 cm square wooden frames constructed of 38 × 89 mm wood and fixed to the ground using 16 mm rebar stakes, to prevent predation and to retain emerged hatchlings.

Beginning about 70 days after date of oviposition, all nests were surveyed daily to observe emerged hatchlings. Care was taken to replace each nest screen and fasten with rebar stakes to ensure that emerging hatchlings were not able to escape from under the screen undetected. All fully emerged hatchlings (Figure 2) were removed from under the protective screen. Maximum carapace length and width were measured to the nearest 0.1 mm using calipers, and weight measured to the nearest 0.1 g using Pesola® spring scales (Medio-Line No. 20010; Baar, Switzerland). Surveys were continued until mid-October 2012 and 2013, and mid-November 2014 and discontinued only after approximately two weeks of no further emergence of hatchlings and onset of cooler temperatures (2012 = 17 days; 2013 = 15 days; 2014 = 13 days). With one exception, no turtles emerged from a nest after two weeks of no emergence. One or two nests were excavated each year after the emergence period to examine condition of eggs and determine if live hatchlings were still present in the nest. All nest screens were removed for the winter and replaced again in May of the following year to monitor potential spring emergence.

FIGURE 2. Hatchling Snapping Turtle (*Chelydra serpentina*) emerged from a roadside nest on Intervale Road, Huntington, Cape Breton County, Nova Scotia, Canada, 11 September 2013. Photo: T. Power.

Results

Between 1999 and 2017 we investigated and verified 72 reports of Snapping Turtle on Cape Breton Island received from both the public and from the observations of NSDNR staff (Table 1). Except for two records for Inverness County (Inverness and West Bay), and one record for Victoria County (Jamesville), all records for Snapping Turtle on Cape Breton Island were in Cape Breton and Richmond Counties. These records indicate a distribution centred on an area of Cape Breton Island south of the Bras d'Or Lakes, with a notable concentration of records from tributaries of Mira River, Cape Breton County (Figure 1). The large number of observers (n = 60) submitting reports over an 18-year period and over a wide geographical area suggests there is no significant reporting bias. Within this larger area, many of the records are centred near the confluence of the Salmon River and Mira River and indicate that although Snapping Turtle nests widely across Cape Breton and Richmond Counties, the area of convergence of Salmon and Mira Rivers is the most important known nesting area. Only two records were located on Mira River which is tidal water: one a failed nest attempt and another a turtle carcass, both observed at Juniper Mountain on the southern shore of the Mira River.

Among 72 records of Snapping Turtle, 62 observations were made within the June–July nesting season and many of these were of confirmed (egg-laying observed) or probable (nest attempt without confirmed egg-laying) nesting females (Table 1). Among all records, only two were confirmed juvenile turtles based on carapace growth rings: one observation of a 13-year old turtle at Petersfield Provincial Park in Westmount, Cape Breton County, and one report of a juvenile turtle (estimated 14 years old from photograph) from near Camp Lake, Cape Breton County.

Snapping Turtles in Cape Breton nested in the gravel shoulder of a paved road (n = 12 nests), a natural riverine gravel bar (n = 12 nests), a semi-vegetated gravel quarry (one nest), and within a child's sandbox (one nest). Other reports of nesting turtles that were investigated (n = 31) showed nest attempts and probable nests located in other areas modified by development, including lawns, laneways, a horse paddock, and other areas cleared of vegetation (Table 1). Among 26 Snapping Turtle nests observed during three years (three in 2012; 10 in 2013; 13 in 2014), date of oviposition ranged from 19 June to 10 July (median = 26 June; Table 2). Dates of nesting for those nests monitored (n = 26) were 26–27 June 2012, 19–28 June 2013, and 25 June–10 July 2014. In addition, incidental observations of nesting activity (turtles nesting or making a nest attempt) on Cape Breton Island from 1999–2017 (n = 31) occurred as early as 17 June 2010 and as late as 26 July 2011 (Table 1). Onset of nesting in each year appeared to be synchronous but the length of the nesting season appeared to vary somewhat from year to year.

TABLE 1. Record number, location, date, sex, age, and behaviour for 75 records of Snapping Turtle (*Chelydra serpentina*) on Cape Breton Island, Nova Scotia, Canada 1953–2017.

Record	Date	Sex	Age	Location	Co.*	Map grid	UTME	UTMN	Behaviour
1013922	1/8/1953	U	A	Port Hood†, ‡	IN	11F5Z5	613478	5095301	unknown
1013923	18/5/1977	F	A	Campbells Brook‡	RI	23X5E3	675488	5071818	unknown
1013924	18/5/1977	M	A	Breac Brook‡	CB	23Z2G5	692560	5087013	unknown
207324	16/6/1999	U	A	Cow Bay Road	CB	14Y3F3	722238	5111961	unknown
214219	25/6/2001	U	A	Glace Bay	CB	43D3F16	730546	5110726	terrestrial movement
997633	22/5/2002	F	A	Glace Bay	CB	15V1C5	733818	5121662	terrestrial movement
225250	8/7/2002	F	A	Big Hill Road	CB	24Z1G2	731018	5096882	nest attempt
233014	6/7/2004	F	A	Grand Mira North	CB	24W2H5	709060	5087549	nest attempt
243552	7/7/2004	F	A	Huntington	CB	24W2G2	707971	5090500	nest attempt
243746	9/7/2004	F	A	Grand Mira North	CB	24W2H2	708959	5090533	nesting
997431	26/6/2005	F	A	Loch Lomond	RI	34Y1G2	685914	5067725	nesting
250324	4/7/2005	F	A	Grand Mira North	CB	24W2H5	709060	5087549	nesting
271432	28/6/2006	F	A	Huntington	CB	24W2H2	708959	5090533	nest attempt
271189	12/7/2006	U	E	Huntington	CB	24W2G2	707819	5090404	nest with eggs
252800	30/6/2007	U	A	Inverness	IN	12W1H2	630729	5121730	terrestrial movement
997428	2/7/2007	U	A	Huntington	CB	24W2G2	708024	5090142	unknown
231973	5/7/2007	F	A	New Boston	CB	24Z1F2	729723	5096524	nest attempt
231972	12/7/2007	U	A	Marion Bridge Hwy.	CB	14X5H1	716349	5102459	terrestrial movement
264421	20/7/2007	U	A	Glace Bay	CB	15V2C2	733968	5119246	terrestrial movement
264435	1/8/2007	U	A	Marion Bridge	CB	24X1F3	714949	5095684	terrestrial movement
231975	7/8/2007	F	A	Marion Bridge	CB	24X1B5	710697	5093166	terrestrial movement
257032	27/6/2008	F	A	Grand Mira North	CB	24W2H5	709164	5087477	nest attempt
997435	15/6/2009	U	A	Caribou Marsh Rd.	CB	14Y5B1	717992	5102587	terrestrial movement
401761	19/6/2009	F	A	Howie Centre	CB	14X4D5	712288	5104344	terrestrial movement
401830	19/6/2009	U	A	Caribou Marsh Rd.	CB	14Y5B2	718143	5101975	terrestrial movement
401831	9/7/2009	U	A	Caribou Marsh Rd.	CB	14Y5B1	718108	5102970	terrestrial movement
401834	17/7/2009	U	A	Albert Bridge	CB	14Z5C2	726867	5102290	terrestrial movement
403805	17/6/2010	F	A	Caribou Marsh Rd.	CB	14Y5B1	718108	5102970	nest attempt
407600	18/6/2010	F	A	Huntington	CB	24W2G2	707807	5090407	nest attempt
997444	18/6/2010	F	A	Huntington	CB	24W2G2	707947	5090382	nest attempt
407598	22/6/2010	F	A	Albert Bridge	CB	14Y1C2	718337	5096531	nest attempt
257122	26/6/2010	F	A	Huntington	CB	24W2G2	707971	5090500	nest attempt
257123	29/6/2010	F	A	Huntington	CB	24W2H2	708959	5090533	nest attempt
407597	2/7/2010	U	E	Huntington	CB	24W2G2	707818	5090394	nest with eggs
997425	8/7/2010	U	A	Jamesville	VI	23W2D1	666628	5090740	terrestrial movement
409130	16/7/2010	U	A	Marion Bridge	CB	24X1F2	714542	5096287	terrestrial movement
997426	17/7/2010	U	A	Marion Bridge	CB	24X1G3	715256	5094805	terrestrial movement
407668	20/7/2010	F	A	Blacketts Lake	CB	14X4A3	709264	5106233	terrestrial movement
997820	15/6/2011	U	A	Sydney Forks	CB	14X4B4	710503	5105510	terrestrial movement
257121	22/6/2011	F	A	Huntington	CB	24W2G2	707971	5090500	nest attempt
407738	26/7/2011	F	A	Huntington	CB	24W2G2	707875	5090395	nest attempt

TABLE 1. (*Continued*)

Record	Date	Sex	Age	Location	Co.*	Map grid	UTME	UTMN	Behaviour
992491	27/6/2012	U	A	Martinique	RI	33Z4A2	651691	5049953	terrestrial movement
997422	28/6/2012	F	A	Grand Mira South	CB	24X2B5	710044	5087747	nest attempt
997423	25/7/2012	F	A	Grand Mira South	CB	24X2A3	710232	5089030	nesting
997574	12/9/2012	U	A	Edwardsville	CB	14X2E6	712290	5114983	terrestrial movement
997395	24/5/2013	U	A	Glace Bay	CB	15V2D2	735003	5120006	terrestrial movement
997389	2/6/2013	U	A	Edwardsville	CB	14X2F5	713824	5115384	terrestrial movement
997397	18/6/2013	U	A	Salmon River Rd.	CB	24W3D2	705267	5084990	terrestrial movement
997402	18/6/2013	F	A	Northside East Bay	CB	14V5G5	700320	5098373	nest attempt
997404	24/6/2013	U	A	Albert Bridge	CB	14Z4A5	724333	5104525	terrestrial movement
997405	24/7/2013	U	J	Westmount	CB	14X3G1	714500	5113959	terrestrial movement
997473	20/8/2013	U	J	Camp Lake	CB	24W3A1	702104	5085865	terrestrial movement
997821	15/9/2013	U	U	Sydney Forks	CB	14X4C3	710598	5106014	aquatic basking
1000594	26/6/2014	U	A	Salmon River Rd.	CB	24W3D2	705103	5085177	terrestrial movement
1000563	10/7/2014	F	A	Albert Bridge	CB	14Z5C3	727142	5101410	nesting
1001650	15/7/2014	F	A	Grand Mira North	CB	24W2H5	709155	5087790	nest attempt
1004867	30/6/2015	F	A	Grand Mira South	CB	24X1F4	714428	5094636	nest attempt
1004878	3/7/2015	U	A	Loch Lomond	RI	23Y5H2	686496	5073463	terrestrial movement
1004875	12/7/2015	F	A	Grand River	RI	34Y2D6	682248	5058236	nest attempt
1004877	13/7/2015	U	A	New Boston	CB	24Z1F1	729948	5097763	terrestrial movement
1004601	16/7/2015	U	A	Albert Bridge	CB	14Z5C2	727932	5102430	terrestrial movement
1007091	13/5/2016	U	A	Marion Bridge	CB	14Y5D5	720295	5098817	terrestrial movement
1007090	26/5/2016	M	A	Glace Bay	CB	15V2C1	733415	5119801	terrestrial movement
1013868	27/6/2016	F	A	Grandique Road	RI	33Z4G5	654606	5046639	nesting
1007694	28/6/2016	F	A	Northside East Bay	CB	14V5G5	700156	5098137	nest attempt
1007749	29/6/2016	F	A	MacDonald Road	CB	24W2E3	706221	5089388	nest attempt
1013869	2/7/2016	F	A	Beaver Cove	CB	13Z4C4	688930	5105128	nesting
1008245	10/8/2016	U	A	Glace Bay	CB	15V2D2	734688	5119633	dead
1008261	12/8/2016	U	A	Grand Mira South	CB	24X1C6	714385	5094632	dead
1013853	18/6/2017	U	A	Dundee	RI	33Y2F1	645312	5062297	terrestrial movement
1012655	24/6/2017	U	A	Albert Bridge	CB	14Z5C3	726886	5101227	terrestrial movement
1013787	30/6/2017	F	A	Salmon River Rd.	CB	24W2G4	708343	5088116	nest attempt
1012894	9/7/2017	U	A	Cannes	RI	34V3D2	658712	5056118	terrestrial movement
1013851	10/9/201	U	A	Dundee	RI	33Y1D6	643968	5062718	terrestrial movement
1013854	2/7/2017	U	A	West Bay	IN	33Y1C5	642343	5063326	terrestrial movement

*CB (Cape Breton County), IN (Inverness County), RI (Richmond County), VI (Victoria County).
†Bleakney (1958).
‡Gilhen (1984).

TABLE 2. Date of oviposition, clutch size, number of hatchlings emerged, dates, duration of hatchling emergence, and hatchling size for 25 protected nests (256 hatchlings) of Snapping Turtle (*Chelydra serpentina*) in a study area at Huntington, Cape Breton County, Nova Scotia.

Nest ID	Nest date	Clutch size	Intact clutch size*	No. of hatchlings emerged	Hatch success (%)	First emergence date	Min. nest days	Last emergence date	Max. nest days	Duration of emergence (days)	No. of days hatchlings emerged	Mean hatchling carapace length (mm) (SD)	Mean hatchling carapace width (mm) (SD)	Mean hatchling mass (g) (SD)
2012-06-27-1	25/6/2012	42	42	est. 20	est. 47.6	est. 7-Sep-12								
2012-06-26-3	25/6/2012	40	40	0	0.0	N/A								
2012-06-26-2	25/6/2012	47	37	24	51.1	11/9/2012	78	28/9/2012	95	17	4	28.3 (0.6)	26.7 (0.9)	7.0 (0.6)
2013-06-19-1	19/6/2013	51	51	40	78.4	11/9/2013	84	25/9/2013	98	14	9	28.6 (0.9)	26.7 (1.0)	8.3 (0.5)
2013-06-19-2	19/6/2013	51	51	9	17.6	13/9/2013	86	13/9/2013	86	1	1	29.4 (0.8)	27.1 (0.8)	7.8 (0.4)
2013-06-19-3	19/6/2013	44	43	16	36.4	13/9/2013	86	22/9/2013	95	9	5	29.8 (0.7)	27.4 (0.8)	8.2 (0.3)
2013-06-19-4	19/6/2013	55	52	11	21.2	14/9/2013	87	23/9/2013	96	9	3	28.1 (0.8)	26.0 (1.3)	7.0 (0.6)
2013-06-19-5	19/6/2013	44	44	11	25.0	14/9/2013	87	23/9/2013	96	9	5	30.3 (0.9)	27.7 (1.3)	8.7 (0.5)
2013-06-24-1	24/6/2013	60	59	3	5.0	24/9/2013	92	24/9/2013	92	1	1	28.4 (0.6)	25.3 (0.9)	7.4 (0.5)
2013-06-24-2	24/6/2013	49	49	4	8.2	17/9/2013	85	20/9/2013	88	3	3	29.4 (0.5)	26.7 (0.8)	7.3 (0.3)
2013-06-28-1	28/6/2013	23	23	0	0.0	N/A	N/A		N/A	N/A	N/A	N/A		
2013-06-28-2	28/6/2013	45	45	2	5.0	20/10/2013	114	20/10/2013	114	1	1	27.9 (0.0)	25.3 (0.4)	5.8 (0.1)
2013-06-28-3	28/6/2013	52	52	24	46.2	14/9/2013	82	26/9/2013	94	12	7	28.7 (0.8)	26.8 (0.9)	7.6 (0.5)
2014-06-25-1	25/6/2014	37	37	20	54.1	14/9/2014	81	21/10/2014	118	37	7	29.2 (0.9)	27.7 (0.6)	8.2 (0.7)
2014-06-26-1	26/6/2014	64	63	24	37.5	9/9/2014	75	25/9/2014	91	16	7	29.0 (1.0)	27.8 (1.1)	7.4 (0.6)
2014-06-26-2	26/6/2014	42	37	3	7.1	22/9/2014	88	16/10/2014	112	24	3	29.8 (1.1)	27.6 (1.5)	7.7 (0.8)
2014-06-26-4	26/6/2014	40	40	28	70.0	19/9/2014	85	5/10/2014	101	16	9	30.1 (0.9)	27.4 (0.8)	9.0 (0.5)
2014-06-26-5	26/6/2014	40	40	1	2.5	30/9/2014	96	30/9/2014	96	1	1	N/A		
2014-06-30-1	30/6/2014	55	55	5	9.1	5/10/2014	97	21/10/2014	113	16	3	26.6 (0.6)	24.9 (0.2)	5.8 (0.4)
2014-06-30-2	30/6/2014	65	64	6	9.2	18/10/2014	110	28/10/2014	120	10	5	27.2 (0.3)	25.9 (0.4)	6.5 (0.4)
2014-06-30-3	30/6/2014	57	55	15	26.3	27/9/2014	89	12/10/2014	104	15	6	29.4 (0.5)	26.9 (0.9)	7.4 (0.5)
2014-06-30-4	30/6/2014	37	35	8	21.6	30/9/2014	92	3/10/2014	95	3	3	30.7 (1.1)	27.7 (0.6)	8.7 (0.6)
2014-07-03-1	3/7/2014	61	61	0	0.0	N/A	N/A		N/A	N/A	N/A	N/A		
2014-07-04-1	4/7/2014	36	36	2	5.6	11/10/2014	99	11/10/2014	99	1	1	25.8 (0.3)	23.7 (0.3)	5.2 (0.4)
2014-07-04-2	4/7/2014	28	28	0	0.0	N/A	N/A		N/A	N/A	N/A	N/A		
2014-07-10-1	10/7/2014	30	30	0	0.0	N/A	N/A		N/A	N/A	N/A	N/A		
Mean		46.0	45.0	10.2	21.5		90		100	11	4	2.9	2.7	7.8
SD		11.0	10.9	10.9	23.1		10		10	9	3	0.1	0.1	0.9
Min		2323	0	0.0		75		86	1	1	2.5	2.4	4.9	
Max		6564	40	78.4		114		120	37	9	3.2	3.0	9.9	
Count		2626	25	25		20		20	20	20	256.0	256.0	256.0	

*The number eggs left intact following oviposition, excavation, and replacement of the clutch (occasionally eggs were destroyed during oviposition or excavation of the nest).

Clutch size for 26 nests protected from predation with wire screen was 23–65 eggs (mean ± SD: 46 ± 11; Table 2). Hatchlings emerged from 20 of 26 protected nests (76.9%); five nests did not produce hatchlings. An additional riverine nest was flooded during hatchling emergence but appeared to have had partial hatchling emergence. Among the 25 protected nests with a known outcome, the number of hatchlings that emerged ranged from 0 to 40 (10 ± 11). The proportion of a clutch that produced emerged hatchlings was 0–78.4% (21.5 ± 23.1).

Among 20 protected nests from which hatchlings emerged during 2012–2014, time from oviposition to emergence of a hatchling (n = 256; Table 2) was 75–120 days (87.2 ± 9.0). Time of first emergence ranged from 9 September to 20 October (75–114 nest days; 90 ± 10) and date of last emergence ranged from 13 September–28 October (100 ± 10). Duration of emergence at a nest ranged from one day (i.e., synchronous emergence; five nests) to 37 days for one nest (mean = 10 days). Among 20 protected nests, number of days on which hatchlings emerged ranged from one to nine (mean = 4).

A total of 256 hatchlings emerged alive from 20 protected nests (Table 2). An additional one and 12 hatchlings, respectively, were excavated and released alive from two of these nests on 11 October 2013. These 13 hatchlings were initially torpid within the nest due to cool temperatures late in the season but became active once removed from the nest, placed in the sun, and were subsequently released. These hatchlings may not have been able to emerge on their own, had the nest not been excavated. However, the latest date of hatchling emergence in 2013 was 11 days later (20 October) when two hatchlings emerged from one nest.

For 256 hatchlings that emerged from protected nests (n = 20), maximum carapace length was 25.0–31.8 mm (29.0 ± 1.2) and maximum carapace width was 23.5–30.0 mm (27.0 ± 1.1). Mass of hatchlings ranged from 4.9 to 9.9 g (7.8 ± 0.9).

Discussion

Snapping Turtle is native to mainland Nova Scotia (Bleakney 1958; Gilhen 1984) but the occurrence of this species on Cape Breton has been uncertain. Bleakney (1958) provides the first record for Snapping Turtle on Cape Breton Island, that of a large adult reported from the beach at Port Hood, Inverness County in 1953. Gilhen (1984) includes this record and two additional occurrences: one at Campbells Brook, Richmond County and another at Breac Brook, Cape Breton County, both observed on 18 May 1977. These three widely scattered locations were believed to be the result of released/escaped captive turtles (Gilhen 1984) and for 22 years, no further observations were recorded for this species on Cape Breton Island. Beginning in 1999, an effort was made to investigate all sightings received from the public by NSDNR and NSM. In addition, NSDNR staff were encouraged to actively record sightings. The accumulated reports began to suggest the species was much more widely distributed than earlier believed and several nesting areas were identified.

Seventy-two verified reports of Snapping Turtle on Cape Breton Island from 1999–2017, together with personal observations, indicate a distribution centred on the area of Cape Breton and Richmond Counties south of the Bras d'Or Lakes (45.5–46.0°N), with a notable concentration of records from tributaries of Mira River, Cape Breton County. Within this larger area, most of the records are centred near the confluence of Salmon River and Mira River. The presence of an important nesting area here, including both riverine and roadside nests, on Salmon River and Intervale Road at Huntington, may largely account for the increased number of reports from this area as Snapping Turtle is highly aquatic, and most reported sightings are of females on land during the nesting season.

The current widespread occurrence and relative abundance of Snapping Turtle on Cape Breton suggests this species is likely native to the Island. The absence of records from 1953 to 1977 and again from 1977 to 1999 is troubling but may simply reflect gaps in searching for and reporting on this species. In this context, Bleakney (1958) discusses similar historical anomalies in documentation of herpetofauna in eastern Canada and elsewhere. The accumulation of reports of Snapping Turtle in Cape Breton since 1999 reflects an effort by the authors to search for reports for this species, to verify all reports received, and to encourage further reporting from observers including both the public and NSDNR staff. Snapping Turtle occurs widely in adjacent mainland Nova Scotia, New Brunswick, and Maine at similar latitudes to that of Cape Breton, so its presence here is not unexpected. Two species of herpetofauna with wide distributions on mainland Nova Scotia which are not native to Cape Breton, are Northern Painted Turtle (*Chrysemys picta*) and American Bullfrog (*Lithobates catesbeianus*). In contrast, Wood Turtle (*Glyptemys insculpta*) is native to both the mainland and Cape Breton Island (Gilhen 1984; Gilhen and Power 2018), even though the presence of this species here was not recognized earlier (Bleakney 1958). Bleakney (1958) discussed the postglacial immigration of amphibians and reptiles into eastern Canada and, based on isostatic land movements and seawater levels, concluded that Cape Breton Island was connected by a land bridge to the adjacent mainland of Nova Scotia between 16 000 and 10 000 years ago. Gilhen (1984) elaborates on the timing, connection, and isolation of geographic features in the Maritime provinces during the postglacial period and resultant impacts on present distributions of herpetofauna. More recently, Shaw *et al.* (2002) present evidence, based on isobase maps and a digital terrain model, to show a land connection from Cape Breton Island to mainland Nova Scotia from about 13 000–8000 years before present (BP) with peak emergence of Cape Breton Island at about 9000 years BP. Snapping Turtle is recognized as one of the dominant turtles within North American glacial age faunas and one of the first to invade following glacial retreat at the end of the Wisconsin (Holman and Andrews 1994).

Bleakney (1958) did not recognize the presence of turtles on Cape Breton, even though he reports on a visual sighting of Snapping Turtle by A.W. Cameron at Port Hood Beach, Inverness County in 1953. Bleakney (1958) suggested that turtles may have arrived too late to take advantage of a land bridge to Cape Breton (as well as Prince Edward Island) and presented a range map for the northern limit for freshwater turtles that excludes Cape Breton Island. However, Bleakney (1958) calculated an "Environmental Temperature Index" to estimate the northern limit for Snapping Turtle that includes Cape Breton Island. The approximate northern limit of distribution of Snapping Turtle in Cape Breton (46.0°N) is well within the range of populations studied elsewhere (e.g., 45.5°N in Ontario [Congdon *et al.* 2008]; 46.0°N in Michigan and 47.2°N in Minnesota [Ewert *et al.* 2005]; 53.0°N in Manitoba [Holman and Andrews 1994]). The tolerance of Snapping Turtle and its eggs to brackish water conditions, including habitation in coastal saltmarshes (Pope 1961; Kinneary 1992; Klemens 1993; Hunter *et al.* 1999), would enhance the ability of this species to colonize Cape Breton Island along a prehistoric land bridge with mainland Nova Scotia. Based on current knowledge of the ecology and distribution of Snapping Turtle, both in Eastern Canada and elsewhere, we conclude this species is native to Cape Breton Island and arrived here along with Wood Turtle via a land connection to mainland Nova Scotia about 10 000 years BP.

Snapping Turtle is known to nest in a variety of natural and disturbed substrates (Congdon *et al.* 2008). In Cape Breton, we recorded the species nesting on natural riverine gravel bars as well as a variety of sites modified by development, including gravel road verges, lawns, laneways, a horse paddock, a child's sand box, and other semi-vegetated areas. Turtles here appeared to choose unshaded nest sites, open to the sun, which may reflect an adaptation to hasten embryogenesis in this northern population, as suggested by Ewert *et al.* (2005). Within its extended range in North America, Snapping Turtle nests earlier in the south than further north (Iverson *et al.* 1997; Congdon *et al.* 2008). Warmer springs result in more rapid follicular development and egg maturation, and earlier onset of nesting (Congdon *et al.* 1987). Date of first observed nesting in Cape Breton (17 June) was somewhat later than in Nebraska (1–12 June; Iverson *et al.* 1997) and southeastern Michigan (22 May–12 June) where first nesting varied annually by 22 days and was significantly correlated with the amount of heat available in March, April, and May (Congdon *et al.* 1987). Obbard and Brooks (1987) used accumulation of heat units in a lake to predict onset of nesting and reported that even though date of first nesting in north-central Ontario varied by 15 days over six years, variation in accumulation of heat units varied by only 7.5%. Nesting in Cape Breton (17 June–26 July), also near the northern limit of the species range (46.0°N), may be somewhat later than that reported for Algonquin Park, Ontario (26 May–7 July; Congdon *et al.* 2008), at a similar latitude (45.5°N).

Clutch size of Snapping Turtles in Cape Breton is large but within the range reported from locations elsewhere in the species range (Iverson *et al.* 1997; Congdon *et al.* 2008). Clutch size of eight nests at Grafton Lake, Queens County, in southwestern mainland Nova Scotia, was 19–41 eggs (Gilhen 1984). Hatchlings in Cape Breton emerged from 76.9% of protected nests. Total nest failure (failure of hatchlings to emerge = 19.2%) appears higher than reported for southeastern Michigan (egg infertility or failure of embryos to develop = 11.8%; Congdon *et al.* 1987). Hatching success among protected nests in Cape Breton (21.5%) was much lower than in north-central Ontario, at a similar latitude (73.2–85.2%: Riley and Litzgus 2013). Probability of survival in protected nests in Cape Breton was 0.215, whereas the probability of survival of unprotected nests (including a 70% predation rate) was 0.22 in Michigan (Congdon *et al.* 1987). Nest predation losses in the Michigan population over 17 years averaged 77% (Congdon *et al.* 1994). Clearly, the already low survivorship to emergence in protected nests in Cape Breton (comparable to that of unprotected nests in Michigan) would be much further reduced by predation. In nests of Snapping Turtle in Cape Breton, an average of 35 eggs in protected nests failed to produce hatchlings whereas in southeastern Michigan, an average of four eggs or embryos died in nests that escaped predation (Congdon *et al.* 1987). High nest failure and low hatchling survivorship to emergence, due to factors other than predation, suggest recruitment may be low in this northern population of Snapping Turtle in Cape Breton. Predated nests were observed in Cape Breton during both nesting and hatchling emergence. Often extended duration of emergence at nests in Cape Breton coupled with observed peaks in predation late in incubation elsewhere (Riley and Litzgus 2014) may facilitate increased predation pressure here.

Snapping Turtle in Cape Breton emerged in September and October, and as generally reported elsewhere (Congdon *et al.* 1987, 2008; Carroll and Ultsch 2007; Baker *et al.* 2013), no spring emergence was observed. Scattered reports of confirmed (Obbard and Brooks 1981; Parren and Rice 2004) or suspected (Bleakney 1963; Congdon *et al.* 1987) spring emergence are recorded for this species and have been linked to the insulating effects of unusually deep snow cover (Obbard and Brooks 1981) and an unusually mild winter (Parren and Rice 2004). Snapping Turtle hatchlings in Cape Breton were observed to emerge later (9 September–28 October) than reported further south (5–24 September in New Hampshire [Carroll and Ultsch 2007]; late August to early October in southeastern Michigan [Congdon *et al.* 1987]). Mean number of days from egg-laying to hatchling emergence in Cape Breton (mean = 87.2, range 75–120) was slightly lower than that reported for north-central Ontario at a similar latitude (~93 days; Riley and Litzgus 2013), and also for Michigan, further to the south (mean = 93.2, range 73–117; Congdon *et al.* 1987). Mean time to first emergence in Cape Breton was slightly shorter (90 days) than in a more southerly population in Indiana (94 days, range 90–97 days; Baker *et al.* 2013). Duration of emergence at a nest in Cape Breton, (mean = 11 days) may be longer than reported elsewhere. In Indiana, mean duration of emergence at a nest was eight days (range 1–20 days) and synchronous emergence occurred occasionally (Baker *et al.* 2013). Synchronous emergence in nests (25%) was much lower in Cape Breton than in southeastern Michigan (65%; Congdon *et al.* 1987).

Emergence of Snapping Turtle hatchlings in Cape Breton appears to be characterized by a high proportion of asynchronous emergence, a protracted duration of emergence at some nests (up to 37 days) as well as emergence on numerous days within the emergence period. Despite this, however, average time from oviposition to emergence may be shorter in Cape Breton than has been reported elsewhere. Both high and low incubation temperatures compromise survival and growth rates of Snapping Turtle hatchlings (Brooks *et al.* 1991). Bobyn and Brooks (1994) found that lower incubation temperature increased mortality and compromised growth and survival of hatchling Snapping Turtles and suggest this is an important determinant of the northern limit of this species, through reduced recruitment. Summer temperatures are thought to be the dominant factor limiting the northern distribution of herpertofauna in Canada (Bleakney 1958; Brooks 2007) and Snapping Turtle approaches the northern limit of its range in Cape Breton.

The relatively large and deep nests of Snapping Turtles likely contribute to the observed temperature differences within nests with depth which has been reported (Packard *et al.* 1985). Packard *et al.* (1987, 1998, 1999) discuss the importance of variation in thermal and to a lesser extent, hydric, conditions of incubating eggs of Snapping Turtle to both size and physiological condition of hatchlings. The high proportion of asynchronous emergence and extended duration of emergence for individual nests in Cape Breton may reflect differing hydric and, especially, temperature conditions within nests, exaggerated by already marginal incubation conditions experienced by this northern population.

Size of Snapping Turtle hatchlings in Cape Breton (n = 256; mean carapace length = 29.0 mm, range 25.0–31.8 mm; mean carapace width = 27.0 mm, range 23.5–30.0 mm; mean mass = 7.8 g, range 4.9–9.9 g) was similar to that of hatchlings in southeastern Michigan (mean carapace length = 29.1 mm, range 23.0–33.0 mm; mean mass = 8.9 g, range 5.0–11.0 g; Congdon *et al.* 1987) and north-central Ontario (carapace length = 27.84 mm [males] and 29.47 mm [females]; mean mass = 9.03 g [males] and 9.68 g [females]; Riley *et al.* 2014). Within nests in Cape Breton, size of emerged hatchlings appears to decrease with both clutch size and date of hatchling emergence but further exploration of this relationship is needed.

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Note

Record longevity of a Spotted Turtle (*Clemmys guttata*)

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Abstract

Turtles are known for their longevity, but the maximum life span for many species remains unknown. Spotted Turtle (*Clemmys guttata*) can live for more than 30 years in the wild, but typical or maximum longevity has not been confirmed. As part of a long-term mark–recapture project in Ottawa, Ontario, near the species' northern limit, an adult female was captured on 27 April 2017. It had first been marked on 11 June 1983, when it was an adult with 17 growth rings on its plastron. Based on the number of growth rings at first capture, and the intervening time, this turtle is a minimum of 51 years old, setting a longevity record for the species. Ten individuals in this population were at least 30 years old when last captured, including a male at least 41 years old. Few of these turtles have grown measurably since being marked in 1983, and it is likely that these minimum ages are underestimates of actual ages.

Key words: Spotted Turtle; *Clemmys guttata*; longevity

Turtles are widely known for their longevity and many species can live for decades in the wild (Gibbons 1987; Ernst and Lovich 2009). Lifespans greater than 50 or 60 years have been confirmed for Wood Turtles (*Glyptemys insculpta*; Brown *et al.* 2015) and Blanding's Turtles (*Emydoidea blandingii*; Congdon *et al.* 2001). Anecdotal observations of turtles with dates carved into their shells suggest that Blanding's Turtles can live more than 75 years (Brecke and Moriarty 1989) and Eastern Box Turtles (*Terrapene carolina*) more than 100 years (Ernst and Lovich 2009), assuming such dates are reliable. An understanding of typical adult longevity is important for calculating life history tables and determining effective conservation strategies for populations. Unfortunately, documenting the precise longevity of such long-lived animals is difficult because determination of ages for multiple individuals from a population requires a long-term mark–recapture study of known-age individuals, while most research studies are relatively short-term.

Spotted Turtle (*Clemmys guttata*) is a small turtle with a maximum recorded carapace length of only 14.25 cm (Ernst and Lovich 2009). The species is restricted to eastern North America from southern Ontario to northern Florida, where it makes use of a variety of shallow wetlands. Habitat loss remains a significant threat across its range (COSEWIC 2014), and Spotted Turtle is considered endangered in Canada (SARA Registry 2018) as well as globally (van Dijk 2011). Individuals can live for more than 30 years in the wild (Seburn 2003; Ernst and Lovich 2009), but few details have been published on longevity in this species in the wild. The estimated maximum longevity is 65 years for males and 110 years for females (Litzgus 2006).

A population of Spotted Turtles occurs in a 2500-ha sphagnum bog owned by the National Capital Commission in Ottawa, Ontario, Canada, near the species' northern range limit (Cook *et al*. 1980). This population was first studied during a mark–recapture project in 1983 (Chippindale 1984). Captured turtles were marked by notching the marginal scutes with a file to assign unique identification codes (Cagle 1939). This work was continued in 1999 (Seburn 2003), and sporadic monitoring of the population has continued. Notches in the shells of Spotted Turtles marked in 1983 remain clear and unambiguous.

On 27 April 2017 during a survey of the bog, I captured an adult female Spotted Turtle that had been first caught and notched as an adult on 11 June 1983 (Chippindale 1984). In 1983, the turtle's plastron was 9.7 cm long and had 17 growth rings. In 2017, 34 years later, its plastron was still 9.7 cm long and had a minimum of 17 faint growth rings. This turtle was presumably an adult in 1983 based on the number of growth rings and the fact that it did not grow in the subsequent 34 years; growth rates for adults are extremely low (e.g., Seburn 2003). Given the number of growth rings in 1983 and the number of intervening years, this turtle was a minimum of 51 years old in 2017. To the best of my knowledge, this is the oldest published age for a Spotted Turtle.

Counts of growth rings are known to underestimate the age of many species of turtles (Wilson *et al.* 2003) including adult Spotted Turtles (Litzgus and Brooks 1998). Adult Spotted Turtles in the study population grew by less than 1 mm and increased the number of growth rings by only 1.1, on average, from 1983 to 1999 (Seburn 2003). Given this lack of growth and addition

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of growth rings, there is no reason to think the turtle was only 17 years old when first marked, meaning this turtle could be considerably older than 51 years.

Other individuals in this population first marked in 1983 demonstrate longevity in excess of 30 years. An adult male first marked when it had 15 growth rings was last caught in 2009, making it a minimum of 41 years old at that time. An adult female first marked when it had 12 growth rings was last caught in 2008, making it at least 37 years old at that point. Both of these turtles could still be alive, as the recapture rate at this site is very low, given the low survey intensity. For example, the adult female caught in 2017 had not previously been captured since 2007. In total, 10 Spotted Turtles first marked in 1983 were at least 30 years old at last capture. This study provides additional evidence that Spotted Turtles are long lived and suggests that conservation efforts should focus on reducing mortality rates of adults.

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Sex-biased seasonal capture rates in Painted Turtle (*Chrysemys picta*)

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Abstract
We examined captures of Painted Turtle *(Chrysemys pict*a) in Algonquin Provincial Park, Ontario, Canada, during the understudied summer–autumn transition period (August–September). The proportion of captured male turtles increased relative to the proportion of females during the late summer and early autumn sampling period, leading to male-biased capture rates in a population with a strongly female-biased sex ratio. We consider explanations for the capture bias in relation to sex-specific activity patterns and briefly discuss the implications of sampling period on the outcome of population structure studies.

Key words: Activity patterns; breeding; capture; *Chrysemys picta*; mating; Painted Turtle; seasonality; sex ratio; population studies; Algonquin Park

Introduction
Painted Turtle (*Chrysemys picta*) is among the most-studied freshwater turtles of North America (Lovich and Ennen 2013). The species' wide longitudinal and latitudinal geographic range (Hecnar 1999; Ernst and Lovich 2009) and relative abundance have supported a large volume of ecological, life history, and population biology studies (e.g., Wilbur 1975; Zweifel 1989; Congdon *et al.* 2003; Browne and Hecnar 2007; Lovich and Ennen 2013).

Much research on Painted Turtle biology has focussed on its active season, which extends from approximately May through August, depending on local regional climate. The overwintering period has also been subject to considerable study, given the unique physiological adaptations of adult and hatchling Painted Turtles to low dissolved oxygen and cold temperatures (Storey *et al.* 1988; Crocker *et al.* 2000; Costanzo *et al.* 2004; Rollinson *et al*. 2008). In contrast, research on Painted Turtle during the transition period between active season and overwintering has been largely neglected. Using observational study of Painted Turtles in Algonquin Provincial Park, south-central Ontario, we report on sex-biased captures during the understudied summer–autumn transition period and consider explanations for the bias in relation to sex-specific activity patterns.

Methods
Research on the biology of Painted Turtles at the Algonquin Wildlife Research Station, near the species' northern range limit, has been ongoing since 1978 under the leadership of R.J.B. and J.D.L. Observational and experimental study on the mating system of Painted Turtles took place during late summer and early autumn 2013 (Moldowan 2014). Aquatic transects at Wolf Howl Pond (45°34'N, 78°41'W), Algonquin Provincial Park, were surveyed by canoe, and turtles were captured by hand and dip net. Between 10 and 44 Painted Turtles (mean = 24) were captured on 19 sampling occasions between 8 August and 24 September 2013 (Julian dates 220 through 267). Sampling was conducted between 1000 and 1600 on clear days with little wind. All observed individuals, regardless of activity (e.g., basking, free swimming, bottom walking), were targetted for capture.

Following capture, the sex of the turtles was recorded based on the presence or absence of sexually dimorphic characters (foreclaw elongation, carapace height, body size, and head shape morphology; Ernst and Lovich 2009; Moldowan *et al.* 2016, 2017). Individuals were counted only once during each sampling occasion. All captured individuals were marked members of the long-term study.

The population under study has a sex ratio of 0.29:1 male:female (Samson 2003; R.J.B. and J.D.L. unpubl. data). To test for a shift in sex ratio during the summer–autumn transition period, we conducted a linear regression analysis with Julian date as the predictor variable and sex ratio as the response variable. We also conducted a χ^2 test to verify that the sex ratio of turtles sampled in this study was reflective of the population sex ratio at large. Finally, linear regression was used to test whether sample size (predictor) affected sex ratio (response) among the captured turtles across all 19 sampling occasions. Findings were considered statistically significant at $\alpha < 0.05$.

Results

The proportion of captured male Painted Turtles significantly increased relative to the proportion of captured females during the late summer and early autumn sampling period (Figure 1). Painted Turtles captured during the summer–autumn transition period demonstrated a significant increase in male:female sex ratio ($R^2 = 0.60$, $F_{1,17} = 24.74$, $P < 0.001$), ranging by nearly an order of magnitude from 0.12 to 1.10 (Figure 2). The sex ratio of all turtles captured or recaptured across the 48-day sampling period was 0.39 male:1 female (129 male and 334 female captures/recaptures) and did not differ statistically from the expected ratio (i.e., the population sex ratio; Samson 2003; R.J.B. and J.D.L. unpubl. data) of 0.29:1 ($\chi^2_1 = 0.45$, $P = 0.57$). Size of the captured sample was not a significant predictor of sex ratio ($R^2 = 0.02$, $F_{1,17} = 0.33$, $P = 0.58$).

Discussion

Our seasonal capture records indicate differences in activity levels between male and female Painted Turtles during the summer–autumn transition period. Male Painted Turtles remain active later in the year than females. These observations are consistent with seasonally male-biased activity in Pond Slider (*Trachemys scripta*; Morreale *et al.* 1984; Thomas *et al.* 1999), Snapping Turtle (*Chelydra serpentina*; Brown and Brooks 1993), and a Virginia population of Painted Turtles (Mitchell 1988). Morreale *et al.* (1984) and Thomas *et al.* (1999) have hypothesized that by extending the length of their active season, males can increase mate-searching activities, improve their chances of mating, and thereby potentially increase their reproductive fitness.

Across its range, Painted Turtle has two breeding periods, one at the beginning (spring) and one at the end (late summer and autumn) of the active season (Sexton 1959; Gibbons 1968; Ernst 1971a,b; Moll 1973; Licht *et al.* 1985; Gist *et al.* 1990; Ernst and Lovich 2009). Temperature (Ernst 1971a; Ganzhorn and Licht 1983; Licht and Porter 1985) and/or photoperiod (Mendonça 1987; Thomas *et al.* 1999) serve as the proximate mechanism(s) triggering the onset of reproductive cycling in temperate turtles. Across the geographic range of Painted Turtle, a gradient in the timing of reproductive activity is expected because of latitudinal differences in the length of the active season (Christiansen and Moll 1973; Moll 1973; Thomas *et al.* 1999). In Algonquin Provincial Park, the active (growing) season for ectothermic vertebrates is short, with an average of 115–125 frost-free days per year (OMAFRA 2013). Thermal and energetic constraints imposed by a northern climate on reproduction (Koper and Brooks 2000; Rollinson and Brooks 2007, 2008) may force female Painted Turtles to reduce the duration of their active season relative to that of males to conserve energy. Late summer and early autumn (August–Septem-

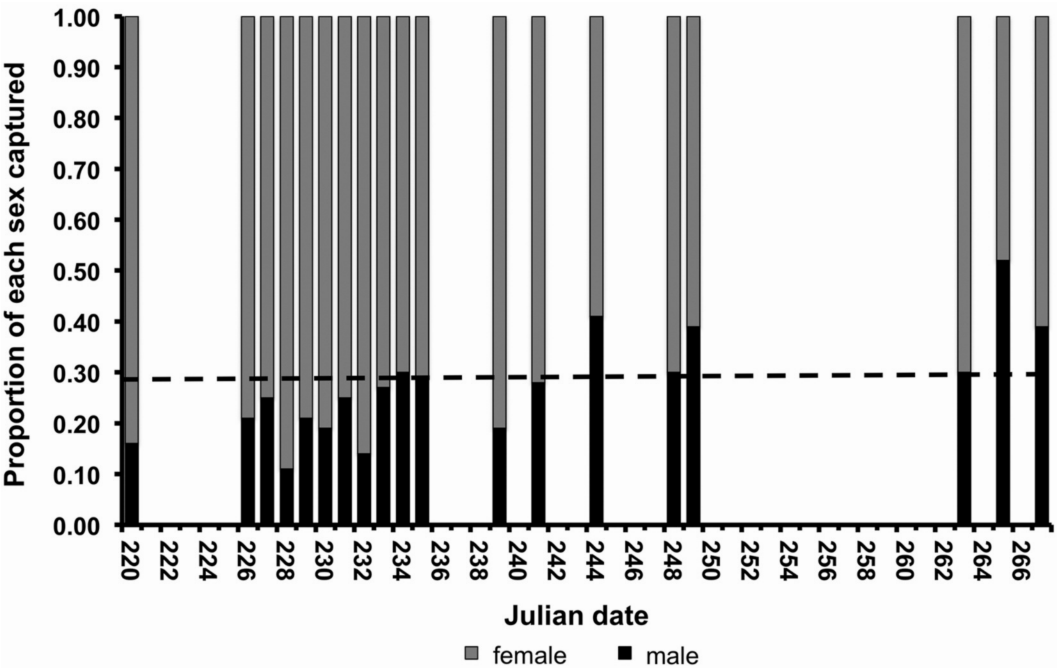

FIGURE 1. Proportion of captured Painted Turtles (*Chrysemys picta*) by sex during late summer and early autumn (8 August to 24 September 2013) in Algonquin Provincial Park, Ontario, Canada. The dashed line represents the expected proportion of males to females (0.29:1) based on the population sex ratio (Samson 2003; R.J.B. and J.D.L. unpubl. data).

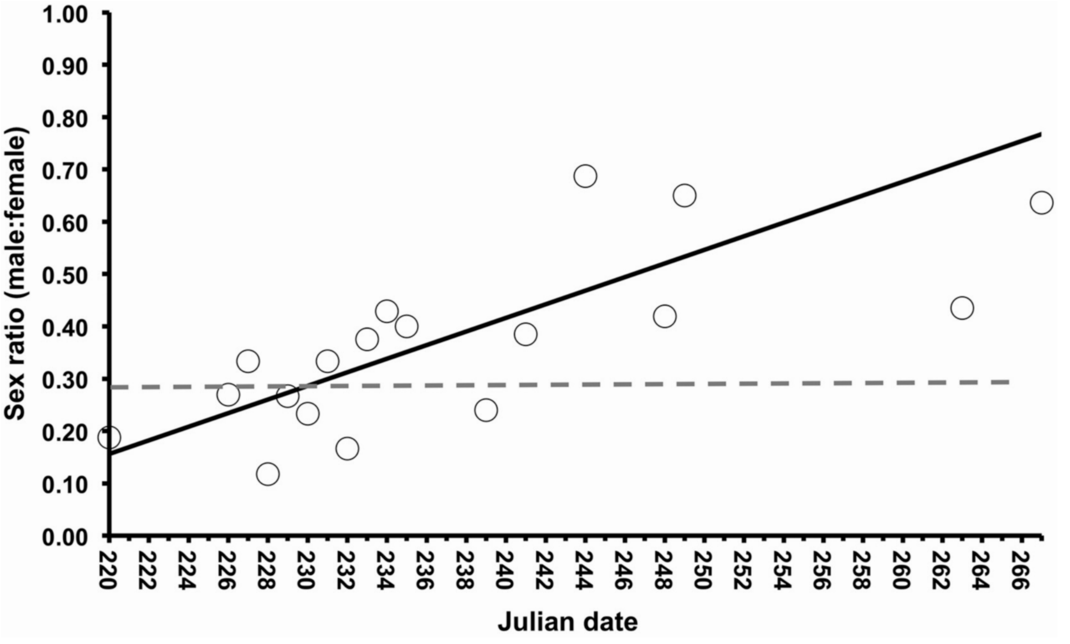

FIGURE 2. Increasing male bias in the sex ratio of captured Painted Turtles (*Chrysemys picta*) in Algonquin Provincial Park, Ontario, Canada, during the late summer–early autumn transition period, 8 August to 24 September 2013 ($y = 0.013x - 2.6926$, $R^2 = 0.60$). The dashed line represents the population sex ratio 0.29:1, male:female (Samson 2003; R.J.B. and J.D.L. unpubl. data).

ber) are energetically taxing times, as female Painted Turtles invest in follicular growth (Gibbons 1968; Congdon and Tinkle 1982; Mitchell 1985; Rollinson and Brooks 2007). Concurrently, male Painted Turtles undergo an increase in testis size from July to September (Gibbons 1968; Moll 1973; Congdon and Tinkle 1982) and an apparent increase in reproductive behaviour relative to females. Despite a reduction in female activity during summer–autumn transition, males may still secure mating opportunities by adopting coercive reproductive tactics (Moldowan 2014). Long-term sperm storage in Painted Turtle promotes multiple mating opportunities throughout the year and can lead to high reproductive success among males that successfully mate (Pearse *et al.* 2002; McGuire *et al*. 2011, 2014).

Our findings highlight the fact that sampling period can have considerable influence on measures of population structure (e.g., sex ratio) of Painted Turtle because of sex-specific activity patterns (Ernst 1971c; Mitchell 1988). Thus, those conducting demographic studies must be aware of sampling biases imposed by time of year. It is unlikely that our observed shift in male and female catchability is simply an artefact of sampling method (Ream and Ream 1966; Koper and Brooks 1998) because we used a consistent capture method over a relatively short sampling period, and our sample size did not affect sex ratio. Furthermore, our study site has been sampled annually for decades, with sampling occurring over many consecutive weeks during spring population inventories (May) and nest monitoring (June), making it unlikely that turtles became exceptionally wary or demonstrated avoidance behaviour during autumn sampling. An increasing frequency of male conspicuousness (Figures 1 and 2) and reproductive activity (Moldowan 2014) provide evidence that late summer and early autumn is an important breeding period in this northern population of Painted Turtles.

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Body temperature influences growth rates of Common Gartersnakes (*Thamnophis sirtalis*)

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Abstract
Habitat selection can have large impacts on animal fitness. Temperature is an important aspect of habitat suitability for ectotherms, and temperature differences between habitats can thus lead to fitness differences. Here, we use an experiment with female Common Gartersnakes (*Thamnophis sirtalis*) to examine the effect of body temperature on change in mass (i.e., growth rate), which is a component of fitness. We placed female gartersnakes in experimental enclosures in old field and in forest and monitored their body temperature and mass throughout the summer. Gartersnakes in old field were warmer than gartersnakes in forest, warmer gartersnakes were more likely to eat earthworms, and warmer gartersnakes gained more mass. We therefore provide evidence that habitat use influences body temperature, and body temperature then influences growth, a component of fitness.

Key words: Common Gartersnake; *Thamnophis sirtalis*; body temperature; fitness; growth rate; habitat; thermoregulation

Introduction
Habitat selection is a major theme in ecology (Morris 2003). An individual's choice of where to live can have profound effects that ripple throughout its life, from immediate effects on safety (Dupuch *et al.* 2009), food availability (Morris and MacEachern 2010), and physiology (Halliday and Blouin-Demers 2014), to fecundity and population level consequences (Lin and Batzli 2001). Habitats can be simply defined as "… subsets of physical and biotic conditions among which population density … of a focal species varies from adjacent subsets" (Morris 2003: 2). Habitats therefore are often defined by their impact on fitness, which highlights the importance of understanding how different abiotic and biotic conditions impact fitness.

For ectotherms, temperature is one of the most important variables in habitat selection (Huey 1991) because they, by definition, rely on environmental temperature (T_e) to maintain their body temperature (T_b), and in turn T_b greatly impacts fitness (Gilchrist 1995). Fitness typically is maximized at some optimal temperature (T_o), and decreases as temperature deviates from T_o (Bulté and Blouin-Demers 2006; Dell *et al.* 2011). Ectotherms that maximize fitness should therefore select habitats that allow them to maintain T_b as close to T_o as possible (Blouin-Demers and Weatherhead 2008).

In our previous work with Common Gartersnakes (*Thamnophis sirtalis*), we demonstrated that they selected warm fields over cool forest, and that selection of old field habitat led to higher growth rate and reproductive success (Halliday and Blouin-Demers 2016a). Despite this correlation, we did not demonstrate explicitly that warmer snakes exhibited higher growth rates. Here, we re-examine these data to explore the relationship between weekly T_b and changes in mass for individual snakes in experimental enclosures in field and forest. We directly test the prediction that warmer snakes have higher growth in mass than cooler snakes, independent of their habitat.

Methods
In June 2014, we built six experimental enclosures in an old field and six enclosures in an adjacent forest (individual dimensions [l × w × h] = 2.67 × 2.67 × 1.3 m) in Pontiac county, Quebec (45.4926°N, 75.9222°W). We built the frames of the enclosures with lumber and stapled polyethylene sheeting to the wood frame to create walls. We buried the walls in the ground at least 10 cm to prevent snakes from escaping. We placed fine mesh over the enclosures to exclude birds, and electric fences around the enclosures to exclude mammalian predators. We placed a plywood board (60 × 60 cm) in each enclosure to act as a refuge. The old field was a mix of grasses and flowering plants, including goldenrod (*Solidago* sp.), milkweed (*Asclepias* sp.), and Tufted Vetch (*Vicia cracca* L.). The forest consisted mostly of Trembling Aspen (*Populus tremuloides* Michaux) with minimal understorey growth.

We captured adult female gartersnakes between late April and early June 2014 near a wetland within 10 km

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of our experimental enclosures and placed 10 individuals in the old field enclosures and 10 in the forest enclosures, with two individuals per enclosure in four of the enclosures in each habitat and one individual per enclosure in two of the enclosures in each habitat. We used gravid females because the main goal of this experiment was to examine the fitness consequences of habitat selection, therefore we measured reproductive output (Halliday and Blouin-Demers 2016a). We randomly assigned females to habitats and enclosures, while ensuring that the body size distribution was similar between habitats. We also randomly assigned half of the females in each habitat to a "low food" treatment, and the other half to a "high food" treatment. In the low food treatment, we offered each female one large earthworm twice per week and in the high food treatment we offered each female one large earthworm four times per week. We offered earthworms to snakes by isolating the snake within its enclosures and dropping an earthworm in front of its head. This typically elicited a feeding response, whereby the snake immediately struck the earthworm or began flicking its tongue at the worm. We recorded whether the snake ate the earthworm. Snakes also had access to food naturally available in the enclosures, so our food treatments represent food supplementation.

Prior to feeding, we measured the skin temperature of each snake with an infrared thermometer (Fluke 566 infrared thermometer, Fluke Corporation, Everett, Washington, USA); skin temperature is highly correlated with internal body temperature in gartersnakes (Spearman's $\rho \geq 0.87$; Halliday and Blouin-Demers 2017a). We held the thermometer 10 cm from the snakes and aimed at the centre of their bodies. We recorded whether the snake was out and basking or whether it was under the cover board. We measured T_b four times per week at 0900. Once per week, we measured the mass of each snake with a spring scale (Pesola AG, Schindellegi, Switzerland). We continued this experiment until the beginning of September (105 days), which was the point when all gravid females had given birth. We include measurements for each female only until the week before it gave birth. By the end of this experiment, the final sample size was six gartersnakes in each habitat; however, we collected sufficient data from all 10 snakes in each habitat to include data from all 20 snakes in the analyses. The loss of snakes was due to escapes and predation.

Analyses

We first conducted a *t*-test to verify that females in each habitat had similar starting masses. We then conducted an analysis to describe the difference in T_b between habitats. We used a linear mixed effects model in R (package lme4; function lmer; Bates *et al.* 2015) with daily T_b of each individual snake as the dependent variable, combinations of food treatment, habitat, the snake's location (i.e., under cover, out of cover), and all two-way interactions as fixed effects, and with snake ID as a random effect. We compared models with Akaike's information criterion (package stats; function AIC; R Core Team 2016) and selected the model with the lowest AIC as the best model. If models were within 2 AIC units of the best model, we considered them to be competing and used the most parsimonious of the competing models as the final model.

For our second analysis, we examined whether a snake ate during a given feeding event using general linear mixed effects models with a binomial distribution (package lme4; function glmer; family: binomial). We used the occurrence/non-occurrence of a feeding event (where 1 = the snake ate the worm and 0 = the snake refused the worm) as the dependent variable and temperature, location, food treatment, habitat, and two-way interactions as fixed effects, and snake ID as a random effect.

For our final analysis, we examined the change in mass for a snake from one week to the next with linear mixed effects models, with change in mass as the dependent variable and combinations of the following independent variables as fixed effects, including two-way interactions: habitat, food treatment, mean temperature over the previous week, and days since the last food item was eaten. We included snake ID as a random effect.

Results

At the beginning of the experiment, females in field and forest habitat ($n = 10$ in each habitat) did not differ significantly in mass (mean ± SE in field: 72.0 ± 9.9 g, in forest: 72.8 ± 11.8 g; $t = 0.05$, $P = 0.96$).

On average, the T_b of gartersnakes was lower in forest than in field (mean difference = 4.6 ± 0.4°C, $t_{720} = 12.33$, $P < 0.01$; Figure 1; Appendix S1). Individuals under cover were cooler than individuals out of cover, especially for snakes in the forest ($t_{720} = 5.45$, $P < 0.01$) or in the low food treatment ($t_{720} = 2.04$, $P = 0.04$).

Gartersnakes were more likely to eat if their T_b was higher (effect size = 0.10 ± 0.03, $t_{564} = 3.76$, $P < 0.01$; Appendix S2), if they were in the low food treatment (effect size = 1.68 ± 0.47, $t_{564} = 3.58$, $P < 0.01$), and if they were in the field (effect size = 1.05 ± 0.47, $t_{564} = 2.23$, $P < 0.01$). All interaction terms in this model were non-significant (Appendix S2).

Regardless of habitat or food treatment, gartersnakes were more likely to gain mass from one week to the next if their mean T_b was higher in the previous week (slope = 0.26 ± 0.11, $t_{174} = 2.24$, $P = 0.03$; Figure 2; Appendix S3). All interaction terms in this model were non-significant (Appendix S3).

Discussion

Habitat selection by ectotherms influences T_b, which in turn influences fitness because of the direct link between T_b and fitness (Blouin-Demers and Weatherhead 2008). In this study, we demonstrate that gartersnakes in our field enclosures had a higher T_b than gartersnakes

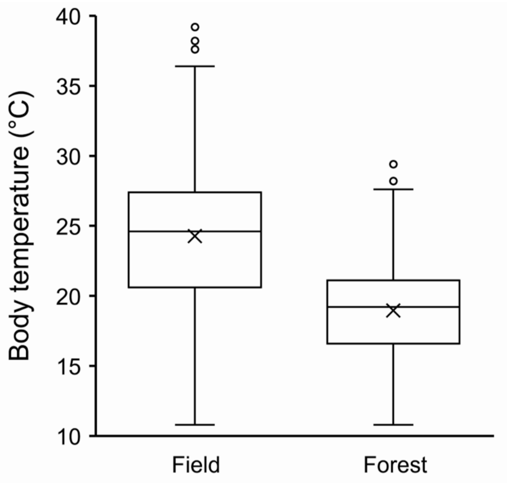

FIGURE 1. Body temperature of female Common Gartersnakes (*Thamnophis sirtalis*) living in enclosures in old field and forest habitat in Pontiac county, Quebec between June and September 2014. Boxes represent the interquartile range, lines within the box are the median, '×' in the box is the mean, whiskers are the 5th and 95th percentiles, and points above the whiskers are outliers. $n = 726$ temperature measurements on 20 individual gartersnakes.

in forest enclosures, and that gartersnakes with higher T_b are more likely to eat and have a greater mass increase regardless of habitat or food treatment. We previously demonstrated that T_e was higher in field than in forest (Halliday and Blouin-Demers 2016a) and here we demonstrate that this increased T_e translated to increased T_b. We also previously demonstrated that gartersnakes are more willing to eat at temperatures closer to their preferred T_b in the laboratory (Halliday and Blouin-Demers 2016b) and here we extend this finding to the wild; we found that gartersnakes are more likely to eat when they are warmer and that warmer gartersnakes grow more or produce larger offspring. We therefore provide direct evidence that habitat use dictates T_b, which then influences growth rate, a component of fitness.

Other studies of ectotherm habitat selection have indicated a strong preference for the habitat that most closely matched optimal temperature (Huey 1991; Calsbeek and Sinervo 2002; Halliday and Blouin-Demers 2014; Paterson and Blouin-Demers 2018). Similarly, several studies have demonstrated the link between temperature and growth rate in ectotherms (Bronikowski 2000; Patterson *et al.* 2017). Our study extends the findings of these previous studies by demonstrating that short-term changes in body temperature (over one week) can lead to changes in growth, and therefore influence fitness.

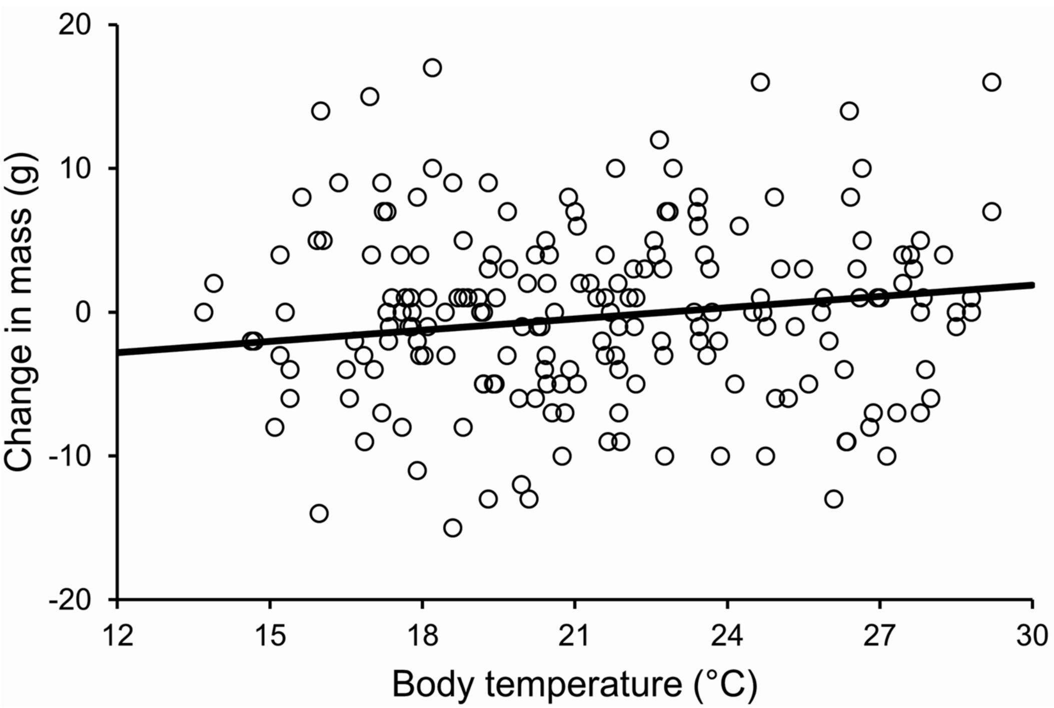

FIGURE 2. The relationship between mean body temperature in the previous week and change in mass for female Common Gartersnakes (*Thamnophis sirtalis*) living in enclosures in old field and forest habitat in Pontiac county, Quebec between June and September 2014. The line represents the relationship between body temperature and change in mass, according to a linear mixed effects model. $n = 195$ change in mass measurements on 20 individual gartersnakes.

Although willingness to eat and growth were both related to T_b, the number of worms eaten did not affect growth, and neither did the food treatment we imposed. This is likely due to an abundance of naturally available worms within our enclosures, which we could not control or account for. In another experiment with similar enclosures, we monitored worm abundance and caught worms throughout the course of our study (Halliday and Blouin-Demers 2017b). In that experiment, worm abundance was on average lower in enclosures with more snakes, which suggests that snakes were eating the worms that entered the enclosures. The worms that we fed to the snakes were an additional meal, but likely did not provide enough additional energy to affect growth detectably. The feeding treatments therefore provide evidence of the link between T_b and foraging but cannot directly link foraging and growth, even though it is logical that individuals that eat more worms should grow more. To test the link between T_b, foraging, and growth effectively one would need to completely control the food intake of study organisms, which is challenging under field conditions. While our field enclosures did not allow us to control food intake and were not entirely escape or predator proof, enclosures do offer natural habitat conditions, including natural variation in temperature and insolation, that increase the ecological realism compared to laboratory studies. Given that the main goal of our experiment was to examine the effect of habitat and temperature on fitness, we feel that field enclosures were more appropriate than more controlled laboratory conditions. Captivity stress is also likely to be lower in field enclosures than in the laboratory.

We used gravid females in our experiment complicating the interpretation of our results. Unlike juveniles, adult males, and non-gravid females, energy intake by gravid females is not only self-directed but also to the developing offspring. We use the term growth rate, but changes in mass are likely happening in both the offspring and in the females. In our previous analysis of this experiment (Halliday and Blouin-Demers 2016a), we demonstrated that females also grew in length, which implies that at least some of the change in mass is directly related to growth of the females and not just to growth of the offspring. Another potential issue associated with using gravid females in this experiment is that they often fast during pregnancy (e.g., Lourdais *et al.* 2002), which has obvious implications for a growth rate study. But this was not the case in our study: all females ate, especially if their body temperature was high.

The effect of T_b on growth was relatively weak (slope = 0.26 g/°C), probably because we measured T_b only four times each week. There was likely greater variation in snake T_b that we did not capture. We measured T_b at the same time every day, so we did not capture daily variation in T_b. A larger sample size with more continuous T_b measurements would likely lead to a stronger relationship between T_b and growth.

In summary, our study demonstrates the link between habitat use and growth, a component of fitness, via the temperature-dependence of foraging and growth. Studies on ectotherms, and to a lesser extent on endotherms, must consider temperature as an important habitat feature that can influence behaviour, physiology, and ultimately fitness.

Author Contributions

Writing – Original Draft: W.H.; Writing – Review & Editing: W.H. and G.B.-D.; Conceptualization: W.H. and G.B.-D.; Investigation: W.H.; Methodology: W.H.; Formal Analysis: W.H.; Funding Acquisition: W.H. and G.B.-D.

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SUPPLEMENTARY MATERIAL:

APPENDIX S1: Model selection and final model output for an analysis of the effect of Common Gartersnake (*Thamnophis sirtalis*) body temperature on growth.

APPENDIX S2: Model selection and model final output for an analysis of feeding behaviour of Common Gartersnakes (*Thamnophis sirtalis*).

APPENDIX S3: Model selection and final model output for an analysis examining the growth of Common Gartersnakes (*Thamnophis sirtalis*).

Snake mortality and cover board effectiveness along exclusion fencing in British Columbia, Canada

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Abstract

We report on snake mortalities along exclusion fencing in southern British Columbia, showing Western Yellow-bellied Racer (*Coluber constrictor mormon*) deaths were disproportionately higher than our encounter rates with the species within the snake community. This suggests racers were susceptible to fence mortality more so than Northern Pacific Rattlesnakes (*Crotalus o. oreganus)* or Great Basin Gophersnakes (*Pituouphis catenifer deserticola)*. Datalogger recordings revealed temperatures under cover boards were well above the tolerable temperatures of the three snake species, although the boards appeared to temper ambient heat more efficiently than natural vegetation. We caution that the effects of fencing and cover boards may vary across ecosystems and snake species.

Key words: *Coluber*; conservation; *Crotalus*; Great Basin Gophersnake; Northern Pacific Rattlesnake; *Pituophis*; reptiles; Western Yellow-bellied Racer

Introduction

Human disturbance imposes drastic changes upon natural environments, often with severe consequences for wildlife populations. Two such effects are barriers to movement, and increasing human-wildlife interactions (Colley *et al*. 2017; Markle *et al*. 2017; Pitts *et al*. 2017). Managers often employ multiple techniques to mitigate negative human-wildlife conflicts. Historically, wildlife fencing is considered an efficient approach for limiting wildlife movement. Most notably, it has been used to reduce road mortality of large macrofauna (Peaden *et al*. 2017) but has also been widely used for herpetofauna (Colley *et al.* 2017; Markle *et al.* 2017).

In general, there are two major fence types used to direct the movements of herpetofauna: drift and exclusion. Drift fences are long continuous barriers used to channel animal movement, often for research purposes by adapting them to trap animals (Willson and Gibbons 2009). Conversely, exclusion fences eliminate animal access to a specific area such as roadways and areas with high human influence (Markle *et al*. 2017).

Exclusion fencing can be an important conservation tool to promote spatial separation between humans and animals that pose a risk, such as venomous snakes. Historical efforts to limit and manage negative snake-human interactions often have included the relocation of animals. However, this strategy has limitations and potential negative consequences on the translocated snakes (Reinert and Rupert 1999; Nowak *et al*. 2002; Brown *et al*. 2009). More recently, fencing has been used to target snakes and other reptiles to limit road mortality and restrict animal movement through various urban settings (Colley *et al.* 2017; Markle *et al.* 2017).

Although sometimes effective, wildlife fences pose potential problems to snakes and other reptiles such as restricting movements or otherwise altering behaviour (Markle *et al*. 2017; Peaden *et al*. 2017). For example, Mohave Desert Tortoises (*Gopherus agassizii*) that encountered roadside fencing had extreme carapace temperatures that approached the species' tolerance limits and exhibited greater movement velocity compared to individuals away from fencing structures (Peaden *et al*. 2017). Furthermore, Wilson and Topham (2009) found that fencing caused road mortality by preventing Tiger Whiptail lizards (*Aspidoscelis tigris*) from retreating from the danger posed by roads. In Australia, Eastern Long-necked Turtle (*Chelodina longicollis*) mortalities (mainly due to overheating) were observed along a pest-exclusion fence, with animals showing signs of sunburn and predation (Ferronato *et al*. 2014). Despite these examples of varying fence effects, the potential direct and indirect negative effects that fencing has on herpetofauna is still largely unknown and understudied, particularly for snakes.

Here we outline observations on the impacts of mitigative exclusion fencing on a snake community in arid southern British Columbia. We compare observations and counts of live and dead snakes detected near the fence, and also report on the use of wooden cover boards as putative thermal refugia for snakes moving along the fencing structure in the hot, open desert habitat.

Methods

Our study site was located on the Osoyoos Indian Reserve (OIR) near the town of Osoyoos (49.03°N, 119.47°W) in the south Okanagan Valley of British Columbia (BC). The 450 ha study area contains a dry, arid ecosystem composed of shrub-steppe habitat dominated by Antelope-brush (*Purshia tridentata* (Pursh) de Candolle) and Big Sagebrush (*Artemisia tridentata* Nuttall). Mean summer (June, July, August) air temperature in Osoyoos and surrounding south Okanagan Valley is approximately 22°C. However, summer mean maximum temperatures can be as high as 33°C and extreme maximum temperatures will exceed 40°C (Environment Canada 2017), making this one of Canada's hottest regions. The study site has been, and continues to be, heavily altered as the landscape shifts towards tourism development including golf courses, vineyards, a resort and campground, and associated roads and parking lots. The study site is home to a long-term snake research project targetting three species-at-risk, Northern Pacific Rattlesnake (*Crotaus o. oreganus*), Great Basin Gophersnake (*Pituophis catenifer deserticola*), and Western Yellow-bellied Racer (*Coluber constrictor mormon*). Both this rattlesnake and gophersnake are listed as threatened species in Canada (SARA Registry 2018a,b) and the racer has been recommended for listing as threatened (COSEWIC 2015). For additional description of the region and the study site, see Brown *et al*. (2009) and Lomas *et al*. (2015).

In an attempt to mitigate negative human-snake conflict, ~4 km of exclusion fencing was built in 2006 to separate natural snake habitat from the high human traffic and popular tourist areas. The fence was constructed of ~60 cm high galvanized mesh hardware cloth with ~0.60 cm square openings and ran approximately north-south through the study area. In 2006, during initial construction of the fence, snake mortalities were observed along a newly constructed section of the fence (one neonate rattlesnake and six racers; O.M.M. pers. obs.). These early observations suggested that snakes may have been dying from exposure to daytime heat while attempting to navigate the new physical barrier.

In 2007 we investigated if the construction of artificial cover, in the form of wooden cover boards, would create appropriate thermal refuge habitat for snakes moving along the new fence structure. Twelve sets of triplet plywood cover boards (70 cm × 70 cm × 7 cm) were placed along the exclusion fence at 30 m intervals (equalling 360 m of the fencing structure), in the area where snake mortalities had been observed the previous year. At each interval, two of the three boards were placed on opposite sides of the fence and the third board was placed 10–15 m east of the fence in the natural habitat as a control. Each cover board was raised approximately 7 cm off the ground by wooden edge pieces, and 15–20 cm of sand was excavated under the centre of each board to ensure access for both large and small reptiles.

Dataloggers (DS1921G Thermochron® iButton®; Baulkham Hills, New South Wales, Australia) were used to record temperature data every hour between May and October 2007. The dataloggers were placed under fence (n = 10) and control (n = 6) cover boards, and under natural vegetation typically favoured by snakes (Big Sagebrush, Rubber Rabbitbrush [*Ericameria nauseosa* (Pallas ex Pursh) G.L. Nesom & G.I. Baird], Antelope-brush; n = 5). We placed an additional datalogger fully exposed on the open ground to collect additional reference data. Furthermore, throughout the course of the 2007 summer field season, we monitored and observed the cover boards for snake use. We compared the average maximum daily temperature (typically 1400–1600 h) between the different treatments throughout July 2007. We chose to focus on July because it typically constitutes the hottest month of the active season in the Okanagan Valley (Environment Canada 2017) when refuge from the heat would be critical.

In 2015, major upgrades along the fence were performed, including repair work, vegetation control, and re-routing approximately 200 m to avoid erosion. This marked the first major, large-scale upgrade to the entire fence structure since its original construction. Over the next two years (2016-2017), fence surveys (walking fence line) were initiated approximately 2–3 times a week between May and October to detect snakes and monitor fence effectiveness. In addition to the fence surveys, we conducted mark–recapture surveys almost daily (5–6 days per week) throughout the entire study area. We captured and marked live-snakes with Passive Integrated Transponders (PIT tags - HPT12 Pre-load; Biomark Inc., Boise, Idaho, USA) to allow for individual recognition in subsequent captures.

Results

Temperature differences between the fence cover boards and control cover boards appeared to stay relatively consistent throughout July, and cover boards had lower average maximum daily temperatures than the native vegetation cover or areas with no cover (Figure 1). Maximum daily temperatures during midsummer (July) routinely surpassed 35°C at all of our

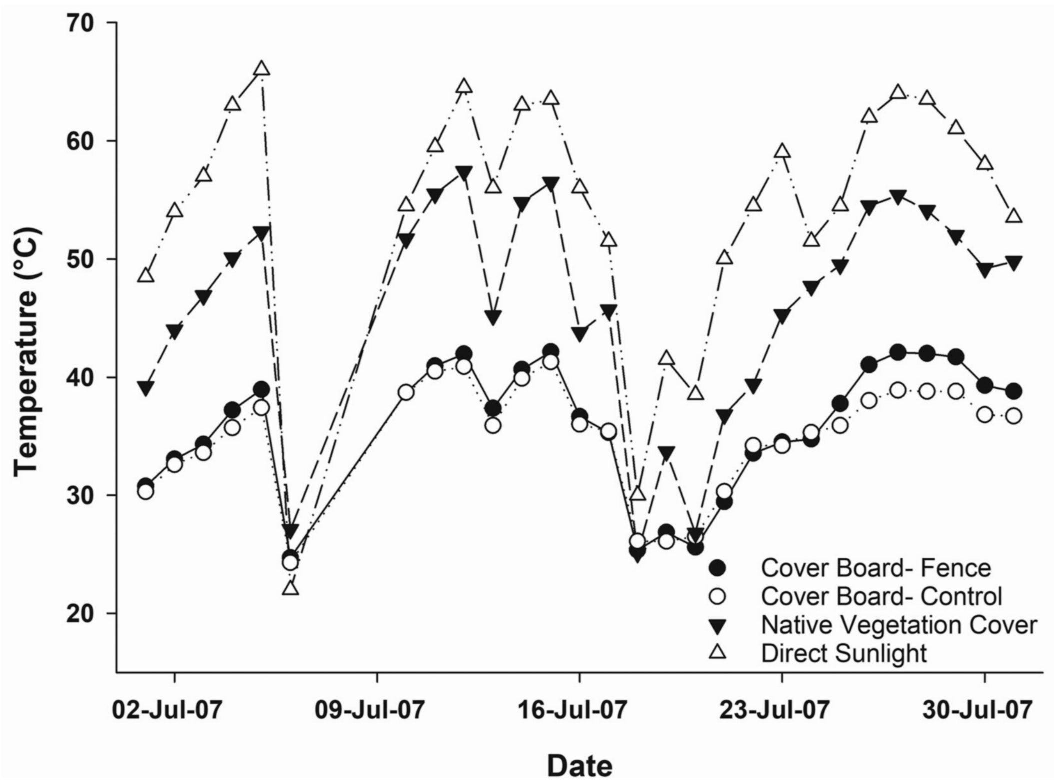

FIGURE 1. Daily mean maximum temperatures of fence (n = 10) and control (n = 6) cover boards, natural vegetation cover (n = 5) and exposed ground (n = 1) in July 2007 on the south Okanagan Valley study site, near Osoyoos, British Columbia.

recording sites (including under cover boards), and temperatures under native vegetation cover occurred in excess of 50°C. We found nine rattlesnakes under cover boards along the fence over the course of the entire 2007 active season.

During the 2016 and 2017 field seasons (following fence upgrading), 341 snakes were captured throughout the entire study area during ongoing mark–recapture and monitoring of the snake community. Specifically, counts of the three main species in the area were 215 rattlesnakes, 62 gophersnakes, and 64 racers. During this same time, we captured 116 live snakes (59 rattlesnakes; 23 gophersnakes; 34 racers; Figure 2) directly along the same section of fence earlier used for the cover board study; however, no snakes were captured under cover boards. We also observed 15 snake mortalities directly along the same fence section (two rattlesnakes; one gophersnake; 12 racers). Additionally, we found six of the 15 dead snakes (one rattlesnake, one gophersnake and four racers) within the section of fence that was added in 2015. We found all snake mortalities along the exclusion fence in the open rather than beneath cover boards. In total, fence mortalities appeared responsible for 33% (15/45) of snake mortality observations throughout our study site during the 2016 and 2017 field seasons (roadkill = 49%, unknown and/or natural mortality = 18%).

The relative proportions of the three snake species within the sample of fence captures differed significantly (R Core Team 2016) from recorded captures over the larger study area (χ^2_2 = 9.4, P < 0.01). At the same time, the relative proportions of dead snakes observed along the fence differed significantly from both live snakes captured near the fence (χ^2_2 = 18.9, P < 0.01) and from those in the general population (χ^2_2 = 36.3, P < 0.01). In all cases, racers were over-represented in the fence mortality data set, and rattlesnakes under-represented (Figure 2).

Discussion

Although using cover boards to monitor snakes and other herpetofauna is a common and efficient practice (Reading 1997; Engelstof and Ovaska 2000; Halliday and Blouin-Demers 2015), they appeared to be under-used by snakes in our study area, as we only observed nine rattlesnakes (no gophersnakes or racers) under cover boards during an entire active summer season. For snakes and other reptiles, thermal requirements while balancing predator avoidance are key drivers of microhabitat selection (Downes 2001; Lelièvre *et al.*

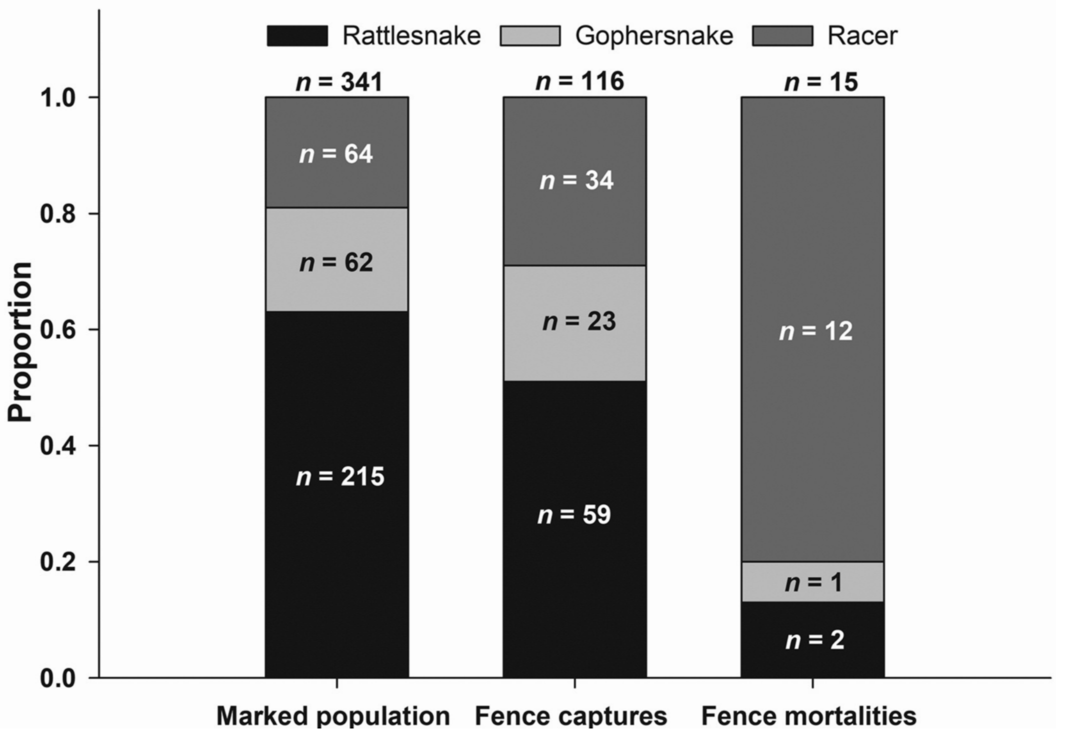

FIGURE 2. Total sample sizes and proportion comparisons of Northern Pacific Rattlesnake (*Crotalus o. oreganus*), Great Basin Gophersnake (*Pituophis catenifer deserticola*), and Western Yellow-bellied Racer (*Coluber constrictor mormon*) marked populations, fence captures, and fence mortality observations during the 2016 and 2017 field seasons at the south Okanagan Valley study site, near Osoyoos, British Columbia.

2010). Based on our capture rates, individual snakes appeared not to be using these cover board 'habitats' heavily during the peak summer season, likely because the high temperatures under the boards negated any benefit in terms of potential predator avoidance or thermal refuge. Average daily maximum temperatures during July under the cover boards were typically far higher than the preferred body temperatures and critical maxima reported for rattlesnakes (28.9°C versus 39–40°C), gophersnakes (26.7°C versus 40.5°C), and racers (28.3°C versus 42.4°C; Brattstrom 1965; Putman and Clark 2017; Figure 1). We acknowledge that operative body temperatures of snakes often may vary from ambient air temperature (Blouin-Demers and Weatherhead 2001), and direct comparisons between air temperature and preferred snake body temperature may be, in some cases, questionable. However, the degree to which our recordings surpassed the published tolerance levels for these snakes strongly suggests the boards would have represented inappropriate microhabitat.

In comparison, average daily maximum temperatures in July under the cover boards were cooler than those recorded under the local native vegetation. This may imply that effective refuge sites (e.g., large rock formations, deep holes) during the peak summer heat may be critical, at least in this particular ecosystem. Modifications to these cover boards would appear necessary for creating suitable thermal refuge habitat for snakes during the height of summer at our study site. Examples of possible modifications include increasing the overall size of the plywood structure (Halliday and Blouin-Demers 2015), applying a coating to the outer surface of the cover board specifically to reflect solar radiation (Synnefa *et al.* 2005), and/or increasing the insulation under the cover boards through pits or underground chambers (C.A.B. and K.W.L. pers. obs.).

Racer mortalities along the fence were proportionally over-represented compared to our overall captures of snakes in the community, strongly suggesting these animals were predisposed to dying near the fence more so than the other two species. The impact of exclusion fencing may be greater for agile and highly active snakes. Species that are relatively active and/or undergo longer migrations may be more likely to encounter fences and other disturbances, potentially becoming isolated from crucial resources (Ferronato *et al*. 2014; Martin *et al*. 2017). Home range and movement data for Western Yellow-bellied Racer in BC are scant, but Brown and Parker (1976) showed home ranges for this species in Utah generally extended no further than 1000 m from den sites. In the Okanagan Valley, the average maximum distance gophersnakes disperse from their dens is 520 m (10.5 ha home range: Williams *et al*. 2012) and rattlesnakes in our study area move an average of 1082 m (25.1 ha home range) from their den location (Brown *et al*. 2009). In the south Okanagan Valley, racers are considered the most diurnally-active species with higher levels of activity, exposure and heat tolerance than other species (Brattstrom 1965; Ernst and Barbour 1989; COSEWIC 2015). Possibly a predilection for movement during the daytime renders racers relatively vulnerable to overheating and other lethal effects experienced while navigating fences and other obstacles.

Sudden increased mortality during the 2016–2017 field seasons could be due to several factors, such as the lack of direct surveying in the past (monitoring is time consuming and requires many working hours), or it may be correlated with fence upgrades that rendered the structure more impermeable to snakes. The specific section of the fence where snake mortalities were observed runs parallel to a lake (to exclude snakes from a large campground), restricting access to riparian habitat for those seeking to rehydrate, hunt, and avoid periods of extreme heat.

Following the new 200-m addition to the fence, we detected relatively more dead snakes along that section than elsewhere in our study site. The six snakes (40% of fence mortalities) found dead within a 20–30 m section of the newly constructed section are of particular interest. These observations, along with the six dead snakes originally observed during initial fence construction in 2006, may suggest new exclusion fencing poses accentuated problems for snakes in the short term. However, without better knowledge on the factors driving snake migration and movements, it is difficult to determine why fencing and changes to fencing structures would increase mortality rates. Additionally, further investigation, long-term monitoring, and more detailed analysis are required to determine potential population-level impacts these fence mortalities are actually having in our study area.

Exclusion fencing has become a common strategy to mitigate human-reptile conflict and can be extremely effective; however, it is clear with our findings that the use of exclusion fencing is not without concern. The broader effects of exclusion fencing need to be investigated further to fully understand the implications and perhaps consequences to animals such as snakes. Similar to concerns raised for reptiles in other hot, dry regions (Ferronato *et al.* 2014; Peaden *et al*. 2017), there appears to be potential negative consequences for snakes encountering fencing in our study area.

Author Contributions

Writing – Original Draft Preparation: D.M.E. and J.R.M.; Writing – Review and Editing: D.M.E., J.R.M., K.W.L., and C.A.B.; Formal Analysis: D.M.E. and J.R.M.; Funding Acquisition: K.W.L. and C.A.B.; Investigation: D.M.E., J.R.M., and O.M.M.; Methodology: D.M.E, J.R.M, O.M.M, and K.W.L.; Supervision: K.W.L and C.A.B.

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Factors affecting litter size in Western Gartersnake (*Thamnophis elegans*) in British Columbia: place, time, and size of mother

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Abstract
Life-history traits of organisms are influenced by both genetic and environmental factors. We used counts of offspring in captive-born litters to determine how geographic location, year-to-year variation, and body size of mother affected litter size of Western Gartersnake (*Thamnophis elegans*) in four widely separated populations in British Columbia. Litter size varied significantly among populations, but that variation was largely explained by differences in maternal body size among populations; that is, larger females had larger litters. With maternal size treated as a covariate, there was no further significant effect of location or of different years within sites on litter size. The overall regression, pooled over sites and years, between litter size and size of mother accounted for 55% of the total variation in litter size. Nonetheless, the significant variation in body size among locations calls for explanation and the consequent differences in litter size could be important demographically. Presumably, the large amount of unexplained residual variation reflects other differences, beyond body size, between individual mothers. Such differences among individuals might be determined by genetics or by environmental effects such as foraging success, but our data cannot address this question.

Key words: Gartersnake; *Thamnophis elegans*; British Columbia; litter size; body size

Introduction
Life histories are suites of co-varying traits that influence the dynamics of a population and therefore its potential rate of increase in numbers. Key life-history traits of animals include clutch/litter size and frequency, offspring size at hatching/birth, individual growth rate, body size, age at reproductive maturity, and mortality rate (Stearns 1992). Thus, the individual organism's life history is a measure of its relative fitness. To the extent that they are heritable, life histories, and the traits that comprise them, are subject to natural selection; different life histories may be advantageous in different situations (e.g., high versus low risk of predation; Reznick and Endler 1982; more versus less variable environments; Bronikowski and Arnold 1999).

Life histories vary among taxa at all taxonomic levels, including lineage-specific effects. For example, most lizards can vary their clutch size, but two unrelated lineages of lizards, geckos and anoles, have fixed clutch size of one or two eggs (Selcer 1990). Small fixed clutches appear to be adaptations to arboreal habitats in the tropics in which these two groups originated, but they may now constrain these lizards from colonizing temperate-zone environments (Ballinger 1983). Most life-history traits, however, are not constant, but vary among populations within species, between individuals within populations, and within individuals during their lifetime. Some of this variation is genetic, but life-history traits typically exhibit low heritability (Stearns 1992), so other factors, including phenotypic plasticity, play an important role in the expression of these traits. Understanding patterns of variation in life-history traits is relevant not only to testing evolutionary theory, but also for wildlife management and conservation.

Successful reproduction is fundamental to an organism's fitness. The simplest measure of reproductive output is clutch or litter size, the number of offspring produced on a given occasion. In snakes, clutch or litter size is the most frequently recorded measure of reproductive output and has been the focus of numerous studies of life-history variation within and among species (Seigel and Ford 1987). Here, we focus on inter-population comparisons of a widely distributed species of snake in western North America, Western Gartersnake (*Thamnophis elegans*), which ranges latitudinally from southern Arizona to central British Columbia (Rossman *et al.* 1996). Throughout this range, *T. elegans* occupies a diversity of environments that differ in climate, biophysical characteristics, and other attributes that could influence the expression of life-history traits, including litter size. Other wide-ranging species of gartersnakes show considerable geographic variation in litter size (Gregory and Larsen 1993, 1996; Tuttle and Gregory 2014).

Because litter size in gartersnakes is often strongly correlated with body size of mother (Seigel and Ford 1987), litter size could vary geographically simply because of geographic variation in body size. However,

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in Common Gartersnake (*T. sirtalis*), variation among sites in litter size was not explained solely by maternal size (Gregory and Larsen 1993); both slopes and elevations of the linear relationships between litter size and maternal size varied among populations. Similar variation in litter size-maternal size relationships was observed between two ecotypes of *T. elegans* in California (Bronikowski and Arnold 1999). Unfortunately, Fitch's (1985) early exploration of geographic variation in litter size of *T. elegans* did not incorporate data on maternal body size.

In addition to geographic variation, litter size in snakes also may vary from year to year, depending on weather, either in the current or previous year (Seigel and Fitch 1985; Brown and Shine 2007; Tuttle and Gregory 2014). Variation in weather within and among years affects prey productivity, and therefore availability of resources to snakes for reproduction. As snakes are ectotherms, their activity and ability to acquire resources also could be affected by weather, independently of resource availability, thereby indirectly influencing reproduction.

Here, we revisit a previous study on reproductive characteristics of *T. elegans* at four widely separated sites in British Columbia (BC; Farr and Gregory 1991), to which we have since added substantially more data. Analysis of litter size in our earlier study was confined to comparisons of different ways of estimating litter size within each site. Here, we test the influences of size of mother, location, and year on litter size across all four populations.

Methods

The four study sites were located, respectively, near Creston in the Kootenay region (KOOT, southeastern BC: 49.12°N, 116.64°W); near Williams Lake in the Chilcotin region (CHIL, central BC: 51.97°N, 122.53°W); at Okanagan Falls in the Okanagan Valley (OKAN, south central BC: 49.34°N, 119.57°W); and near Victoria on Vancouver Island (VANI, southwestern BC: 48.48°N, 123.55°W). These four sites represent distinctly different habitat types. The KOOT site is a complex of extensive marshes bordered by forested slopes, with additional riverside habitat. The CHIL site is a dry, sparsely vegetated grassland with scattered small, isolated ponds. The OKAN site is mainly riverside habitat. Finally, the VANI site is an estuary. All of these sites, except for VANI, were also included in Gregory and Larsen's (1993, 1996) analyses of geographic variation in reproductive characteristics of *T. sirtalis*.

In this study, we recorded litter size through exact counts of offspring borne by gravid females held in captivity until parturition. Our 1991 study consisted of 78 litters collected between 1975 and 1988, albeit not in all years and in different years for each location. For this new analysis, we have added 18 litters from KOOT collected in 1996 for laboratory experiments (Gregory and Skebo 1998; Gregory *et al.* 1999) and 20 from OKAN collected between 1990 and 2000 (P.T.G. unpubl. data). Conditions under which snakes were maintained in captivity are detailed in Farr and Gregory (1991) and Gregory and Skebo (1998). The additional snakes from OKAN were housed and maintained at University of Victoria as described in Farr and Gregory (1991).

Although most young were born alive, some litters contained dead young and/or undeveloped eggs. From a strictly demographic perspective, only live births matter. However, from an energetic perspective, dead and undeveloped young still represent an investment in reproduction and, together with live young, comprise potential litter size. Furthermore, as it is unclear to what extent the occurrence of dead or undeveloped young is due to stresses experienced by gravid females in captivity (Gregory 2001), excluding these classes of offspring might artificially deflate litter size estimates. Our previous studies suggest that litter size, relative to maternal body size, in a given population is less variable when all components are included (Farr and Gregory 1991; Gregory *et al.* 1992). Finally, counting all litter elements enables comparison with other studies based on estimates of litter size from abdominal palpations in the field or dissections of females in early pregnancy. That is the approach that we have taken here.

In the analyses of variance (ANOVA) and covariance (ANCOVA) that follow, we treat location and year as random factors. Location is a random factor because we did not choose these four study sites for any particular features relevant to life-history variation, but simply because they had populations of *T. elegans*. Similarly, we did not choose years based on weather or any other factors. The years in which we collected data differed for each site, so location and year are not crossed in an orthogonal factorial design; rather, year nested within location is the appropriate model for combined analysis of these two factors. We did all analyses using SAS 9.3 software (SAS Institute Inc. 2011) and a conventional alpha level of 0.05 for rejection of null hypotheses; *F*-tests were based on Type III sums of squares.

We analyzed the data in stages. First, we combined data for all years for each site and did separate one-way ANOVAs among sites of both size of mother (snout-vent length, SVL) and litter size. Second, to separate the effects of maternal SVL and location on litter size, we ran an ANCOVA of litter size among locations (again combining years for each location), with maternal SVL as a covariate. We first ran the analysis with the interaction of SVL × location included (as a test of homogeneity of slopes), then re-ran it with the interaction removed if that effect was non-significant. Third, for each location, we performed an ANCOVA of litter size among years, again with maternal SVL as a covariate and the same considerations concerning the interaction SVL × year. Fourth, we combined the data across all locations and years for an overall ANCOVA of litter size, with maternal SVL as covariate and location and year as factors (year nested within location).

Although litter size is a fundamental life-history trait, it is not the only measure of a female's reproductive output. For example, in snakes, offspring size also often varies with maternal size (Seigel and Ford 1987). Because the variable litter mass incorporates both litter size and offspring size, we repeated the analyses described above with litter mass, rather than litter size, as a dependent variable.

Results

We analyzed data from 118 litters (KOOT: 49 litters over five different years; CHIL: 29 over four; OKAN: 31 over seven; VANI: nine over four). Samples in some years were very small, especially for VANI.

Mean litter size was significantly different among locations (ANOVA, $F_{3,114} = 14.74$, $P < 0.0001$; Figure 1), but the pattern of variation was mirrored by significant differences in mean size of mother among locations ($F_{3,114} = 27.23$, $P < 0.0001$; Figure 2). The test of slope heterogeneity of litter size on maternal SVL among locations was non-significant (interaction between location and SVL, $F_{3,110} = 1.90$, $P = 0.13$), so we dropped the interaction term and proceeded with the ANCOVA, which revealed a highly significant effect of maternal SVL on litter size ($F_{1,113} = 138.66$, $P < 0.0001$), but no difference among locations ($F_{3,113} = 0.41$, $P = 0.75$). Thus, the relationship between litter size and maternal body size for the four populations was best described by a common linear regression (Litter Size = 0.048 × Female SVL − 16.56, $r^2 = 0.55$, $F_{1,116} = 140.80$, $P < 0.0001$; Figure 3).

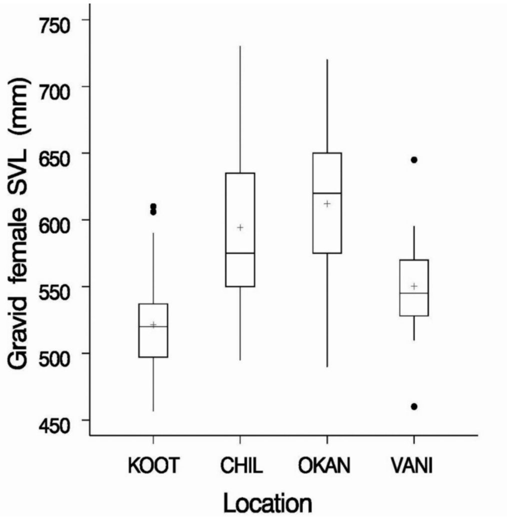

FIGURE 2. Boxplots of body size (snout-vent length, SVL) of gravid female Western Gartersnake (*Thamnophis elegans*) at four sites in British Columbia. See Figure 1 caption for sample sizes and explanation of boxplots. Locations defined as in Figure 1.

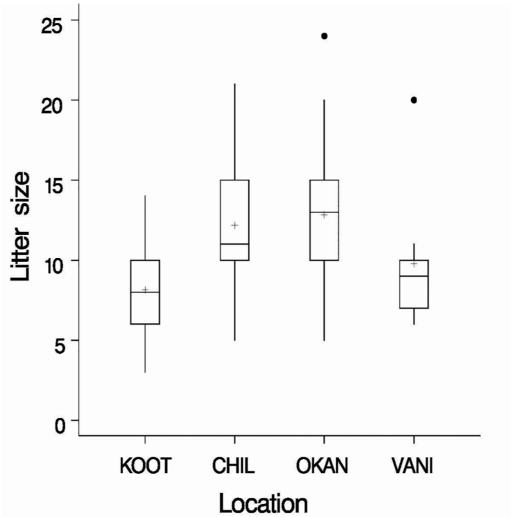

FIGURE 1. Boxplots of litter size of Western Gartersnake (*Thamnophis elegans*) at four sites in British Columbia. Upper and lower ends of boxes represent 75th and 25th percentiles (quartiles), respectively; horizontal line in each box is the median and the mean is indicated by +. Whiskers extend to the most extreme value not exceeding 1.5 times the interquartile distance; individual points represent more extreme observations. KOOT = Kootenay, CHIL = Chilcotin, OKAN = Okanagan, VANI = Vancouver Island. Sample sizes are: KOOT $n = 49$; CHIL $n = 29$; OKAN $n = 31$; VANI $n = 9$.

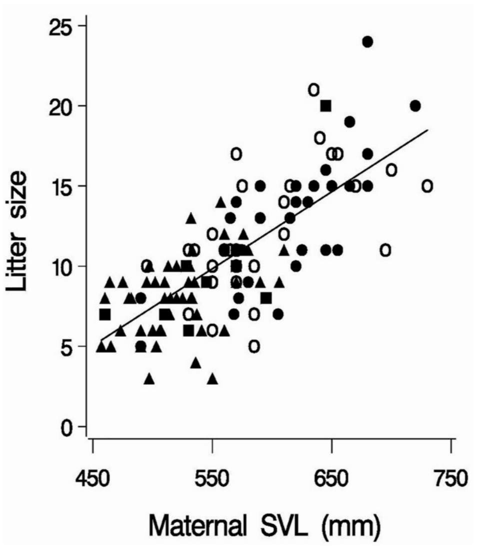

FIGURE 3. Plot of litter size against body size (snout-vent length, SVL) of maternal Western Gartersnake (*Thamnophis elegans*) for four sites in British Columbia. Line represents linear regression of litter size on maternal body size for all locations combined (Litter Size = 0.048 × Female SVL − 16.56). KOOT snakes: triangles ($n = 49$); CHIL snakes: open circles ($n = 29$); OKAN snakes: filled circles ($n = 31$); VANI snakes: squares ($n = 9$). Locations defined as in Figure 1.

When we compared litter size among years for each location, with maternal SVL as a covariate, the interaction between year and maternal SVL was non-significant in each case (Table 1). With no evidence of heterogeneity of slopes, we performed the ANCOVA for each location with the interaction term omitted from the model and found that for each location, there was again a significant positive relationship between litter size and maternal SVL, but no significant variation in litter size among years (Table 2).

The final analysis including all factors again showed that maternal size had a highly significant effect on litter size ($F_{1,97} = 49.51$, $P < 0.0001$), but that neither location ($F_{3,97} = 0.45$, $P = 0.72$) nor year (nested within location; $F_{16,97} = 0.76$, $P = 0.73$) significantly influenced litter size. Overall r^2 for this analysis was 0.60, leaving 0.40 of the total variation in litter size as residual or unattributed.

Litter mass was highly correlated with litter size ($r = 0.87$, $n = 107$, $P < 0.0001$) and the analysis of litter mass essentially duplicated that of litter size, so we omit those additional results here.

TABLE 1. Tests of heterogeneity of slopes of litter size against maternal snout-vent length (SVL) among years (SVL × year interaction) for Western Gartersnake (*Thamnophis elegans*) at each study site. Main effects (SVL, year) also were included in the model, but results are not shown (see Table 2 for these effects in reduced ANCOVA model). KOOT = Kootenay, CHIL = Chilcotin, OKAN = Okanagan, VANI = Vancouver Island.

Location	F_{df}	P
KOOT	$1.14_{4,39}$	0.35
CHIL	$1.21_{2,22}$	0.32
OKAN	$1.65_{5,18}$	0.20
VANI	$3.90_{1,3}$	0.14

TABLE 2. Analyses of covariance (ANCOVA) of litter size among years, with maternal snout-vent length (SVL) as covariate, for Western Gartersnake (*Thamnophis elegans*) at each study site. Slopes of regression of litter size on maternal SVL were homogeneous among years in each case (see Table 1). Locations defined as in Table 1.

Location	Test	F_{df}	P
KOOT	SVL	$7.46_{1,43}$	0.0091
	Year	$0.61_{4,43}$	0.6549
CHIL	SVL	$11.78_{1,24}$	0.0022
	Year	$0.11_{3,24}$	0.9546
OKAN	SVL	$23.41_{1,23}$	< 0.0001
	Year	$0.70_{6,23}$	0.6536
VANI	SVL	$5.90_{1,4}$	0.0720
	Year	$1.33_{3,4}$	0.3811

Discussion

It is worth considering at the outset the degree to which our conclusions were influenced by the methods we used. Holding gravid females in captivity may have a number of effects on litter characteristics because the gravid snake is not usually free to feed or thermoregulate in the same manner as a wild snake (Farr and Gregory 1991). The overall ANCOVA model that we used has practical limitations (Ballinger 1983) and our data set represents an imperfect nested design (e.g., the data are non-orthogonal, years within location were not chosen strictly at random). Nevertheless, our analysis contributes to a broader understanding of geographic and temporal variation in litter size of *T. elegans* and suggests directions for future studies.

Our study has three major findings: litter size of *T. elegans* varies significantly among populations, significant differences in maternal body size among populations account for much of the observed variation in litter size, and little geographic or temporal variation in litter size remains after effects of maternal body size are taken into account. Thus, most of the residual variation in litter size (after maternal size effects have been removed) is due to further differences among individual mothers and/or other unmeasured factors.

Two important issues emerge from this analysis. First, because litter size varies with maternal body size, which varies significantly among populations, we need to explain geographic variation in body size. Second, we need to determine the extent to which variation in litter size among individual females is determined by genetic or environmental factors (e.g., differences in foraging success).

Significant body-size variation among populations has been observed for numerous snake species (e.g., Semlitsch and Moran 1984; Schwaner 1985; Plummer 1987; King 1989; Gregory and Larsen 1993, 1996; Madsen and Shine 1993; Tuttle and Gregory 2012), but explanations vary. For example, body size often increases with size and/or availability of prey (Schwaner 1985; Shine 1987; Madsen and Shine 1993; Boback 2003; Filippakopoulou *et al.* 2014). Smaller size might also be partly attributable to higher mortality from various causes, including predation (King 1989; Filippakopoulou *et al.* 2014). Climate may also play a role. The temperature-size rule predicts that ectotherms should grow more slowly, but reach larger sizes, in colder environments (Angilletta and Dunham 2003). However, departure from the temperature-size rule is common (Tuttle and Gregory 2012) and most species of snakes are actually smaller at higher latitudes and elevations (Ashton and Feldman 2003).

At present, we can offer no explanation for the pattern of body size variation that we observed in *T. elegans* in British Columbia. However, the two sites with relatively large *T. elegans* in our study (CHIL and OKAN) also had larger *T. sirtalis* than most other sites in Gregory and Larsen's (1993) comparative study of that species, suggesting that similar environmental factors may explain at least some variation in body size within these two closely related species.

Thamnophis elegans is a wide-ranging species, but there has been little documentation of geographic variation in its reproductive characteristics. Based on data from several subspecies combined, Fitch (1985) showed that litter size generally declined from the southern part of the range to the north. Although our data for KOOT and VANI are consistent with this trend, litter sizes of *T. elegans* from CHIL and OKAN are much larger than those from farther south. In fact, the mean litter size (12.8) and maximum litter size (24) that we recorded for OKAN snakes are larger than any reported by Fitch (1985). However, Bronikowski and Arnold (1999) reported similar maximum litter size for large *T. elegans* in northern California. Unfortunately, Fitch's (1985) analysis did not include body sizes of snakes, limiting its comparative value here.

The consistent relationship between litter and maternal body size that we observed for *T. elegans* in British Columbia contrasts observations for populations in northern California. There, lakeshore and meadow ecotypes of *T. elegans* occur in contrasting environments and exhibit differences in numerous life-history traits, including the relationship between litter size and maternal size (Bronikowski and Arnold 1999). The overall relationship that we observed is very similar to that seen for the meadow ecotype; in contrast, lakeshore snakes have a steeper relationship (Bronikowski and Arnold 1999). It would be informative to determine whether British Columbia populations also match the California meadow ecotype in other life-history traits.

Other species also show geographic variation in the litter size-maternal size relationship. For example, in *T. sirtalis*, the relationship between litter size and maternal SVL varies strongly among populations, in both slope and intercept (Larsen and Gregory 1993), especially between eastern and western Canada (Gregory and Larsen 1996). Populations of *T. sirtalis* range from those comprised of small females that produce large numbers of young to those consisting of large females that produce small litters. Correlated with this is variation in neonate size, large litter size usually being accompanied by small offspring (Larsen and Gregory 1993). However, offspring size of *T. elegans* varies relatively little among our study sites (Farr and Gregory 1991). Geographic differences in the relationship between litter size and maternal size also have been observed in Red-bellied Snake (*Storeria occipitomaculata*; Semlitsch and Moran 1984; Brodie and Ducey 1989). In all of these studies, geographic variation in body size accounts for only a small fraction of the variation in litter size.

A perhaps surprising result of our study is the lack of variation among years in litter size, but our samples were small. That said, Brodie and Ducey (1989) also found no significant variation between years in maternal size-adjusted litter size of *S. occipitomaculata*. In Rough Greensnake (*Opheodrys aestivus*) clutch size did not vary among years at one site (Plummer 1983) but did at a second site (Plummer 1997). Seigel and Fitch (1985) determined that, even after correcting for differences in maternal body size, clutch size varied significantly among years in four populations (different species) of snakes, and that this variation was related to rainfall (larger litter sizes in wetter years). This finding prompted Seigel and Fitch (1985) to caution researchers about the limitations of data from short-term (especially from just one year) studies to characterize reproductive habits, an admonition with which we concur. The temporal variations in clutch size reported by Seigel and Fitch (1985) far exceed those that we observed, and it is possible that the environment in their study area (Kansas) is more variable than any of ours. In most cases, their samples extended over a greater number of years than did ours, increasing the likelihood of observing extreme values. Litter size of Plains Gartersnake (*Thamnophis radix*) in Alberta also varies among years in relation to the previous year's rainfall and temperature (Tuttle and Gregory 2014). In addition to the temperate-zone snakes cited above, weather-related annual variation in clutch or litter sizes have been reported in tropical snakes (Brown and Shine 2007) and in other reptilian taxa (e.g., Bleu *et al.* 2013; Hedrick *et al.* 2018).

Weather per se presumably has an indirect effect on clutch size through resource acquisition, possibly by limiting activity and foraging opportunities (e.g., in cool conditions; Tuttle and Gregory 2014) or by influencing prey abundance and availability. For example, Seigel and Fitch (1985) attributed higher clutch size of Ring-necked Snake (*Diadophis punctatus*) in wet years to increased prey availability. Other studies have explicitly demonstrated the link between year-to-year variation in litter size and prey availability, whether driven by weather or other factors (Andrén and Nilson 1983; Brown and Shine 2007; King *et al.* 2008). However, in Brown Water Python (*Liasis fuscus*) changes in prey availability influenced clutch size only slightly, instead affecting the post-oviposition body condition of females (Madsen and Shine 1999).

The search for general patterns among diverse groups of organisms is a central aim of life-history research. But comparative studies also are needed at the intraspecific level, because potentially confounding phylogenetic factors are reduced in such studies and because they should allow us to distinguish proximal from evolutionary causes of variation (Brown 1983). The issue of genetic versus non-genetic sources of variation will not be a simple one to resolve (Ballinger 1983; Stearns 1992). But we believe that it is essential to understand the degree to which important traits vary naturally in the field, both spatially and temporally, to provide the background against which to interpret eventual experimental results.

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Note

Erythrism in Spring Peeper (*Pseudacris crucifer*) in Maritime Canada

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Abstract
We document three cases of erythrism in Spring Peeper (*Pseudacris crucifer*) in New Brunswick and Nova Scotia. Although the source of erythrism in Maritime *P. crucifer* remains uncertain, the occurrences reported here demonstrate this colour morph to be a widespread, although apparently rare, form in the Canadian Maritimes region.

Key words: Spring Peeper; *Pseudacris crucifer*; amphibian; colour variant; New Brunswick; Nova Scotia

Kolenda *et al*. (2017) noted that the documentation of colour anomalies may contribute to our understanding of the ecological history and phenotypic plasticity of species and recorded a variety of colour aberrations in amphibians. In amphibians, albinism (lack of pigment) and leucism (partial loss of pigment) seem to predominate; axanthism (loss of yellow pigment) may be less common (Dyrkacz 1981; Betchtel 1995; Jablonski *et al*. 2014). Erythrism (abnormal redness) appears to be rare in amphibians, although Moore and Ouellet (2014) reported prevalences of erythrism in Red-backed Salamander (*Plethodon cinereus*) as high as 50%. Chromatophores fortified with pteridines, carotenoids, or flavins generally underlie red-yellow colouration in lower vertebrates (Hubbard *et al.* 2010), including amphibians (Hoffman and Blouin 2000). Recent evidence shows that pheomelanin may also be responsible (Wolnicka-Glubisz *et al.* 2012).

Cases of erythrism in amphibians in Maritime Canada have previously been restricted to Red-backed Salamander. Bleakney and Cook (1957) and Gilhen (1968) have reported erythristic individuals from Nova Scotia, while Cook and Bleakney (1961), Ekstrom (1973), and Jongsma (2012) have all reported this colour form of the species in New Brunswick. There are, apparently, no reports of erythrism in amphibians from Prince Edward Island (Cook 1967; Moore and Ouellet 2014).

Although skin colour in Spring Peeper (*Pseudacris crucifer*) may vary, adults and juveniles are normally light tan through dark brown to grey, usually with a distinctive, dark, x-shaped mark on the back, dark banding or spotting on the legs, and a dark stripe on the side of the head (Dodd 2013). Cook (1967) and Gilhen (1984) reported that Maritime Spring Peepers likewise range in colour through shades of brown or grey, but the x-shaped pattern on the back is usually distorted or fragmented and connected to additional markings (Figure 1).

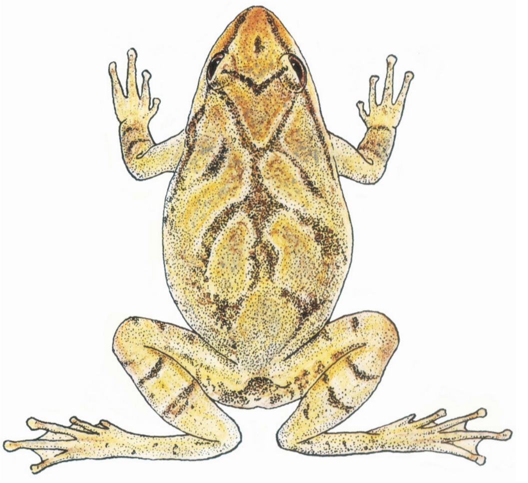

Figure 1. Male specimen of Spring Peeper (*Pseudacris crucifer*) from Prince Edward Island showing normal colour morph for Maritime Canada. Note the fragmented x-marking on the back, characteristic of the species in the region. Original line drawing of Canadian Museum of Nature specimen 3956-4 scanned from Cook (1967) and tinted with chalk pastels by A. Karstad.

Here we document cases of erythrism in Spring Peepers from Maritime Canada reported to us at the Nova Scotia and New Brunswick Museums by members of the public.

On 30 September 2008, observer 1 discovered a uniformly orange Spring Peeper inside an empty paint tin at L'Ardoise, Richmond County, Cape Breton, Nova Scotia (45.6151°N, 60.7663°W; Figure 2A). On 16 September 2014, observer 2 reported a (juvenile) uniformly orange Spring Peeper on a screen door 2 km east of the Petitcodiac Bridge, Riverview, New Brunswick (46.0687°N, 64.7801°W; Figure 2B). On 18 September

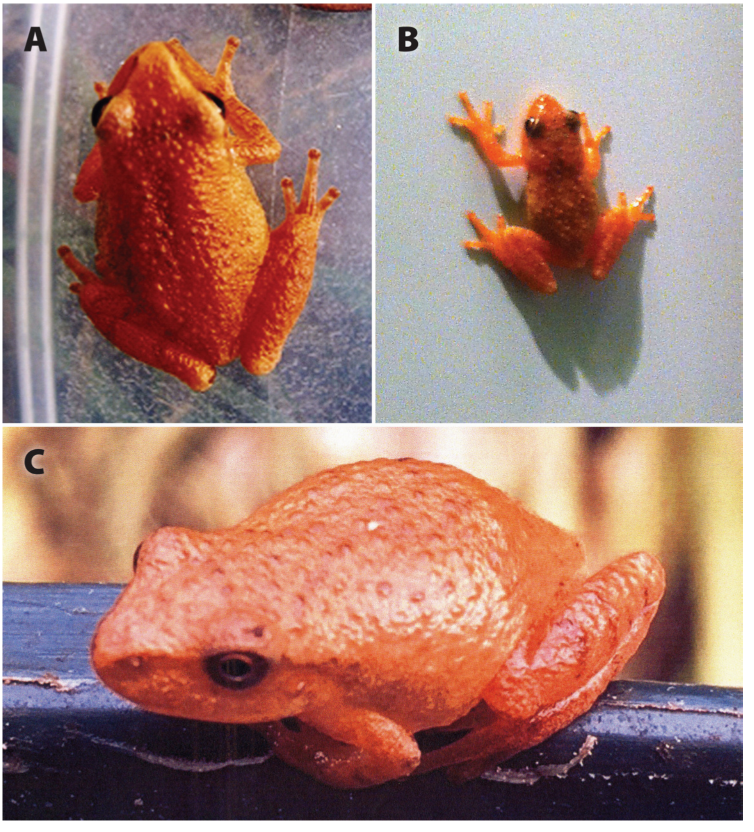

FIGURE 2. Three erythristic specimens of Spring Peeper (*Pseudacris crucifer*) from Maritime Canada: (A) L'Ardoise, Richmond County, Cape Breton, Nova Scotia; (B) Riverview, Westmorland County, New Brunswick; (C) Duncan's Cove, Halifax County, Nova Scotia. Photos: Nova Scotia Museum files.

2016, observer 3 photographed a uniformly orange Spring Peeper at Duncan's Cove, Halifax County, Nova Scotia (44.4990°N, 63.5258°W; Figure 2C). Each of these erythristic Spring Peepers lacked the x-shaped mark on the dorsum, and banding on the legs and face was reduced.

Kolenda *et al.* (2017) hypothesized that cases of erythrism in Common Eurasian Spadefoot Toad (*Pelobates fuscus*) in Poland are the result of high iron concentrations in water and soil, presumably intensifying the colour of erythrophores. Umbers *et al.* (2016) found that dietary carotenoids influence the saturation and hue of yellow pigments in Australian Southern Corroboree Frog (*Pseudophyrne corroboree*). Thurow (1961) attributed genetic, rather than environmental factors, to the presence of erythrism in Red-backed Salamander. Others have suggested that the erythristic form of this species may be a Batesian mimic of the terrestrial eft stage of the predator-toxic Red-spotted Newt (*Notopthalmus viridescens;* Cassell and Jones 2005 and references cited therein).

There appear to be no previous reports of erythrism in *Pseudacris crucifer*, although Telford (1952) briefly mentioned the collection of two "brick red" Little Grass Frogs (*Pseudacris ocularis*) in Florida. Although the source of erythrism in Maritime Spring Peepers remains uncertain, the three occurrences reported here demonstrate this colour morph to be a widespread, although apparently rare, form in the Canadian Maritimes region. We encourage further reporting of erythrism in Spring Peepers and other Canadian amphibians.

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Ready for bed: pre-hibernation movements and habitat use by Fowler's Toads (*Anaxyrus fowleri*)

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Abstract

We used radio-tracking to investigate movement patterns and habitat use of Fowler's Toads (*Anaxyrus fowleri*) during late summer and early fall in a relatively undisturbed lakeshore dune and beach habitat at Long Point, Ontario. Small radio transmitters were fitted to 11 adult toads with an external harness made from fine surgical plastic tubing wrapped around the body behind the front limbs. We located radio-tagged toads morning and evening, for a maximum of 9 days, recording their locations using Global Positioning System units. Initially, the toads were located on the upper beach or in the fore-dunes during the day, either dug in under the sand or hiding beneath debris; in the evening, they were generally active on the lower beach close to the water line. After a storm and the onset of cooler autumn weather, the toads tended to move further from the water line. They also curtailed their nightly activity and retreated deeper into the sand. As this sort of behaviour was not observed during the summer, we interpret it as pre-hibernation movement to more stable sites away from the beach where the animals can burrow deeply into the sand to lie dormant during the winter.

Key words: Fowler's Toad; *Anaxyrus fowleri*; radio-tracking; amphibian; habitat use; behaviour; movement; spatial ecology; hibernation; Long Point; Ontario

Introduction

Compared with their spring movements to aquatic breeding sites, the autumnal movements of temperate zone, pond-breeding amphibians to overwintering sites are not well understood (Miwa 2017). However, there is evidence that anurans may alter their habitat preferences late in their active season and begin to seek particular sites for hibernation that they would otherwise tend not to use (Koskela and Pasanen 1974; Bull 2006; Lee and Park 2009; Yu and Guo 2010; Ludwig *et al.* 2013). For example, Canadian Toads (*Anaxyrus hemiophrys*) in Minnesota are known to hibernate deep inside earthen mounds on the prairie (Tester and Breckenridge 1964), whereas Western Toads (*A. boreas*) in Alberta may overwinter in peat hummocks, squirrel middens, cavities under spruce trees, or other such sheltered sites (Browne and Paszkowski 2010a). In both cases, particular habitat features allow the animals to retreat deeply into the ground to escape inhospitable surface conditions. The animals' use of these habitats suggests that they alter their behaviour to seek out such sites as winter approaches (Browne and Paszkowski 2010b).

At its northern range limit, Fowler's Toad (*Anaxyrus fowleri*) is a shoreline beach and sand dune specialist (Breden 1988; Green 2005). At night, during summer, individuals forage along wet, sandy shores. By day, they either seek refuge under debris or bask in the warm sand of the fore-dunes that line the beach (Marchand *et al.* 2017). However, such shore-facing sites are highly vulnerable to disturbance during winter storms and are, therefore, unlikely to provide sufficient protection for overwintering animals. To survive the winter, the toads must be able to dig deeply enough into the ground to escape penetrating ground frost at sites that are sheltered from severe weather and protected from flooding.

Thus, they should have quite different microhabitat preferences for overwintering sites compared with summer refuge sites and should begin their pre-hibernation movements to such sites coincident with particular environmental conditions as summer turns into fall. The opportunity to study such movements arose during the course of a radio-tracking study of Fowler's Toads toward the end of their active season at Long Point, Ontario, when a severe storm brought a significant change in the weather.

Methods

Study site

The Big Creek National Wildlife Area (Figure 1) is at the western base of Long Point, Ontario, on the north shore of Lake Erie (42°34'N, 80°28'W). Inland from the lake lies a sandy beach largely devoid of vegetation, then dunes and marsh. The fore-dunes facing the beach are vegetated largely with American Beachgrass (*Ammophila breviligulata* Fernald) and Riverbank Grape (*Vitis riparia* Michaux), whereas the dune tops and back-dunes feature a variety of forbs, willow shrubs (*Salix* spp.), and Eastern Cottonwoods (*Populus del-*

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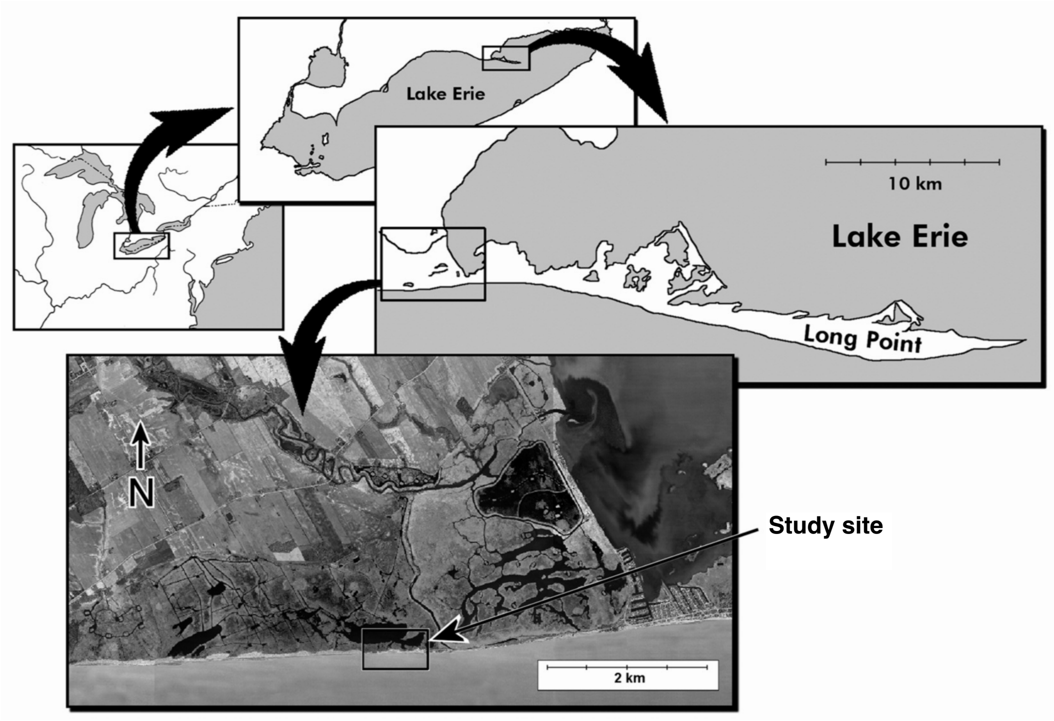

FIGURE 1. Location of the study site at Big Creek National Wildlife Area, Long Point, Ontario (42°34'N, 80°28'W). Aerial photo courtesy of Ontario Ministry of Natural Resources and Forestry.

toides W. Bartram ex Marshall). Historically, marshland located just north of the dunes and dominated by cattails (*Typha* spp.) and Common Reeds (*Phragmites australis* (Cavanilles) Trinius ex Steudel) served as spring breeding habitat for the toads (Green 1989, 2005). We obtained temperature and wind speed data for the study period (30 August to 8 September 2008) from the records of the LONG POINT (AUT) weather station, located about 33 km to the east, near the tip of Long Point (Environment Canada 2013).

Radio-tracking

We used radio-tracking (Marchand *et al.* 2017) to locate animals in the morning and evening from 30 August to 8 September 2008. We tagged adult toads with an external 0.51-g BD-2 radio-transmitter (Holohil Systems Ltd., Carp, Ontario, Canada) attached to a harness made of plastic surgical tubing with monofilament fishing line threaded through it to enable us to tie it around the toad's body (Figure 2). We attached the harness behind the toad's front limbs, rather than around the waist (Bartelt and Peterson 2000), so that it would not interfere with the animal's ability to dig into the ground. Toads were captured and tagged in the evening when they were active and tracked beginning the following morning.

We measured the snout-to-vent length (SVL) of each individual using dial calipers, noted its sex, photographed it for later identification, and assigned it an identity number for reference. As toads have specific patterns of blotches and spots on their backs (Schoen *et al.* 2015), we could readily identify each individual by comparing it to its photograph. We released all toads at the point of capture immediately after they had been tagged.

We located the radio-tagged toads every morning, when they were dormant, and evening, when they were usually active on the beach, using an HR2600 Osprey receiver (H.A.B.I.T. Research, Victoria, British Columbia, Canada) and a three-element Yagi antenna. In the morning, we checked to determine that transmitters were still properly attached to the tagged toads. Usually, we could do this visually without disturbing the animal, as the resting toads were most often at or close to the surface of the sand, with the transmitter's antenna clearly visible. If neither the toad nor its transmitter was visible at the surface, we carefully pushed aside the sand to locate it and register how deeply the toad had buried itself, with minimal disturbance to the animal. In the evening, we captured all tagged toads that were active to check the condition of the harness. We removed the harness if we saw any signs of abrasion and tagged a different toad if we could find one. We tagged an initial three toads on the first evening of the study and three more on the second evening. Thereafter, we tracked up to seven toads at a time.

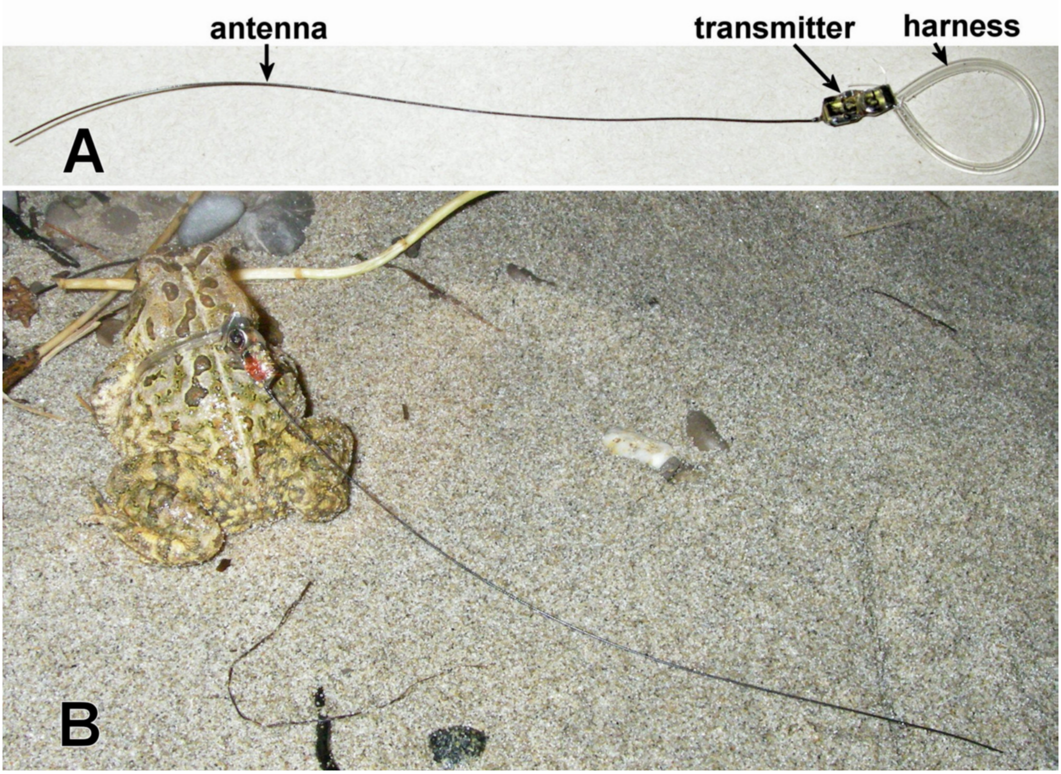

FIGURE 2. Radio-transmitter, showing harness (A) and attachment to a Fowler's Toad (*Anaxyrus fowleri*; B). Photos: D.M. Green.

Mapping

We mapped the locations of radio-tagged toads as universal transverse mercator (UTM) coordinates (NAD 83 datum) with accuracy better than 3 m using a Magellan Mobile Mapper 6 global positioning system unit and Mobile Mapper software (MiTAC Digital Corp., San Dimas, California, USA). We saved all coordinates as .shp files to download into ArcPad 7.1.1.12 software (ESRI Inc., Redlands, California, USA). We used a geo-referenced aerial photo of the region dated 2006 as the base map.

Analysis

We calculated distances travelled by the toads between mapped locations, including total straight-line distance, distance parallel to the water line, and distance perpendicular to the water line. The beach runs in an east–west direction, so distances travelled by the toads east or west parallel to the water line were calculated as the difference between each capture's easting; distances travelled north or south, perpendicular to the water line, were calculated as the difference between each capture's northing. We calculated the toads' daily average movements by correcting for the number of days over which the distances were travelled. We also computed the average distances the toads moved over 24 h (night-to-night and day-to-day) to provide estimates of nighttime activity and distances between daytime refuges. To test whether the toads tended to change the location of their daytime refuge sites to areas further away from the lake in response to the change in the weather following the storm, we used mixed effects linear regression to compare distances of refuge sites away from the Lake Erie water line, with timing (pre-storm versus post-storm) as a fixed effect and the individual toads as a random effect.

Results

Weather conditions during the study

During the first five days of the study, the weather remained clear and dry with daytime high air temperatures around 24°C, nighttime lows around 19°C, light winds under 20 km/h, and very little surf on the lake (Figure 3). On the evening of 4 September 2008, a strong storm with south winds up to 57 km/h brought waves high up the beach that altered or obliterated many of the minor features of the beach, including beach pools. Toads were inactive during the storm. The weather became variable after that, with alternating periods of sun and clouds, some showers, occasional thunderstorms, and winds up to 37 km/h. The temperature rose to 25°C as the storm hit, then fell to 15°C before oscillating between 17°C and 20°C for several days afterward.

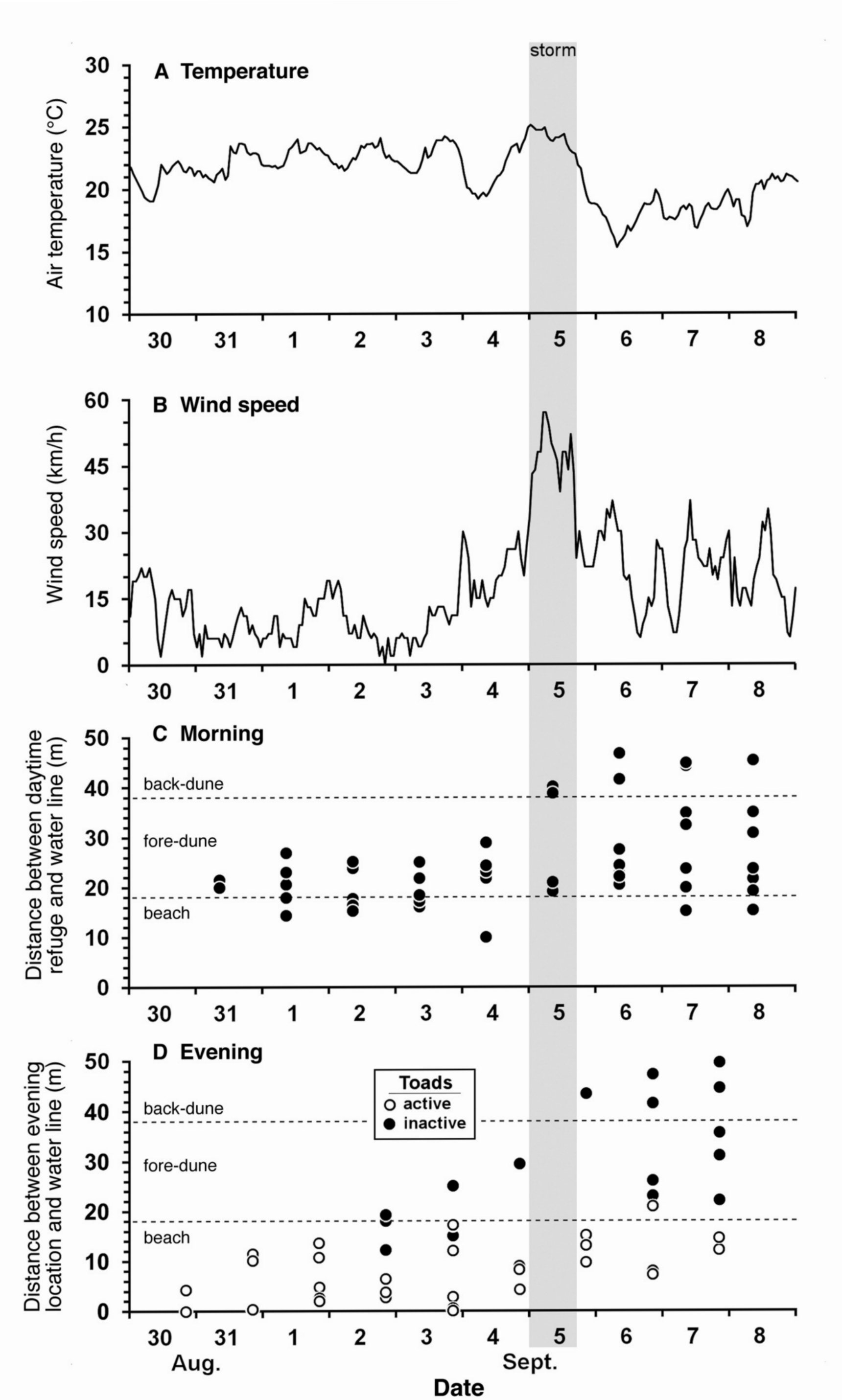

FIGURE 3. Weather conditions and locations of Fowler's Toads (*Anaxyrus fowleri*) relative to the Lake Erie water line at Big Creek National Wildlife Area, Long Point, during the study period (30 August to 8 September). The timing of a storm accompanied by high waves on the beach is indicated by the grey bar. A. Air temperature. B. Wind speed. C. Distance of daytime refuges of toads from the water line. D. Distance of evening locations of toads from the water line.

Toad movements and habitat use

We located and radio-tagged a total of 11 toads (Table 1), consisting of four females (mean ± SE SVL = 64.8 ± 3.0 mm) and seven males (SVL = 58.2 ± 0.4 mm). We were able to track two of these toads continuously for all nine days but the average number of tracking days was 4.7 per toad. Four toads managed to shed their transmitters, one after only a day, but we found two of these animals again, two and four days later. Four toads, with their transmitters, disappeared and could not be relocated. Three toads that had worn the harnesses for five days or more showed signs of abrasion behind the parotoid glands. Six transmitters were recovered at the end of the study.

For the most part, the toads moved within a limited area mainly travelling to and along the lower part of the beach on the damp sand at night and retreating to hiding places in the dry sand at the top of the beach and fore-dune during the day. Total distances travelled by toads during the study period ranged from 34 m to well over 600 m (Table 1). Daily average movements ranged from 14.2 m/day to about 125 m/day. Movements parallel to the water line ranged from about 11 m to over 440 m. Long-distance displacements of over 100 m by three toads occurred while they were active at night on the lower and upper beach. Toad 5 used the same hiding place consistently during the day for several days before embarking on an extensive trek 273 m westward. Toad 9 also exhibited long-distance movements parallel to the water line, traversing 441 m in two days, and then used the same refuge site for the next three days. Two toads were relatively sedentary: toad six moved only 26.7 m parallel to the shore over eight days, whereas toad eight moved 17.3 m over six days. Toads were found largely in areas characterized by relatively un-vegetated dunes and the absence of invasive Common Reeds.

Movements perpendicular to the water line were constrained by the width of the beach, but tended to increase after the storm as toads ventured further away from water to find daytime refugia (Figure 3). Before the storm, toads were located by day in refuge sites on the upper beach and fore-dune, on average 20.0 ± 0.9 m (n = 26) from the water line. Some of the animals used particular refuge sites, such as a hollow under a driftwood log, over many days or buried themselves in the sand to a depth of 3–5 cm, generally no deeper than the surface layer of dry sand. Most often, however, animals were found partly buried in dry sand with head and back exposed.

Following the storm, we noted a tendency for the animals to dig deeper into sand at refuge sites farther from the water line. Toad 3, for example, moved to the back-dune immediately after the storm was over, 11.3 m further from the water line, and dug down 60 cm into the sand. Toads 1, 6, and 8 also descended over 30 cm into the sand. Toad 9 moved 10.5 m further from the water line and toads 10 and 11 found refuges sites farther inland than any of the refuges used by any toads before the storm. The animals' daytime refuge sites were found an average of 29.2 ± 2.1 m (n = 25) from the water line after the storm, a significantly greater distance than before the storm (mixed effects linear regression: $F_{1,42.8}$ = 22.2, $P < 0.001$).

Discussion

Movement behaviour

Our results corroborate observations that Fowler's Toads inhabiting lakeshore habitats move on a daily basis between lakeside foraging sites at night and sand dune refuge sites during the day (Breden 1988; Marchand *et al.* 2017). Generally, the toads move very little, but there are occasional movements over larger distances, consistent with a generalized, fat-tailed Lévy-type distribution of movement distances (Marchand *et al.* 2017). Because the toads are evidently capable of travelling over 200 m in a day, dispersal movements

TABLE 1. Movements of Fowler's Toads (*Anaxyrus fowleri*) at the Big Creek National Wildlife Area, Ontario, over 10 days in August and September 2008.

Toad no.	SVL, mm	Sex	No. of days tracked	Distance moved, m		Extent of movement, m	
				Total	Mean/day	East–west*	North–south*
1	57.1	♂	9.0	229	25.4	57.1	22.9
2	62.2	♀	9.0	496	55.1	102.1	24.4
3	72.6	♀	9.0	164	18.2	40.2	45.2
4	66.1	♀	2.0	34	17.0	10.9	20.3
5	58.5	♂	4.0	377	94.3	298.1	19.7
6	58.4	♂	8.0	130	16.2	26.7	39.1
7	59.4	♂	2.0	78	39.0	71.7	13.3
8	59.7	♂	6.0	85	14.2	17.3	21.9
9	58.3	♀	5.0	623	124.6	442.2	17.0
10	57.8	♂	4.0	174	43.4	76.2	32.4
11	56.8	♂	4.5	78	17.4	26.7	49.6

Note: SVL = snout-to-vent length.

*East–west movement was parallel to the Lake Erie water line and north–south was perpendicular to the water line.

of many kilometres along the lakeshore in a season are feasible (Smith and Green 2006).

Pre-hibernation behaviour

After the storm, the toads appeared to be readying themselves for winter dormancy. Several animals appeared to respond to changes in weather conditions by shifting their movement and refuge-seeking behaviour to sites away from the more dynamic fore-dunes facing the beach to the protected back-dunes on the leeward side. We also observed that once individuals shifted their refuge sites further from the beach, they were less likely to resume their nightly nocturnal activity, foraging along the lakeshore beach. Instead they buried themselves deeper into the sand. None of these observed behaviours was apparent during summer (Boenke 2011).

It is possible that the high waves on the beach during the storm may have, in part, triggered this response. Natterjack Toads (*Epidalia calamita*) in Britain have been observed to shift refuge sites in response to tidal inundation (Denton and Beebee 1993). More probably, however, the combination of environment conditions, such as colder temperatures, increased rainfall, and decreased day length that appears to evoke pre-hibernation movements in other anurans (Koskela and Pasanen 1974; Miwa 2017) also contributed to the behavioural changes seen in these toads. Fowler's Toads at Long Point are not active in the spring at temperatures below 14°C (Green 1989, 2005); thus, the nighttime low temperatures following the storm approached the lower limits of the toad's normal activity range.

Based on our findings, it seems apparent that the active season for Fowler's Toads may typically come to an end in early to mid-September at the latitude of Long Point. As these toads typically emerge from hibernation in early to mid-May (Green *et al.* 2016), their active season lasts only about four months, compared with eight months of winter dormancy. Shifting their refuge habitat preferences to sites more likely to enable overwinter survival would appear to be a favoured adaptive response.

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The observed decline of Western Toads (*Anaxyrus boreas*) over several decades at a novel winter breeding site

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Abstract
The Western Toad (*Anaxyrus boreas*) population of the Atlin Warm Springs in northwestern British Columbia has persisted since at least 1924. An extraordinary feature of the population has been winter breeding in late February to early March, while nearby cold-water populations breed in late-May. Metamorphosis of tadpoles, enhanced by the warm water, occurs as early as late-March. In 2008, Amphibian Chytrid Fungus (*Batrachochytrium dendrobatidis*) was documented in toadlets at the warm springs. Until 2005, as many as eight egg clutches and 25 breeding adults had been observed at the warm springs, after which the population declined. In 2017, novel spring breeding occurred in a cooler pond in the spring complex. Future observations will help determine whether the population is recovering and whether breeding phenology and habitat use have changed.

Key words: Amphibian Chytrid Fungus; *Anaxyrus boreas*; *Batrachochytrium dendrobatidis*; breeding population; breeding habitat; northwestern British Columbia; Western Toad; warm springs

Introduction
Since at least 1924, the Western Toad (*Anaxyrus boreas*) population of the Atlin Warm Springs has received substantial attention from biologists and naturalists, inspired by the relatively dense population that bred in a small and discrete habitat near the town of Atlin, British Columbia. The population occurs at the most northerly latitude of the species' range (Matsuda *et al*. 2006; Slough and Mennell 2006; Slough 2013). Cook (1977) collated some of the records of Western Toads from Yukon and northern British Columbia, and Slough (2009) summarized additional observations and specimens collected from 1924 to 2009. Additional observations to 2012 were contributed by B.G.S. to the COSEWIC assessment and status report on the Western Toad, Non-calling population (COSEWIC 2012). An unusual feature of the warm springs population was that breeding occurred in late February through early March, while adjacent cold-water populations congregated to breed in a 2-week period from late May through early June after ice breakup (Slough and Mennell 2006).

Local residents of Atlin and Whitehorse have traditionally observed toadlets at the springs over the Easter holidays (i.e., shortly after the vernal equinox on 21 March). Early breeding, in late March, has also been reported for Western Toad populations at warm springs in Utah (Thompson 2004). Some toads in Utah did not hibernate and were active year-round. It is not known whether the toads of the Atlin Warm Springs hibernate or remain active in winter.

Methods
The Atlin Warm Springs is a cluster of geothermal springs that arise near Warm Bay on the east side of Atlin Lake in northwestern British Columbia (59.404°N, 133.575°W), 20 km south by southwest of the town of Atlin, and about 650 m from the lake (Figure 1). A second set of springs is located about 300 m to the west, and both drain into Atlin Lake. There are several underground sources of spring water, although most of the water emerges in three primary source pools. The largest source pool (≤10 m in diameter and 1 m deep) and several smaller pools (<0.5 m in depth), drain into a common stream. The largest pool was mechanically excavated for bathing.

The water is clear and odourless. Water temperature is 29°C at the large source pool, with pool and drainage stream temperatures 23–27°C at breeding sites in March and up to 29°C in summer. A single cooler spring-fed pond (15°C in winter) lies at a slightly lower elevation in the centre of the warm springs complex (spring 2017 breeding site in Figure 1). Shallow tufa (calcite) basins are present where the stream cascades downslope and runs underground for about 30 m. The tufa deposits are porous and may provide hibernacula, hiding places, and foraging habitat for Western Toads.

Annual growth of vegetation in the springs begins in March. Vegetation consists of green algae, Small Duckweed (*Lemna minor* L.) and introduced Small-leaved Watercress (*Nasturtium microphyllum* Boenninghausen ex Reichenbach). Lake Chub (*Couesius plumbeus*) in-

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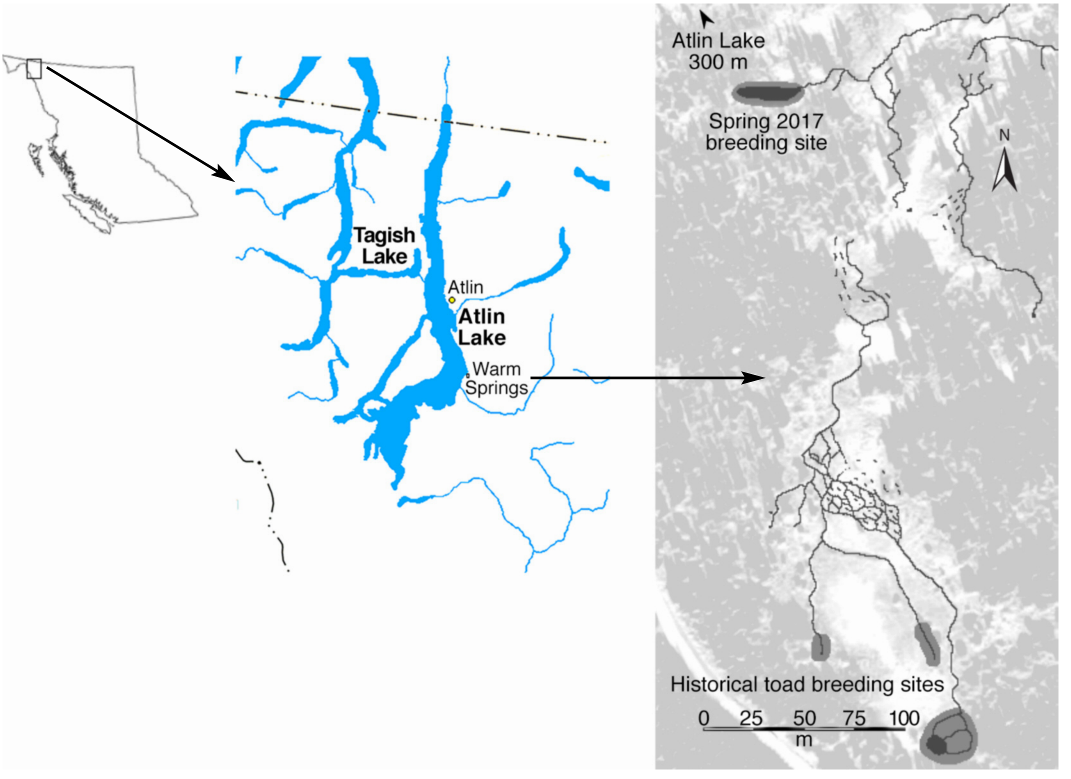

FIGURE 1. Atlin Warm Springs complex, northwestern British Columbia (59.404°N, 133.575°W), showing historical winter and 2017 spring breeding sites (grey shading). Breaks in streams indicate underground flow. Forest and meadows shown in background of spring complex with Imagery ©2018 DigitalGlobe, map data ©2018 Google.

habit the springs. We have observed Red Marshworm (*Lumbricus rubellus*), a potential prey of the Western Toad, to be abundant in the meadows surrounding the springs. Goldfish (*Carassius auratus*) were introduced to the western springs in about 2000 (S. Badhwar pers. comm. 11 March 2007), and Red Cherry Shrimp (*Neocaridina davidi*) were introduced to the eastern springs between October and December 2015 (A.dB. pers. obs.). Lake Chub and Red Cherry Shrimp are absent from the cooler pond.

Between 1996 and 2018, we searched for Western Toads in the Atlin Warm Springs using visual encounter surveys of the source springs, streams, and surrounding meadows (Table 1). The breeding sites and meadows encompassed about 1 ha and were surveyed in 1–2 h. Adults were rarely found far from water or outside of the breeding season. They may have dispersed from the site to other summer foraging habitats, or they may have gone underground into crevices created by the tufa. We also solicited observations from Environment Yukon and Environment Canada based out of Whitehorse. In addition, observations were made by A.dB. during a study of Lake Chub and Cherry Shrimp in 2017.

Results

Numerous observations of Western Toads at the Atlin Warm Springs from 1924 through 2005 indicate that a healthy breeding population persisted for at least 80 years (Table 1). After 2005, breeding activity and sightings of adults became sporadic, suggesting a population decline. Amphibian Chytrid Fungus (*Batrachochytrium dendrobatidis* [*Bd*]) was detected on Western Toad juveniles and adults from adjacent Atlin Lake in 2007 and on toadlets from the warm springs in 2008 (Slough 2009). Since 2005, observations have consisted of two clutches of eggs in 2008, one toadlet and one adult in 2012, and one toadlet in 2014. There has been no other evidence of breeding at the historical breeding sites within the springs in other years between 2006 and 2018. Three dead adult Western Toads were found in or near the springs on 7 March 2005, where at least four aggregations of recently hatched tadpoles were present. There was no obvious trauma to the dead toads.

Breeding behaviour, involving ≥25 adults and ≥8 egg clutches, was observed between 7 and 22 March in five years between 1998 and 2005 (Figure 2). Records of newly hatched larvae suggest that oviposition occurred during or before 4–10 March. Larvae that were

TABLE 1. Western Toad (*Anaxyrus boreas*) observations at the Atlin Warm Springs, northwestern British Columbia (59.404°N, 133.575°W), 1996–2018. Larval stages after Gosner (1960). Absence of data for some years indicate that the site was not visited.

Date	Eggs	Tadpoles	Terrestrial stages
Early April 1996	0	Numerous	0
22 March 1998	0	Wide range of stages (26–45), from early to near metamorphosis	0
12 February 1999	0	0	0
13 March 1999	≥8 clutches	Newly hatched (stage 20)	1 dead yearling; ≥6 adults, including 4 calling males and spawned female
9 March 2001	0	Early to mid-stages (20–30+)	≥25 breeding in 4 areas
7 March 2005	0	≥4 recently hatched aggregations (stage 26+)	1 male and 3 dead adults (1 frozen on land, 2 in stream)
21 March 2005	0	To stage 40	0
21 March, 3 June 2006	0	0	0
12 March, 19 April 2007	0	0	0
10 March 2008	0	~ 500 tadpoles (stages 26–30). Estimated: 2 clutches	0
10 May 2008	0	0	100s metamorphs (stages 44–46)
27 April 2009	0	0	0
6 April 2010	0	0	0
15 March, 2 July 2011	0	0	0
12 August 2012	0	0	1 adult, 1 toadlet (S. Stotyn, S. Cannings)
18 March 2013	0	0	0
28 June 2014	0	0	1 toadlet (S. Stotyn, S. Cannings)
20 June 2016	0	0	0 (S. Stotyn, S. Cannings)
16 May 2017	0	0	0 (J. Hobbs)
17 June 2017	0	3 aggregations, possibly from one egg clutch, downstream from traditional breeding sites	2 adults (A.dB., E. Titley)
25 February, 31 March, 27 May 2018	0	0	0 (B.G.S., A.dB.)

Sources: Observations by B.G.S. unless noted. Presence/absence data to 2012 were previously presented by Slough (2009) and COSEWIC (2012).

near metamorphosis (stage 45; Gosner 1960) observed on 22 March 1998 placed oviposition in mid-February using developmental times of Olson (2005). However, development may be more rapid in the warm water of the springs compared with cold-water habitats, as egg and tadpole development are largely temperature dependent (Matsuda *et al*. 2006). Western Toad eggs reportedly hatch within 3–12 days (Olson 2005) or 7–10 days (Matsuda *et al*. 2006) across the species' range. Goettl (unpubl. data 1996 as cited in Loeffler 2001) reported Western Toad eggs hatching in 5–7 days at 19°C with completion of metamorphosis 45 days post-breeding in the Southern Rocky Mountain population. Maxell *et al*. (2002) have reported time to hatching of ≤7 days in Montana, with metamorphosis ≤42–49 days post-oviposition. Metamorphosis may take up to three months in some systems (Olson 2005).

At least three clusters of tadpoles (possibly from one egg clutch) were observed at the only cooler pond within the Atlin Warm Springs complex on 17 June 2017, long after the late March to early April metamorphosis, which follows winter breeding (Figure 2). The tadpoles were not handled on site, but, from photographs, they appear to be at Gosner stage ≥30, indicating breeding in late May, as is typical for regional cold-water populations. Two adults were observed in terrestrial meadow habitat adjacent to the historical warm springs breeding habitat.

Discussion

Batrachochytrium dendrobatidis must be considered a factor contributing to the local population decline of Western Toads observed from 2006 to 2018. The fungus causes the infectious disease chytridiomycosis, a global threat to Western Toads across the range of the species (summarized in COSEWIC 2012). Water temperatures in the warm springs (average of 26°C in winter) are near the thermal maximum for *Bd* growth (26–28°C; Stevenson *et al*. 2013); however, the thermal tolerance of *Bd* strains is variable and the fungus is known to be adaptable to temperature conditions (Voyles *et al*. 2017). A temperate strain of *Bd* from

FIGURE 2. Western Toad (*Anaxyrus boreas*) tadpoles in the Atlin Warm Springs, northwestern British Columbia (59.404°N, 133.575°W), on 7 March 2005 (a) and 17 June 2017 (b). Photos: B. Slough (a) and A. deBruyn (b).

California grew well at 2–27°C and following freeze and heat shock treatments (Voyles *et al.* 2017). The Atlin Warm Springs are not likely a refuge from *Bd*.

The recovery of the Western Toad population of the Atlin Warm Springs may be limited by life cycle and reproduction. Females mature at 4–6 years of age, and most breed only once in their lifetime (summarized in COSEWIC 2012).

Climate change and severe weather are expected to have a low impact on Western Toad populations in British Columbia (Environment and Climate Change Canada 2016), although the predicted increase and frequency of droughts may threaten small wetland breeding sites and micro-sites used for rehydration (Provincial Western Toad Working Group 2011). Climate warming is expected to affect the phenology of breeding, larval development, and hibernation. In 2005, a single stochastic cold weather event during breeding did not appear to be the cause of mortalities and the subsequent population decline. In fact, March 2005 was relatively mild: daily mean −1.1°C, versus a long-term mean of −5.5°C for 1981 to 2010 (Environment and Climate Change Canada 2018; data from Atlin, British Columbia weather station, 20 km north-northwest of the Atlin Warm Springs). Nonetheless, activity during freezing temperatures, such as movements from hibernacula to breeding sites, places Western Toad at risk of exposure.

Amphibians including Western Toads are known to exhibit adaptive responses to climate change, such as adjusting breeding phenology in response to warmer temperatures (Blaustein *et al*. 2001; Urban *et al*. 2014). Other plastic responses include enlarged clutch size, more rapid growth and development rate, and increased survival. This plasticity is possibly shared by the Atlin Warm Springs population of Western Toads.

We can only speculate on the cause of the novel spring and cool-water breeding observed in 2017. Was the warm springs Western Toad population extirpated and re-colonized by individuals with cold-water breeding patterns and habitat preference, or did surviving toads switch phenology and habitat in response to unknown factors in the warm springs? Western Toad tadpoles were observed at four sites on Atlin Lake in 2017 (Hobbs 2018), where the population appears healthy. The aggregating behaviour of cold-water tadpoles along shallow shorelines, where the water is sun-warmed, has not been observed at the warm springs.

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Note

The use of an anthropogenic structure by Eastern Red-backed Salamander (*Plethodon cinereus*)

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Abstract
Eastern Red-backed Salamanders (*Plethodon cinereus*) are abundant in much of eastern North America. Although they typically live on the forest floor, individuals may venture off the ground while foraging. An adult salamander was observed using a backcountry privy as cover; after being displaced, it returned to the original location within 9 h. Furthermore, the salamander scaled a 50-cm vertical height to return to that location. The salamander may have been using the privy as part of its territory and feeding on flies attracted by the faecal matter inside.

Key words: Eastern Red-backed Salamander; *Plethodon cinereus*; homing; climbing; foraging; territoriality; Algonquin Provincial Park; Ontario

Lungless salamanders (Plethodontidae) are a diverse group of small forest- and stream-dwelling salamanders (Petranka 1998). Most species are strongly associated with forest floor habitats and cover, such as rocks and woody debris. Cover provides foraging opportunities and moist refuges that prevent evaporative water loss from the body (Spotila 1972; Jaeger 1980; Feder and Londos 1984).

Eastern Red-backed Salamander (*Plethodon cinereus*) is a common salamander in eastern North America and has been the subject of numerous ecological studies (reviewed by Petranka 1998 and Anthony and Pfingsten 2013). Jaeger *et al.* (1993) note its homing behaviour after being displaced, and many authors have documented its ability to climb (Jaeger 1978; reviewed in McEntire 2016). Here, I present an observation of a single Eastern Red-backed Salamander that used artificial cover, quickly returned to the location after being displaced, and climbed a vertical wooden surface to do so.

On the morning of 15 July 2017, I arrived on a small island in McCraney Lake, Algonquin Provincial Park, McCraney Township, Ontario (45°33'N, 78°61'W) to camp for the night. The maximum daily air temperature was 26ºC (minimum 14ºC, mean 20ºC). Of the 15 days leading up to the observation, precipitation fell on 10 days for a total of 55.6 mm, recorded at the weather station located at the East Gate of Algonquin Provincial Park (near Whitney, Ontario), ~50 km away (Environment Canada 2017). After inspecting the campsite, I proceeded to locate the privy, about 20 m away. At 1130 I lifted the lid and observed an adult Eastern Red-backed Salamander sheltering under the lid where the wood was in close contact with the seat. I moved the salamander to the forest floor, 1.5 m away. The following morning, at 0840, I returned to the privy to find that the salamander had returned to its exact original location.

The salamander was an adult, of the red-striped morph (Figure 1). I did not measure the snout-to-vent length or determine sex. I compared photos of the salamander from both days and used the pattern of small white head spots and markings on the tail to confirm that it was the same individual. Several slugs (Dusky Arion, *Arion subfuscus/fuscus* (Draparnaud, 1805)) and many flies were also found under the privy lid.

An Algonquin Provincial Park backcountry privy measures 82.5 cm (length) by 61 cm (width) by 51 cm (height), and has a hinged lid to allow the user to open and close it. The privy is constructed of Eastern White Cedar (*Thuja occidentalis* L.). Park maintenance crews inspect and repair privies regularly, and this unit was in good condition. No vegetation, sticks, or branches were touching the privy and, therefore, not aiding the salamander's climb.

Eastern Red-backed Salamanders have a relatively small home area, typically 0.16–0.33 m^2 (Petranka 1998). In addition, they have a well-developed homing ability; when moved distances of 30 m most individuals are able to return, some even over distances of 90 m (Jaeger *et al.* 1993). Therefore, it is not surprising that the salamander was able to quickly (within 9 h, and presumably less time, if activity is largely nocturnal) find its way back to its shelter; however, it also had to climb the vertical surface (51 cm) of the exterior of the privy.

Many lungless salamanders can make use of arboreal habitats and will climb vegetation and rock faces (McEntire 2016). Opportunistically, arboreal species, such as Eastern Red-backed Salamander, climb vegetation for several reasons. For example, Eastern Red-backed Salamanders that climbed vegetation had more food and larger prey items in their stomachs compared with those found foraging on the ground, suggesting

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Figure 1. a. Algonquin Provincial Park backcountry privy with open lid. Note the Eastern Red-backed Salamander (*Plethodon cinereus*) found under the lid (arrow) returned to this location, after being moved the previous day. b. Close-up of *P. cinereus* as found. The salamander was taking cover under the lid and possibly feeding on the abundance of small flies. 15 July 2017, Algonquin Provincial Park, Ontario. Photos: D. LeGros.

that climbing offers better foraging opportunities (Jaeger 1978). Salamanders may also climb vegetation to reduce predation risk or avoid dominant conspecifics on the ground (Roberts and Liebgold 2008). Although the extent of arboreal habitat use by temperate plethodontid salamanders is not well known, a growing body of work suggests that many species are using vertical habitats, such as plants, trees, and rock faces, more often than previously thought (McEntire 2016). Arboreal activity, like surface activity, in lungless salamanders is linked with wet conditions (LeGros 2013; McEntire 2016). Although the list of species and types of climbing continues to grow, little information is available regarding salamanders climbing human-made structures.

Adult Eastern Red-backed Salamanders are highly territorial and will aggressively defend territories from conspecifics to maintain access to quality food sources and mates (Jaeger 1982a; Jaeger and Forester 1993; Mathis *et al.* 1995; Petranka 1998). As the salamander in this observation was found under the privy lid during the day and quickly returned after being displaced, it likely included this cover as part of its territory (Mathis *et al.* 1995).

This observation is unique because the salamander established a territory 50 cm above ground, under artificial cover, which may have provided regular access to prey. An abundance of small flies emerged from the opened lid of the privy, most likely attracted to the human faecal matter contained inside. Although none of the flies was collected or identified, they were small and easily consumed by salamanders.

Dipterans are consumed by Eastern Red-backed Salamanders (Petranka 1998) and may make up as much as 10% of the diet of wild individuals (Jaeger unpubl. data, as cited in Jaeger and Barnard 1981). Eastern Red-backed Salamanders are capable of assessing prey quality and density and learn to forage optimally. In the laboratory, salamanders will use different foraging strategies when presented with low and high densities of two species of flies: for example, specializing in larger flies and ambushing them, rather than indiscriminately pursuing smaller flies (Jaeger and Barnard 1981; Jaeger *et al.* 1982b). Although it appears possible for Eastern Red-backed Salamanders to learn to take advantage of prey in high densities, they are not efficient patch foragers (Hill *et al.* 1982). Structurally simple environments with few obstacles and cover, such as the seat surface of the privy, improve the ability of the salamander to locate prey (Jaeger and Barnard 1981).

Although plethodontid diversity may be high in some regions of Appalachia, in central Ontario, Eastern Red-backed Salamander is the only representative of its genus (Petranka 1998). The lack of species diversity may allow this salamander the opportunity to expand its ecological niche in this region. In addition, the presence of privies throughout Algonquin and other provincial parks that offer backcountry camping opportunities may serve as an unintentional resource that concentrates invertebrate prey that feed on randomly distributed resources like dung. There are approximately 1900 similar privies located throughout Algonquin Provincial Park. According to several backcountry staff, who have checked thousands of privies over a span of many years, none has ever noted a salamander under the lid (three Algonquin Provincial Park staff members pers. comm. 11 November 2017). Although Eastern Red-backed Salamanders will defend a territory to access prey and mates, if the cover object is disturbed frequently, they may abandon the territory (Marsh and Goicochea 2003); thus, it is likely that salamanders do not occupy privies at regularly used campsites. Despite the lack of observations, privies could be a significant source of concentrated foraging opportunities for salamanders and other predators of insects.

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Observations of Mudpuppy (*Necturus maculosus*) bycatch in a recreational ice fishery in northern Ontario

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Abstract
Bycatch in fisheries is a well-explored topic, although less so in recreational fisheries. We encountered frequent bycatch of Mudpuppy (*Necturus maculosus*), a neotenic aquatic salamander that is active in winter, in passively baited ice-fishing gear targetting teleost fishes. We noted hook location in Mudpuppies captured by two hook types: J-hooks and circle hooks. Our prediction was that circle hooks would reduce the frequency of deep hooking of Mudpuppies, which is often cited as an important predictor of post-release mortality in fishes. We found no difference in the frequency of deep hooking of Mudpuppies captured by circle or J-hooks, although, in a subset of Mudpuppies (n = 13) held for 24 h after capture, one death occurred (8%). Further research may be necessary to determine whether deeply hooked Mudpuppies can pass or shed hooks and survive beyond the 24-h period we monitored. However, our findings suggest that anglers and managers should consider refinements to handling practices for Mudpuppies captured as bycatch, because they are likely to survive if handled cautiously. These results, which are among the first describing non-fish bycatch in recreational fisheries, call for managers and anglers who encounter Mudpuppies during recreational fishing to seek more information and educational opportunities to improve the fate of this important component of temperate freshwater ecosystems and ecological indicator species that is incidentally captured by ice fishing.

Key words: Mudpuppy; *Necturus maculosus*; fisheries management; winter biology; circle hook

Introduction
In many nations, recreational fisheries are more economically valuable than the commercial sector, with billions of fish captured annually by recreational angling (Cooke and Cowx 2004; Tufts *et al.* 2015). The methods used to target fish in recreational fisheries tend to be more limited than in commercial fisheries, as fishing is predominantly conducted by hook and line with various lures, flies, or baits used to attract fish to hooks. Although the gear selected by anglers is often chosen to suit a specific target species or group of species (Pope *et al.* 2016), the incidental bycatch of non-target fishes can be considerable, as is the potential for capture of non-target taxa. Freshwater bycatch is an emerging conservation challenge (Raby *et al.* 2011; Stoot *et al.* 2013), although the literature has been focussed predominantly on commercial fishing (e.g., Silva and Best 1996; Bell and Lyle 2016).

Little research has been carried out on ice fishing, a type of recreational fishery popular at higher latitudes (Deroba *et al.* 2007; Twardek *et al.* 2018). Ice fishing involves drilling or cutting through ice to gain access to winter-active fish. Typically, a hook is baited with live or cut bait and set using rod or passive lines at an appropriate depth for the targetted game fish. Most jurisdictions allow for more than one line per angler at any one time and this, combined with water conditions and hole size, make observation difficult, hindering angler-mediated selectivity.

Understanding the impact of fishing practices on captured species is necessary to achieve sustainable fisheries. Best practices in recreational fisheries can be implemented to minimize impacts on captured animals (Brownscombe *et al.* 2017). This includes appropriate selection of terminal tackle (i.e., hooks), which is often regulated by management authorities (Schill and Scarpella 1997; Cerdà *et al.* 2010). Circle hooks have been marketed as an effective tool for reducing mortality of captured fish by minimizing deep-hooking (Serafy *et al.* 2012). The circle hook is designed with the point oriented 90° to the shank so that it rotates when ingested by an animal and lodges more frequently in the lips rather than the gullet. Circle hooks are used in both commercial and recreational fisheries to minimize bycatch of non-target fish as well as other taxa such as marine turtles (Cooke and Suski 2004; Sales *et al.* 2010).

Mudpuppy (*Necturus maculosus*) is a species of neotenic freshwater salamander native to North American lakes and rivers. Mudpuppy activity is highest in cold temperatures, and they feed on many of the same prey items as game fish (Shoop and Gunning 1967; Beattie *et al.* 2017). Although not listed as at risk in most jurisdictions, including Canada (SARA Registry 2018), declines in population levels have been reported (Mifsud 2014; Harding and Mifsud 2017), and several United States agencies have granted them various conservation statuses (Matson 2005). Mudpuppies are long-lived (Bonin *et al.* 1995) and late to mature (Bishop 1943), likely making them sensitive to adult mortality (Congdon *et al.* 1994). Siltation and chemical pollutants (Bonin *et al.* 1995; Matson 1998, 2005) are likely chronic threats to local populations, and bycatch in recreational ice fisheries is a recognized but poorly quantified risk.

Capture of Mudpuppies by ice fishing is incidental in the winter, when Walleye (*Sander vitreus*) and other teleosts are targetted with baited hooks, often on passively set lines near the substrate where Mudpuppies are most active (Craig *et al.* 2015). Mudpuppies may ingest hooks on set lines, resulting in deep-hooking, a topic that has been extensively explored for teleost species and consistently demonstrated to be one of the most important predictors of post-release mortality in recreational catch-and-release fisheries (Muoneke and Childress 1994). Although Mudpuppies may be captured by recreational anglers, their presence in lakes may not be well known among anglers, and some anglers may cull them out of spite or misunderstanding of their ecological role (Craig *et al.* 2015). Retrieval, handling, unhooking, and release of Mudpuppies may be inconsistent among anglers with a poor understanding of the species biology, particularly without guidelines regarding best practices. Moreover, it is uncertain whether Mudpuppies captured and released through ice holes are likely to survive or if the retrieval, exposure to air and cold, handling, or hooking damage will lead to mortality.

In this study, we compare the hooking of Mudpuppies captured on two terminal hooking gears, circle hooks and J-hooks, and quantify the short-term survival of Mudpuppies released following recreational angling.

Methods

Mudpuppies were captured as bycatch (Figure 1) between 2100 and 0700 while fishing for Walleye on South Bay, Lake Nipissing, Ontario, Canada (46.2730°N, 79.8022°W). Between 10 January and 3 February 2017, we set passive lines using tip-ups, which have a spring-loaded mechanism for signalling the hooking of a fish that has struck a baited hook passively suspended beneath the ice. The sensitivity of these devices is set to detect the presence of larger teleost fishes that pull on the spool with more force than Mudpuppies; thus, the reliability of the flag signal to detect Mudpuppies was poor. Tip-ups were set 15–30 cm off bottom (depth ~7–8 m) with both circle and J-style hooks (Octopus 4 and Octopus circle 4; Gamakatsu, Tacoma, Washington, USA) baited with live shiners (e.g., *Notropis* spp.) and weighted with a 7-g lead sinker. Water temperature remained at 4°C in the hypolimnion layer where Mudpuppies were captured, while ambient air temperature varied from −19.4°C to 3.3°C during the study period.

Mudpuppies were landed by angling in approximately 20 s, with little variation among individuals. For each Mudpuppy that was captured, we estimated the length (to the nearest centimetre) and characterized the anatomical hooking location. Following practices of local anglers who captured Mudpuppies, we removed the hooks from individuals hooked in the lip and cut the lines on all deeply hooked Mudpuppies. The observation period resulted in about 45 s of air exposure. A subset of 13 Mudpuppies was transferred into conical holding pens (volume = 0.5 m^3) suspended beneath the ice at the depth at which the Mudpuppies were captured (~7–8 m). Nets were emptied after 24 h to determine Mudpuppy survival. No net held more than three Mudpuppies during an overnight holding period.

Because of this small sample size, statistical analysis was not feasible to determine drivers of mortality; thus, we simply provide accounts of the mortality. A χ^2 test was used to evaluate potential differences in hooking locations of Mudpuppies caught by circle and J-style hooks using the chisq.test function in R (R Core Team 2017).

Results

During an estimated 3655 rod-h on Lake Nipissing using both passive and active lines, we captured 80 Mudpuppies, ~0.02/rod-h. Although not quantified, most Mudpuppies were captured at night and on passive baited lines. For our study, we captured 48 Mudpuppies on passively set ice fishing lines. One of these was captured by a dead-stick (i.e., ice fishing rod passively suspending a baited lure) with a treble hook and was excluded from further description because of low sample size with this gear; however, this individual was hooked in the outer lip and survived. We were unable to measure most Mudpuppies because they responded to capture and handling by curling into a small ball. However, we estimate that most were ~18–22 cm long. At these sizes, they are not likely to be fully mature (McDaniel *et al.* 2009).

Only four of the 47 Mudpuppies (9%) were shallow hooked in the lips; the remainder had ingested the baited hook, which we assumed was lodged inside the stomach (Figure 2). There was no difference in the incidence of deep hooking with circle hooks compared with J-hooks ($\chi^2_1 < 0.01$, $P = 1.00$). Despite the high frequency of deep hooking, only one of 13 Mudpuppies died (8%) during the 24-h holding. This individual was captured using a circle hook and ingested the hook. All other Mudpuppies were released back into the water.

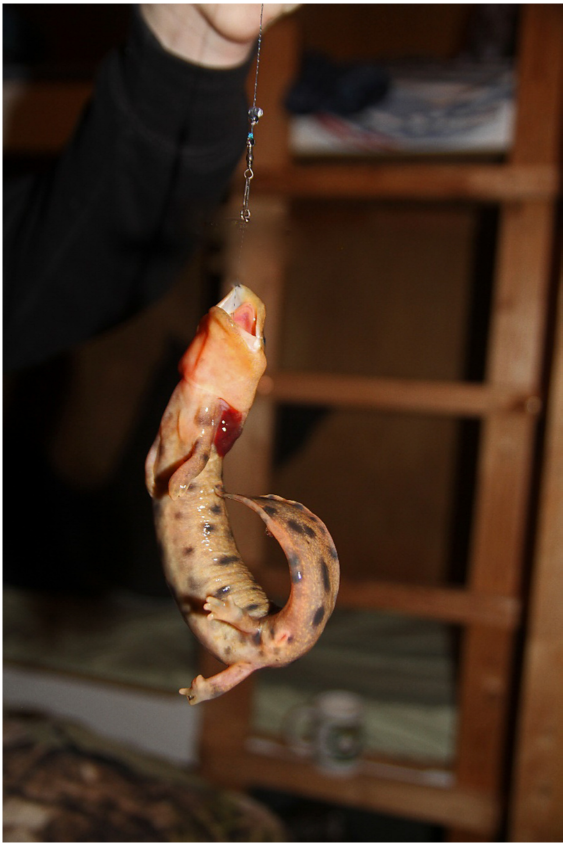

FIGURE 1. Mudpuppy (*Necturus maculosus*) captured by ice fishing in Lake Nipissing, Ontario, Canada. This individual was not included in the study, but is representative of the type of capture event investigated. Photo: W.M. Twardek.

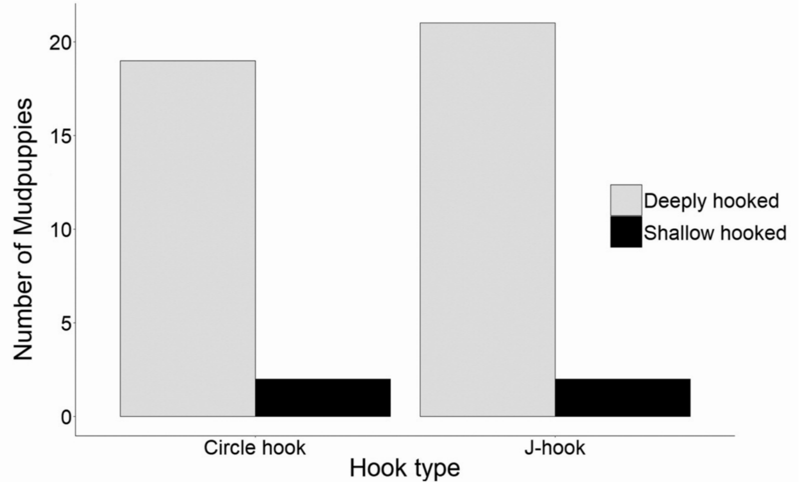

FIGURE 2. Hooking locations, characterized visually, and hook types observed to capture Mudpuppies (*Necturus maculosus*) while ice fishing in Lake Nipissing, Ontario, Canada.

Discussion

This was an opportunistic study of Mudpuppies conducted during an ice fishing project targetting Walleye, and sample sizes were small. However, it is clear that a large number of Mudpuppies may be captured and released by recreational anglers in winter ice fisheries. Our findings present the first evidence that Mudpuppies survive encounters with recreational anglers even when deeply hooked and call for additional research on the extent and impact of recreational bycatch of Mudpuppies.

Encounters with anglers in the fishery suggested that they were unfamiliar with Mudpuppies and unaware of their presence in Lake Nipissing, which is a prominent ice fishing destination. We observed some anglers capturing Mudpuppies and jettisoning them onto the ice to inspect them before we suggested that they cut the line and release them down the hole. We did not study the effect of prolonged exposure to sub-zero air temperatures, but given that Mudpuppies respire by lungs, gills, and through the epithelium, these external organs (gills and skin) may be sensitive to freezing temperatures and the formation of ice crystals on these structures could cause permanent damage. Additional research is necessary to determine the effect of cold air exposure, but presumably the most risk-averse and recommended behaviour would be for anglers to rapidly unhook (or cut) Mudpuppies from the line and release them back into the water with limited air exposure. This is consistent with guidelines for fish captured either incidentally or intentionally that are destined to be released (Cook *et al.* 2015), but could be more urgent at lower temperatures.

Relative to most fish captured by hook and line, the observed rates of deep hooking in Mudpuppies were high (Hühn and Arlinghaus 2011). This is likely related to the feeding ecology of Mudpuppies that use interlocked lips to suction-feed on prey (Gans and Nussbaum 1992). Some anglers targetting Walleye or other teleosts may insist on removing hooks from deeply hooked Mudpuppies; however, evidence from teleosts consistently suggests that hook removal from deeply hooked animals results in organ injury and bleeding, whereas cutting the line may allow the animal to pass or shed the hook (e.g., Weltersbach *et al.* 2016). Although we did not experiment with different hook removal techniques, our results suggest that cutting the line and releasing deeply hooked Mudpuppies results in infrequent short-term mortality. Further research may investigate whether survival is significantly different for hook removal compared with cutting the line. However, removing the hook from a deeply hooked Mudpuppy would most likely be fatal; thus, we only ever cut the line. Whether Mudpuppies can successfully expel a hook could be further studied using longer-term observations of survival or radiography (see Weltersbach *et al.* 2016).

In this study, we found that circle hooks did not reduce the frequency of deep-hooking Mudpuppies and, therefore, are not necessarily an effective means of improving the fate of Mudpuppies captured by anglers. However, larger sized hooks may preclude swallowing by Mudpuppies and their potential could be further investigated alongside a Walleye fishery to compare catch rates of Walleye and critical hooking rates of Mudpuppy. Observed high rates of deep-hooking are likely similar to those naturally occurring in the fishery but may be because of low sensitivity of the tip-ups, which were calibrated for detecting bites from Walleye.

Mudpuppies are an important component of freshwater ecosystems and are long-lived and late maturing, life history traits that make them vulnerable to overexploitation as bycatch in recreational fisheries (Matson 2005; Craig *et al.* 2015). Their presence in freshwater systems is a good indicator of ecosystem health (Craig *et al.* 2015), and their conservation should be a priority for those who work for natural resource management agencies, including fisheries managers, to ensure that they are covered in fishing regulations. Given that we frequently captured Mudpuppies while fishing for Walleye, a better understanding of the responses of Mudpuppies to angling may be necessary to provide recommendations to anglers who capture them, dispel myths about their negative interactions with gamefishes, and promote best handling practices so that Mudpuppies can be released from ice fisheries alive (Craig *et al.* 2015).

Author Contributions

Writing – Original Draft: R.J.L, W.M.T.; Writing – Review & Editing: R.J.L., W.M.T., S.J.C.; Conceptualization: R.J.L., W.M.T., S.J.C.; Investigation: R.J.L., W.M.T.; Methodology: R.J.L., W.M.T.; Formal Analysis: R.J.L.; Funding Acquisition: S.J.C.

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Book Reviews

Book Review Editor's Note: *The Canadian Field-Naturalist* is a peer-reviewed scientific journal publishing papers on ecology, behaviour, taxonomy, conservation, and other topics relevant to Canadian natural history. In line with this mandate, we review books with a Canadian connection, including those on any species (native or non-native) that inhabits Canada, as well as books covering topics of global relevance, including climate change, biodiversity, species extinction, habitat loss, evolution, and field research experiences.

Currency Codes: CAD Canadian Dollars, USD US Dollars, EUR Euros, AUD Australian Dollars, GBP British Pound.

Botany

Catalogue of the Vascular Plants of New York State, Memoirs of the Torrey Botanical Society, Volume 27

By David Werier. 2017. Torrey Botanical Society, New York Botanical Gardens. 542 pages, 35.00 USD, Cloth or E-book.

David Werier's recent *Catalogue of the Vascular Plants of New York State* presents an extremely thorough revision of previous New York state lists, resting on at least two centuries of botanical exploration and documentation. The volume incorporates comprehensive taxonomic updates, reflecting the significant research that has resulted in revisions at the species, generic, and even family levels. Importantly, older synonyms are well-indexed, which is very helpful in these days of frequently changing nomenclature.

The catalogue is the result of extremely thorough herbarium research by Werier, who personally reviewed and confirmed specimens of all but 107 of the 3922 taxa reported for the state. Werier has undertaken a dedicated and even dogged correction of previous misidentifications. In addition to the list of accepted taxa, the catalogue also contains an updated list of excluded and (helpfully) expected taxa. Werier has painstakingly documented his methods including rationales for inclusion, exclusion, and the inevitable cases of doubt. Specimen and sometimes barcode numbers are cited directly. There is also extensive documentation of hybrids. I have yet to find anything absent from the index.

It is interesting that in a populous state as well-botanized as New York, 24 native species have been added to the flora since 2003 (not including changes in taxonomic concepts). Tellingly, the majority of recent additions to the New York flora are non-native. It is the attention to non-native species that presents the greatest innovation in this catalogue. Unusually, Werier includes not only naturalized but also "not-naturalized" species in this category, meaning that he includes even those species that are not believed to persist over winter. He has created a unique and fairly effective method of categorizing these taxa, providing baseline information on each taxon's first documentation in New York, which may well be extremely valuable in the years ahead.

At times, one might wish Werier were a bit less comprehensive in this regard, as the "not-naturalized" flora includes even single waifs collected around grist mills in the 19th century. About half of his 1585 documented non-native species are "not-naturalized" (i.e., not persistent), or their status is unknown. In groups with large numbers of introduced species (e.g., Poaceae), the inclusion of these can be somewhat distracting, and Werier admits that the vast majority have little influence on the ecology of natural areas. Some inclusions are even an amusing stretch (e.g., Avocado [*Persea americana*] collected "from new compost"). But to be comprehensive is a worthy goal, and such distractions will probably prove insignificant compared to the long-term value of this catalogue.

If I had a wish for this volume, it would be the inclusion of a bit more ecological information and a map on New York's physiographical or ecological regions in the introduction, in order to place the checklist in context. It would also be helpful to see brief information on the abundance and range of each taxon within the state. With the hardcover volume already totalling 542 pages, one understands that space was limited. Admittedly, the catalogue is intended to be used together with the excellent New York Flora Atlas website (http://newyork.plantatlas.usf.edu) to which it is linked, and where one can find range maps. A catalogue such as this can spur botanists to document lesser-known groups, and Werier strongly encourages this. It seems likely that new discoveries and further iterations of this edition will follow.

This catalogue will appeal most strongly to the professional or serious amateur botanist. For botanists in regions of Ontario and Quebec adjacent to New York State, it offers many attractions. Plants know no jurisdictional boundaries, and this work provides a quick reference to determine the presence and conservation status of species and hybrids just across the border. This can offer some interesting surprises. I have also been using it as a quick hardcopy reference for its reliably current taxonomy and extensive inclusion of synonymy. Used with distribution maps of species in the online New York Flora Atlas, it can also point to species that are relatively common in New York, but which may be overlooked in adjacent areas north of the border. With its thorough inclusion of non-native species, it may (alas) offer a bellwether of things to come. And, more positively, it presents a tantalizing list of southern rarities for the dedicated botanical tourist. New York botanists are fortunate to have such a resource for their state for the foreseeable future.

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Flora of Florida Volume 5 (Dicotyledons, Gisekiaceae through Boraginaceae)

By R.P. Wunderlin, B.F. Hansen, and A.R. Franck. 2018. University Press of Florida. 303 pages. 69.95 USD, Cloth.

With the publication of Volume V of the *Flora of Florida*, this monumental project is half way there. There was a long pause after the 2000 publication of the first part (*Flora of Florida Volume I, Pteridophytes and Gymnosperms*, University Press of Florida) but a flurry of production has seen Volumes II through V released in the last three years (see reviews of the earlier volumes in Canadian Field-Naturalist 130: 248–249, https://doi.org/10.22621/cfn.v130i3.1890 and 131: 375–376, https://doi.org/10.22621/cfn.v131i4.2090). Two more volumes will need to be published to complete coverage of the pteridophytes, gymnosperms, and dicots. Then three more volumes treating monocots will still be required—so there is much ground to be covered yet. But with the half-way point reached, the authors' ambitious goal of having all ten volumes in print by 2020 may yet be achievable.

The vascular plant species of approximately 400 taxa in 34 families are treated here, including numerous species in major groups with northern components such as Ericaceae, Cornaceae, Rubiaceae, Sarraceniaceae, and Apocynaceae. The physical characteristics of each taxon presented in this sturdily bound, hard-cover book are described with precise but not overly technical terminology, presented in small but easily-readable type. This is particularly important because the text is unillustrated. Readers are encouraged to consult the on-line *Atlas of Florida Plants* (http://florida.plantatlas.usf.edu) for photos of most taxa and for more detailed range information than is provided by the adequate but brief summaries in the text. Nomenclatural detail is a strength of the *Flora of Florida* project in general and this volume is no different, with quite exhaustive synonymy being provided for many species. The 46 synonyms identified for Deerberry (*Vaccinium stamineum*) might be a record for any species treated so far!

As before, effective species identification keys, taken or updated from Wunderlin's *Guide to the Vascular Plants of Florida*, published in 1998 by University of Florida Press, are placed immediately after each genus description. Alphabetically arranged species treatments follow, each beginning with the aforementioned comprehensive synonym. The sheer number of rare and endemic taxa described in this volume dramatically underscores the remarkable biodiversity of Florida. Although there appear to be fewer subspecific taxa treated in Volume V than in earlier installments, the authors seem to strike a middle ground along the lumping-splitting spectrum. They do not accept recent fine splitting of some long-established and particularly complex taxa (e.g., *Opuntia humifusa*, p. 37). In most such cases at least, they explain their reasons for doing this and note alternative interpretations.

As with the other volumes, this treatment addresses many species that reach southern Canada and northern range limits seem to be reflected quite accurately for the most part. These treatments provide Canadian botanists with an interesting regional perspective and context "from away" which can be quite different from our own. The treatment of over two dozen species of milkweed (*Ascelpias*; pp. 212–224), for example, puts the smaller Canadian diversity of that genus into startling perspective, to say nothing of discussions of over a dozen pitcher plant (*Sarracenia*) taxa (pp. 102–108).

Let us hope the momentum for completing the *Flora of Florida* holds up and the remaining five volumes are indeed released by the end of 2020. For now, however, we can appreciate and celebrate this latest excellent contribution towards that goal of enumerating and describing the vascular plants of one of the most floristically diverse parts of our continent.

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Islands of Grass

By Trevor Herriot. Photography by Branimir Gjetvaj. 2017. Coteau Books. 224 pages, 39.95 CAD/USD, Cloth.

If you have always wanted to explore Grasslands National Park (GNP) in southern Saskatchewan but haven't managed to pull that off yet, get this book to see why you have to move it to the top of your 'Must See' list. But if you have managed to navigate across the vast ocean of Canadian prairie grain fields to visit that remarkable landscape, you should also get this book to remind yourself why that long, big-sky drive was worth it. Either way, *Islands of Grass* offers an accurate, visually stunning, and verbally inspirational portrayal of GNP and its sister native grasslands across the northern Great Plains.

I refer to GNP and sister native grasslands as separate entities; sadly, that is all too true. Less than 20% of the original native prairie grassland remains and less than 4% of that is in protective status. While we are quick to disparage overdevelopment and history of abusive land use in more heavily populated forested landscapes, especially in the east, the native prairie of western Canada actually constitutes the most ecologically reduced and imperilled of all major Canadian biomes.

But let's get back to celebrating it, which *Islands of Grass* is all about. At first glance it is tempting to treat this small, well constructed, and full colour volume as a 'coffee table' book. And it is, though much more as well. Gjetvaj's images are routinely wonderful and frequently breathtaking. I've had the good fortune of visiting GNP on three (far-too-short) occasions and the take-away feeling from those visits is demonstrably reflected in these images. Capturing the depth and size of prairie landscape in a photograph is really tough, as my innumerable lifeless attempts to do so document only too well. Somehow Gjetvaj achieves an almost three-dimensional quality in many of his images. Scanning his landscape vistas in *Islands of Grass*, one can almost hear the meadowlarks singing.

And reading Herriot's text, you can almost smell the locoweed (*Oxytropis*), sagebrush (*Artemisia*), and dust —with perhaps a *soupçon* of bison poop! His words are as illustrative and evocative as the book's photography. This is not a traditional "natural history of…" book but, nonetheless, it contains an abundance of well researched (and referenced) information on the evolution, significance, and ecology of native grasslands. Its discursive presentation means that you have to dig a bit to pull it all together, but you will learn a lot about native grassland dynamics, even if you thought you already knew a good deal about the subject. Herriot delves deeply into how native grassland sounds and feels, into the magic of the place, and how it can provide a reasonably perceptive visitor with a better perspective on their place on this planet. It's quite remarkable, really.

Appropriately, the book is dedicated to the late George Ledingham. For decades he was the doggedly determined inspiration for a grasslands national park. Herriot gives him full credit for his pivotal role and nicely captures the personality of this important resident of the grasslands. A pillar of the prairie naturalist community, Ledingham was elected an Honorary Member of the Ottawa Field-Naturalists' Club largely for his work towards the establishment of GNP (see Canadian Field-Naturalist 127: 76–81, https://doi.org/10.22621/cfn.v127i1.1414). It was disappointing and a bit surprising, however, not to see a photo of George in here, ideally out on the prairie, of course.

Islands of Grass employs insights into iconic prairie fauna such as American Bison (*Bison bison*), Black-tailed Prairie Dog (*Cynomys ludovicianus*), Kit Fox (*Vulpes macrotis*), sage grouse (*Centrocercus* sp.), and Burrowing Owl (*Athene cunicularia*) to describe and explain the nature, scope, and significance of change in this landscape. Not a lot of cheery news there, it must be said. Some, but not a lot. Accordingly, the conservation message is strong throughout the book. The ongoing important but currently losing battle to keep native prairie community pastures in public ownership, for example, receives considerable well-reasoned discussion and argument. It is not surprising to report that large scale agribusiness does not come off well in that discussion.

All this is expressed in Herriot's comfortable, unhurried, and discursive way, even if Chapter 5, "Possible Prairie", does seem to repeat the core conservation messages a bit too often. There is a tendency throughout to somewhat romanticize the conservation role of independent, multi-generational ranching and farming families, conclusions that seem a tad culturally biased.

Similarly, I don't think a negative word is expressed regarding Aboriginal activities, historic or contemporary, in regards to prairie land use or cultural attitudes. One need only to visit the remarkable Head-Smashed-In Buffalo Jump World Heritage Site in Alberta (another insightful place concerning the natural and human history of the Canadian prairies), however, to appreciate that land management by prairie people has always been directed by what was seen to be in their own best interest. Just like people everywhere. I would have liked to see the message more strongly expressed that effective conservation in the grasslands (or anywhere) is not driven by cultural affiliations or altruism but is fundamentally grounded in enlightened self-interest.

My favourite line in the book has got to be "whether you are a microbe or a buffalo, all flesh is grass" (p. 31). That pretty much makes the point, doesn't it? It all comes back to the grass, both in the prairie and in this informative and inspiring book.

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ENTOMOLOGY

Lady Beetles of the Northwest Territories

By Environment and Natural Resources. 2018. Government of the Northwest Territories. 75 pages, freely available (contact 867-767-9237 or NWTBUGS@GOV.NT.CA), PDF.

The best things in life are free—and sometimes they come from a government. In a world where we frequently speak of including and engaging people, we are pleased to see good examples of these actions. This book is an outstanding example. Although based on a deep analysis of scientific information, it can be used by both kids and scientists as a current and reliable source. And yes, it does include all 33 species of lady beetles (Family Coccinellidae) known to occur in the Northwest Territories (NWT).

Lady beetles are popular, not just because they are mostly attractive and friendly, but also because of their reputation for controlling garden pests. One of the major events in Inuvik every year (attended by the town's children and their parents) is the release of boxes of hundreds of lady beetles in spring to control pests (and avoid pest control using poisonous substances). This event occurs in the huge town greenhouse (a modified hockey rink) where all local communities in the Mackenzie Delta region of NWT have plots for growing a great variety of vegetables. Similar events occur in other larger northern communities.

Lady beetles are also part of the 'balance of nature'. Because they are frequently seen and easily identified, they can be helpful in monitoring the condition of the environment. Some kinds of lady beetles have become rare and have undergone rapid declines for reasons that are not entirely understood. Knowing more about lady beetles may be a step toward a better understanding of ecology in the north. Prior to this book there was nothing to help with the monitoring of this group of insects in NWT.

On the inside front cover of the book is written: "If you would like this information in another official language, call us". The nine official native languages used in NWT are listed. It is also available in French and the English version has a lot of French text. Flip to the inside back cover to find a list of helpful resources, including the complete Canadian context for this work and the major sources of information (the fit, the basis, and where to go further).

The first part of the book is full of valuable general information. It starts with a checklist of NWT lady beetles. This is followed by the characteristics and ecology of lady beetles. Morphological features are illustrated and can be conveniently found at the front of the book. These pages are used with the key and species descriptions and will be referred to often. This first part answers most of the questions people frequently ask. Did you know that the Transverse Lady Beetle (*Coccinella transversoguttata*), although not yet endangered, is considered to be a species of "Special Concern" by the Committee on the Status of Endangered Wildlife in Canada? This is because it has declined greatly in southern Canada, but in NWT large declines have not yet occurred. This is yet another indication of NWT having a less impacted environment than southern Canada (but note that effects of climate change may be more pronounced in NWT than in any other Canadian province or territory).

At the end of this general section is an unusual identification key to the species. This key is a series of alternative choices that lead to the identity of a species. What makes it unusual is that it is not technical and is based on features of easily evaluated colour patterns.

The species information, with a full page for each species, is half of the 75-page book. The layout of these pages is very well planned with an illustration of the insect colour and pattern in the upper left and a distribution map in the lower right. Information on various subjects is readily available under bold headings. Note that Yukon, northern British Columbia, and the northern prairie provinces border on NWT and this book will be useful in those regions and beyond.

Although it does not have an index, it is easy to make one. A checklist starting on page four is available for page numbers (on the left margin). I suggest that if you are going to be using the book a lot, just leaf through it and add the page numbers to this list. It is easily done because the species accounts are in the same order as the species in the checklist beginning with the Winter Lady Beetle (*Brumoides septentrionis*) on page 38. This is a pleasant way to develop some familiarity with the diversity of lady beetles.

What I like most about this Guide is that, like its companion guides listed below, it will inspire contact with nature and a better understanding of the Canadian north. These are a few of the things that we definitely need. It deserves an award!

See also:

Environment and Natural Resources. 2016. Butterflies of the Northwest Territories. Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, Northwest Territories, Canada.

Environment and Natural Resources. 2017. A Field Guide to Bumble Bees of the Northwest Territories. Environment and Natural Resources, Government of the Northwest Territories, Yellowknife, Northwest Territories, Canada.

PAUL CATLING

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Naïades et exuvies des libellules du Quebec : clé de determination des genres

By Raymond Hutchinson et Benoit Ménard. 2016. Entomofaune du Québec (EQ) Inc. 71 pages, 116 anatomical drawings, and 15 plates of illustrations (79 colour photos), 25.00 CAD, Cloth with spiral-binding and thick, semi-gloss paper for intensive use in the lab. Available from http://entomofaune.qc.ca.

This guide is most importantly a key to the determination of the genera (groups of similar species) of nymphs (naiads, larvae) of the dragonflies and damselflies of Quebec. As Michel Savard very correctly points out in the Foreword, an accurate name derived from a key is an essential starting point from which a huge amount of information on a species becomes available. This book was partly prepared to assist in the provincial survey aimed at developing an ongoing dragonfly atlas project in Quebec. It will be of value in all of eastern Canada and the adjacent United States where genera are similar.

The authors are in an excellent position to provide information on dragonfly larvae. Both have written many scientific and popular articles about dragonflies. Raymond Hutchinson has served for decades as the science teacher at the children's camp at Port-au-Saumon. Benoit Ménard is relentless in his hobby pursuit of dragonflies and uses his artistic talents to great advantage. All artwork in the book is his. Both authors have reared many hundreds of dragonfly larvae to adults in order to make a connection between features of larval skins and adults of many different species. They have popularized dragonflies with the public through popular articles, TV programs, radio and newspaper interviews, presentations, and workshops. In science and field biology they successfully promoted the study of dragonfly larvae which has led to new ecological understanding and discoveries of new species in Quebec. Author credibility varies among books, but this is as good as it gets.

On the back cover this book is advertised as a guide "for the Francophone naturalist". An informative book is one that anyone can benefit from regardless of language or how much effort has to be used to learn from it. This is simply an informative book that is in French because it is focussed on Quebec. I recommend it to the Anglophone naturalist as well because it is helpful for a region that is three times the size of Quebec to the south, east, and west. The essential part of the book, the key, is not difficult for anyone to understand. For example, it is easy to imagine that "première partie de l'antenne" means the "first part of the antenna". There are illustrations with arrows to help.

The book is valuable for many reasons. There is the issue of convenience. If you want to identify dragonfly larvae you will have to deal with the larger keys to genera in Needham *et al*. (2014) and Westfall and May (2006). This is because keys to larger geographic areas are longer and more complicated because of the increased number of taxa (many of which do not occur anywhere near the area of interest).

Then there is the question of why you might want to identify dragonfly larvae to genera at all. Well, dragonflies are useful bioindicators but at a particular time when you survey adults, not all dragonflies in the area will be flying because flight times for different species vary. Some will only be present as larvae while others will have already emerged for a secretive life in the forest canopy leaving only the empty exuviae (skins from larval transformation) as indicators of their presence. Only by surveying the larvae and the exuviae as well as the adults is a complete survey possible. This idea is emphasized by the authors and some evidence is available to support it (e.g., Catling 2003).

The introductory section is full of interesting information. Behaviour and ecology are well summarized. Some dragonflies are so secretive as adults that there is no other way to find them than to search for the nymphs and exuviae. Without understanding the larvae, you know only 10% of the dragonfly's life. This section also indicates how to distinguish dragonfly and damselfly larvae from other aquatic insects and from each other. It also describes how to catch the larvae (also called naiads or nymphs) using the preferred flat strainer net, which has revolutionized the collecting of aquatic insects (and was popularized by the authors). The first part of the book also contains a very helpful and informative overview of aquatic environments occupied by the different genera. There is information available for grouping Quebec dragonflies under habitats (e.g., Hutchinson and Ménard 2007a; Catling 2009; Hutchinson 2011) which may be outlined in an update.

The key is outstanding, based on the most easily used characters and with illustrations to assist in most of the decisions. Having identified a species to genus, it is necessary to return to the basic North American manuals which are referenced in the text (Westfall and May 2006; Needham *et al*. 2014), but by this time some of the most difficult work has been easily accomplished. If these latter North American manuals are not available, there are some other options for species identification. For example, Quebec (and northeastern North America) has many species in common with Michigan, so the online keys updated to 2017 in Bright and O'Brien (2017) will be helpful. See also Bright (2017) for *Ophiogomphus* nymphs. These keys sometimes employ different (and perhaps better) characters than the older keys in the larger manuals (and they are shorter).

Following the key are 12 plates of outstanding illustrations. The value of these in identification is substantial, whether careful line drawings or photographs of excellent quality. These pages contain 95 pictures and of course there are numerous illustrations elsewhere.

It is a very well illustrated book. The plates are followed by a useful glossary, list of major references, and a helpful index.

A companion update or a second edition for this book seems to be a good idea for three reasons:

(1) Although some groups (genera) are difficult and require more work, there are distinctive species in some of these genera that are easily identified. For example, the discovery of Maine Snaketail (*Ophiogomphus mainensis*) in Ontario was based on larvae which have the most distinctive antennae in the genus (Catling and Brownell 1999). Also, the discovery of l'épithèque de Brunelle (*Neurocordulia michaeli*) in Quebec was based on exuviae with a key to the latter in the Charest and Savard (2014) report.

(2) The members of some genera are easily identified and keys with illustrations have been produced for all that occur in eastern Canada. This is true for *Stylurus* (e.g., Catling 2000; Bright and O'Brien 2017).

(3) Along the same lines there is information on the ecology and characteristics of larvae, some especially referring to Quebec (and eastern Canada) that could have been mentioned here (perhaps in the list of genera and associated habitats). See, for example, Catling (2004) and Hutchinson and Ménard (2007b).

Making reference to this information, or better still, including it, would be helpful to the dragonfly survey effort. It seems unfortunate not to make some useful information available only because it cannot be complete for some groups.

This work will further promote the study of dragonfly larvae, something that the authors have been doing for a long time. It is excellent and valuable, and yet another important contribution from two outstanding Canadian field biologists.

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A Field Guide to Insects of the Pacific Northwest

By Robert Cannings. 2018. Harbour Publishing. 7.95 CAD, Pamphlet.

This field guide is a handy little pamphlet that interested naturalists can easily bring anywhere with them to help identify common insects around the Pacific Northwest. The field guide starts with a small amount of information about what an insect is, how insects grow, and why insects are important. It has attractive macro photos of 55 species (although the publisher's website [Harbour Publishing 2018] says there are more than 60) organized in 19 taxonomic orders. A very short description of the species (or sometimes, of the order) next to each image provides a bit of background about the species. Its glossy, laminated finish would stand up to some light precipitation, but would not last in any significant rain. This field guide is clearly targetted towards amateur naturalists interested in learning some of the basics about insect ecology and identification in the Pacific Northwest and, from that perspective, it is excellent.

The author, Dr. Robert Cannings, is Curator Emeritus of Entomology at the Royal British Columbia Museum, where he has been studying insects since 1980. His main interests are in dragonflies and robber flies; he wrote the handbook to dragonflies of British Columbia (Cannings and Stuart 1977).

Given its target audience, this is not an exhaustive field guide. It lists between one and nine species for each taxonomic order; five taxonomic orders with rare or hard to see species were not included. According to the publisher's website, the species that were chosen are common but not familiar, the goal being to introduce amateur naturalists to the diversity of insects within the region. From this perspective, the author did an excellent job choosing insects, focussing on interesting native species that an amateur naturalist is likely to come across if they were actively looking for insects. For example, within the Order Hymenoptera (Sawflies, Wasps, Bees, and Ants), the guide lists the Western Bumble Bee (*Bombus occidentalis*) and Blue Orchard Bee (*Osmia lignaria*), but not the Western Honey Bee (*Apis mellifera*), even though most members of the public would think of a honey bee when they think about bees. The guide focusses on the wonderful native bees of the region rather than listing the well known, yet introduced, Western Honey Bee.

While this guide is an excellent introduction to the diversity of insects in the Pacific Northwest, it does not contain the information that is typically expected from a field guide. Nonetheless, it is a good resource for amateur naturalists interested in learning about the insects in this region.

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ZOOLOGY

A Natural History Study of Leech (Annelida: Clitellata: Hirudinida) Distributions in Western North America North of Mexico

By Peter Hovingh. 2016. Alphagraphics. 460 pages, freely available, print or electronic (DVD). "This is a free and public available document for the benefit of naturalists, scientists, those who manage natural resources, and the curious." For a copy, contact Alphagraphics, 9247 South State Street, Sandy, Utah, USA, 84070.

Specifically for Canadian field biologists, this work will serve as a standard and current reference for freshwater leech occurrence over a large area of western Canada. Recent works for other parts of Canada include Madill (1988), Ricciardi (1991), Grantham and Hann (1994), Schalk *et al*. (2001), Madill and Hovingh (2007), and Langer *et al*. (2018).

In general, this is also a major contribution to the distribution and taxonomy of leeches. It began with the purpose of determining the geographical distribution of freshwater leeches and possible aquatic connectives explaining this distribution. It was initially aimed at the question of which leech fauna occurred in isolated springs of the eastern Great Basin and how and when the leeches got there. These and related questions are discussed in detailed sections on high elevation, the Pacific Coast, Columbia-Snake River drainages, the Great Basin, the Colorado River Basin, and the Western Great Plains.

The basic tools of analysis are geography, fish distributions, and drainage basins. It will be of interest to Canadians that the collections from field surveys supporting the work in Canada and Alaska are at the Canadian Museum of Nature, Ottawa (CMN-A). There are eight main sections. Those of most interest to Canada are the first and third sections: 1. Species descriptions and distributions; and 3. Latitudinal postglacial movement. Each section has a table of contents, abstract, introduction, methods, contents, and a comprehensive and very useful list of references.

"Species descriptions and distributions" includes distribution maps for 48 species followed by notes on 38 species accounting for distribution, taxonomy, and distinctive features. Distributions are thought to have developed in the Cretaceous period with differentiation of genera in the Paleocene epoch. The maps and information are current, but illustrations of the leeches are also useful in recognition. These illustrations are derived from one of the classic identification tools of Klemm (1982), which is available by online request (see Literature Cited, below). The text on individual species provides specific information on distributions. The distribution of the Fish Leech (*Piscicola geometra*), for example, is noted as congruent with that of a major host, Northern Pike (*Esox lucius*), and collection data for Canadian collections is in the appendix on page 187.

The taxonomic details are helpful. It is noted, for example, that previous ecological and distributional studies of *Theromyzon rude*, previously the North American bird leech, cannot assume the correct name unless reproductive organs were examined and described. This means that the very high levels of parasitism of waterfowl reported north of Yellowknife by Bartonek and Trauger (1975) may have involved another species, despite the fact that these authors were careful with identification at the time (see discussion of identification in Trauger and Bartonek 1977). The high levels of parasitism by *Theromyzon* and the fact that more species of waterfowl had been reported as parasitized by leeches in the Northwest Territories than anywhere else in North America (Trauger and Bartonek 1977 published a map) is still of interest, but the need for correct names in retrieving scientific information makes it important to track the changes and redefined species. For *Theromyzon* it will be helpful to consult the work of Oosthuizen and Davies (1992, 1993) and Davies and Oosthuizen (1993). The latter includes a helpful chart for the identification of all North American species.

In "Latitudinal postglacial movement" it is suggested that five leech species may have occurred in unglaciated Beringia, and four species may have occupied glacial refugia on the west coast from Haida Gwaii northward. Postglacial colonization followed dispersal patterns similar to those of fish. Spread from postglacial refugia in eastern Canada has been discussed elsewhere (Madill and Hovingh 2007). An interesting story is associated with the leech *Cystobranchus mammillatus*, which is hosted by the Eurasian Burbot (*Lota lota lota*). This fish subspecies occurs east to the Mackenzie Delta but the North American Burbot (*Lota lota maculosa*) occurs north to Great Slave Lake. Very little mixing has been reported in the Mackenzie River Basin. It seems possible that the North American subspecies reached the basin from the unglaciated territory to the south (Missouri-Mississippian), whereas the mainly Eurasian subspecies occupies its unglaciated Beringian territory. In North America, the leech has thus far been reported only from the Mackenzie Delta. Could it be a true disjunct (from western Siberia) surviving in the relatively mild delta region, and lost from the intervening territory as a result of Pleistocene climatic extinctions? To the remarkable fauna of the Northwest Territories, we can add (at least for now) a fish leech that is found nowhere else in North America.

This work is full of interesting material. As well as being a very helpful source on the natural history and taxonomy of leeches, there is detailed coverage of geological and climatic history and the distribution and taxonomy is updated over the classic work of Klemm (1985) and others. Much of what has been written about North American leeches is referenced here making the work a useful foundation for a better understanding of a fascinating group.

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OTHER

The Inner Life of Animals: Love, Grief and Compassion – Surprising Observations of a Hidden World

By Peter Wohlleben. Translated from the German by Jane Billingshurst. 2017. Greystone Books. 277 pages, 24.95 CAD, Cloth.

The book has not one but two subtitles: "Love, Grief and Compassion – Surprising Observations of a Hidden World". In general, subtitles give me negative feelings, but as everything has them nowadays I have given up caring. Of the three versions of the title, I think the third is the least appropriate. For most naturalists there is not a lot here that is likely to surprise them. The book is a collection of anecdotes and observations, some commonplace, some very astute, about animal behaviour. They derive in part from the author's own observations on a farm and woodlot in Germany and in part from an eclectic selection of readings in the press, on the web, and—to a lesser extent—in the popular and peer-reviewed scientific literature. Only 23 of 101 references are to original scientific papers. A foreword by Jeffrey Moussaieff Masson gets big billing on the cover but consists of only four pages.

The author begins with a few tart comments on the sins of 'scientists'. He is seconded in these opinions by the aforementioned Masson. Like many other writers, they want us to believe that science is obscuring the truth about animal intelligence, not through malice, but through blind adherence to antiquated 'science-think'. This is certainly a widespread belief and one that contributes to the general distaste for 'expert' opinion. It is unfortunate, because I think many of the author's criticisms are aimed at straw wo/man thinking characteristic of the 20th, rather than the 21st century. His avowed intent is to "help you see the animal world… not as mindless automatons driven by an inflexible genetic code [apparently his idea of science-think], but as stalwart souls and lovable rascals". Does he succeed?

Overall, if anyone did believe in the 'mindless automatons' interpretation of animal behaviour, then I think this book will certainly help to disabuse them: spending any substantial amount of time observing animals in the wild or even pets in our homes will do the same. Animals undoubtedly have the capacity to love and hate, to cheat and act remorseful, to show fear, bravery and indecision, to be selfish and selfless and everything in between. If you are looking for examples of such behaviours, then this book is a good place to start. I certainly gleaned many tidbits of Natural History that I was not aware of.

Among the different animals covered, bees, chickens, goats, dogs, and horses get plenty of coverage, as they belong to the author's household. He gives a good shout-out for pigs, which I was glad to see because I always feel they don't get their dues as truly intelligent and sensitive animals, a fact that forced me to renounce bacon in later life. The author also writes a good deal about ravens and crows, which he posits as "the apes among birds". I particularly liked his description of a crow being evasive about caching an acorn while being watched. I have had an identical experience trying to watch ravens caching seabird eggs: they won't do it as long as anyone else, human or raven, is watching.

Sy Montgomery, author of *The Soul of an Octopus* (Atria Books 2015), says on Amazon that *The Inner Life of Animals* "will rock your world". If you are an experienced naturalist, that is unlikely to be true, but if you know someone who likes kitten videos on YouTube (and there are millions of them, both viewers and videos), but does not know a lot about animals otherwise, then this book might make the perfect gift. The book was published in collaboration with the David Suzuki Institute and supported by the Canadian and British Columbian governments, as well as, more obscurely, by the Canada Council and British Columbia Arts Council, and printed in Canada on ancient-forest-friendly paper.

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The Subjugation of Canadian Wildlife: Failures of Principle and Policy

Max Foran. 2018. McGill-Queen's University Press. 439 pages, 39.95 CAD, Cloth.

THIS IS A VERY IMPORTANT BOOK. The title of the book very aptly sums up its contents. It is not a balanced account of wildlife management in Canada but a polemic about its failures. As such, it is an uncomfortable read for (full-disclosure) an ex-employee of Environment Canada. I began by being very resistant to the central message of the book: that our failure to protect Canadian wildlife stems from a "homocentric" approach to nature, but by the end I was, if not converted, at least much more respectful of the author's arguments. Moreover, his contentions are extensively documented in 120 pages of small-type notes and bibliography, so these are well-founded arguments.

The book is in two sections: Part 1 deals with our "belief system" relating to nature and how it manifests itself in the treatment of predators, especially apex predators (wolves, grizzlies, and Cougars [*Puma concolor*]), as well as 'other wildlife' exemplified by the contentious spring hunt for Black Bears (*Ursus americanus*), Ontario's Mourning Dove (*Zenaida macroura*) hunt, and the notorious Newfoundland seal hunt. Part 2 deals with wildlife habitats and how we manage them, including a very useful discussion of the various legislative tools available to the Government of Canada, the provinces, and the territories and how they are being applied (or misapplied). This section deals at length with the *Species at Risk Act* (SARA), where Environment Canada is the villain of the piece, as well as with the establishment and management of protected areas, in which Parks Canada is featured as a major sinner. Among the good guys exposing the sins of the bureaucracy, Ecojustice and the Canadian Parks and Wilderness Society feature prominently.

Two themes run through the book: the first is the idea that animals, at least higher vertebrates, have a capacity for suffering that should require more humane treatment by us than is currently the norm. This theme echoes, in a more formal and scholarly manner, the concerns of Wohlleben's book covered in the previous review (Canadian Field Naturalist 132: 76, https://doi.org/10.22621/cfn.v132vi1i.2127). In fact, the two books make an interesting contrast in styles, with Wohlleben trying to convince us gently and humorously to be nicer to animals, while Foran hits us on the head with a two-by-four.

The second theme is the over-riding influence of economics, in the form of human security, jobs, and profit, in determining the outcomes of human-wildlife conflicts. This is hardly news, but the very detailed descriptions of events surrounding the cases of the Black-tailed Prairie Dog (*Cynomys ludovicianus*), the Greater Sage-grouse (*Centrocercus urophasianus*), the Nooksack Dace (*Rhinichthys cataractae* – Chehalis lineage), the Southern Resident Killer Whales (*Orcinus orca*), and others, highlight the sort of wilful blindness that goes into attempts to satisfy both economic and environmental interests. These sections would be very valuable reading for any politicians or public servants engaged in implementing SARA. They illustrate the fact that, in a society where information is readily available, decisions are open to the judgement of history.

I did have some caveats about the book. In a work that deals, among other things, with the ethics of hunting, the word 'meat' never appears. Nor was our relationship with pets or domestic animals discussed. But the belief system that the author laments, in which animals are treated as disposable resources, surely stems from our carnivorous habits. The heavy hunting of Moose (*Alces americanus*) in Newfoundland, for instance, treated as inhumane culling in the book, provides a very important element in the local diet. The same goes for deer hunting in Haida Gwaii and doubtless in many other places, even ignoring the obvious needs of indigenous peoples, especially the Inuit. Culling—the killing of animals to adjust ecosystem imbalances—comes in for much criticism, but the many cases where unique local ecosystems are being very clearly degraded by introduced species (e.g., rats or Raccoons [*Procyon lotor*] on seabird colonies, deer on Anticosti Island) are not considered. In fact, the author casts doubt on the validity of any sort of cull carried out with a view to rebalancing the ecosystem, claiming we do not have sufficient knowledge of ecosystem dynamics.

For me, among the most distressing shortcomings of our attempts to conserve wildlife in Canada is the fact that, despite the vast size of the country, many of our protected areas are too small to support viable populations of large mammals. You have to ask yourself whether, if a large country like Canada, with a well-educated population, generally inclined to look favourably on wildlife, cannot manage its wild species sustainably, what hope is there for the planet as a whole? The wake-up calls have been so loud, for so long, that our brains no longer hear them. Perhaps that is why Max Foran felt he had to adopt such a strident tone in this book. It is a very sobering read.

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Half-Earth: Our Planet's Fight for Life

By Edward O. Wilson. 2017. Liveright Publishing Corporation. 272 pages, 25.95 USD, Cloth, 16.95 USD, Paper.

In *Half-Earth*, renowned entomologist and conservation biologist Edward O. Wilson argues for why we should protect half of Earth's surface in order to conserve biodiversity. Earth's biodiversity is disappearing at the fastest rate in history, and this high extinction risk is linked directly to human activities, including habitat loss and overexploitation. And because we have yet to describe all species on Earth, it is likely that a large number of species will go extinct before we have the chance to describe them. E.O. Wilson has led a career filled with discovering species new to science, so he is well suited to describe and champion the race to describe life on this planet before it disappears. But the goal isn't simply to have the opportunity to describe species and learn more about the natural world around us. The goal is to preserve biodiversity because it is the ethical thing to do, species extinction has cascading effects within ecosystems which are difficult to predict, and because biodiversity benefits humans in countless ways.

In this book, Wilson first describes the conservation challenge (i.e., species are going extinct more quickly than we can discover them). He then describes the diversity of life that we do know, showing examples from a wide range of taxa. Finally, he makes a case for why we need to preserve half of Earth's surface, and makes recommendations for key areas that we should preserve. Unlike other recommendations (e.g., Aichi Biodiversity Targets, https://www.cbd.int/sp) for how much area needs to be preserved, Wilson uses the ecological concept known as the species-area relationship to back-up his recommendation. According to the species-area relationship, if half of Earth's habitats are preserved, then 85% of Earth's current biodiversity will not go extinct, at least not from the loss of habitat or overexploitation within that habitat. This does not account for other threats, such as climate change, but rather focusses on habitat loss, which is the greatest threat to biodiversity. Wilson does allude to these other threats in this book, but they are not the main focus of the Half Earth argument. It is fitting that Wilson uses the species-area relationship to back-up his thesis, because he is well known for using the species-area relationship in his seminal work with Robert MacArthur, the theory of island biogeography. The species-area relationship has been shown countless times in nature, so its utility for the Half Earth argument seems sound.

My main critique of this book is that it mostly focusses on terrestrial biodiversity. Wilson is a terrestrial ecologist, so he likely focussed on the aspect of biodiversity with which he was most familiar. It could even be argued that in a popular science book such as this, it is probably better to use examples from areas that the readers are most familiar with (i.e., on land, rather than in water). However, it is likely that the greatest number of undiscovered species live in marine environments. Wilson does give a few marine examples, especially in Chapter 13, "The Wholly Different Aqueous World", where he focusses on the marine world and provides examples such as the number of invertebrate species that can be found just within the surf along a beach. However, in Chapter 15, "The Best Places in the Biosphere", all the examples are focussed on the terrestrial biosphere. I believe that this book would have benefited from a more balanced perspective on biodiversity, such that the preservation of half Earth doesn't just come across as preservation of half of terrestrial Earth, with almost no mention of aquatic Earth. Wilson could have spent more time focussing on how to achieve conserving half of Earth. Indeed, a quick web search reveals counter opinions that half of Earth is too much to conserve. As well, Wilson could have led readers through the process of achieving half Earth. Current conservation targets, such as the Aichi targets, aim for 17% of terrestrial area and 10% of marine areas to be protected by 2020. Many countries are struggling to meet these targets, let alone protecting 50% of the planet. Wilson does provide some guidance on which areas should be preserved, specifically aiming at biodiversity hotspots and areas with unique biodiversity, as well as promoting corridors connecting such areas. These are useful suggestions, but are not that different from suggestions for the Aichi targets.

This book will be an excellent read for anyone who wants to understand the current conservation crisis, learn more about biodiversity, or simply read a well-written book about the natural world.

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Best Places to Bird in the Prairies

By John Acorn, Alan Smith, and Nicola Koper. 2018. Greystone Books. 266 pages, 24.95 CAD, Paper.

I was looking forward to reviewing this book because I am not that familiar with birding sites in Saskatchewan and Manitoba; however, I also learned of a few new sites in Alberta, such as Gull Lake and the Alberta Grain Terminal in Edmonton (think Prairie Falcons [*Falco mexicanus*] and Gyrfalcons [*Falco rusticolus*] attacking all of those Rock Pigeons [*Columba livia*] feeding on spilled grain). This is the second "Best Places to Bird …" book (see my review of the Cannings' book on British Columbia in Canadian Field-Naturalist 131: 85, https://doi.org/10.22621/cfn.v131i1.1974) by Greystone Books—perhaps a series is in the offing?

Of course, any 'best of' book will leave out some of the reader's favourite places. One such place for me is Waterton Lakes National Park, where one can bird from prairie grasslands to the alpine in a single day. However, I cannot quibble with any of John Acorn's choices as great places to go birding. The Alberta chapter does not seem to have any geographical order to the sequence of sites, so it is harder for birders to read up on good areas in proximity to where they are. The Manitoba section is also quite random, while the Saskatchewan section handles this much better. There is a two-page map spread of the three provinces immediately after the table of contents, with the sites named and numbered. The relevant map is then repeated in advance of the descriptive section for each province.

Each chapter covers a site and begins with a general description of why it's special, often with personal anecdotes from the author. This is accompanied by at least one excellent photo of a species described therein. That is followed by a more detailed "Birding Guide" that describes what species you might expect to find, where, and in what season. The "Getting There" section is often longer than the "Birding Guide", with lots of detail, which is helpful because many of these areas will not be found on provincial road maps (and I suspect your vehicle's navigation system might not be much help in some areas either). There is an excellent detailed map for each site which uses "terrain" view, showing streets and roads, rather than just a sketch map. There is some repetition between these two sections, but I'm not sure it could have been handled any differently.

I noticed a few typos and other errors: the photo of a Harlequin Duck (*Histrionicus histrionicus*, p. 128) is captioned as an adult male but is actually a subadult male, which is also the typical age class to be found east of the breeding range. Right and left forks of the road were mixed up in the road description on page 139. And Archie Belaney was known as Grey Owl, and may have been great, but was not known as Great Gray Owl (p. 161; probably a result of relying on the computer's spell checking function). The map of Beaudry Provincial Park (p. 208) does not label the "prairie trails" which are referenced in the description and which could be helpful. There is occasional inconsistent use of plurals of bird names throughout the book; for example, a sentence that references Canvasbacks (*Aythya valisineria*) in the plural and Ruddy Duck (*Oxyura jamaicensis*) in the singular (p. 241). An additional resources chapter, with websites, birding hotlines, agency/site phone numbers, etc. might have been helpful.

With the exception of Churchill, Manitoba, the book really only covers the southern third of the Prairie Provinces…but then that is where most of the access is, and the most habitat diversity. And that is where most of the human population lives and visits. If you are planning to visit any of these three provinces, or even if you live there but want to explore new areas, this guide will definitely help you to maximize your birding experience.

CYNDI M. SMITH
Canmore, AB, Canada

Deep Into Yellowstone: A Year's Immersion in Grandeur and Controversy

By Rick Lamplugh. 2017. CreateSpace Independent Publishing Platform. 294 pages, 15.95 USD, Paper.

Deep Into Yellowstone is a fascinating read about Rick Lamplugh's year-round experience of living at the gateway of Yellowstone National Park. After having volunteered in the Lamar Valley for three consecutive winters at the historic Lamar Buffalo Ranch from 2012 to 2014, and writing his first tome *In the Temple of Wolves* (self-published 2013) about that experience, Rick and his wife Mary decided to move. They moved from Oregon—their home of 35 years—to Gardiner, Montana, to be close to and permanently part of the grandeur of the world's first national park. They were insulated from the world's ills when volunteering deep within the park in the Lamar, but quickly found themselves living at the edge of controversy in Gardiner. Here there was the hunting of Yellowstone wolves outside the park, the debate about the economic and ecosystem benefits of wolves, the community effort to stop a possible gold mine on the park's border, the outrage over the plan to remove grizzlies from the endangered species list, and the battle to stop the slaughter of park bison (p. 19).

Having visited Yellowstone over 20 times and written my own book, *My Yellowstone Experience* (Eastern Coyote Research 2013), on the great park, I was engrossed with Lamplugh's easy-to-read writing style and engaging accounts. He immerses us in all four Yellowstone seasons, starting with winter, writing 7–9 essays during each season (31 total). There we get to go on "hikes" and cross-country skiing forays with Rick and Mary (and usually another friend or two) and learn about the special resources of the park including the park's many thermal features and its abundant and diverse fauna. We learn about the importance of predators to the ecosystem—especially wolves—and the controversy about the degree to which wolves are benefiting the ecosystem. I tend to agree with his conclusions—and that of Bob Beschta of Oregon State University (Chapter 23)—that wolves have dramatically benefited the ecosystem and have been the key to returning the park to ecological health. Lamplugh also shares incredible insights of raven-wolf behaviour and how the two have evolved together making some wonder how ravens survived before wolves returned to the ecosystem in the mid-1990s. As Lamplugh states, "The presence of wolves and grizzlies defines wildness and causes me to use my senses fully; to be in the moment, and to accept my humble place in nature's grand scheme" (p. 261).

I particularly appreciated how Lamplugh wears his heart on his sleeve and fights for the animals and resources that cannot speak for themselves. He is clearly not a fan of how the states of Montana, Idaho, and Wyoming plan to hunt Grizzly Bears (*Ursus arctos*) after delisting (pp. 80–81) similar to how those jurisdictions have allowed a veritable slaughter of wolves outside the park since the states retained control of managing those animals (pp. 14–15). Rick also relates to us about the tragic and angering circumstances of park bison getting captured and sent to slaughter by Yellowstone wildlife managers (a large bison trap near Gardiner is located within the park) and killed by a "firing squad" (Chapter 3) of hunters at the park's immediate border all for leaving the invisible protections of the park. Some 7000+ Bison have died at Yellowstone's borders since 1985 (p. 57). It is particularly personal for him when he is biking and skiing in areas where bison will die later on that winter. These in-depth descriptions of his experiences will inspire readers to help protect the wildlife and landscape of this treasured national park.

Rick coins the term "meanderthal", one who likes to explore/wonder, and it perfectly describes his approach to life. While on a hike or a backpacking trip, if he sees an animal track—say a fresh wolf print in a dusting of snow—he will follow the animal and see how it was behaving in its environment. Maybe he—or more aptly Mary with her keener eye—will spot the actual animal. While we are deep within the husband and wife team's adventures, Lamplugh often digresses and explains complex science in layman's terms ranging from animal behaviour such as the ecological benefits of wolves or wolf territoriality and aggression to the unique hydrothermal features and geology of the region such as how geysers function (p. 135). His detailed descriptions provided me with a reminder of the "soothing sulfur-scented breezes" (p. 132), that "timeless Yellowstone scent" (p. 123), surrounding geyser basins and other geothermal areas, as well as the slick, scented oil smell of sagebrush when rubbing its tiny grey-green leaves (p. 155). Yet there is just enough science quoted from professionals to provide the reader an accurate understanding of each issue with "eyes wide open" (Chapter 21) but not too much where one might get bored, or confused, by reading highly technical information.

Along the way, Rick takes us into the halls—literally—of local buildings where he attends meetings to help protect wolves and other creatures. While the vast majority of people support conserving animals like wolves, most don't know that a small minority is gunning for wolves as the animals leave the protection of the park's seamless borders. Fortunately, wildlife managers are learning the values of conserving wolves and have—up until now—kept hunting quotas relatively low so wolves don't get killed when leaving the park. Having people like Rick and Mary there to defend them is vital.

The end of the book focusses on folks loving our national parks to death. Currently, over four million people visit Yellowstone a year even though it's only really built to support around 2.5 million. This puts a strain on the park's incredible resources, and Rick proposes solutions that benefit the park, such as having daily quotas and a reservation system so the park isn't loved to death. He correctly points out that certainly not all people, and especially not all politicians, would support these restrictions. He even notes that he is part of the problem whereby watching wildlife and habituating them to people—such as the Grizzly Bear he describes (p. 254)—can make it a target if that individual leaves the park and meets a person having a rifle, not binocular, in his eye-sights.

I really enjoyed the book and Lamplugh's writing style. In the acknowledgments he describes that he self-published the book yet there were only a few very minor errors, as it has been professionally edited. There are no pictures throughout the book except on the covers and there is no introduction to set the stage; therefore the book—after the table of contents—just starts in winter. However, the book is so easy-to-read that is not a distraction. There is also no index, although one is not really needed for an essay-styled book, nor is there a list of references used at the end of the book despite him clearly using many sources within the book. This last omission does not sidetrack from the value of the read because he quotes most sources by name or sometimes by book or article written. So, if you want to travel to, inquire about, or safeguard the world's first national park, I highly recommend this book. *Deep into Yellowstone* will give you a deep appreciation for Yellowstone and a better knowledge of the controversies threatening the park and its surroundings.

JONATHAN (JON) WAY

Eastern Coyote/Coywolf Research, Osterville, MA, USA

NEW TITLES

Prepared by Barry Cottam

Please note: Only books marked † or * have been received from publishers. All other titles are listed as books of potential interest to subscribers. Please send notice of new books—or copies for review—to the Book Review Editor.

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Currency Codes: CAD Canadian Dollars, USD US Dollars, EUR Euros, AUD Australian Dollars, GBP British Pound.

BOTANY

Atlas of Poetic Botany. By Francis Hallé. Contribution by Éliane Patriarca. Translated by Erik Butler. 2018. MIT Press. 128 pages and 42 colour illustrations, 24.95 USD, Cloth.

Flora of the Pacific Northwest, Second Edition. An Illustrated Manual. By C. Leo Hitchcock and Arthur Cronquist. 2018. University of Washington Press. 936 pages, 86.00 USD, Cloth.

***Flora of Florida, Volume VI: Dicotyledons, Convolvulaceae through Paulowniaceae.** By Richard P. Wunderlin, Bruce F. Hansen, and Alan R. Franck. 2018. University Press of Florida. 352 pages, 70.00 USD, Cloth.

Brilliant Green: The Surprising History and Science of Plant Intelligence. By Stefano Mancuso and Alessandra Viola. 2018. Island Press. 192 pages, 17.00 USD, Paper. Cloth and E-book editions published in 2015.

The Biology of Grasslands. Biology of Habitats Series. By Brian J. Wilsey. 2018. Oxford University Press. 320 pages, 95.00 CAD, Cloth, 45.95 CAD, Paper. Also available as an E-book.

Brilliant Green: The Surprising History and Science of Plant Intelligence. By Stefano Mancuso and Alessandra Viola. Foreword by Michael Pollan. 2018. Island Press. 192 pages, 18.95 CAD, Paper.

***Sedges and Rushes of Minnesota: The Complete Guide to Species Identification.** By Welby R. Smith. Photography by Richard Haug. 2018. University of Minnesota Press. 696 pages, 1100 colour plates, and 248 maps, 39.95 USD, Paper.

CONSERVATION

Where the Animals Go: Tracking Wildlife with Technology in 50 Maps and Graphics. By James Cheshire and Oliver Uberti. 2017. W.W. Norton. 192 pages, 39.95 USD, Cloth.

Essential Readings in Wildlife Management and Conservation. Edited by Paul R. Krausman and Bruce D. Leopold. 2018. Johns Hopkins University Press. 696 pages, 53.00 USD, Cloth, 49.95 USD, Paper.

Ecology and Recovery of Eastern Old-Growth Forests. By Andrew M. Barton and William S. Keeton. 2018. Island Press. 288 pages, 80.00 USD, Cloth, 40.00 USD, Paper or E-book.

Species Conservation: Lessons from Islands. Ecology, Biodiversity and Conservation Series. Edited by Jamieson A. Copsey, Simon A. Black, Jim J. Groombridge, and Carl G. Jones. 2018. Cambridge University Press. 396 pages, 131.95 CAD, Cloth, 51.95 CAD, Paper.

ENTOMOLOGY

***Beetles: The Natural History and Diversity of Coleoptera.** By Stephen A. Marshall. 2018. Firefly Books. 784 pages, 95.00 CAD, Cloth.

Aleocharine Rove Beetles of Eastern Canada (Coleoptera Staphylinidae Aleocharinae): A Glimpse of Megadiversity. By J. Klimaszewski, R.P. Webster, D.W. Langor, A. Brunke, A. Davies, C. Bourdon, M. Labrecque, A.F. Newton, J.-A. Dorval, and J.H. Frank. 2018. Springer. 891 pages, 249.99 USD, Cloth, 189.00 USD, E-book.

The Asian Hornet (*Vespa velutina*): Threats, Biology and Expansion. By S. Martin. 2017. IBRA. 106 pages, 32.50 GBP, Paper.

Insect Behavior: From Mechanisms to Ecological and Evolutionary Consequences. Edited by Alex Cordoba-Aguilar, Daniel Gonzalez-Tokman, and Isaac Gonzalez-Santoyo. 2018. Oxford University Press. 416 pages, 100.00 CAD, Cloth, 49.95 CAD, Paper. Also available as an E-book.

Insect Biodiversity: Science and Society, Second Edition, Volume 1. Edited by Robert G. Foottit and

Peter H. Adler. 2017. Wiley-Blackwell. 904 pages, 158.47 CAD, Cloth, 126.99 CAD, E-book.

Insect Biodiversity: Science and Society, Second Edition, Volume 2. Edited by Robert G. Foottit and Peter H. Adler. 2018. Wiley-Blackwell. 1024 pages, 180.00 CAD, Cloth, 144.99 CAD, E-book.

Pacific Northwest Insects. By Merrill A. Peterson. 2018. Seattle Audubon. 528 pages and 1725 colour photographs, 37.95 CAD, Paper.

Buzz: The Nature and Necessity of Bees. By Thor Hanson. 2018. Basic Books. 304 pages, 35.50 CAD, Cloth, 288 pages, 21.99 CAD, E-book.

Stouts, Millers & Forky-Tails: Insects of Newfoundland and Labrador. By Tom Chapman, Carolyn Parson, Hugh Whitney, and Peggy Dixon. 2018. Boulder Publications. 200 pages, 29.95 USD, Paper.

Butterflies of the World. By Adrian Hoskins. 2018. Johns Hopkins University Press. 312 pages and 368 colour photographs, 34.95 USD, Cloth.

Amazing Arachnids. By Jillian Cowles. 2018. Princeton University Press. 328 pages, 45.00 USD, Cloth, 35.00 USD, E-book.

Ornithology

***Birds of Nunavut, Volume 1: Nonpasserines, Volume 2: Passerines.** Edited by James M. Richards and Anthony J. Gaston. 2018. University of British Columbia Press. 820 pages, 805 colour photos, and 155 maps, 125.00 CAD, Cloth.

***North American Ducks, Geese & Swans: Identification Guide.** By Frank S. Todd. 2018. Hancock House. 208 pages, 29.95 CAD, Paper.

The Cooper's Hawk: Breeding Ecology & Natural History of a Winged Huntsman. By Robert N. Rosenfield. 2018. Hancock House. 164 pages, 29.95 CAD, Paper.

Behavior of the Golden Eagle: An Illustrated Ethogram. By David Ellis and N. John Schmitt. 2018. Hancock House. 102 pages and 88 illustrations, 29.95 CAD, Cloth or Paper.

Papa Goose: One Year, Seven Goslings, and the Flight of My Life. By Michael Quetting. Foreword by Stacey O'Brien. 2018. Greystone Books. 248 pages, 29.95 CAD, Cloth.

The Handbook of Bird Families. By Jonathan Elphick. 2018. Firefly Books. 344 pages, 35.00 CAD, Paper.

Hummingbirds. By Ronald Orenstein. Photography by Michael and Patricia Fogden. 2018. Firefly Books. 256 pages, 35.00 CAD, Paper. Cloth edition published in 2014.

Far from Land: The Mysterious Lives of Seabirds. By Michael Brooke. Illustrations by Bruce Pearson. 2018. Princeton University Press. 264 pages, 29.95 USD, Cloth, 24.00 USD, E-book.

Owls of the World. By James Duncan. 2018. Johns Hopkins University Press. 192 pages and 127 colour illustrations, 29.95 USD, Cloth.

Listening to a Continent Sing: Birdsong by Bicycle from the Atlantic to the Pacific. By Donald Kroodsma. 2018. Princeton University Press. 336 pages, 21.95 USD, Paper, 16.99 USD, E-book. Cloth edition published in 2016.

Zoology

***Guide to the Parasites of Fishes of Canada. Part V: Nematoda.** By Hisao P. Arai and John W. Smith. Edited by Michael D.B. Burt and Donald F. McAlpine. 2016. Zootaxa 4185, Magnolia Press. 274 pages, free PDF available at https://biotaxa.org/Zootaxa/article/view/zootaxa.4185.1.1.

The Behavior and Ecology of Pacific Salmon and Trout, Second Edition. By Thomas P. Quinn. 2018. University of British Columbia Press. 548 pages, 70.00 CAD, Paper.

Vaquita: Science, Politics, and Crime in the Sea of Cortez. By Brooke Bessesen. 2018. Island Press. 256 pages, 33.95 CAD, Cloth.

Ecology and Conservation of the Diamond-backed Terrapin. Edited by Willem M. Roosenburg and Victor S. Kennedy. 2018. Johns Hopkins University Press. 296 pages, 79.95 USD, Cloth.

The Book of Snakes: A Life-Size Guide to Six Hundred Species from around the World. By Mark O'Shea. 2018. University of Chicago Press. 858 pages and 2400 colour plates, 55.00 USD, Cloth. Also available as an E-book.

Handbook of the Mammals of the World, Volume 8. Insectivores, Sloths and Colugos. Edited by Don E. Wilson and Russell A. Mittermeier. Illustrations by Toni Llobet. 2018. Lynx Edicions in association with

Conservation International and IUCN. 710 pages, 160.00 EUR / GBP, Cloth.

Walker's Mammals of the World: Monotremes, Marsupials, Afrotherians, Xenarthrans, and Sundatherians. By Ronald M. Nowak. 2018. Johns Hopkins University Press. 784 pages and 508 colour photos, 99.97 USD, Cloth.

Beachcomber's Guide to Seashore Life in the Pacific Northwest, Third Edition. By J. Duane. 2018. Harbour Publishing. 240 pages and 400 colour photos, 26.95 CAD, Paper.

OTHER

Island at the Centre of the World: The Geological Heritage of Prince Edward Island. By John Calder. 2018. Acorn Press. 280 pages, 24.95 CAD, Paper or E-book.

Kings of the Yukon: An Alaskan River Journey. By Adam Weymouth. 2018. Penguin UK. 288 pages, 16.99 GBP, Cloth or E-book.

***Inheritors of the Earth: How Nature Is Thriving in an Age of Extinction.** By Chris D. Thomas. 2018. Penguin UK. 320 pages, 9.99 GBP, Paper or E-book.

***Frog Pond Philosophy: Essays on the Relationship Between Humans and Nature.** Culture of the Land Series. By Strachan Donnelley. Edited by Ceara Donnelley and Bruce Jennings. Foreword by Frederick L. Kirschenmann. 2018. University Press of Kentucky. 266 pages, 80.00 USD, Cloth, Paper, or Web PDF, 30.00 USD, E-book.

The Biology of Urban Environments. Biology of Habitats Series. By Philip James. 2018. Oxford University Press. 320 pages, 95.00 CAD, Cloth, 45.95 CAD, Paper. Also available as an E-book.

Environmental Attitudes through Time. By R.J. Berry. 2018. Cambridge University Press. 276 pages, 39.95 CAD, Paper.

Natural Enemies: An Introduction to Biological Control. Second Edition. By Ann E. Hajek and Jørgen Eilenberg. 2018. Cambridge University Press. 452 pages, 56.95 CAD, Paper.

***Mark Catesby's Legacy: Natural History Then and Now: The Art and Science of our Environment and the Choice we Face in the Future.** By M.J. Brush and Alan H. Brush. 2018. Catesby Commemorative Trust. 191 pages and 32 original watercolour plates, 28.95 USD, Paper.

Darwin's Man in Brazil: The Evolving Science of Fritz Müller. By David A. West. 2018. University Press of Florida. 340 pages, 79.95 USD, Cloth, 26.95 USD, Paper. Cloth edition published in 2016.

The Wonderful Mr Willughby: The First True Ornithologist. By Tim R. Birkhead. 2018. Bloomsbury Publishing. 368 pages, 27.00 USD, Cloth, 18.90 USD, E-book.

Honeybee Hotel: The Waldorf Astoria's Rooftop Garden and the Heart of NYC. By Leslie Day. 2018. Johns Hopkins University Press. 208 pages, 22.95 USD, Cloth or E-book.

Still Waters: The Secret World of Lakes. By Curt Stager. 2018. W.W. Norton. 272 pages, 26.95 USD, Cloth.

News and Comment

Upcoming Meetings and Workshops

The Wildlife Society Annual Conference

The 25th Wildlife Society Annual Conference Meeting to be held 7–11 October 2018 at the Cleveland Convention Center, Cleveland, Ohio. Registration is currently open. More information is available at http://twsconference.org.

Student Conference on Conservation Science-New York

The 9th annual Student Conference on Conservation Science-New York to be held 24–26 October 2018 at the American Museum of Natural History, New York, New York. More information is available at https://www.amnh.org/our-research/center-for-biodiversity-conservation/convening-and-connecting/student-conference-on-conservation-science-new-york-sccs-ny.

North American Caribou Workshop

The 17th North American Caribou Workshop, organized by Environment and Climate Change Canada in partnership with Natural Resources Canada and a number of non-governmental organizations, to be held 29 October–2 November 2018 at the Delta Ottawa City Centre, Ottawa, Ontario. The theme of the conference is: 'Working Together'. Registration is currently open. More information is available at http://www.nacw2018.ca/Homepage.

James Fletcher Award for *The Canadian Field-Naturalist* Volume 131

The James Fletcher Award is awarded to the authors of the best paper published in a volume of *The Canadian Field-Naturalist* (CFN), and first started with Volume 130 (see 130: 285, http://doi.org/10.22621/cfn.v131i3.2071). The award is in honour of James Fletcher, founder of the Ottawa Field-Naturalists' Club (OFNC) and the first editor of CFN's earliest iteration, *Transactions of the Ottawa Field-Naturalists' Club*. A subcommittee of the OFNC Publications Committee selected the top three papers in Volume 131 of CFN and the full committee made the final selection. The award for Volume 131 of CFN goes to:

Thomas Reimchen. Diverse Ecological Pathways of Salmon Nutrients Through an Intact Marine-terrestrial Interface. Canadian Field-Naturalist 131(4): 350–368. https://doi.org/10.22621/cfn.v131i4.1965

– This paper describes the flow of nutrients from salmon in spawning streams throughout the food web in both aquatic and riparian habitats in a protected reserve on Haida Gwaii, British Columbia. The paper is very clearly written, and an immense amount of work went into it.

Congratulations to Tom Reimchen for his excellent paper.

The other short-listed finalists were:

Marion Barbé, Louis Dubois, Jean Faubert, Martin Lavoie, Yves Bergeron, and Nicole J. Fenton. Range Extensions of 35 Bryophyte Species in the Black Spruce–Feather Moss Forest of Western Quebec, Canada. Canadian Field-Naturalist 131(3): 258–269. https://doi.org/10.22621/cfn.v131i3.1901

– This paper describes range extensions for an impressive number of bryophytes (35) in northern Quebec, and represents an impressive addition to the flora of the region.

Peter W. Hall, Paul M. Catling, Paul L. Mosquin, and Ted Mosquin. European Skipper Butterfly (*Thymelicus lineola*) Associated with Reduced Seed Development of Showy Lady's-slipper Orchid (*Cypripedium reginae*). Canadian Field-Naturalist 131(1): 63–68. https://doi.org/10.22621/cfn.v131i1.1952

– This paper presents a clear, hypothesis-driven study, examining the influence of European Skipper Butterfly on the fitness of Showy Lady's-slipper Orchid.

Congratulations to these finalists. We would also like to show our appreciation to all authors who chose to share their interesting and valuable field-based studies with the readers of Volume 131 of *The Canadian Field-Naturalist*.

William D. Halliday and Jeffery M. Saarela
OFNC Publications Committee

Francis Cook Appointed to the Order of Canada for his Exceptional Contributions to Canadian Herpetology and *The Canadian Field-Naturalist*

Francis Cook, former Editor-in-Chief and Associate Editor of *The Canadian Field-Naturalist* (CFN) and long-time and Honorary Member of The Ottawa Field-Naturalists' Club, was appointed to the Order of Canada on 29 June 2018. The Order of Canada is one of our country's top civilian honours, awarded in recognition of an individual's outstanding achievement, dedication to community, and service to Canada (Governor General of Canada 2018). In Francis' case, this was "For his dedication to the development of Canadian herpetology and for his lifelong contributions to a specialized publication in the field" (Governor General of Canada 2018).

Francis has contributed to the development of herpetology in Canada in many ways. Contributions include:

- his involvement with the Committee on the Status of Endangered Wildlife in Canada (COSEWIC), chairing the COSEWIC subcommittee for amphibians and reptiles from 1981–1994 and serving subsequently as a COSEWIC reviewer;
- his tenure as Curator of the Herpetology Section for the Canadian Museum of Nature, where he helped increase the museum's herpetology collection from 14 000 to an impressive 133 000 specimens; and
- his contributions to the scientific literature, with 63 published scientific works on herpetology, including books, book chapters, monographs, and journal articles.

Francis has also made an exceptional contribution to CFN. When Francis Cook stepped down as Associate Editor in 2016 he completed 48 years of service to the journal. This included his 35-year tenure as Editor-in-Chief, a service three times longer than any other Editor in the 139-year history of CFN (and its predecessors). For a more detailed accounting of the contributions listed above, please see the Introduction to this Special Issue (Halliday and Seburn 2018) and Catling *et al*. (2016).

CFN offers its congratulations to Francis Cook for this well-deserved honour!

Literature Cited

Catling, P., D. Brunton, J. Saarela, and F. Pope. 2016. Francis Cook steps down after long and distinguished service with the Ottawa Field-Naturalists' Club and the *Canadian Field-Naturalist*. Canadian Field-Naturalist 130: 385–387. https://doi.org/10.22621/cfn.v130i4.1944

Governor General of Canada. 2018. Order of Canada Appointments, June 29, 2018. Accessed 12 August 2018. https://www.gg.ca/document.aspx?id=17122&lan=eng.

Halliday, W.D, and D.C. Seburn. 2018. Introduction to the special issue on herpetology in Canada. Canadian Field-Naturalist 132: 1–3. https://doi.org/10.22621/cfn.v132i1.2113

AMANDA E. MARTIN
Assistant Editor – *The Canadian Field-Naturalist*

Minutes of the 139th Annual Business Meeting (ABM) of the Ottawa Field-Naturalists' Club 9 January 2018

Place and time: Neatby Building, Carling Avenue, Ottawa, Ontario, 7:00 pm
Chairperson: Diane Lepage, President

Over 50 attendees spent the first half-hour reviewing the minutes of the previous ABM, the financial statements, Treasurer's Report, and annual reports of the Ottawa Field-Naturalists' Club (OFNC) committees for 2016–2017. The meeting was called to order at 7:30 pm.

1. Minutes of the Previous Annual Business Meeting

It was moved by Lynn Ovenden and seconded by Gord Robertson that the minutes of the 138th Annual Business Meeting be accepted as distributed and published in *The Canadian Field Naturalist* (CFN).

Carried

2. Business Arising from the Minutes

Nil.

3. Communications Relating to the Annual Business Meeting

Nil.

4. Treasurer's Report by Ann Mackenzie

Ann presented the financial statements for the year ended 30 September 2017, which were reviewed by the accounting firm of Welch LLP. They show that OFNC's expenses were higher than revenues, as expected. The budget for 2017–2018, approved by the Board in October 2017, again forecasts a shortfall. Expenses will exceed revenues for the next several years as we employ the funds from the 2014–2015 bequest of Violetta Czasak to further the objectives of the OFNC. This will also result in a decline in our investment account and interest income.

Ann explained the deferral method used by OFNC for recognizing revenue from membership fees, grants, and CFN charges in the financial statements: it means recognizing revenue in the year in which the related expenses are incurred. The Club is fine-tuning the method for calculating these amounts. As a result, the financial statements show more deferred revenue this year than previous years, particularly for multi-year grants and CFN charges. Most subscription revenue for CFN volume 131 (2017) was deferred because only one issue of volume 131 was published by 30 September 2017. (A second issue was published in December 2017.) The by-issue review of CFN accounts also shows that CFN costs are rising but revenue is declining. In answer to a question about the print subscription, the price for members has been $30/year since 2010 and about 65 members get it.

This has been a year of transition for the role of Treasurer. Ann identified six other OFNC members who also volunteer much time to managing financial aspects of the OFNC. In order to simplify and ease this work, Ann and the new bookkeeper, Katryna Coltress, are using new accounting software procedures to register requests for payment and generate cheques. The number of bank accounts and internally restricted accounts have been reduced. Donation receipts are sent throughout the year and are computer generated. As well, three more members (Catherine Hessian, Tanja Schueler, and Bob Bergquist) have recently volunteered to handle cheque deposits, mail, Paypal transactions, and the charitable donation receipts.

In closing, Ann thanked Ken Young, the bookkeeper and accountants for their support.

Moved by Ann MacKenzie and seconded by Rémy Poulin, that the financial statements be accepted as fair representation of the financial position of the Club as of 30 September 2017.

Carried

5. Nomination of the Accounting Firm

Moved by Ann MacKenzie and seconded by Fenja Brodo, that the accounting firm of Welch LLP be contracted to conduct a review of the OFNC's accounts for the fiscal year ending 30 September 2018.

Carried

6. Committee Annual Reports

A summary of each report was given with an opportunity for questions and answers.

Moved by Lynn Ovenden and seconded by Barry Cottam, that the committee reports be accepted as distributed.

Carried

7. New OFNC Website

We have a new website, just launched on 8 January 2018, and built over the past two years by several members and a local web company on a WordPress platform. OFNC members from several parts of the Club can contribute news and keep the content up-to-date. Annie Bélair provided a visual tour of the new website.

8. Nominations for Board of Directors positions

Relevant Excerpts from the OFNC Constitution (revised February 2000)

Article 8 – "The Council shall consist of the officers of the Club and up to eighteen additional members, all members of the Club."

Article 12 – "The officers of the Club and other members of the Council shall be elected annually at the Annual Business Meeting. The nomination of sufficient persons for election to the various offices and membership of the Council shall be the responsibility of the Nominating Committee, which shall act in the manner prescribed in the By-Laws.

The Council shall, at the earliest possible date, appoint chairs and members of Standing and ad hoc committees and Editor and Business Managers, as required for club publications."

Fenja Brodo presented the slate of candidates nominated to the Board of Directors for 2018:

EXECUTIVE COMMITTEE

Diane Lepage	President
Jakob Mueller	1st Vice President and Chair, Events Committee
Lynn Ovenden	Recording Secretary
Treasurer	Ann MacKenzie

DIRECTORS

Fenja Brodo	Past President
Robert Cermak	Chair, Birds Committee
Owen Clarkin	Chair, Conservation Committee
Edward Farnworth	Representative, Fletcher Wildlife Committee
Catherine Hessian	Member-at-Large
Anouk Hoedeman	Chair, Safe Wings Ottawa
Diane Kitching	Representative, Macoun Field Club
Gordon Robertson	Chair, Education and Publicity
Jeff Saarela	Chair, Publications
Henry Steger	Chair, Membership
Eleanor Zurbrigg	Chair, Awards
Ken Young	Chair, Finance

EX OFFICIO:
Annie Bélair, Editor of *Trail & Landscape*
Dwayne Lepitzki, Editor of *The Canadian Field-Naturalist*

Moved by Fenja Brodo and seconded by Ernie Brodo that this slate of nominees be accepted as members of the Board of Directors of the OFNC for 2018.

Carried

Fenja acknowledged Rémy Poulin's departure from the Board after several years of service as the Chair of Finance Committee and before that of Birds. She expressed pleasure at Ken Young's return to the Board, as Chair of Finance. Committee chairs will be approved by the Board of Directors at the January 2018 meeting.

9. New Business and General Discussion

Bob Cermak asked which committee manages the OFNC facebook and twitter accounts. Currently, no committee is responsible for these social media. Gord Robertson serves as the Board's liaison to the Facebook group. The twitter account is inactive.

10. Adjournment

Moved by Julia Cipriani and seconded by Gord Robertson that the meeting be adjourned.

Carried

LYNN OVENDEN
Recording Secretary

Annual Reports of OFNC Committees for October 2016–September 2017

Awards Committee

The Awards Committee manages the process to annually recognize those OFNC members and other qualified persons who, by virtue of their efforts and talents, are deserving of special recognition. In late 2016, nominations were received and evaluated (see awards criteria at http://ofnc.ca/about-ofnc/awards), resulting in nominees for five awards being recommended to the Board of Directors for approval. Biographies were written for each award winner for publication in the Club's journals and posting on the website. The awards were presented at the annual Awards Night in April 2017. The recipients' names, type of award (in brackets) and rationale for recognition follow below.

- Dr. John McNeill (Honorary Member): In recognition of lifetime contributions to Canadian botany and botanical nomenclature.
- Gordon Robertson (Member of the Year): For enthusiastic support of many activities of the Club.
- Sandra Garland (George McGee Service): For long and dedicated service to the Club and Fletcher Wildlife Garden projects.
- Richard Waters (Conservation – Member): For engaging students in designing and building nest boxes and installing them in appropriate habitat.
- The City of Ottawa (Conservation – Non-member): For modifying habitat to aid hatchling Snapping Turtles at the Britannia Conservation Area.

President Diane Lepage selected Carolyn Callaghan as the recipient of the 2016 President's Prize for her achievements in leading delivery of the CFN online with an innovative presence.

The committee thanks Mark Brenchley for helping with awards certificate design and printing. We thank Sandra Garland for technical support to the awards section of the club's website.

Awards Committee: Irwin Brodo, Julia Cipriani, Christine Hanrahan, Karen McLachlan Hamilton

ELEANOR ZURBRIGG, Chair

Birds Committee

The Birds Committee and the Club des Ornithologues de l'Outaouais organized another successful Ottawa Christmas Bird Count in December 2016. Though the official OFNC Falcon Watch is defunct at the moment, several members continue to keep an informal watch on the Heron Road nest site. Three more young Peregrines (*Falco peregrinus*) successfully fledged from this location this season. Safe Wings Ottawa has left the Birds Committee to become a standing committee of the club. This past summer saw the renewal of the Club's agreement with the Department of National Defence for access to the causeway at the Shirley's Bay. New rules of access were put in place to ensure that club members will continue to enjoy this special privilege.

CHRIS TRAYNOR, Chair

Conservation Committee

The signature accomplishment of the OFNC Conservation Committee in 2017 was successfully spearheading a campaign, along with Ontario Nature, the David Suzuki Foundation, and other organizations, to end the Snapping Turtle (*Chelydra serpentina*) hunt in Ontario. The province had proposed limiting the hunt due to long-term, increased pressure on the Snapping Turtle population from habitat loss, road mortality, and hunting/poaching. Eliminating the hunt altogether is a simpler and more effective measure to help stabilize the declining Snapping Turtle population.

Members of OFNC-Conservation offer public outreach and active conservation work in the field. We led numerous conservation events this year, including: 25 guided public nature tours, six public lectures, six bio-inventories, and attendance/contribution to at least 10 conservation-related meetings. Our committee members continued to enthusiastically document wildlife near Ottawa and further afield with over 9000 observations entered into iNaturalist alone, and hundreds of records into other databases; many of these observations were of species of significant conservation interest.

As in previous years, we met regularly to discuss and plan actions regarding species of conservation concern (both threatened indigenous species, and emerging potentially invasive exotics) and habitat conservation/restoration projects. We collaborated on conservation work with a number of external organizations and other OFNC committees throughout the year.

Our committee gained two members this year: we were pleased to welcome Susan Gallinger, and Jakob Mueller (chair of OFNC-Events).

OWEN CLARKIN, Chair

Education and Publicity Committee

Several new projects were undertaken this year. One involved the installation of "storyboards" in eight locations around the Fletcher Wildlife Garden (FWG). The storyboards, designed by Mark Brenchley, were mounted on cedar posts; each can hold two removeable 8.5×10" posters (one in English, one in French) showing seasonal wildlife that may be seen near that post. Spring, summer, fall, and winter posters have been displayed in turn. Gord also developed a flyer with a scavenger-hunt-like list of animals and plants at FWG that visiting families can use when they visit.

Another new event this year was a springtime open house at the Interpretation Centre. Several members hosted about 40 visitors with drinks, cookies, and tours of the garden. The event was well publicized with an excellent radio interview by CBC's Giacomo Panico on the morning of the event.

This year we had only one application for sponsorship to the Youth Summit of Ontario Nature. She attended the event and gave an informative and illustrated presentation at Neatby of her stay. Lucy Patterson and Kathy Conlan were again judges at the annual Ottawa Regional Science Fair. They presented three awards ($100 each) to the winning students.

We brought the OFNC display to a number of public events, including: City of Ottawa's Wildlife Speaker Series at Centrepointe and City Hall, Migratory Bird Day at Brewer Park, Bug Day at the Neatby Building, Gatineau Park Bioblitz, Earth Day at Hunt-Club Riverside Park Community Centre. Bug Day was especially successful this year with 100s of attendees visiting our microscope tables. A callout for volunteers yielded 12 enthusiastic OFNC members who assisted with identifying insects and observing specimens under the microscopes.

GORDON ROBERTSON, Chair

Events Committee

The Events Committee planned, coordinated or supported:

- 44 outings
- 9 monthly meetings, including the annual business meeting (This is normally 10; however, the March meeting was postponed, and later cancelled.)
- 5 other presentations or workshops
- 2016 Awards celebration at St. Basil's Church, held on 25 February.

The focus of outings, workshops, and monthly meetings included birds (18), general natural history (13), botany (7), insects (6), amphibians and reptiles (5), conservation (2), geology (2), photography (2), snails (1), lichens (1), and astronomy (1).

Unusually poor spring weather, including record-breaking precipitation and high, prolonged flooding of the Ottawa River, led to a number of postponements and cancellations. At least 6 events were rescheduled between March and June. A herpetological expedition to Morris Island and a mothing night in Larose Forest were among the cancellations.

Monthly meetings continue to be held in Salons A & B of the Neatby Building. Ensuring the availability of the venue has been an issue, causing the sudden postponements of the March and April meetings. The January business meeting was held at the Fletcher Interpretation Centre.

Committee members in 2017: Holly Bickerton, Julia Cipriani, Owen Clarkin, Hume Douglas, Margaret Hart, Bev McBride, and Jakob Mueller.

If you have ideas for events or would like to lead an outing or event, please contact Jakob Mueller (jm890_7 AT hotmail.com) or any other member of the committee.

JAKOB MUELLER, Chair

Finance Committee Annual Report 2017

Ann MacKenzie assumed the duties of Treasurer this year, and Rémy Poulin took over from her as Investment Manager. Work continued to have the bookkeeper take on additional functions and to take full advantage of technology.

The budget for 2017–2018 was prepared and presented to the Board in September for approval in October. While a shortfall of revenues over expenses of $84 thousand is estimated, recent history suggests that the actual deficit will be less. Regardless, such a shortfall is considered manageable given the Club's overall strong financial position with investments totalling almost $1.525 million at the end of September 2017.

The Club's accounting framework includes internally restricted funds that, over time, grew to eight in number. This is unnecessarily complex and, with the increasing use of separate account codes to track specific expenditures, provides little practical benefit. Consequently, in September, the Finance Committee proposed to the Board that the system be streamlined by reducing the number of these funds to three. The Board voted to approve this change starting in October 2017.

RÉMY POULIN, Chair

Fletcher Wildlife Garden

This year has been a very productive one at the Fletcher Wildlife Garden in spite of the very wet and cool start to the outdoor season. We recruited a large number of new volunteers and several new corporate and student groups helped with more physical tasks. Our work groups and individuals overseeing designated areas of the FWG, called nodes, combined to make a workforce that had a noticeable impact on the garden's appearance. In several areas, our work to remove invasive species (Dog-strangling Vine [*Vincetoxicum rossicum*], comfrey, buckthorn) is particularly evident. Over 5500 hours of volunteer time was spent maintaining the various parts of the Fletcher Wildlife Garden.

Visitors

The number of visitors, local, national, and international, has increased, and volunteers have received many positive comments about the garden. The Fletcher Wildlife Garden is part of the Ottawa Garden Council and the Garden Promenade, which increased our visibility to the public and encouraged more visitors. High praise was received from the Ontario Environment Commissioner who toured the Fletcher Wildlife Garden early in the spring. Our Sunday afternoon open Resource Centre, the Back Yard Garden, the Butterfly Meadow, and the Amphibian Pond are popular points of interest. The addition of several information posts has helped visitors understand the wide variety of flora and fauna that can be found at the Fletcher Wildlife Garden.

Amphibian Pond

Work on the pond started early in the spring when the company contracted to dredge the pond returned to do contouring work, finish the pathway around the pond, and spread topsoil along the south bank. A large work group then planted over 2400 plants native wildflowers on the south bank. A chain-link fence was installed around the pond to protect the new plantings and prevent dogs from entering the pond. The plentiful rains ensured a good survival rate of the new plants; however, erosion meant that the new pathway had to be repaired several times to avoid accidents to walkers. Large quantities of Flowering Rush (*Butomus umbellatus*), an aquatic invasive species, returned in abundance and was removed manually throughout the summer.

Plant Sale

The plant sale was, again, a very successful event. A large number of old and new customers pushed our sales to over $5000. This is one of our most labour-intensive activities, involving a large number of volunteers.

Fletcher Plaque

Parks Canada has erected a plaque on the Fletcher Wildlife Garden grounds to commemorate James Fletcher, Canada's first Dominion Entomologist and Botanist appointed in 1884. He oversaw the creation of the Arboretum and of a botanic garden to bring together all the native species of plants in Canada and to test the hardiness and adaptability of shrubs and trees growing in northern climates. James Fletcher was also a founding member of the Ottawa Field-Naturalists' Club.

Pollinator Project

With support from Friends of the Earth, Ottawa University students built and planted three raised pollinator beds at the FWG. These will be maintained as model "pollinator gardens in a box" to show visitors what plants can be grown in a small space to help pollinators.

TED FARNWORTH, Fletcher Wildlife Garden Committee

Macoun Club

The Committee organized the activities of the Macoun Field Club by telephone and e-mail. All four Committee members have been leaders with the Macoun Club for periods in the order of 10, 20, and 30 years, so matters of routine management are divided up into familiar patterns. Sixteen meetings were held indoors, with some presentations being made by outside speakers and others by Macoun Club leaders. There were 17 field trips, mostly to familiar places; one, to the Brewer Park pond, was a joint event coordinated with the OFNC.

The Club works closely with the National Capital Commission to monitor for, study, and attempt to control invasive plants in and near the Macoun Study Area in Stony Swamp. An illustrated record of all events was maintained on the Club's website (http://ofnc.ca/programs/macoun-field-club). Issue no. 71 of *The Little Bear* magazine was written and illustrated by Macoun Club participants.

For the second time, Macoun Club Committee members also volunteered to provide a field program to a Carleton University environmental-science class in the Macoun Club's Nature Study Area.

The Committee Chair, who has maintained the Macoun Club's independent web site for years, participated in the OFNC's Website Working Group, and kept a duplicate Macoun Club site on the new platform up-to-date throughout the year in case it should go live at any time.

ROBERT E. LEE, Macoun Club Committee

Membership Committee

The distribution of Club membership for 2017 on 30 September 2017 is shown in the table below, with the corresponding numbers shown in brackets for 30 September 2016. "Other" represent mostly affiliate organizations that receive complimentary copies of the Club's publications. There was an increase of 77 in membership in 2017 and showed a return to the upward trend in membership noted since 2013 with the exception in 2016. Members within 50 km of Ottawa comprised 738 of the membership of 848.

Families of children in the Macoun Club are given complimentary membership to encourage interest in the Club in the longer term. Macoun Club participation increased slightly in 2017.

HENRY STEGER, Chair

Publications Committee

The Publications Committee manages publication of the Club's scientific journal *The Canadian Field-Naturalist* (CFN), the Club's regional publication *Trail & Landscape*, and Special Publications. The committee also advises OFNC with respect to issues relating to research including research grants. Publications Com-

	CANADIAN		USA		OTHER		TOTAL	
	2017	2016	2017	2016	2017	2016	2017	2016
Individual	399	(358)	7	(8)	0	(0)	406	(364)
Family	316	(286)	0	(0)	1	(0)	316	(287)
Student	24	(19)	0	(1)	0	(0)	24	(20)
T&L	2	(2)	0	(0)	0	(0)	2	(2)
Honorary	25	(25)	0	(0)	0	(1)	26	(25)
Life	40	(41)	3	(3)	1	(1)	44	(45)
Other	24	(24)	0	(0)	1	(1)	25	(25)
Macoun Club	18	(16)					18	(16)
TOTAL	848	(771)	10	(12)	3	(3)	861	(784)

mittee meetings were held on 26 November 2016, 3 May 2017, and 4 October 2017. Committee members were Annie Bélair (Editor, *Trail & Landscape*), Dan Brunton, Carolyn Callaghan, Paul Catling, Barry Cottam (Book Review Editor, CFN), William Halliday (Journal Manager, CFN), Karen McLachlan Hamilton, Diane Kitching, Dwayne Lepitzki (Editor-in-Chief, CFN), Amanda Martin (Assistant Editor, CFN), Frank Pope, Jeff Saarela (Chair), David Seburn, and Eleanor Zurbrigg, who newly joined the committee.

Trail & Landscape

A major achievement this year was the launch of the re-designed *Trail & Landscape*. The first 50 volumes of the publication were printed primarily in black and white. The first two issues of volume 51 in 2017 were printed in colour in the "old format", and the new all-colour design appeared in volume 51(3) (July–September 2017), a Special 50th Anniversary Issue. Work on the new design was led by *Trail & Landscape* Editor Annie Belair, and involved back-and-forth consultation with the Publications Committee. Feedback on the new format from Club membership has been extremely positive and encouraging.

The Canadian Field-Naturalist

Three issues of CFN were published: 130(3), 130(4), and 131(1). Beginning with 130(3), a new subheading was added to the cover page of the journal: "THE CANADIAN FIELD-NATURALIST: A JOURNAL OF FIELD BIOLOGY AND ECOLOGY", to reflect the type of content we publish. Barry Cottam began his tenure as Book Review Editor with volume 130(2). Publication of 130(3) completed the Editor-in-Chief transition from Carolyn Callaghan to Dwayne Lepitzki. Ken Young, former chair of the Finance Committee, continued to manage CFN subscriptions, page charge invoices and budget tracking, and Eleanor Zurbrigg took over subscriptions in summer 2017. Copy editing of CFN papers was provided by Sandra Garland and Dr. John Wilmshurst of Jasper, Alberta, a new member of the team.

Digital Object Identifiers (DOIs) were successfully implemented in CFN. A DOI is a unique alphanumeric identifier for a piece of content (e.g., a scientific paper) that is permanent and can be linked to on the web. DOIs have been assigned to all journal content as far back as 117(2), and beginning with 131(1), DOIs are included in the references. On the journal website, low resolution PDF files of CFN content going back to volume 125 were replaced with higher-resolution files, and all content is now posted in high resolution.

In 131(1) a new type of content was introduced in CFN. "Thematic Collections" are editor-selected compilations of previously published contributions to both CFN and *Trail & Landscape*, on a central theme with links to each article. The first Thematic Collection focussed on alvars in Canada.

Several papers published this year in CFN received regional and national media coverage, reflecting not only the important contributions to science published in the journal but also the importance and relevance of the journals content—and the Club as a whole—to broader society in Canada. These papers all deal with issues related to climate change: expanded range limits of boreal birds in the Torngat Mountains, northern Labrador (http://dx.doi.org/10.22621/cfn.v131i1.1957), reported on by The Telegram (St. John's); expanded range limits of Beaver (*Castor canadensis*) into tundra habitat in Yukon and Alaska (http://dx.doi.org/10.22621/cfn.v130i4.1927), reported on by Radio Canada International and the Canadian Broadcasting Corporation (CBC); and interactions between Belugas (*Delphinapterus leucas*) and Killer Whales (*Orcinus orca*) in Hudson Bay (http://dx.doi.org/10.22621/cfn.v130i4.1925), reported on by the Canadian Press. Even content published over seventy years ago in CFN was mentioned in the media: in July 2017, the Ottawa Citizen reported that the arrival in Ottawa of Ring-billed Gulls (*Larus delawarensis*), which now are everywhere, was first reported in CFN in 1946. A 2016 *Trail & Landscape* article on long-term change in the pine grove vegetation at the Britannia Conservation Area, Ottawa, was reported upon by the Ottawa Citizen (16 August 2017), and again several weeks later following the major windstorm that damaged many trees in the area.

Back issues of CFN were stored for decades in the Saunders Building, Central Experimental Farm, Agriculture and Agri-Food Canada, under the stewardship of W.J. Cody and, most recently, Paul Catling. In early 2017, the committee was informed that this storage space would no longer be available. Upon consolidation of the material, it was determined that these archives comprised volumes 109 to 123, with a few missing issues. In the current digital age, demand for hard copy back issues is practically nonexistent. Accordingly, a decision was made to divest the club of much of this space-consuming material. A small team of committee members convened, and subsets of available back issues were sorted and moved to the Red Barn on the Farm for temporary storage. This backlog material is freely available to anybody who wants it. The remainder of the back issues were recycled. More recent back issues (vols. 124 to present) are currently being stored by Wendy Cotie, our typographer who lays out CFN.

Ottawa Field-Naturalists' Club Research Grants

2017 was the third year of the Ottawa Field-Naturalists' Club Research Grants program. Research grants support field-based research activities that reflect and promote the Club's objectives within eastern Ontario and/or western Quebec, focussed particularly upon the Club's study area. A total of $15 000 is available each year to fund research proposals. The call for proposals for 2017 awards was sent around in November 2016, with an application deadline of 15 January 2017. A subcommittee convened and chaired by Dr. Tony Gaston reviewed all proposals and recommended funding all four of them. The funding recommendations were submitted to the Board of Directors, who approved all of them. One applicant subsequently declined the funding, resulting in three projects being funded:

- Paul Catling, independent researcher. Changing status of terrestrial snails in Ottawa.
- Mary Ann Perron, Ph.D. candidate, University of Ottawa. Are urban ponds good wildlife habitat?
- David Seburn, Seburn Ecological Services. Identifying breeding locations of the threatened Western Chorus Frog (*Pseudacris triseriata*) in eastern Ontario.

JEFFERY M. SAARELA, Chair

Treasurer's Annual Report, 2017

The Financial statements for the year ended 30 September 2017 have been prepared by our accounting firm, Welch LLP based on a review they conducted of our financial records. We appreciate the considerable assistance of Mark Patry and Eric Leibmann. We do not get our books audited.

The financial statements are on an accrual basis which results in deferrals of funds received, such as membership fees, to the extent that there is a benefit owing to others after the date of the financial statements. We are continuing to fine tune our method of calculating these amounts which has resulted in greater deferrals this year than previous years. For example the CFN received subscription revenue for Volume 131 (2017) but only one issue of that volume was published by September 30th. As a result 75% of the subscription revenue was deferred. Furthermore, we received more grants this year than previously. Since a large portion of these grants relate to projects in the future our deferred revenue related to contributions is also higher. Note 6 of the Financial Statements (available at http://www.canadianfieldnaturalist.ca/index.php/cfn/article/view/2117/1999) provides more detail.

The last payment from the Czasak bequest was in 2015 and since then we have been incurring losses. We will be seeing expenses exceeding revenues for the next several years as we employ the bequest to further the objectives of the Club. This will also result in a decline in our investment account and interest income. The budget for 2017–2018 was approved by the Board on 16 October 2017. It forecasts a shortfall of $84 000. Our budgets tend to overstate our shortfall because many revenue sources are uncertain. The budget for 2016–2017 projected a deficit of $114 000 when, in fact it was $43 000.

Our investments are in conservative bonds with maturities spread over future years somewhat evenly. As we continue to incur deficits more of the investments will be liquidated to provide the necessary cash. Remy Poulin has been our investment manager in 2017 and Catherine Hessian will be assuming that responsibility in 2018. They work closely with our investment advisor, Sue Anderson at BMO Nesbitt Burns and follow the investment policy approved by the Board.

This was a year of transition as the role of Treasurer changed from Ken Young to myself on 10 January 2017. At the same time it was our first full fiscal year with a new bookkeeper, Katryna Coltress at Plus Associates, and new accounting software procedures. I am working to simplify the role of the Treasurer so that it can be undertaken without a huge time commitment. Part of that process is to use technology and programs to the greatest extent possible. Some of the changes are:

a) The number of bank accounts has been cut from three to one.
b) All requests for payments are electronic submissions with no paper and some are on automatic payment. Individual claimants scan their receipts before forwarding for payment.

c) Cheques are generated from our accounting software, Quick Books, to fit in window envelopes.
d) Donation receipts are sent throughout the year rather than year end and are computer generated. We are exploring sending them electronically while still meeting the CRA requirements.
e) Treasurer assistants are helping with deposits and donation receipts.
f) The number of internally restricted funds is being reduced to three from eight.

We are continuing to seek out ways to simplify the financial/administrative aspects of the club including subscription management for CFN and invoicing author charges.

As I have undertaken my treasurer duties I have been thankful for the generous support I received from the previous treasurer, Ken Young, and from the Board members, the Bookkeeper and the accountants who have been very patient with my learning curve.

ANN MACKENZIE, Treasurer

The Ottawa Field-Naturalists' Club Awards for 2017, presented February 2018

Eleanor Zurbrigg, Irwin Brodo, Julia Cipriani, Christine Hanrahan, and Karen McLachlan Hamilton

On February 24th, 2018, members and friends of the Ottawa Field-Naturalists' Club (OFNC) gathered for the Club's Awards Night at St. Basil's Church in Ottawa to celebrate the presentation of awards for achievements in the previous year. Awards are given to members or non-members who have distinguished themselves by accomplishments in the field of natural history and conservation or by extraordinary activity within the Club. Four Club awards were presented for 2017, for: (1) redesigning *Trail & Landscape*, (2) long time service for the Events Committee, (3) advocacy and science to ban the hunt of Snapping Turtles (*Chelydra serpentina*) in Ontario, and (4) nature-based education in Ottawa.

As well, a President's Prize was presented and a new award was announced—the James Fletcher Award—that is issued by the Publications Committee.

Member of the Year Award: Annie Bélair

This award recognizes a member judged to have contributed the most to the Club in the previous year.

Annie Bélair has been an active member since she joined in 2004, but in 2017 her contributions were exceptional.

When Annie became Editor of *Trail & Landscape* (T&L) in 2016, one of her goals was to revamp the publication, giving it a more contemporary look for its 50th anniversary in 2017. She began by looking at publications from other natural history clubs. Then mock-ups were produced by a professional graphic designer and reviewed by the Publications Committee. With these mock-ups as inspiration, and with the committee's suggestions in mind, Annie sprang into action. The result is the publication you see today.

Initially the plan was to create the new look by changing T&L to the current standard magazine-size format and to move away from its black-and-white style. The transformation was gradual, beginning with colour images (made possible by a generous bequest to the OFNC) in the first two issues of 2017. The complete reveal was seen in July's special anniversary issue where margins were reduced, creating less white space, titles were changed in size, and a new multi-coloured writing style was incorporated throughout. Some images now occupy an entire page while others bleed onto the facing one. And the front cover will be different with each issue, highlighting an article found within. The new version of T&L is quite eye-catching. Creating the makeover was no easy task. To produce the 79-page anniversary issue, Annie spent 8–12 hours each and every weekend day and 1–2 hours each night during the week for the entire month of May and the beginning of June. She formatted the articles she received, contacted Club members to acquire images, and even wrote articles herself to fill the gaps she saw with respect to content fitting for this special issue. The final version was one extremely large document that she had to split it into sections so it could be submitted to the printer electronically. Then she had to make sure all the sections were compiled correctly. It takes an extremely focussed individual to accomplish all this within a six week production window.

In 2017, Annie's contribution to the Club was not solely as Editor of T&L. She sat on the Board of Directors and was a member of the Publications Committee, where she contributed to all the meetings. She was also involved in the redesigning of the OFNC website, and continued to help with the Macoun Club and the Awards Night. Where did she find the time?

What a year it was for Annie, our Member of the Year.

(Prepared by Karen McLachlan Hamilton)

George McGee Service Award: Julia Cipriani

This award is given in recognition of a member who has contributed significantly to the smooth running of the Club over several years.

This year, Julia Cipriani is the recipient of the 2017 George McGee Service Award. Julia probably needs little introduction, for she has been involved with so many OFNC activities that she is well-known. Julia joined the OFNC in 2004, and within a few years was volunteering her time and energy to any number of club projects and initiatives.

From 2007 to 2013, she was a keen volunteer with the Fletcher Wildlife Garden's Butterfly Meadow project, which relies heavily on dedicated people to maintain the habitat. In the earlier days, when Julia became involved, the meadow was still in the process of being expanded and revamped, and Julia was instrumental in helping create the Butterfly Meadow we see today.

Earlier still, in 2006, Julia joined the OFNC Board of Directors, where she served for several years as a Member-at-Large. Later she re-joined the Board as Chair of the Events Committee from 2014 through 2016.

Julia has been a key participant in the very active Events Committee (previously, Excursions and Lectures) from 2007 to the present, both as a member, and as the Chair. Being extremely organized, she contributes greatly to the smooth operation of this committee. It is not unknown for her to arrange more than a dozen events a year, and as another member of the committee said, "We would not have the same number or breadth of events without the work she does". She is also ever on the lookout for people to serve as trip leaders, or to give presentations at the monthly meetings. Even at the Awards Night, she does not rest, but seeks out any potential new leaders or presenters willing to contribute their expertise. Julia says that she enjoys learning about the natural world, and this fuels her determination to continue looking for people who can introduce the beauty and wonder of nature to others. She says that being an extrovert and feeling comfortable talking to strangers helps! It is also her low-key but passionate approach that makes it hard for them to say "no". In addition, she gives tremendous encouragement to other committee members, and provides them with guidance and tools which enable them to be important contributors to the Events Committee. Julia also attends almost every OFNC monthly meeting, and many of the field trips, helping to make sure they run smoothly. Furthermore, Julia has hosted all but one of the committee meetings at her house since 2012. And she provides not only a warm and welcoming atmosphere, but snacks too.

In addition to her busy engagement with the Events Committee, Julia was also very active with the Soiree/Awards Night from 2008 to 2016. Initially, she volunteered to help find gifts for the silent auction, visiting businesses such as Focus Scientific, Wild Birds Unlimited, and many more. Soon enough, however, she also began to take on more of a role in preparing the food for the Awards Night, and then, from 2011 to 2016, she purchased the food for the event, a not inconsiderable job, as well as continuing to help with preparation.

During Ann MacKenzie's term as OFNC President, Julia worked with her on ways to expand and engage membership. As part of this initiative, she co-facilitated several sessions seeking ideas on how to garner interest in the OFNC.

And last, but not least, Julia has been a keen member of the Awards Committee since 2009, providing valuable ideas and input, writing citations, and helping with a variety of necessary tasks.

For all these reasons and more, we are pleased to honour Julia Cipriani with the 2017 George McGee Service Award.

(Prepared by Christine Hanrahan, using much of Jakob Mueller's nomination)

Conservation Award – Member: David Seburn

This award recognizes an outstanding contribution by a member in the cause of natural history conservation in the Ottawa Valley, with particular emphasis on activities within the Ottawa District.

This year David Seburn is the recipient of the Conservation Award – Member for his determination and contributions to the effort to ban the Snapping Turtle hunt in Ontario.

David Seburn spent 20 years as an independent amphibian and reptile ecologist, and is now the freshwater turtle specialist for the Canadian Wildlife Federation. He is a member of the Ottawa Field-Naturalists' Conservation and Publications committees and chair of the Canadian Herpetological Society's conservation committee.

In 2012, David was awarded the Ottawa Field-Naturalists Club's award for Conservation for his significant efforts in turtle research and conservation in the Ottawa area. He was part of a group that unsuccessfully lobbied the Ontario government to ban the Snapping Turtle hunt at that time.

The Ontario government designated the Snapping Turtle as a Species at Risk, but held on to their position to retain the hunt. When the Ontario government opened comments on changes to the provincial hunting regulations in 2016, there was renewed interest in trying to end the hunt. David held his position that the hunt was not based on science and publicized the risks Snapping Turtles face, including habitat loss, persecution, and road kill. It can take 20 years or more for an individual turtle to mature, making it difficult for populations to rebound from losses. Adult females are particularly vulnerable to road kill during the nesting season when they are looking for places to lay their eggs. When females do successfully lay eggs, their nests are often raided by foxes, Raccoons (*Procyon lotor*), and other predators.

David worked with many naturalist organizations, including our own Ottawa Field-Naturalists' Club and Ontario Nature to engage and motivate others to ask the Ontario government to end the Snapping Turtle hunt. He helped keep the short-sightedness of the hunt in the news and on social media. The Ontario government received more than 11 000 comments calling for the end of the Snapping Turtle hunt, and in early 2017 the hunt was finally banned. The turtle is currently listed as a species of "Special Concern".

On their website, Ontario Nature acknowledges that, "It was a collaborative journey of dogged determination, fueled by letters to ministers, petitions, reports, opinion editorials, action alerts, blogs, and social media campaigns. When the going got tough, the fair and informed coverage by the press and by the Environmental Commissioner of Ontario helped immensely to buoy weary spirits and keep the issue in the public eye".

David was a key player in the process. He used his powers of persuasion via the internet to keep the issue in the news. A brief search of the subject will give rise to several links describing his tenacious effort to keep the hunt in view.

It is for his promotion and advocacy to ban the hunting of Snapping Turtles in Ontario, that the OFNC is pleased to present David Seburn with the Conservation Award for a Member for 2017.

(Prepared by Julia Cipriani. Material from the Ontario Nature website was accessed January 2018, http://www.ontarionature.org/connect/blog/at-long-last-an-end-to-the-snapping-turtle-hunt)

Mary Stuart Education Award: Teachers of Regina Street Alternative School

This award is given to a member, non-member, or organization, in recognition of outstanding achievements in the field of natural history education in the Ottawa Region.

We at the OFNC firmly believe that the well-being of the natural world in the near and distant future lies in the love of nature that is developed in the young. Unless young people are fortunate enough to have access to natural history clubs like the Macoun Field Club, their appreciation of nature is usually acquired through experiences they have with their family and the lessons they learn at school, especially if they have teachers such as those at the Regina Street Alternative School.

This school, situated adjacent to Mud Lake in the Britannia area, has over the past six years developed an extraordinary program of general learning based on exposing their students to a variety of outdoor experiences. Essentially, the teachers have made Mud Lake part of their school. The teachers have both brought nature into the classroom and used the natural environment as the classroom.

Robert James, the principal of the school, describes it as follows: "On a weekly basis students go down to Mud Lake with an educational focus. It could be anything from a math activity to a writing exercise. Students are able to share a common experience in a natural setting and take control of their own learning". For example, math classes explored mathematical patterns in nature and then found out how to determine the height of a tree using geometry, how to display data results using graphs, and how to calculate probabilities with regard to the occurrence of natural events. Social Studies classes included drawing maps, finding out how various levels of government preserve natural spaces, and First Nations connections with the environment.

The outdoor projects continue into the school hallways with artwork and conversations, undoubtedly inspiring other students to explore the area. Kathleen Turner, of the MacSkimming Outdoor Education Centre, notes that, "The staff at Regina … have learned along with their students. Their curiosity and motivation to explore the natural environment has not only brought the students' learning to life, but has also helped shape an observant, kind, and curious community of students". The students have, in turn, inspired their parents' interest in the natural world, not surprising because, as we all know, we often learn much from our children.

The imaginative and resourceful teachers at Regina Street School have become mentors throughout the Ottawa-Carleton District School Board based on their experience with inquiry-based lesson plans and classroom management techniques using outdoor spaces. Because of their inspired and inspiring leadership in natural history education, the elementary school teachers at the Regina Street Alternative School are the 2017 winners of the OFNC's Mary Stuart Education Award.

(Prepared by Irwin Brodo)

President's Prize: Adrienne Jex and Greg Lutick

This award is given at the President's discretion in recognition of a member for unusual support of the Club and its aims.

For 2017, I would like to acknowledge the service given by Adrienne Jex and Greg Lutick.

Adrienne and Greg are the resourceful and dependable couple who about four years ago took over the refreshment table at our club's monthly meetings, shortly after we moved into the Neatby Building facility. They have successfully coped with a difficult situation—the water is far away and plugs for the electric kettles are inconvenient and they need to come early to heat the water and set up their table. They invested in equipment to keep the brewed coffee hot and at most monthly meetings we are treated to their homemade goodies, the most imaginative being the cupcake moths that they made for the talk on Moths and Mothing. These were particularly relished. When Adrienne and Greg cannot make a monthly meeting, they see to it that somebody else is covering for them.

For their dependability, creative imagination, and for adding a special touch to our monthly meetings, I wish to award Adrienne and Greg the President's Prize for 2017.

(Prepared by Fenja Brodo and Diane Lepage, President)

James Fletcher Award: Diana Bizecki Robson, John H. Wiersema, C. Barre Hellquist, and Thomas Borsch

New in 2017, the James Fletcher Award recognizes the best paper published in *The Canadian Field-Naturalist* in a particular volume, commencing with volume 130 (2016). The award is administered by the Publications Committee of The Ottawa Field-Naturalists' Club.

The first recipients of this new award are Diana Bizecki Robson, John H. Wiersema, C. Barre Hellquist, and Thomas Borsch for their paper entitled "Distribution and ecology of a new species of water-lily, *Nymphaea loriana* (Nymphaeaceae), in Western Canada", Canadian Field-Naturalist 130(1): 25–31. https://doi.org/10.22621/cfn.v130i1.1787. The paper describes an extensive field investigation of the distribution and ecology of a newly described aquatic plant species endemic to the Prairie Boreal Region of Canada. It represents foundational research on a new taxonomically important species and will be referred to for decades to come.

Congratulations to authors Robson, Wiersema, Hellquist, and Borsch, who have been sent personal copies of the award certificate.

(Prepared by Annie Bélair based on material from Dan Brunton and Jeffery Saarela,
see Canadian Field-Naturalist 131(3): 285.
https://.doi.org/10.22621/cfn.v131i3.2071

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